The Nutritional and Feeding Status of Children Living within Institution-based Care and an Evaluation of Process of the Child Nutrition Program.

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Department of Population Health Faculty of Epidemiology and Population Health

LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE

Funded by: Holt International

Declaration

I, Emily DeLacey, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract

Background

Malnutrition is a major global health issue. Orphaned and vulnerable children, such as those in institution-based care (IBC), are especially at-risk. Some 9.42 million children live in IBC worldwide but data on this group is sparse. The overall aim of this PhD was to generate evidence to improve future nutritional and feeding services for children living within IBC globally.

Methods

A systematic review compiled and evaluated available evidence on the nutritional status of children in IBC. Two retrospective analyses of surveillance data described the current nutritional and feeding status of children living within IBC who participate in the Child Nutrition Program (CNP). Shewhart control charts and funnel plots explored inter-site and over-time variations in nutritional status and logistic regression examined associations between feeding difficulties and disability taking into account natural variation. An evaluation of the process described the implementation of CNP.

Results

Children in IBC were commonly born prematurely 294/697 (42.2%) or low birth weight 514/895 (57.4%). Many had disabilities 739/2926 (25.3%), were malnourished 1048/2812 (37.3%) and/or anemic 717/2494 (28.7%). Children with disabilities had higher prevalence of malnutrition and feeding difficulties compared to counterparts without disabilities. The adjusted risk of having a feeding difficulty was 5.08 times (95%CI: 2.65–9.7, $p \leq 0.001$) higher in children with disabilities than those without. Many children saw their feeding difficulties resolve after 1-year in CNP. Suboptimal hygiene, dietary and feeding practices were reported in IBC. Mixed-methods evaluation of the implementation of CNP indicates that strong leadership/relationships, frequent training, funding and adequate staffing are needed for successful implementation.

Conclusion

Malnutrition (stunting, underweight and wasting) and feeding difficulties are common in IBC, especially among children with disabilities. Supporting safe interactive and nutritious mealtimes should be prioritized to ensure overall health and development. Program evaluations can help improve interventions and underpin programmatic growth and scaling.

Preface and Acknowledgements

I would like to first thank all my field teams, partners and colleagues whose meaningful work to improve the lives of so many children and families made this research possible. I want to thank Holt International for their support, participation, and commitment to my vision of integrating research into our work.

I would like to acknowledge and give all the thanks to Dr. Marko Kerac, my primary supervisor, who has made all of the difference and taught me the skills to be successful. His time and guidance are beyond appreciated and are the reason why I was successful in this PhD. He is an incredible teacher and the best academic supervisor. I am privileged to have had the opportunity to work with him and immensely grateful for the endless hours he spent guiding and supporting me through my PhD. My deep gratitude to my other supervisors Dr. Cally Tann and Professor Elizabeth Allen and to my advisory committee members, Professor Nora Groce and Dr. Tracey Smythe. All these people provided tremendous support, guidance, and encouragement.

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Additional thanks to Michael Quiring, Caryl Garcia, Merzel Demasu-ay of Kaisahang Buhay Foundation, Inc., and Dr. Ethan Bergman of Central Washington University.

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List of Abbreviations

CC	Community care
CLS	Children living on the streets
CNP	The Child Nutrition Program
DAG	Directed Acyclic Graph
ELBW	Extremely low birth weight
FBC	Family-based care (orphaned or abandoned children living in community settings)
HAZ	Height-for-Age Z-score
IBC	Institution-based Care
IQR	Inter-quartile range
LBW	Low birth weight
LMICs	Low- and middle-income countries
LSHTM	The London School of Hygiene and Tropical Medicine
MUAC	Mid-upper Arm Circumference
MUACAZ	Mid-upper Arm Circumference-for-Age Z-score
NGO	Non-governmental organization
NHS	Nutrition and Health Services
OR	Odds Ratio
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
PICO	Patient/population, intervention, comparison, and outcomes
REC	Research ethics committee
RR	Relative risk/ risk ratio

SCMC-AEI	St. Cabrini Medical Center - Asian Eye Institute Ethics Review Committee
ToT	Training of Trainers
UK	United Kingdom
UNICEF	United Nations Children’s Fund
US	United States
WAZ	Weight-for-Age Z-score
WHO	The World Health Organization
WHZ	Weight-for-Height/Length Z-score

Definitions

Child Nutrition Program: The Child Nutrition Program is Holt International's nutrition and feeding intervention program designed to improve the nutrition and feeding practices for vulnerable children by providing training, resources and support to caregivers and sites.[1]

Children with disabilities: The UN Convention on the Rights of Persons with Disabilities defines persons with disabilities, including children, as "All persons with disabilities including those who have long-term physical, mental, intellectual or sensory impairments which, in interaction with various attitudinal and environmental barriers, hinders their full and effective participation in society on an equal basis with others."[2]

Feeding difficulties: A term which encompasses feeding issues or challenges, regardless of severity, etiology, or effects. It includes any difficulties that affect the process of providing food to the child or the child consuming the meal.[3]

Feeding practices: A term which encompasses the interactions between a child and caregiver during mealtimes. These practices can be influenced by various factors such as socio-economic status or a child's ability, age or cultural beliefs and practices.[3-5]

Institution-based care: Care for children in group residential care facilities often run by the government, non-profits or faith-based organizations. Also commonly referred to as orphanages, alternative care, institutions, children's homes or care homes.[6]

Self-fed/self-feeding: When children feed themselves using their own fingers, utensils and cups. It is the process of setting up, arranging and bringing food and liquid from a plate, bowl or cup to their mouth. Self-feeding using the fingers typically begins around 6-7 months old when children start eating solid foods. Typically, by 12-14 months old, children take on more of an active role using spoons and cups on their own to feed themselves. Age appropriate self-feeding is considered an important developmental skill.[7]

Special diets: Eating regimens for certain food allergies/intolerances or chronic conditions, such as diabetes, epilepsy or kidney disease. They also include therapeutic diets such as modified texture diets such as pureed, soft or liquid diets.[7]

Chapter 1: Introduction

1.1 Background

1.1.1 Child Malnutrition Globally

Malnutrition continues to affect many countries worldwide with millions of children having inadequate access to nutritious food.[8-11] Some 45.5 million children younger than 5 years old are wasted (too thin for their height), 149.2 are stunted (too short for their age, commonly seen as a marker of chronic malnutrition) and 38.9 million are overweight.[10,11] Almost half of the deaths among children younger than 5 years old have undernutrition as an underlying factor.[8,10] Malnutrition also predisposes to long-term impairments such as diminished cognition, disability and suboptimal performance at school, work and non-communicable diseases.[8,10] Substantial progress has been made in the last two decades in saving the lives of children younger than 5 years globally but children in low-and middle-income countries (LMICs) continue to be at a higher risk.[11] [12] According to UNICEF, less than half of all children aged 5 years and younger reside in low- and middle-income countries.[11] However, almost two thirds of all children who are stunted, and three quarters of all children who are wasted, live there.[11]

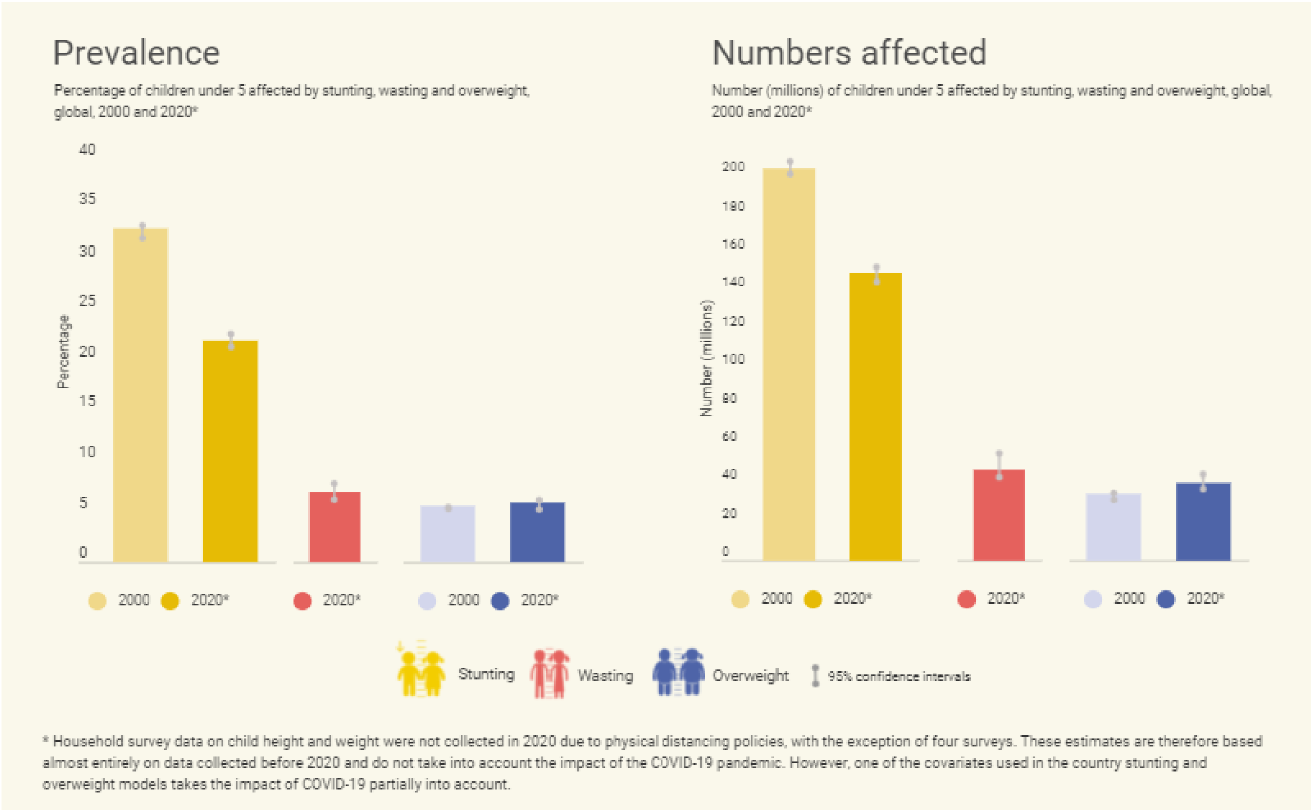

Figure 1.1: Comparison of global malnutrition status (stunting, wasting and overweight) for children in 2000 and 2020

Source: UNICEF/WHO/World Bank Joint Child Malnutrition Estimates, 2021 Edition.[11]

1.1.2 Children Living within Institution-based Care (IBC)

UNICEF estimates there are 140 million orphans worldwide who have lost either one, or both, parents.[13] Although most live with other family members, some live in alternative care settings including institution-based care (IBC), although many of the children living within IBC are not orphans.[13,14] There is concern that an increased number of children will end up in IBC because of loss of family or due to economic constraints related to the COVID-19 pandemic.[15,16] IBC is defined by the United Nations as residential care provided in any non-family-based group setting, such as places for emergency care and all other short- and long-term residential care facilities.[17] Children who live in IBC are protected under the UN Convention on the Rights of the Child, which requires alternative care to provide children with standards of living, including adequate nutrition, health services and education, which support their full development.[18] There are 3.18 million to 9.42 million children ages 18 years and younger who live in IBC globally.[19]

Despite there being such a larger number of children in IBC, evidence on the needs of this population remains limited.[20] Children enter into IBC with many pre-existing nutritional, developmental, medical and neurological conditions.[21-23] IBC can have detrimental effects on children's health and development both immediately and in the long term.[22,24,25] Children's emotional development, mental health, relationships, self-regulation, executive functions, immune systems and growth can be impacted.[22,25-27] In addition, children in IBC may be at increased risk for malnutrition, infections and illnesses.[23,24]

1.1.3 Children with Disabilities

Globally there are nearly 240 million children living with disabilities or about 1 in every 10 children. [20,28,29] Of those, 93 million children are living with moderate to severe disabilities.[30-33] Disabilities can impact children's ability to function and carry out basic activities. There is also the relationship between disabilities and the environments in which children live, which may be unaccommodating for the child to fully participate.[2,18,20,34] The framework for the International Classification of Functioning, Disability and Health defines disabilities as causing impairments, limitations or restrictions to children's ability to function or participate in activities.[34] The ICF Framework integrates both factors impacting the child and their environment — connecting both disabilities as medical conditions and as limitations in terms of environments, cultural contexts and policies.[34]

Despite the ratification of the Convention on the Rights of the Child and Convention on the Rights of Persons with Disabilities and inclusion in the Sustainable Development Goals, children with disabilities continue to be excluded.[2,18,35,36] There is often very limited data and information on children with disabilities, due to their often exclusion from official health surveys, statistics, research and nutritional programs.[20,36]

According to recent data from UNICEF [20,28], children with disabilities are:

- 24 percent less likely to receive early stimulation and responsive care
- 25 percent more likely to be wasted and 34 per cent more likely to be stunted
- 49 percent more likely to have never attended school
- 51 percent more likely to feel unhappy

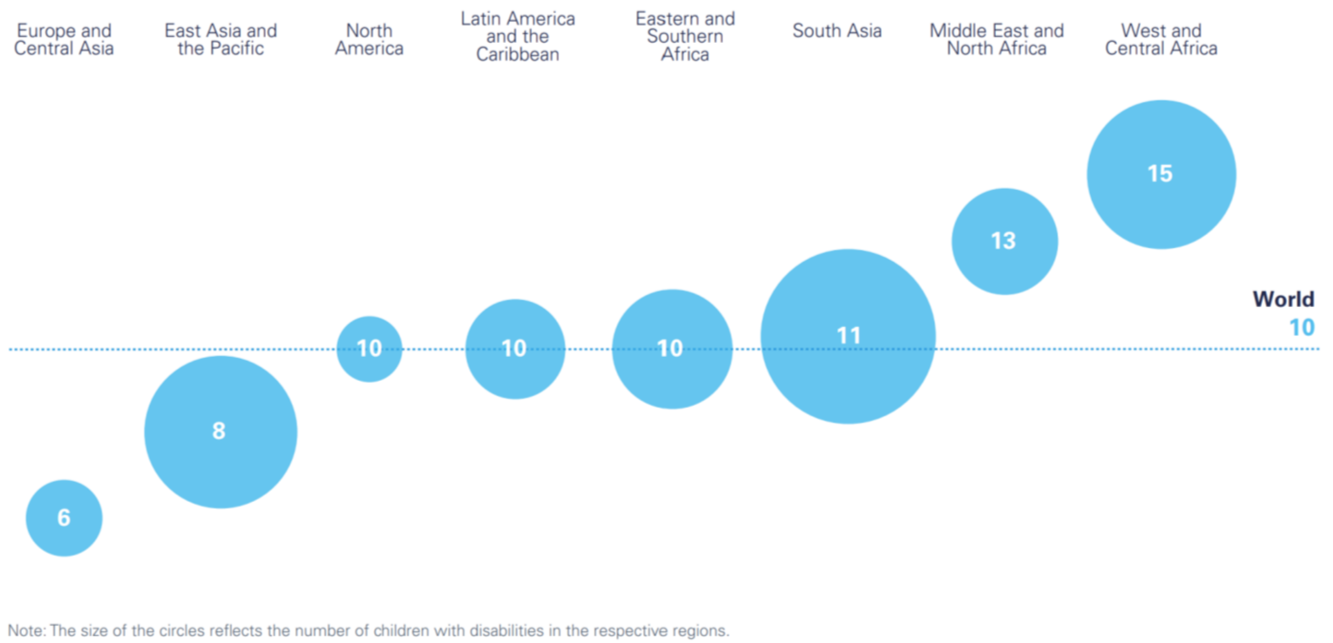

Figure 1.2: Percentage of children aged 0-17 years old with disabilities

Source: UNICEF's *Seen, Counted, Included*: Using data to shed light on the well-being of children with disabilities[20]

1.1.4 Malnutrition, Disability and Institution-based Care

Disabilities are especially prevalent among children in low- and middle-income countries where malnutrition is a leading cause of childhood mortality.[8,12,32] There is limited knowledge about the nutritional status of children with disabilities and addressing this knowledge can have challenges, even in the methods of measuring nutritional status. Children with disabilities are at increased risk for a number of reasons including physical challenges with eating or other feeding difficulties, inadequate feeding practices by caregivers, social or cultural contexts, or food insecurity.[20,30] For some children, poor nutrition can also worsen their disabilities and make recovery more difficult, if not impossible.[12,30,32] Children with disabilities are also overly represented in IBC, with nearly 25% of children in IBC having a disability.[20,37,38] When children with disabilities reside in IBC, they can be at risk for malnutrition due to limited staffing, gaps in caregiver knowledge on how to meet their needs and even discriminatory practices.[7,20,37]

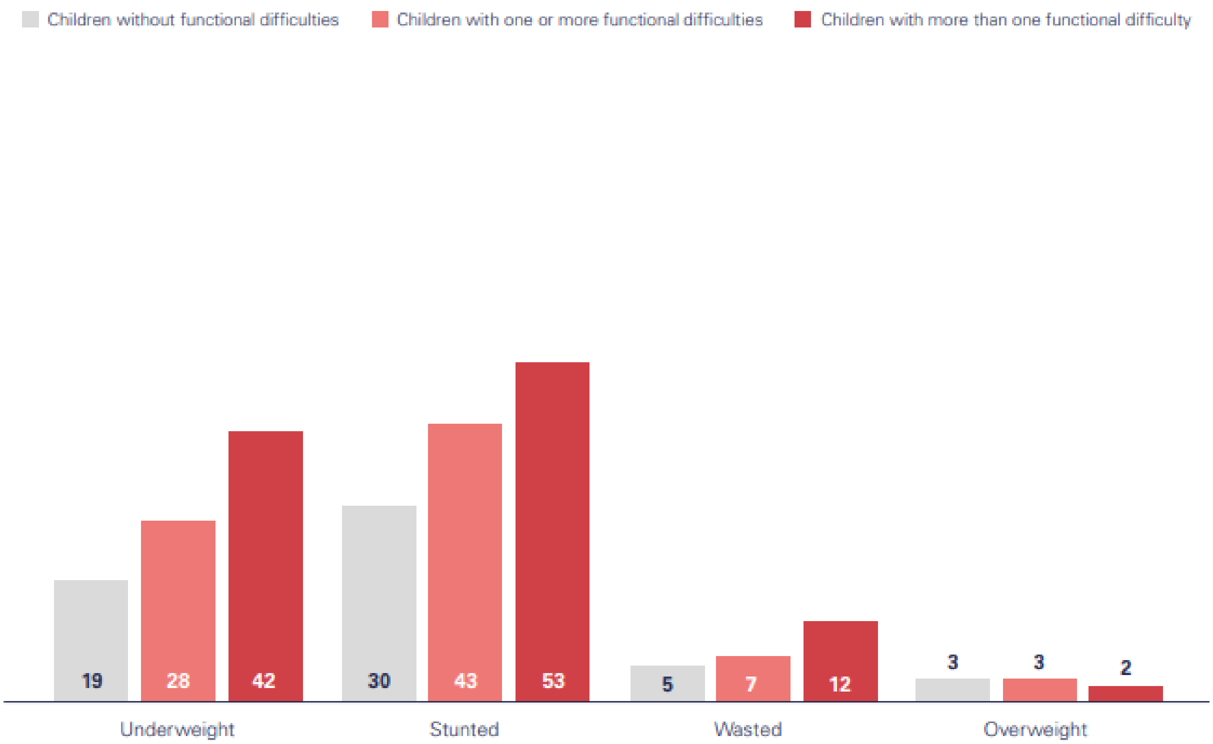

Figure 1.3: Percentage of children aged 24- 59 months who are underweight, stunted, wasted or overweight

Source: UNICEF's *Seen, Counted, Included*: Using data to shed light on the well-being of children with disabilities[20]

1.1.5 Feeding Practices and Feeding Difficulties

There are millions of children worldwide who have limited access to nutritious food or the resources and support needed to safely and successfully eat.[11] How children are fed plays a critical role in their nutrition status and overall development but there is currently limited information available, especially for children living within IBC and those children with disabilities.[3,39] Feeding difficulties and malnutrition predispose children to long-term impairments such as impaired cognition, disability, suboptimal school performance and adult non-communicable diseases (NCD).[8,10,12] Feeding and mealtimes are an important part of children's days and make up as much as 50% of the time a child may spend with their caregiver during the day. They are often one of the main opportunities for children to interact, learn and develop skills with the support of their caregivers. [23,40] Children with disabilities often need additional time, support and assistance to safely, successfully and comfortably eat.[20]

1.2 Holt International

This PhD is supported by Holt International. Holt International is a 66-year-old child welfare non-profit organization serving more than 17 locations/countries around the world through family strengthening, care for orphaned and vulnerable children and adoption services programming.[1,41,42] Holt's mission is to "find and support permanent, loving families for children who are orphaned, abandoned or at serious risk of separation from their family, provide services to ensure that children will grow and develop to their fullest potential and lead the global community in advocating on behalf of the world's most vulnerable children".[41] In each of the countries where Holt works there are either Holt country offices and teams or partners through which they implement programs and services and maintain relationships with local governments.[42]

In 2021, Holt provided;

- Services for 1,036,117 children and individuals
- Health and medical care for 32,645 children
- Nutritional support for 48,505 children and pregnant women
- Over 124,000 health screenings for children and individuals
- Supplements and prenatal vitamins to over 50,000 children and individuals
- Training for 4,692 caregivers
- Access to clean water to 6,503 families
- Over a million meals to children and families

Figure 1.4: Holt International Country Programs

Source: Holt International[41]

1.2.1 Holt International's Child Nutrition Program

Holt International's Child Nutrition Program started in 2014 at two pilot sites to address the nutrition and feeding needs of children living within IBC.[1] Since then, the program and resources have expanded to serve vulnerable children in community-based settings, foster care systems, health centers and IBC. The program has a Training of Trainers (ToT) structure and provides training, resources, support and an electronic health record system to sites. Core content of the program focuses on child nutrition, feeding, positioning, hygiene and sanitation, maternal health, nutrition and growth monitoring, health screenings and individual and sitewide behavior change. Routine monitoring and evaluations are completed as part of the program structure. The program operates in eight countries: China, India, Mongolia, the Philippines, Ethiopia, Vietnam, Uganda and Haiti. Over 7,000 children at 68 sites have participated in the program, including over 800 children with disabilities. More than 40,000 health screenings have been conducted and more than 2,200 caregivers have been trained on CNP curriculum.

1.2.2 Relationship between Holt International and this PhD

I have worked for Holt since 2016 as its director of Nutrition and Health Services (NHS). Through this role, I oversee all nutrition and health programming in all the countries where Holt works.[1,41]

The department provides services in four key domains:

1. Nutrition and Feeding Interventions (The Child Nutrition Program)
2. Health and Medical Interventions
3. Water Access, Sanitation and Hygiene (WASH) services
4. Food Assistance

I lead the service sector from our headquarters office in the U.S. and have teams at eight of our country program offices or partner offices in China, India, Mongolia, the Philippines, Vietnam, Haiti, Uganda, and Ethiopia. In each of the countries where Holt works, I maintain strong relationships with partners, country offices and government officials. This involves regular visits to the countries and close working relationships with teams and programs but I do not oversee the day to day management of local staff.

As we continued to grow Nutrition and Health Services at Holt, I developed additional goals for my department. My first goal was to provide the highest quality evidence-based child-centric services. My second goal was to advocate and raise awareness of the needs of the vulnerable children and the families that we serve. My third goal was to grow services and programs to reach more children and families. To do this, a new strategy had to be identified. When I started in 2016, we had one pilot nutrition program serving about 200 children but had the capacity to do so much more. After a couple years of building up the child nutrition program, I met Dr. Kerac at the Nutrition and Growth Conference in Amsterdam in 2017. After connecting and discussing some opportunities around the work I was doing, Dr. Kerac suggested a PhD with the London School of Hygiene and Tropical Medicine. Completing a PhD would give me the opportunity to develop my professional skills and ability to become an independent researcher, inform our evidence-based programs and most importantly, to highlight the needs of the children and families that we serve.

I presented this vision and proposal to Holt and Holt agreed to support the PhD and integration of the research into the work my department was already doing. Holt saw the value in conducting research that could elevate its profile and make its work known to global audiences, in addition to providing insights to improve our programs and services. Since then, it's grown from a single pilot program to an entire service sector for the organization, providing services for over 350,000 children and families and over a million nutritious meals each year.

Organizationally, Holt has committed to my long-term vision to build up Holt's capacity to do research and expand nutrition and health programs.

As I prepared my application to LSHTM, I brainstormed possible areas for my research where there were gaps in the information currently available and key areas we needed additional insights for our programs. There was notably limited information available for the children in IBC who participate in our programs. I decided that integrating my research into the operations of the Child Nutrition Program and specifically looking at the nutritional needs of children living in IBC would be most beneficial to Holt and our department's strategy and needs. After starting my PhD in fall of 2018, I worked with my LSHTM supervisors, my teams at Holt and our partners to strategically plan research that would best benefit the children in Holt's programs.

1.3 Rationale for Research

There are millions of children younger than 18 years old living in institution-based care globally and the numbers entering IBC are increasing due to the COVID-19 pandemic.[15,19] These vulnerable children can be at risk for malnutrition because childhood presents critical periods of growth and development, during which unaddressed malnutrition can have long-term consequences to development.[3,8,43] For children in IBC, how they are being fed is just as important to what they are being fed. Feeding difficulties in tandem with poor nutrition can predispose children to long-term impairments such as diminished cognition, disability, suboptimal school performance and adult non-communicable diseases (NCD).[3,11,12,39] Provision of services to children in IBC is often precluded by facilities limitations in terms of time, finances, staffing and competing priorities.[23,27,43] Describing the nutritional and feeding status of children in IBC is an important step in addressing their needs. Learning from the implementation of programs working to address their needs can also play a key role in the provision and expansion of quality services for this population of vulnerable children.

1.4 PhD Aim and Objectives

1.4.1 Overall Aim

The overall aim of this PhD was to generate evidence to improve future nutritional and feeding services for children living within IBC globally.

1.4.2 Objectives

Focusing on Holt International's Child Nutrition Program in Mongolia, China, India, the Philippines, Vietnam and Ethiopia, I had 4 related objectives for this PhD:

Objective 1: Systematically examine the currently available evidence base on the nutritional status of children living within IBC globally.

Objective 2: Describe and evaluate the nutritional status of children living within IBC.

Objective 3: Describe and evaluate the feeding difficulties and practices of children living within IBC.

Objective 4: Identify and evaluate key factors underlying program implementation of the Child Nutrition Program.

1.5 Thesis Structure

The thesis for this PhD is presented in the "research paper style" format, following the London School of Hygiene & Tropical Medicine research degree regulations. The thesis is composed of several related journal articles which have been published or submitted to peer-reviewed journals. The Table of Contents outlines the content of this thesis. This thesis is divided into seven chapters, references and an annex. The chapters of this paper consist of connecting information and the research papers. An overview of the component chapters is provided below.

Chapter 1: Provides background on the status of malnutrition globally, children in IBC, children with disabilities, Holt's Child Nutrition Program and my relationship to Holt, CNP and this PhD. The rationale for this PhD, aim and objectives are included.

Chapter 2: Addresses Objective 1 and details the currently available evidence on the nutritional status of children living within institution-based care globally. Chapter 2 has been published in a peer-reviewed journal (PeerJ).

Chapter 3: Addresses Objective 2 and describes and analyzes the nutritional status of children living with IBC who participate in Holt's Child Nutrition Program. Chapter 3 has been published in a peer-reviewed journal (BMJ Open).

Chapter 4: Addresses Objective 3 and describes and analyzes the feeding practices and difficulties of children living within IBC who participate in Holt's Child Nutrition Program. Chapter 4 has been published in a peer-reviewed journal (Maternal and Child Nutrition).

Chapter 5: Addresses Objective 4 and describes the implementation of Holt's Child Nutrition Program in two countries. Chapter 5 is under peer review (Public Health Nutrition).

Chapter 6: Draws together the lessons learned from the research presented in chapters 2-5 and provides an overall discussion of that work, including its strengths and limitations.

Chapter 7: Provides recommendations and conclusions including implications for caregivers, practitioners, program managers, policy, programs and research.

Annex: Includes supplementary information for research included in chapters 2-5 and additional research undertaken, including two additional research papers.

1.6 Description of PhD Research

Table 1.1: Description of this PhD thesis

(See Annex A for full description of contributions by the candidate and co-authors for each section)

Chapter Number and Title		PhD Objective	Sub-objectives	Methods	Paper
1	Background, rationale, aims and objectives	Background, rationale, aims and objectives for this PhD thesis	Describe the nutritional status of children globally Provide overview of IBC Summarize the status of children with disabilities globally Provide an overview of CNP	Literature review	
2	Systematic Review of the Nutritional Status of Children In IBC	**Objective 1:** Systematically examine the currently available evidence base on the nutritional status of children living within IBC globally.	To describe the nutritional status of children living within IBC by looking at anthropometric and nutritional status indicators in relation to age, disability, geography, gender and related factors.	Systematic review	The nutritional status of children living within institutionalized care: A systematic review, published in PeerJ [38]
3	Nutritional Status of Children in IBC	**Objective 2:** Describe and evaluate the nutritional status of children living within IBC.	1. Describe children's nutritional status, focusing on core anthropometric measures of growth (underweight, wasting, stunting, overweight) and anemia. 2. Explore inter-site variations and potential factors underlying those, notably disability. 3. Explore any changes in nutritional status over time in IBC.	Literature review Descriptive statistics Control charts and Funnel plots	Nutritional status of children living within institution-based care: A retrospective analysis with funnel plots and control charts for programme monitoring, published in BMJ Open [6]

Chapter Number and Title		PhD Objective	Sub-objectives	Methods	Paper
4	Feeding status of children in IBC	**Objective 3:** Describe and evaluate the feeding difficulties and practices of children living within IBC.	1. Describe the children's feeding methods, practices and associated difficulties. 2. Explore potential factors underlying these practices and difficulties, notably disability. 3. Explore any changes in feeding difficulties over time in IBC.	Literature review Descriptive statistics Qualitative analysis of themes Narrative synthesis Fisher's exact test Generalized linear model	Feeding practices of children living with institution-based care: A retrospective analysis of surveillance data, published in Maternal and Child Nutrition.[7]
5	Evaluation of the Process of the Implementation of CNP	**Objective 4:** Identify and evaluate key factors underlying program implementation of the Child Nutrition Program.	1. Describe the implementation of the Child Nutrition Program in Mongolia and the Philippines. 2. Summarize the barriers, disruptions, enablers and solutions for implementation at a caregiver, site, country, multinational implementers and policy level. 3. Explore key factors important for implementation and growth of CNP.	Literature review Descriptive statistics Independent samples t-test Two-sided Fischer's Exact Test Semi-structured interviews, thematic framework analysis	Learning from the implementation of the Child Nutrition Program: A mixed methods evaluation of process, published in Children.
6	Discussion	To discuss the main findings of this thesis	Discuss overall strengths and limitations.		
7	Recommendations, implications and conclusion	To provide a summary of recommendations, describe research implications and conclusion	Summarize recommendations for caregivers, programs, policy and implications for future research.		

1.6.1 PhD Publications and related outputs

List of research papers included in this thesis

Paper 1: **The nutritional status of children living within institutionalized care: A systematic review**

DeLacey E, Tann C, Groce N, Kett M, Quiring M, Bergman E, Garcia C, Kerac M. 2020. The nutritional status of children living within institution care: a systematic review. PeerJ 8:e8484 https://doi.org/10.7717/peerj.8484

Paper 2: **The nutritional status of children living within institution-based care: A retrospective analysis with funnel plots and control charts for program monitoring**

DeLacey E, Hilberg E, Allen E, et al Nutritional status of children living within institution-based care: a retrospective analysis with funnel plots and control charts for programme monitoring BMJ Open 2021;11:e050371. doi: 10.1136/bmjopen-2021-050371

Paper 3: **Feeding practices of children within institution-based care: A retrospective analysis of surveillance data**

DeLacey, E., Allen, E., Tann, C., Groce, N., Hilberg, E., Quiring, M., Kaplan, T., Smythe, T., Kaui, E., Catt, R., Miller, R., Gombo, M., Dam, H., & Kerac, M. (2022). Feeding practices of children within institution-based care: A retrospective analysis of surveillance data. Maternal & Child Nutrition, e13352. https://doi.org/10.1111/mcn.13352

Paper 4: **Learning from the implementation of the child nutrition program: A mixed methods evaluation of process**

DeLacey, E.; Tann, C.; Smythe, T.; Groce, N.; Quiring, M.; Allen, E.; Gombo, M.; Demasu-ay, M.; Ochirbat, B.; Kerac, M. Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process. Children 2022, 9, 1965. https://doi.org/10.3390/children9121965

List of other related research papers included in the annex

Paper 5: The nutrition status of individuals adopted internationally as children: A systematic review

Ivey, R.; Kerac, M.; Quiring, M.; Dam, H.T.; Doig, S.; DeLacey, E. The Nutritional Status of Individuals Adopted Internationally as Children: A Systematic Review. Nutrients 2021, 13, 245. https://doi.org/10.3390/nu13010245

Paper 6: Use of mid-upper arm circumference measurement among children with disabilities: A systematic review

Hayes, J., et al. (2022). "Mid-upper arm circumference (MUAC) measurement usage among children with disabilities: a systematic review." Pending peer review, Maternal and Child Nutrition.

Dissemination: Conferences and Presentations (see Annex A-G)

1. Research For Nutrition Conference- Action Against Hunger (ACF), Poster Presentation: A systematic review of the nutritional status of children living within institutionalized care; Nov. 20-21, 2019, Nanterre, France
2. American Society of Nutrition Conference, Poster Presentation: Nutritional status of children living within institutionalized care: A systematic review; May 30- Jun. 2, 2020, online
3. London School of Hygiene and Tropical Medicine Poster Day, Poster Presentation: A systematic review of the nutritional status of children living in institutionalized care; Mar. 7-17, 2020, online
4. London School of Hygiene and Tropical Medicine Poster Day, Poster Presentation: The nutritional status of children living in institutionalized care with control charts and funnel plots for program monitoring; Apr. 21-May 15, 2021, online
5. 8th International Conference on Nutrition and Growth, Poster Presentation: The nutritional status of children living in institutionalized care with control charts and funnel plots for program monitoring; Aug. 26- 28, 2021, online
6. Speaker Presentation: Nutrition & disability among children in IBC: Programmes, Policies & Why PhDs Matter; Sep. 28, 2021, LSHTM, London, UK
7. Speaker Presentation: Global Nutrition, Disability and why PhDs Matter; May 25th, 2022, Central Washington University, USA

8. National Council for Adoption, Speaker, Presentation: The Nutrition and Feeding of Children in Institution-based Care; Jun. 15-17, 2022, Indianapolis, USA
9. Global Health Practitioners Conference, Poster Presentation: The use of mid-upper arm circumference (MUAC) among children with disabilities: A systematic review; Oct. 3-5, 2022, Washington D.C., USA

1.7 Ethics

Where required, ethical approval was obtained from the London School of Hygiene and Tropical Medicine's Research Ethics Committee. Annex B-G includes full ethics documents and all approvals for papers 1-6. The evaluation of process (Chapter 5, Paper 4) was also approved by the National Center of Public Health of Mongolia and the Medical Ethics Control Committee of the Mongolian Ministry of Health and from the St. Cabrini Medical Center - Asian Eye Institute Ethics Review Committee (SCMC-AEI) Ethics Review Committee in the Philippines. Further details on ethics and ethics reference numbers are described in individual chapters.

1.8 Funding

Funding for PhD tuition was provided by Holt International. Costs of traveling and staying in London for PhD work were covered by myself. Holt International covered the costs for some of the publications and others were published under LSHTM Open Access agreements. Publication costs are specified in chapters 2-5 and Annex B and C. Research was integrated into work through my department, so there were no additional research costs.

Chapter 2: Systematic Review of the Nutritional Status of Children in IBC (Paper 1)

2.1 Scope of Chapter

This chapter presents the first research paper titled "The nutritional status of children living within institutionalized care: A systematic review".[38] This work was published in PeerJ on Feb. 6, 2020 as an open access article under the Creative Commons Attribution License. Copyright: © 2020 DeLacey et al. Although the research was not funded, Holt International paid for publication costs to allow for open access of the research to improve the accessibility of the information to all audiences.

This paper presents the findings of a systematic review on literature on the nutritional status of children living with institutionalized care globally. Additionally, the gaps in information identified in this paper helped us to focus our research aims on our subsequent papers about this population. This paper highlighted the limited recent evidence on the nutritional status of children living within institutions. Children in care were found to be malnourished including both undernutrition, overnutrition and micronutrient deficiencies.

2.2 List of figures

2.3 List of tables

Appendix S2: PRISMA checklist

Appendix S3: Studies excluded and reasons

2.4 Citation

DeLacey E, Tann C, Groce N, Kett M, Quiring M, Bergman E, Garcia C, Kerac M. 2020. The nutritional status of children living within institutionalized care: a systematic review. PeerJ 8:e8484 https://doi.org/10.7717/peerj.8484

2.5 Research Paper

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed <u>for each</u> research paper included within a thesis.

SECTION A – Student Details

Student ID Number	lsh1804647	**Title**	Ms
First Name(s)	Emily		
Surname/Family Name	DeLacey		
Thesis Title	The Nutritional and Feeding Status of Children Living within Institution-based Care and an Evaluation of Process of the Child Nutrition Program.		
Primary Supervisor	Marko Kerac		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?	PeerJ https://peerj.com/articles/8484/		
When was the work published?	Published February 6, 2020		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	N/A		
Have you retained the copyright for the work?*	**No**	Was the work subject to academic peer review?	**Yes**

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	

Stage of publication	Choose an item.

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	Emily DeLacey and Marko Kerac conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, and approved the final draft. Cally Tann conceived and designed the experiments, analyzed the data, authored or reviewed drafts of the paper, and approved the final draft. Nora Groce, Maria Kett, Michael Quiring, Ethan Bergman and Caryl Garcia analyzed the data, authored or reviewed drafts of the paper, and approved the final draft.

SECTION E

Student Signature	Emily DeLacey
Date	June 6 2022

Supervisor Signature	Marko Kerac
Date	June 21, 2022

The nutritional status of children living within institutionalized care: a systematic review

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ABSTRACT

Background. There are an estimated 2.7 million children living within institutionalized care worldwide. This review aimed to evaluate currently available data on the nutrition status of children living within institutionalized care.
Methods. We searched four databases (Pubmed/Medline, CINHAL Plus, Embase and Global Health Database) for relevant articles published from January 1990 to January 2019. Studies that included information on anthropometry or micronutrient status of children living within institutionalized care were eligible for inclusion. The review is registered on PROSPERO: CRD42019117103.
Results. From 3,602 titles screened, we reviewed 98 full texts, of which 25 papers were eligible. Two (8%) studies reported data from multiple countries, nine (36%) were from Asia, four (16%) from Africa, three (12%) from Eastern Europe, four (16%) from the European Union and one (4%) from each of the remaining regions (Middle East, South America and the Caribbean). Twenty-two (88%) were cross sectional. Ten (40%) of the studies focused on children >5 years, seven (28%) on children <5 years, seven (28%) covered a wide age range and one did not include ages. Low birth weight prevalence ranged from 25–39%. Only five (20%) included information on children with disabilities and reported prevalence from 8–75%. Prevalence of undernutrition varied between ages, sites and countries: stunting ranged from 9–72%; wasting from 0–27%; underweight from 7–79%; low BMI from 5–27%. Overweight/obesity ranged from 10–32% and small head circumference from 17–41%. The prevalence of HIV was from 2–23% and anemia from 3–90%. Skin conditions or infections ranged from 10–31% and parasites from 6–76%. Half the studies with dietary information found inadequate intake or diet diversity. Younger children were typically more malnourished than older children, with a few exceptions. Children living within institutions were more

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Additional Information and Declarations can be found on page 32

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malnourished than community peers, although children living in communities were also often below growth standards. High risk of bias was found.
Conclusions. This study highlights the limited amount of evidence-based data available on the nutritional status of children in institutions. Of the studies reviewed, children living within institutionalized care were commonly malnourished, with undernutrition affecting young children particularly. Micronutrient deficiencies and obesity were also prevalent. Data quality was often poor: as well as suboptimal reporting of anthropometry, few looked for or described disabilities, despite disability being common in this population and having a large potential impact on nutrition status. Taken together, these findings suggest a need for greater focus on improving nutrition for younger children in institutions, especially those with disabilities. More information is needed about the nutritional status of the millions of children living within institutionalized care to fully address their right and need for healthy development.

Subjects Epidemiology, Global Health, Nutrition, Pediatrics
Keywords Children, Nutrition, Orphanage, Children with disabilities, Anthropometry, Nutritional deficiency, Malnutrition, Institutionalized care, Residential care, Low birth weight

INTRODUCTION

Malnutrition impacts millions of children around the world (*Black et al., 2013*; *The World Bank Group, 2019*; *UNICEF, 2019*). In 2018 for children younger than 5 years old, 49 million children were wasted, just under one in four (21.9%) were stunted and 5.9% were overweight (*UNICEF, 2019*). Almost half of the deaths among children younger than 5 years old have undernutrition as an underlying factor (*Black et al., 2013*; *UNICEF, 2019*). In some countries, up to half of adolescents are stunted, as many as 11% are too thin, up to 5% are obese and over 50% are anemic (*Black et al., 2013*). Being malnourished has many adverse consequences including increased risk and severity of infections, increased risk of disability, and death (*Black et al., 2013*; *Groce et al., 2014*; *McDonald et al., 2013*; *Myatt et al., 2018*). This can be a part of a cyclical interaction between infections and undernutrition which leads to poor nutritional status, illnesses and impacted growth.The first 1,000 days of a child's life are particularly important because poor nutrition at this stage also predisposes children to long-term impairments such as stunted growth, impaired cognition and poor performance at school and work (*Black et al., 2013*; *UNICEF, 2019*).

Some children are at higher risk of malnutrition, such as orphans and children living within institutionalized care (*UNICEF, 2019*). UNICEF estimates that there are some 140 million orphans worldwide who have lost either one or both of their parents (*UNICEF, 2017*). Although most orphans live with other family members, some live in institutionalized care or residential care facilities (*UNICEF, 2017*). Institutionalized care is defined by the United Nations as residential care that is provided in any non-family-based group setting, including all other short- and long-term residential care facilities (*United Nations General Assembly, 2009*). Many non-orphans live in institutionalized care for a variety of reasons, including social or economic (*van IJzendoorn et al., 2011*; *The Children's Health Care Collaborative Study Group, 1994*). These children are also vulnerable (*Baron, Baron*

& Spencer, 2001; The Children's Health Care Collaborative Study Group, 1994). Though family-based care is the ideal environment for all children, this is not always possible (Petrowski, Cappa & Gross, 2017; The Children's Health Care Collaborative Study Group, 1994).

Approximately 2.7 million children ages 17 years and younger live in residential care globally: 120 children per 100,000 (Petrowski, Cappa & Gross, 2017). The UN Convention on the Rights of the Child states that when it is in a child's best interest and they cannot remain in their family, alternative-care options need to be provided for the child. Alternative-care solutions include foster care or institutional care. These alternative-care options need to meet a standard of living adequate for a child's full development, including children with disabilities; particularly in regard to education, health, development, nutrition and other essentials (United Nations Human Rights Office of the High Commissioner, 1990).

Children in institutional care often face numerous adversities prior to admission and many enter institutionalized care with pre-existing nutritional, developmental, medical and neurological conditions (Baron, Baron & Spencer, 2001; The Children's Health Care Collaborative Study Group, 1994; The St Petersburg-USA Orphanage Research Team, 2005; The St. Petersburg- USA Orphanage Research Team, 2008). Some have disabilities or were born prematurely or with low birth weight and many have had exposure to drugs or alcohol, HIV, stress or a range of other issues—all of which can impact their health. (Baron, Baron & Spencer, 2001; Groce et al., 2014; The Children's Health Care Collaborative Study Group, 1994; The St. Petersburg- USA Orphanage Research Team, 2008). Often there is limited or no information about children's early lives or exposures prior to coming into care (The Children's Health Care Collaborative Study Group, 1994; The St Petersburg-USA Orphanage Research Team, 2005; The St. Petersburg- USA Orphanage Research Team, 2008). Those entering institutionalized care may experience further negative issues when admitted: ongoing risk of suboptimal nutrition, poor growth or growth failure, neglect or abuse, impacted physical and mental development, diarrhea, anemia, infections and diseases because of the conditions in the care centers (Frank et al., 1996; Johnson & Gunnar, 2011; The Children's Health Care Collaborative Study Group, 1994). Disability can be both a contributing factor and a result of malnutrition. In addition, disabilities, micronutrient deficiencies and malnutrition can all lead to increased morbidities and mortality (Groce et al., 2014; McDonald et al., 2013; Myatt et al., 2018).

Often because of limited staffing, time and fiscal constraints, institutions are able to only provide basic care needs for children instead of addressing children's individual needs for healthy and full development (van IJzendoorn et al., 2011; Whetten et al., 2014). Factors impacting children's nutrition status in care centers include inadequate or poor quality of food or inappropriate types of food; inadequate stimulation or attention; improper use of medications; inappropriate feeding practices; and poor hygiene and sanitation leading to frequent illnesses and negatively impacting utilization of nutrients (Frank et al., 1996; van IJzendoorn et al., 2011; The St. Petersburg- USA Orphanage Research Team, 2008).

METHODS

The aim of our review was to better understand the current nutritional status of children in care by looking at anthropometric and nutritional status indicators in relation to age, disability, geography, gender and related factors, with an ultimate goal of improving policy and practice to better meet the needs of this unique and vulnerable population.

We analyzed existing published peer-reviewed literature on the nutrition status of children in institutional care by examining anthropometric data, micronutrient status and other factors including disability status, gender and age. PRISMA guidelines were followed throughout the review process and a PROSPERO registration was completed prior to the start of the study (PROSPERO 2019: CRD42019117103, https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=117103) (*Moher et al., 2009*; *National Institute for Health Research, 2019*).

The review primarily evaluated observational and intervention studies. Inclusion criteria included material published between January 1990 and January 2019 in English and contained research related to orphanages/institutionalized care, children, nutrition, anthropometric data or micronutrient status. We selected these dates because the Convention on the Rights of the Child went into effect in 1990, and since then, there have been significant changes in institutional care and changes in the understanding of the needs of children in institution-based care (IBC) (*Frank et al., 1996*; United Nations Human Rights Office of the High Commissioner).

In order to be included in this review, the studies must have addressed a population of children younger than 18 years old (with the exception of one study which included children as old as 20 years but was retained for informational value), been peer reviewed and included at least one measurement of nutrition status through standardized tools, such as WHO Growth Standards or WHO Growth References and definitions (*World Health Organization, 2019a*; *World Health Organization, 2019b*). Anthropometric indicators of interest included: weight for age, length/height for age, weight for length/height, head circumference for age and mid-upper arm circumference for age. Micronutrient status, clinical signs/symptoms and dietary information were also included when available. Emily DeLacey, the principal investigator, and Dr. Marko Kerac determined and used the search strategy. Four electronic databases were searched through OVID from December 2018 through January 2019: Pubmed/Medline, CINHAL Plus, Embase and Global Health Database. For details of our search strategy, see Appendix S1. Initial article screening was based on title and abstract, following which full texts were assessed for eligibility against our pre-specified inclusion/exclusion criteria. Discussions with the research team resolved any questions of eligibility with Dr. Cally Tann deciding any discords. A data extraction table was used to summarize key information from the final selection of articles into tables and columns organized by related themes and areas.

Nutritional status was determined according to reported anthropometry, whether reported by z-scores (standard deviations from a reference population) or percentiles. Micronutrient status and intake were also reported on and included prevalence of anemia or micronutrient deficiencies. Other key data areas included disability status, birth weight, sex, age, dietary intake and any reported disease, illness or infection which could impact nutrition status. Heterogeneity in the type of interventions prevented our ability to conduct a meta-analysis of the study, so a narrative synthesis was used.

RESULTS

We found a total of 3,973 papers. After 371 duplicates were removed, the remaining 3,602, were screened by title and abstract. All but 98 articles were excluded during this phase. Of the 98 identified as potentially eligible, we were unable to locate seven, 53 had insufficient anthropometry or used non-standard measurements, 10 did not have appropriate population or study type and three were excluded because the anthropometric data existed in another study. Twenty-five studies met our inclusion criteria (Fig. 1). Most studies (22, 88%) were cross sectional (Table 1). The most commonly researched region was Asia with nine studies (36%), followed by Africa with four studies (16%). Three (12%) were from Eastern Europe, four (16%) from the European Union and one (4%) from each of the remaining regions (Middle East, South America and the Caribbean). Kenya and India were the most commonly researched countries and were each included in four studies (Table 1). Ten (40%) focused on children older than 5 years, seven (28%) on children younger than 5 years, seven (28%) covered a wide age range and one did not include ages. Twelve (48%) included control or comparison groups of children who were community children (CC) or orphaned, separated or abandoned children living in family-based care (FBC), or children living on the streets (CLS). Control groups were typically orphaned children living in family-based care (FBC) or community children (CC) with no history of institutional care and the groups were selected from different settings including from local schools, communities, clinics or hospitals, lists, house-to-house census or other child-related programs (*Braitstein et al., 2013*; *Johnson et al., 2010*; *Whetten et al., 2014*). Eight (32%) studies mentioned or analyzed gender differences (Tables 1 and 2). A history of low birth weight (LBW) were also common (25% to 39%).

Children with disabilities

Of the 25 studies reviewed, 12 (48%) did not state whether they included children with disabilities (Tables 1 and 2). Eight (32%) of the studies stated that children with disabilities were excluded, leaving only five (20%) mentioning children with disabilities in their reporting, but either excluded them from analysis or did not state whether or not they were excluded. Only one study included any anthropometric measurements for children with disabilities (*Lewindon et al., 1997*). The St. Petersburg-USA Orphanage Research Team found that 21% of children had disabilities (*The St Petersburg-USA Orphanage Research Team, 2005*). Miller and colleagues found 16% of institution-based children (IBC) had significant disabilities and 75% had developmental delays (*Miller et al., 2006*).

Anthropometrics

Undernutrition, micronutrient deficiencies and overweight/obesity were reported in varying ways. Prevalence of undernutrition differed markedly: stunting (low length/height for age) from 9 to 72%; wasting (low weight for length/height) from 0 to 27%; underweight

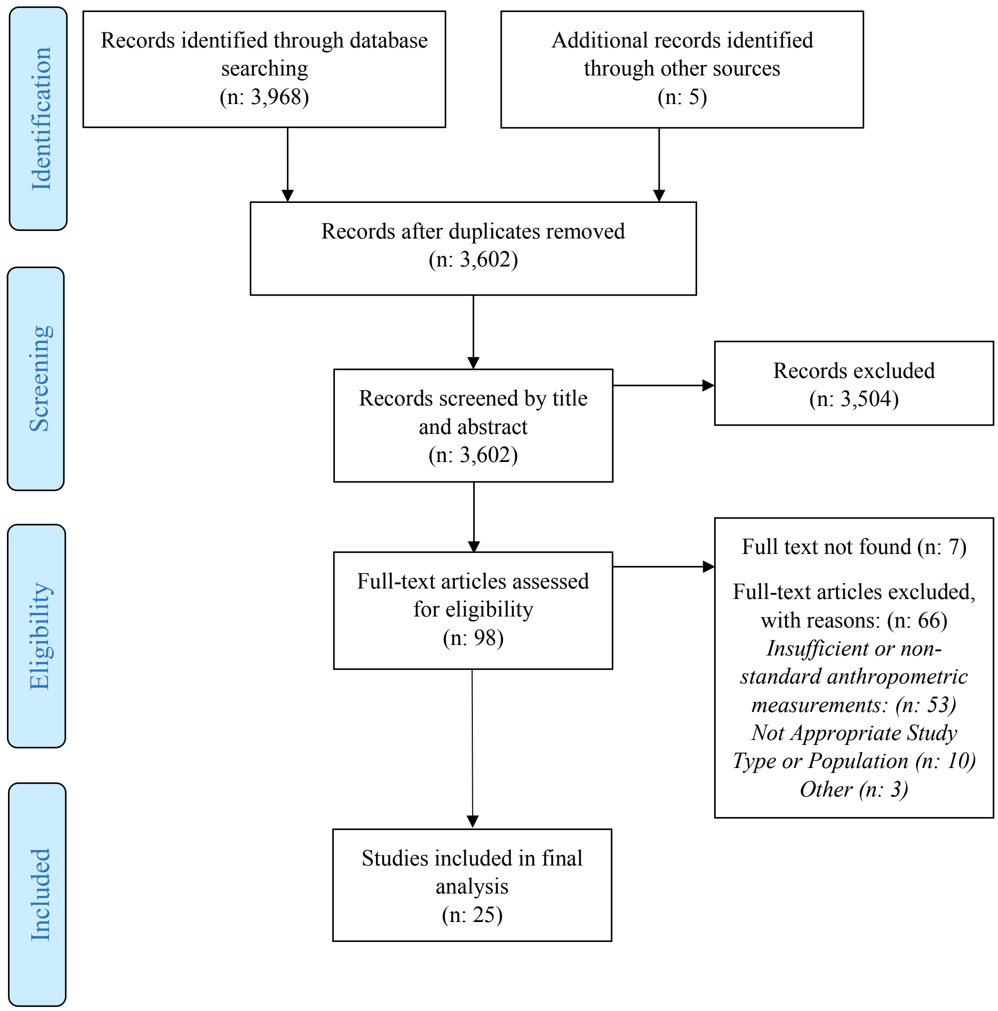

Figure 1 **PRISMA flow diagram.**

Full-size DOI: 10.7717/peerj.8484/fig-1

(low weight for age) from 7 to 79%; low BMI (body mass index) ranged from 5 to 27% (Table 2). Ten to 32% of children were overweight or obese. Panpanich et al. found children younger than 5 years old to be more stunted, wasted and underweight than older children and below WHO growth standards (*Panpanich et al., 1999*). The prevalence of small head circumference ranged from 17 to 41%.

Micronutrients, clinical signs/symptoms and infections

Clinical signs or symptoms were reported in 48% (12) of the studies (Table 3). Five (20%) mentioned HIV but two of these were conducted in institutions for children with HIV (*Kapavarapu et al., 2012*; *Myint et al., 2012*). Excluding the facilities for children with HIV, HIV prevalence was from 2 to 23%. One study found a higher prevalence of morbidity among children in IBC than CC ($p < 0.05$) (*Mwaniki, Makokha & Muttunga, 2014*). The prevalence of parasites ranged from 6 and 76%, with Lesho and colleagues finding 10%

Table 1 **Description of studies included in review.** Description of studies included in the review of children living within institutionalized care.

Author, year	Study design	Country	Number of institutions	Study population	Gender (percent female)	Disability
			Multi-Country			
Whetten et al. (2014)	Longitudinal Cohort	Cambodia, Ethiopia, India, Kenya, Tanzania	83	n: 2,283, IBC: 993 (43.5%) and FBC: 1,290 (56.5%), median age 9 years at baseline, range 6–12 years and median age 12 year at year 3 follow-up, range 8–16 years	IBC: 43%, FBC: 47%	Unknown, Special needs homes excluded
Whetten et al. (2009)	Cross Sectional	Cambodia, Ethiopia, India, Kenya, Tanzania	83	n: 2,837, IBC: 1,480, 6–12 years, mean age 9 years, FBC: 1,357	IBC: 42.8%, FBC: 47.1%	Unknown, Special needs homes excluded
			Africa			
Aboud et al. (1991)	Cross Sectional	Ethiopia	1	n: 81, 5–14 years, IBC mean age 9.5 years ± 2.8, FBC mean age 9.7 ± 2.6	25.9 %	Unknown
Braitstein et al. (2013)	Cross Sectional	Kenya	19	n: 2862, IBC: 1337, FBC: 1425, CLS: 100, 0–18 years, median age 11.1 years	46%	Unknown, HIV included
Mwaniki, Makokha & Muttunga (2014)	Cross Sectional	Kenya	4 Schools (multiple orphanages attended)	n: 416, IBC: 208, CC:208, range 4–11 years, 50% 4–7 years and 50% 8–11 years	50%	Excluded
Panpanich et al. (1999)	Cross Sectional	Malawi	3	n: 293, IBC: 76, mean age 6.44 ± 4.69, range 0-<15 years, FBC: 137, mean age 7.92 ± 2.62, CC: 80, mean age 6.1 ± 3.17	Total: 45.4% , IBC: 44.7%, FBC: 44.5%, CC: 47.4%	Unknown, HIV included

(*continued on next page*)

DeLacey et al. (2020), *PeerJ*, DOI 10.7717/peerj.8484

Table 1 (*continued*)

Author, year	Study design	Country	Number of institutions	Study population	Gender (percent female)	Disability
			Asia			
Bin Shaziman et al. (2017)	Cross Sectional	Malaysia	5	n: 85, 13–18 years	–	Excluded
Chowdhury et al. (2017)	Cross Sectional	Bangladesh	1	n: 232, 6–18 years, mean age 13.38 years ± 3.69	44%	Excluded
Hearst et al. (2014)	Cross Sectional	Kazakhstan	10	n: 308 children, 0- 3 years	–	Excluded
Kapavarapu et al. (2012)	Prospective Longitudinal	India	1	n: 85, mean age 9.2 years, range 4–14	40%	Unknown, HIV group home
Kroupina et al. (2014)	Cross Sectional	Kazakhstan	6	n: 103, ages 5–29 months, mean 14.89 months ± 6.85)	49.5%	Excluded
Lewindon et al. (1997)	Cross Sectional	Hong Kong	1	n: 215, 11.9 years ± 5.2, range 1.9–27	47%	Included, 3 residential wards for children with disabilities
Myint et al. (2012)	Cross Sectional	Myanmar	1	n: 60, 2–15 years, >5: 26.7%, 5–10: 56.7%, 11–15: 16.6%	53.3%	Unknown, HIV group home
Sarma et al. (1991)	Cross Sectional	India	70	3,822, 6–18 years	–	Unknown
Zahid & Karim (2013)	Cross Sectional	Bangladesh	1	n: 49, 6–15 years, mean age 8.72 years ± 1.38	61%	Included, 8.7%

(*continued on next page*)

Table 1 (*continued*)

Author, year	Study design	Country	Number of institutions	Study population	Gender (percent female)	Disability
Eastern Europe						
Lesho et al. (2002)	Cross Sectional	Moldova	–	n: 367	–	Unknown
Miller et al. (2006)	Cross Sectional	Russia	3	n: 234, mean age 21 months ± 12.6, range 1.5 months to 6 years	45% (gender not recorded for 12 children)	Included, 16% severe disabilities, 75% developmental disabilities but excluded from analyses
The St Petersburg-USA Orphanage Research Team (2005)	Cross Sectional	Russia	3	n: 325 children, 0–5 years	–	Included, 8% of the intake sample (N: 383) but 21% of the children in residence (N:302) were considered to have a disability but excluded from analyses
European Union						
Johnson et al. (2010)	Cross Sectional	Romania	6	n:136, mean age 21 months ± 7.32; range 5 months- 2.7 years	50%	Excluded
Martins et al. (2013)	Prospective Longitudinal	Portugal	15	n: 49, mean 7.14 months ± 6.17) range 0–21 months	49%	Excluded
Pysz, Leszczynska & Kopec (2015)	Cross Sectional	Poland	5	n:153, range 7–20 years	43.8%	Unknown
Smyke et al. (2007)	Cross Sectional	Romania	6	n: 208, IBC: 123, CC: 66, 5 months–2.6 years, mean age 20.65 months ± 7.26	IBC: 50.4% CC: 53%	Excluded

(*continued on next page*)

Table 1 (*continued*)

Author, year	Study design	Country	Number of institutions	Study population	Gender (percent female)	Disability
			Middle East			
El-Kassas & Ziade (2017)	Cross Sectional	Lebanon	2	n: 153, 5–14 years, mean age 8.86 ± 2.45 years	62.7%	Unknown
			South America			
Nunes et al. (1999)	Cross Sectional	Brazil	1	n: 243, 1–15years	30.3%	Included, HIV included
			The Caribbean			
Nelson (2016)	Cross Sectional	Jamaica	3	n: 226, IBC n: 113, 5–18 years, mean 10.66 ± 3.67 years, CC n: 103, mean 10.28 years ± 3.20	IBC: 38.9%, CC: 58.3%	Unknown, HIV and other infectious diseases excluded

Notes.

Study population: IBC, Institution-based care; FBC, Family-based care (orphaned or abandoned children in community settings); CC, Community children (non-orphans); CLS, Children living on the street.

of children in IBC having three or more parasites (*Lesho et al., 2002*). Skin infections, varicella zoster, tuberculosis, impetigo, dental issues, ear/nose/throat problems, respiratory infections, diarrhea and other conditions or illnesses were frequently reported among IBC (Table 3). Skin conditions or infections ranged between 10 and 31%, and Kapavarapu and colleagues found 75% of children had an infection within the first three months of admission to a site (*Kapavarapu et al., 2012*). Seven (28%) reported on micronutrient status or intake and the prevalence of anemia ranged from 3 to 90%. Hearst and colleagues found over a third of children had low vitamin D (*Hearst et al., 2014*). Other micronutrient deficiencies discussed included iodine, zinc, albumin, as well as vitamins A and B (Table 3). Edema, conjunctival pallor, xerophthalmia and goiters were found more in children in IBC than those living in FBC (*Aboud et al., 1991*).

Dietary diversity, intake and food security

Eight (32%) studies discussed dietary diversity, intake or food security (Table 3). Mwaniki and colleagues found that diet diversity was lower in children living in IBC than for CC ($p < 0.05$). Diets were reported to have a high reliance on starches and legumes (*Mwaniki, Makokha & Muttunga, 2014*). Of the studies that assessed dietary intake, 50% found adequate intake. Dietary adequacy varied; from children in IBC at 3.9 times higher risk of consuming inadequate calories to having 362% higher intake than estimated average requirements for some nutrients. The one study which reported on food security found that children in IBC had higher food security when compared to children in FBC, 42% vs. 2% (*Braitstein et al., 2013*).

DISCUSSION

The nutritional status of children living in institutions has the potential to adversely impact their health and well-being, yet out of 3,602 papers from four major databases, only 25 peer-reviewed papers presented evidence based findings on the children's nutrition status (Fig. 1). All 25 reviewed studies indicated that many of the children in institutionalized care faced some form of malnutrition. The available data suggests that children living within institutionalized care are commonly malnourished: affected by undernutrition, overweight and micronutrient deficiencies. With few exceptions, mostly of older children, children living within institutionalized care were significantly below standards for growth, diet and micronutrient status and were often below comparison groups of their community peers. Nutrition status varied between care centers and between the ages of children, with younger children at a higher risk of being malnourished. There may be a number of reasons why this is the case, such as younger children have a harder time feeding themselves, especially if disabilities are present, and young, poorly nourished children are at risk of not surviving to become older children in institutional settings (*McDonald et al., 2013*; *Myatt et al., 2018*; *The Children's Health Care Collaborative Study Group, 1994*). Diet inadequacy, micronutrient deficiencies and illnesses or infections were also found to be prevalent in children of all ages.

To our knowledge, this is the first systematic review of the nutrition status of children living within institutionalized care. It is important because 2.7 million children worldwide

Table 2 **Anthropometric measurements and results.** Anthropometric data of children living within institutionalized care in various countries.

Author, year	Growth reference	Weight for age (WAZ)	Weight for-length/height (WHZ)	Length/height for age (HAZ)	BMI-for-Age	Head circumference for age	Other	Results
				Multi-Country				
Whetten et al. (2014)	WHO growth charts	–	–	IBC: Mean −1.0 ± 1.4, FBC: Mean −1.0 ± 1.3	IBC: Mean −0.7 ± 1.0, FBC: Mean −0.7 ± 1.2	–	–	This study does not support the hypothesis that IBC is systematically associated with poorer well-being than FBC for orphaned and abandoned children ages 6 to 12 in countries with high rates. Much greater variability among children within care settings was observed than among care-setting types.
Whetten et al. (2009)	WHO growth charts	–	–	IBC: Mean −0.96 ± 1.46, FBC: Mean −1.03 ± 1.29, Weighted IBC vs. FBC: Mean (CI) 0.011 (−0.08, 0.10)	IBC: Mean −0.68 ± 0.97, FBC: Mean −0.73 ± 1.39, Weighted IBC vs. FBC: Mean (CI) 0.072 (−0.01, 0.16)	–	–	While it is possible that respondent bias accounts for better subjective health scores for IBC, the lack of significant differences on the biometric scores and the lower prevalence of recent illness suggest that the growth and overall health of IBC is no worse than that of FBC. There were no differences between children in IBC and FBC in mean height for age or BMI for age.
				Africa				
Aboud et al. (1991)	NCHS	IBC: >80%: 64% <80%: 36% FBC: >80%: 73.5% <80%: 25.6% p = NS	IBC: >80%: 97.3% <80%: 2.7% FBC: >80%: 95.6% <80%: 4.1% p = NS	IBC: >90%: 76% <90%: 24% FBC: >90%: 91.8% <90%: 8.2% $p < 0.05$	–	–	–	The children in IBC were more likely to be short for their age indicating early and chronic malnutrition. Both groups of children had a high probability of weighing less than the standard for their age. Using both anthropometric and clinical signs of malnutrition, 27 (33%) IBC showed nutritional problems on two or more indices.
Braitstein et al. (2013)	WHO	≤ 10 years, n: 2131 ≥-2 *z*-scores OR unadjusted IBC: 1 FBC: 0.87 (0.56–1.34)	≤ 5 years, n: 380 ≥-2 *z*-scores OR unadjusted IBC: 1 FBC: 1.02 (0.55–1.90)	0–18 years, n: 2842 ≥-2 *z*-scores OR unadjusted IBC: 1 FBC: 2.27 (1.74–2.94) CLS: 4.95 (3.13–7.82) % Stunting IBC: 59% FBC: 74% CLS: 88%	10–18 years, n: 2374 ≥-2 *z*-scores OR unadjusted IBC: 1 FBC: 0.70 (0.49–1.01) CLS: 0.58 (0.31–1.08) High BMI ($p < 0.001$) IBC: 10% FBC: 16% CLS: 19%	–	–	FBC were more than twice as likely as children in IBC to be stunted (AOR: 2.6, 95% CI [2.0–3.4]). CLS were nearly six times more likely to be stunted compared to children in IBC (AOR: 5.9, 95% CI [3.6–9.5]). IBC have improved nutrition status and are more likely to have an adequate diet and much less likely to be stunting compared to FBC. Children in IBC were more likely to be normal weight for height compared to FBC ($p = 0.024$)
Mwaniki, Makokha & Muttunga (2014)	*World Health Organization Multicentre Growth Reference Study Group (2006)*	IBC n: 69 % underweight: 33.2% CC n: 31 % underweight: 14.9% Total n: 100 % underweight: 24% $p > 0.0001$	IBC n: 19 % wasted: 9.2% CC n: 20 % wasted: 9.7% Total n: 39 % wasted: 9.4% $p = 0.866$	IBC n: 98 % stunted: 47.2% CC n: 51 % stunted: 24.5% Total n: 149 % stunted: 35.8% $p > 0.0001$	–	–	–	The risk of stunting was 2.8 times higher and underweight was 0.043 times higher among IBC compared with CC.

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Table 2 (*continued*)

Author, year	Growth reference	Weight for age (WAZ)	Weight for-length/ height (WHZ)	Length/ height for age (HAZ)	BMI-for-Age	Head circumference for age	Other	Results
Panpanich et al. (1999)	NCHS	<5 years Mean z-scores: IBC: −2.17 ± 1.46 FBC: −1.82 ± 1.19 CC: −1.37 ± 1.28 Moderate underweight (<-2 z-scores) %: IBC: 54.8% FBC: 33.3% CC: 30% Severe underweight (<-3 z-scores) %: IBC: 38.7% FBC: 16.7% CC: 6.7% ≥5 years Mean z-scores: IBC: −0.91 ± 0.96 FBC: −1.11 ± 1.10 CC: −1.24 ± 1.00 Moderate underweight (<-2 z-scores) %: IBC: 6.8% FBC: 23.9% CC: 20.8%	<5 years Mean z-scores: IBC: −0.35 ± 1.15 FBC: −0.68 ± 1.10 CC: −0.45 ± 0.93 Wasting (<-2 z-scores) %: IBC: 9% FBC: 12% CC: 0% ≥5 years Mean z-scores: IBC: −0.08 ± 0.91 FBC: −0.64 ± 0.99 CC: −0.53 ± 0.79 $p < 0.05$ for variance between the three groups Wasting (<-2 z-scores) %: IBC: 0% FBC: 5.3% CC: 2.3%	<5 years Mean z-scores: IBC: −2.75 ± 1.29 FBC: −2.20 ± 1.51 CC: −1.61 ± 1.57 $p < 0.05$ for variance between the three groups Stunting (<-2 z-scores) %: IBC: 64.5% FBC: 50% CC: 46.4% ≥5 years Mean z-scores: IBC: −1.07 ± 1.51 FBC: −1.07 ± 1.51 CC: −1.41 ± 1.41 Stunting(<-2 z-scores) %: IBC: 9.1% FBC: 30.4% CC: 34%	–	–	–	Younger than 5 years old, the mean z-scores of W/A, W/H and H/A for all groups were much lower than those of the NCHS reference population. More malnutrition of children in IBC younger than 5 years than those in FBC and CC. Girls were more malnourished in IBC than boys ($p < 0.05$). 44.1% IBC who stayed less than 1 year were undernourished compared with 12.2% who stayed ≥1 year ($p < 0.05$). Children in IBC ≥ 5 years of age were less stunted and wasted than FBC and CC, which suggests that children in IBC have greater long-term food security than FBC and CC. "Older orphanage children seem to have better nutrition than village orphans."
					Asia			
Bin Shaziman et al. (2017)	WHO Growth References	–	–	–	Severely thin 4.7% Thin 2.4% Normal 61.2% Overweight 16.5% Obesity 15.3%	–	–	–
Chowdhury et al. (2017)	WHO Growth References, Essence of Pediatrics 2011 ranges for malnutrition	Total malnourished: 60.3%, Mild: 43.1%, Moderate: 16.8%, Severe: 0.4%	–	–	–	–	–	Children 15 to 18 years old were most malnourished. Higher malnutrition among the boys than girls in the age group of 15–18 years old but gender did not have a significant effect on severity. Malnutrition was higher during the first four years in the orphanage. With increasing duration in the orphanage, malnutrition levels gradually declined.
Hearst et al. (2014)	*World Health Organization (1995)*, *World Health Organization Multicentre Growth Reference Study Group (2006)*	n: 286, mean z-score: −1.3 ± 1.5, median −1.3 31.5% underweight	n: 286, mean z-score: −0.7 ± 1.5, median −0.6 22.1% wasting	n: 286, mean z-score: −1.5 ± 1.9, median −1.5 36.7% stunting	–	–	–	72% of the children had one or more growth, nutrition or developmental deficits, and 24% had three or more deficits. The growth-related indicators coincide with the high prevalence of low albumin, indicating generalized chronic undernutrition and suggest macronutrient deficiencies that could be due to inadequate diets, infections and/or inflammation or impaired nutrient absorption or utilization secondary to the psychosocial stress of living in an institution. Prevalence for growth-related deficiencies and anemia in indicate IBC are more at risk compared with corresponding results for data from 90 CC of a similar age attending local child care centers.

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Table 2 (*continued*)

Author, year	Growth reference	Weight for age (WAZ)	Weight for-length/ height (WHZ)	Length/ height for age (HAZ)	BMI-for-Age	Head circumference for age	Other	Results
Kapavarapu et al. (2012)	NCHS, CDC, *World Health Organization Multicentre Growth Reference Study Group (2006)*	25th percentile: −3.73 Median: −2.75 75th percentile: −2.05 Underweight (WAZ <−2): 79% Over 36 months median WAZ increased to −1.74, 25th percentile −2.46, 75th percentile-1.03 ($P < 0.001$).	25th percentile: −2.29 Median: −1.30 75th percentile: −0.56 Wasting (WHZ <-2): 27% Median WHZ scores increased to −0.10, 25th percentile −0.18, 75th percentile −0.01 over 36 months ($P = 0.49$)	25th percentile: −3.06 Median: −2.69 75th percentile: −1.94 Stunting (HAZ <-2): 72% Over 36 months Median HAZ also increased to −1.63, 25th percentile −2.19, 75th percentile: −0.77 ($P < 0.001$).	–	–	–	"Irrespective of the ART status, a decrease in underweight, stunting and wasting was seen at the end of 36 months. There was an observed higher rate of *z*-score increase among children not yet on ART compared to that of those who were on ART was probably attributable to the fact that children on ART had a more advanced forms of disease along with co-morbidities which resulted in slower rate of improvement in growth than children with a milder form of disease and who did not need to be treated with ART. All received age and gender appropriate nutrition along with additional nutrition supplements such as iron when required. These results suggest that dietary support (both macronutrients and micronutrients) may have a role in improving nutritional outcomes in HIV-infected individuals, thereby improving quality of life and perhaps indirectly reducing disease-related mortality."
Kroupina et al. (2014)	*World Health Organization Multicentre Growth Reference Study Group (2006)*	Mean: −1.34 ± 1.17, range −4.9 to 0.94 <-2 *z*-scores: 22.3%	Mean: −0.63 ± 1.41, range −4.44 to 2.84 <-2 *z*-scores: 19.4%	Mean: −1.62 ± 1.61, range −5.49 to 3.11 <-2 *z*-scores: 35.5%	–	n:102, mean: −1.70 ± 1.27, range −4.53 to 1.90 <-2 *z*-scores: 41.2%	–	"We found that all three of the growth parameters departed substantially from expected levels relative to those of healthy children." Prevalence of low birth weight was 35%, compared to 6% national population, was found to be a significant negative predictor of developmental status.
Lewindon et al. (1997)	Not specified n:141	Mean: −3.9 *z*-scores	–	–	–	–	Triceps Skin Fold Median: 58.6%	–
Myint et al. (2012)	WHO	–	–	Short Stature: 18.3% Stunted 45%	Underweight: 26.7% Overweight: 8.3% Obese: 1.7%	–	–	Nutritional problems seen in 60% of the children. "No significant difference in nutritional status nor proportion of short stature and stunted was seen among boys and girls. There is no association of HIV staging and nutritional status."
Sarma et al. (1991)	NCHS	Girls mean wt range (kg): 16.5 ± 2-46.8 ± 9.66 Boys mean wt range (kg): 16.3 ± 2.18-49.3 ± 6.96	–	Girls mean ht range (cm): 104 ± 6.30-154.2 ± 5.64 Boys mean ht range (cm): 106 ± 6.52-166.0 ± 9.49	–	–	Girls mean arm circumference (cm): 15 ± 0.78–22.7 ± 3.59 Boys mean arm circumference (cm): 14.5 ± 1.04-23.3 ± 0.60	Growth was similar in all regions analyzed. Heights and weights were far below NCHS figures, suggesting a high degree of growth delay and stunting but were higher than urban slum or rural counterparts. The extent of delay, in terms of age, was up to 3 years.

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Table 2 *(continued)*

Author, year	Growth reference	Weight for age (WAZ)	Weight for-length/ height (WHZ)	Length/ height for age (HAZ)	BMI-for-Age	Head circumference for age	Other	Results
Zahid & Karim (2013)	Nutrition survey of Rural Bangladesh 1996	Mean: −0.39 ± 1.22 Underweight: 13% Normal: 84.8% Overweight: 2.2%	Mean: 0.38 ± 1.36 Wasted: 2.7% Normal: 83.8%, Overweight: 8.1% Obese: 5.4%	Mean: −0.76 ± 1.02 Stunted: 8.7% Normal: 89.1% Tall: 2.2%	Underweight: 10.87% Normal: 60.87% Overweight: 21.74% Obese: 6.5%	–	–	–
				Eastern Europe				
Miller et al. (2006)	WHO (excluding head circumference which was compared to American standards) n: 201, mean z-scores (excluding CWD)	Birth: −1.34 ± 0.08 Placement: −1.59 ± 0.12 Present: −1.50 ± 0.12	–	Birth: -.62 ± .14 Placement: −1.45 ± 0.13 Present: −1.48 ± 0.10	–	Birth: −1.55 ± 0.12 Placement: −1.38 ± 0.11 Present: −1.20 ± 0.11	–	75% (84/112) of children's records available indicated developmental delays. Measurements did not differ significantly between boys and girls, nor did they correlate with age at placement or current age of the children. Children with a prior diagnosis of FAS tended to have lower anthropometric z-scores at all time points than those without this diagnosis, but the results were significant only for birth height ($p = 0.04$), birth weight ($p = 0.02$), and placement head circumference ($p = 0.01$). >90% of children with high phenotypic scores had moderate or severe developmental delays.
The St Petersburg-USA Orphanage Research Team, 2005	CDC, USA Vital Statistics, and standards for the Northwestern Region of the Russian Federation.	Mean: −1.68 (1.39) CC (n:66):-0.06 (1.02) $p < 0.01$ Intake ($N = 327$, 309) Residents ($N = 236$, 216) Russian 10th percentile: 41–67% 25th percentile: 58–78% 50th percentile: 90–97% 75th percentile: 96–98% 90th percentile: 99% CDC 10th percentile: 55–63% 25th percentile: 73–81% 50th percentile: 90–91% 75th percentile: 97% 90th percentile: 99%	Mean: −0.60 (1.20) CC (n:66): 0.002 (0.99) Intake ($N = 294$, 304) Residents ($N = 231$, 219) Russian 10th percentile: 24% 25th percentile: 49–54% 50th percentile: 93–90% 75th percentile: 97–95% 90th percentile: 100–98% CDC 10th percentile: 29–25% 25th percentile: 49–50% 50th percentile: 93–90% 75th percentile: 97–95% 90th percentile: 100–98%	Mean: −1.56 (1.37) CC (n:60): 0.06 (0.98) $p < 0.001$ Intake ($N = 327$, 304) Residents ($N = 237$, 218) Russian 10th percentile: 34–54% 25th percentile: 49–73% 50th percentile:91–95% 75th percentile: 95–98% 90th percentile: 98–99% CDC 10th percentile: 43–61% 25th percentile: 61–77% 50th percentile: 78–90% 75th percentile: 93–96% 90th percentile: 97–99%	–	Mean: −1.17 (1.33) CC (n:60): 0.17 (0.79) p<0.001 Intake ($N = 329$, 298) Residents ($N = 238$, 197) Russian 10th percentile: 44–53% 25th percentile: 63–74% 50th percentile: 92–96% 75th percentile: 97–99% 90th percentile: 99–100% CDC 10th percentile: 44–46% 25th percentile: 64–68% 50th percentile: 89–85% 75th percentile: 97–91% 90th percentile: 98–97%	Chest Circumference Intake ($N = 329$) Residents ($N = 237$) Russian 10th percentile: 40–43% 25th percentile: 57–63% 50th percentile: 93–92% 75th percentile: 97–96% 90th percentile: 99%	Disabilities: prenatal narcotic exposure, fetal alcohol syndrome, physical deformity, Down syndrome, cerebral palsy, hydrocephalus, microcephalus, heart disorder, other. Non-Specific Disabilities: encephalopathy, growth insufficiency, dystrophy. HIV+ reside in a separate facility. Intake: 27% LBW, 5.5% VLBW Residents: 39.1% LBW, 8.8% VLBW For height, weight, head circumference and chest circumference, more than 35 to44% of the children at intake are below the 10th percentile for their gender in physical size relative to the northwestern Russian Federation and 43 to55% are below the 10th percentile of USA standards. Approximately 90% or more are below the median of both these standards.
				European Union				
Johnson et al. (2010)	CDC 2000 IBC: n:125, 21.0 months ± 7.4 CC: n: 72, 19.3 months ± 7.1	IBC: mean −1.23 ± 1.08, P ≤.001 z-scores ≤−2: 25%, P ≤.001 CC: mean −0.05 ± 1.00 z-scores ≤−2: 0	IBC: −0.67 ± 1.14, P ≤.001 z-scores ≤−2: 16%, P<.01 CC: 0.16 ± 0.96 z-scores ≤−2: 2%	IBC: mean −0.84 ± 0.86, P ≤.001 z-scores ≤−2: 9%, P<.05 CC: 0.13 ± 0.91 z-scores ≤−2: 2%	–	IBC: mean −1.10 ± 0.99, P ≤.001 z-scores ≤−2: 17%, P<.01 CC: −0.15 ± 0.86 z-scores ≤−2: 2%	–	24% of children living in IBC compared to 3% CC were low birth weight (p ≤.001).

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Table 2 (*continued*)

Author, year	Growth reference	Weight for age (WAZ)	Weight for-length/ height (WHZ)	Length/ height for age (HAZ)	BMI-for-Age	Head circumference for age	Other	Results
Martins et al. (2013)	*World Health Organization (2009)*, Latent Class Analysis (LCA) Mean, SD	Persistently low (n: 10, 20.4%) Percentile T0 (admission): 1.23 ± 1.60 Percentile T1: 3.91 ± 6.52 Percentile T2: 2.11 ± 3.39 Percentile T3: 4.39 ± 6.07 Deteriorating (n: 12, 24.5%) Percentile T0 (admission): 19.04 ± 28.63 Percentile T1: 20.85 ± 23.25 Percentile T2: 15.48 ± 21.87 Percentile T3: 17.83 (18.47) Improving (n: 16, 32.7%) Percentile T0 (admission): 24.02 ± 26.42 Percentile T1: 27.92 ± 26.82 Percentile T2: 27.42 ± 28.85 Percentile T3: 30.13 ± 23.98 Persistently high (n: 11, 22.5%) Percentile T0 (admission): 59.45 (32.81) Percentile T1: 55.95 (27.71) Percentile T2: 52.71 (26.30) Percentile T3: 58.06 (28.73)	–	Persistently low (n: 18, 36.7%) Percentile T0 (admission): 3.17 ± 4.47 Percentile T1: 4.52 ± 5.24 Percentile T2: 2.32 ± 2.67 Percentile T3: 4.56 ± 4.39 Deteriorating (n: 9, 18.4%) Percentile T0 (admission): 44.51 ± 27.02 Percentile T1: 49.52 ± 12.37 Percentile T2: 21.44 ± 9.64 Percentile T3: 23.83 ± 15.70 Improving (n: 14, 28.6%) Percentile T0 (admission): 15.00 ± 10.00 Percentile T1: 18.17 ± 11.54 Percentile T2: 29.14 ± 26.88 Percentile T3: 32.47 ± 12.18 Persistently high (n: 8, 16.3%) Percentile T0 (admission): 76.41 ± 32.50 Percentile T1: 71.26 ± 29.18 Percentile T2: 72.82 ± 14.49 Percentile T3: 78.42 ± 20.35	–	Persistently low (n: 11, 22.5%) Percentile T0 (admission): 5.92 ± 6.72 Percentile T1: 6.13 ± 6.35 Percentile T2: 10.05 ± 8.55 Percentile T3: 14.62 ± 13.79 Deteriorating (n: 9, 18.4%) Percentile T0 (admission): 34.43 ± 29.00 Percentile T1: 42.92 ± 29.14 Percentile T2: 37.79 ± 28.21 Percentile T3: 18.02 ± 14.35 Improving (n: 16, 32.7%) Percentile T0 (admission): 40.42 ± 26.75 Percentile T1: 55.36 ± 24.56 Percentile T2: 60.50 ± 12.84 Percentile T3: 66.05 ± 15.10 Persistently high (n: 13, 26.5%) Percentile T0 (admission): 68.93 ± 24.39 Percentile T1: 90.05 ± 8.58 Percentile T2: 89.58 ± 9.33 Percentile T3: 91.18 ± 7.89	–	Being younger at institutional admission posed a significant risk factor for impaired physical development across the three domains. Being a boy was a risk factor for compromised growth in weight and head circumference. Findings lead the researchers to believe that slower growth rates may be linked to younger infants in depriving contexts being highly susceptible to insufficient stimulation and support. The data shows that the pre- and perinatal circumstances that precede institutionalization influence children's development in institutions. Children's physical status at birth was also significantly associated with their growth trajectories. Children born longer, heavier and with larger head circumferences stayed in the persistently high groups for height and weight. The most favorable weight trajectory was associated with better interactions with caregivers.

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Table 2 (*continued*)

Author, year	Growth reference	Weight for age (WAZ)	Weight for-length/ height (WHZ)	Length/ height for age (HAZ)	BMI-for-Age	Head circumference for age	Other	Results
Pysz, Leszczynska & Kopec (2015)	University of Physical Education in Krakow (percentiles)	–	–	–	Thinness or Underweight: 14% boys and 5% girls Normal BMI: 86% boys and 92% girls Overweight or obesity: 6% boys and 6% girls	–	Thickness of the sum of three skin folds in normal ranges: boys 83% and girls 85%	Thickness of skinfolds was measured in ∼90% of the participants both genders (in relation to a wide range of standards, between 10 and 90 percentiles). Strong correlation between the thickness of skinfold and gender. The average thicknesses of various skinfolds were higher in girls than in boys.
Smyke et al. (2007)	CDC IBC:123 CC: 62	Mean z-scores: IBC: -1.25 ± 1.07 CC: $-.06 \pm 1.02$ $p < 0.01$	Mean z-scores: IBC: $-.79 \pm 1.03$ CC: $.002 \pm .99$ $p < 0.001$	Mean z-scores: IBC: $-.89 \pm .90$ CC: $.06 \pm .98$ $p<0.001$	–	Mean z-scores: IBC: $-.77 \pm .97$ FBC: $.17 \pm (.79)$ $p < 0.001$	Size IBC: $-.93 \pm .77$ FBC:$.044 \pm (.89)$ $p < 0.001$	Children living in IBC had poorer growth compared to CC. When birthweight was entered as a covariate, findings were similar, with the exception of weight for height, which was no longer significantly different. Physical size was examined and found that it was associated (positively) only with birth weight.
					Middle East			
El-Kassas & Ziade (2017)	*World Health Organization (2009)*	–	–	Stunting: <10 years: 11.3% ≥10 years: 16.4% Total: 13.7% $p = 0.352$	Normal: 90.8% Overweight (≥+2SD): 7.2% Obese (≥+3SD): 2% $p = 0.311$	–	–	Increasing age (OR: 5.201, 95% CI [1.347–20.085]), irregular breakfast intake (OR: 6.852, 95% CI [1.462–32.12]), and increased screen time more than two hours per day (OR: 12.126, 95% CI [2.659–55.288]) were associated with significantly higher odds of being stunted. Older age group had a higher prevalence of overweight and obesity, compared to the younger age group.
					South America			
Nunes et al. (1999)	NCHS, type classified according to the Seone-Lathan classification	–	–	–	–	–	–	41% were malnourished, including both chronic and acute malnutrition cases. 49% of the girls and 40% of the boys had malnutrition. No significant difference between malnourished children and controls. 3% cerebral palsy; 3% developmental delay; 2.1% with microcephaly; .8% with fetal alcohol syndrome; 4.3% ADDH; 1.3% Down syndrome.

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Table 2 (*continued*)

Author, year	Growth reference	Weight for age (WAZ)	Weight for-length/ height (WHZ)	Length/ height for age (HAZ)	BMI-for-Age	Head circumference for age	Other	Results
					The Caribbean			
Nelson (2016)	WHO	IBC Girls 5–11 years (n: 24): 0.006 ± 0.748 IBC Boys 5–11 years (n: 38): −0.229 ± 1.09 20% of IBC were mildly underweight, and 2.5% were moderately underweight. CC Girls 5–11 years (n: 39): 0.905 ± 1.30 CC Boys 5–11 years (n: 33): 0.252 ± 0.871 7.3% of CC were mildly underweight.	–	IBC Girls 5–11 years (n: 24): 0.509 ± 1.21 12–18 years (n: 20): 0.065 ± 0.962 IBC Boys 5–11 years (n: 33): −0.239 ± 1.29 12–18 years (n: 10): 0.991 ± 2.57 15.3% of IBC were mildly stunted, and 4.5% were moderately stunted. CC Girls 5–11 years (n: 39): 1.065 ± 0.984 12–18 years (n: 21): 0.785 ± 1.17 CC Boys 5–11 years (n: 33): 0.591 ± 0.928 12–18 years (n: 10): −0.044 ± 1.30 4.9% of CC were mildly stunted.	–	–	Mean MUAC IBC Girls 5–11 years (n: 24): 18.08 cm ± 2.0 12–18 years (n: 20) 22.55 cm ± 2.87 IBC Boys 5–11 years (n: 38): 17.35 cm ± 3.8 12–18 years (n:31): 23.21 cm ± 2.9 CC Girls 5–11 years (n: 39): 19.87 cm ± 3.6 12–18 years (n: 21) 24.01 cm ± 2.54 CC Boys 5–11 years (n: 33): 18.17 cm ± 2.1 12–18 years (n:10): 23.11 cm ± 3.1 Mean Triceps Skinfold IBC Girls 5–11 years (n: 39): 18.08 cm ± 2.0 12–18 years (n: 21) 22.55 cm ± 2.87 IBC Boys 5–11 years (n: 33): 17.35 cm ± 3.8 12–18 years (n:10): 23.21 cm ± 2.9 CC Girls 5–11 years (n: 39): 19.87 cm ± 3.6 12–18 years (n: 21) 24.01 cm ± 2.54 CC Boys 5–11 years (n: 33): 18.17 cm ± 2.1 12–18 years (n:10): 23.11 cm ± 3.1	Children living in institutional care were at higher risk for malnutrition. Young girls living with family members had significantly better anthropometric assessments of growth as compared to their peers living in IBC. However, the effect sizes were small, explaining only 4.4% (HAZ) to 10.3% (WAZ) of the variance in measurements of nutritional status observed between these groups.

Notes.

Study population: IBC, Institution-based Care; FBC, Family-based Care (orphaned or abandoned children in community settings); CC, Community Children (non-orphans); CLS, Children living on the Street.

WHO, World Health Organization; NCHS, National Center for Health Statistics (USA); CDC, Centers for Disease Control (USA); BMI, Body Mass Index; ht, height; wt, weight; MUAC, Mid-pper Arm Circumference.

Table 3 Diet, micronutrient status, clinical signs/ symptoms and infections results. Diet, micronutrient status, clinical signs/ symptoms and infections of children living within institutionalized care in various countries.

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
Multi-Country			
Whetten et al. (2009)	–	–	By caregiver report, children living in institutions were also less likely to have had a cough, diarrhea or fever in the two weeks before the interview (19.9 vs. 41.2%, weighted difference 220.6%, 95% CI [224%,218%]) or to be sick on the day of the interview (5.9% vs. 12.2%,), weighted difference 26.1%, 95% CI [28%, 24%]).
Africa			
Aboud et al. (1991)	–	–	Edema: IBC (4%), FBC (0%) Conjunctival Pallor: IBC (4%), FBC (0%) Xerophthalmia: IBC (15.5%), FBC (8.2%) Goiter: IBC (2.7%), FBC (2%) Nutritional problems were not significantly more prevalent among IBC.
Braitstein et al. (2013)	Using the Household Food Insecurity Access Scale (HFIAS), 42% of IBC and 2% of FBC reported being food secure. 95% of children in IBC reported an adequate diet compared to 93% of children in FBC and 99% of SLC, ($p = 0.009$).	–	HIV rates: IBC (2.1%), FBC (1.3%), SLC (1%) ($p = 0.001$)

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Table 3 (*continued*)

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
Mwaniki, Makokha & Muttunga (2014)	Using a 24hr diet recall and Nutri Survey program, diets were assessed. A total of 63 and 37 food items were consumed by the CC and IBC respectively. Only 7.2% of IBC consumed more than three food groups compared to 45.2% of CC. 92.9% of IBC and 54.8% of CC consumed less than four food groups ($p < 0.05$). CC had significantly ($p < 0.05$) higher diversity of foods served than IBC. Energy intake: The total mean energy intake among CC was 1,890 Kcal per day and was significantly higher ($p < 0.05$) than that of IBC. The intake of energy by IBC who took lunch was 1,547 Kcal compared to the energy intake of CC who also took the three meals of the day ($p < 0.05$). The mean energy intake of IBC who did not take lunch was less than half of that of CC. IBC who attended school away from the orphanage had two meals (mainly breakfast and supper) in a day during school days and three meals during the weekend and did not meet their daily needs compared to CC who always had three meals. IBC had 3.9 times higher risk of consuming inadequate calories compared to CC. Orphanages tend toward exclusive reliance on starches and legumes. Food in orphanages mainly depended on donations.	–	IBC Diarrhea: 11.5% Cough/ colds: 12.5% Fever: 1.4% Vomiting/skin rashes: 7.7% FBC Diarrhea: 2.4% ($p = 0.015$) Cough/colds: 2.9% ($p = 0.14$) Fever: 0.5% ($p = 0.8$) Vomiting/skin rashes: 0.5% ($p = 0.006$) Prevalence of morbidity was significantly ($p < 0.05$) higher among the IBC compared to CC children and 1.2 times higher risk of being sick. IBC had significantly ($p < 0.05$) higher prevalence of diarrhea and cold/cough compared to CC. IBC were twice less likely to wash hands at critical times compared to CC. 48% of IBC reported washing hands after visiting the toilet the day before the interview compared to 78.2% of CC. 49.4% of IBC and 78.2% of CC washed their hands before meals. There was also a higher proportion (76.3%) of IBC who reported washing hands with soap during the critical times compared with the CC (12.8%) ($p < 0.01$). Vaccination among IBC compared to CC ($p < 0.05$).

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Table 3 (*continued*)

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
Panpanich et al. (1999)	–	–	Illness in past four weeks (%) IBC: 35% FBC: 37% CC: 51% Undernutrition was present in 42% of IBC who had a history of illness in the last month compared with 18.8% of those who reported no illness ($p < 0.05$). HIV rates: IBC 23% (3/13)
		Asia	
Hearst et al. (2014)	–	The nutritional status, based on blood biomarkers, revealed that 37.1% of the children were anemic, 21.4% had low albumin, 38.1% had low vitamin D, 5.5% were iodine-deficient and 2% had low serum zinc.	–

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Table 3 (*continued*)

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
Kapavarapu et al. (2012)	Dietary intake was compared with the Indian Recommended Dietary Allowance (RDA). A 24-h dietary recall revealed that children <7 years received 75% of the RDA for energy, and older children received 93 to 107% of RDA for energy. All children received adequate (>100% RDA) amounts of both protein and fat.	Hemoglobin (Hb) level was measured using automated blood analyzer. Results indicated that anemia was a prominent manifestation of HIV. Although baseline prevalence of anemia was only 40%, during the study period the cumulative incidence rose to 85%.	75% had infections in the initial period (of <3 months) of admission into the facility. Pulmonary tuberculosis: 8% Impetigo: 31% Varicella zoster: 24% Chronic suppurative otitis media: 15% Parotitis: 13% HIV Group Home
Kroupina et al. (2014)	–	Venous blood samples were used for assessment of hemoglobin status. Anemia status was not found to be predictive of development status. "A significant percentage of the children in Kazakh institutions have micronutrient deficiencies; most strikingly, over half the sample was found to be anemic."	–
Lewindon et al. (1997)	–	–	Children with disabilities in long-term care at increased risk for H. pylori infection. 61% were seropositive for H. Pylori. 55.4% of 157 pediatric patients (<16yrs) were seropositive compared with 50 control group children ($p > 0.0002$). Children with disabilities frequently have excessive drool and contact with saliva could be an opportunity for the transmission of H. plyori.

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Table 3 (*continued*)

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
Myint et al. (2012)	–	–	Ocular manifestations: 5.1% Systemic comorbidities: 40% Chronic otitis media: 26.6% Pulmonary tuberculosis: 13.3% HIV Group Home
Sarma et al. (1991)	Dietary intake was compared with the Indian Council of Medical Research's (1984) recommended dietary allowance (RDA). 1,150 children were selected for dietary analysis. Energy intakes fell short compared to the RDA for most children and the deficit was higher in older children when compared to younger children.	Most common nutritional deficiencies encountered: vitamin A (2–8.5%), vitamin B complex and anemia.	Pallor indicating anemia: 2–17% Phrynoderma: 1.2–6.8% Angular stomatitis: 1–32% Dental mottling: 1–18% Dental decay: 1–22% Cough, cold, fever, diarrhea, infections of the skin, eyes and ear/nose/throat complaints were most common. Deficiencies and morbidities were more common in younger age groups.

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Table 3 (*continued*)

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
Zahid & Karim (2013)	Food intake was obtained by 24 h food-weighing method for seven days. The average food intake were calculated by using the Institute of Nutrition and Food Science. Total food intake was about double the intake of similar children in the 1995–96 nutrition survey. Mean energy (2,270 kcal), protein (65 grams), carbohydrate (335 grams) and fat intake (73 grams). Carbohydrates, protein and fat provide 59%, 12% and 29% of total calories respectively. Protein intake was 65 grams, about 50% higher than the requirement and the 1995–96 nutrition survey of the urban location of the same group. Energy intake was found 20% higher than requirement and about 42% higher compared to 1995–96 nutrition survey. Average intake of IBC was higher than the national intake and the nutritional status of IBC was also found to be better than the national average by any nutritional criteria. Studies consider this to be potentially attributed to better health and care system prevailing in the orphanage apart provision of high-calorie and protein-rich food and that the nutritional status IBC, who are nutritionally disadvantageous, can be improved through organized feeding and better hygienic conditions.	Mean intake calcium 826 mg, iron 31 mg, vitamin A 6,462 IU, carotene 10,508 µg, vitamin B1 1.60 mg, vitamin B2 1.64 mg, niacin 19 mg, vitamin C 111 mg and zinc 10.2 mg. "Compared to 1995–96 nutrition survey, IBC had significantly higher micronutrient intake."	–

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Table 3 (*continued*)

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
Eastern Europe			
Lesho et al. (2002)	–	90% of children had anemia and one-fourth had severe anemia.	76% of children had parasites and 10% were infected with three or more. Disease frequency: Dermatologic: 17% Respiratory: 5% Genitourinary disorders: 3% Ear, nose and throat: 4% Psychiatric: 3%
European Union			
Pysz, Leszczynska & Kopec (2015)	Diets were chemically analyzed using the Kjeldahl method and Soxhlet method and compared to Polish Estimated Average Requirements. Results indicate that daily diets meet about 80% of recommended intake of energy, fat and carbohydrates. The intake of protein with daily diets exceeded EAR value and ranged from 115 to 362% (average 214.2%). It has been also found that the intake of basic nutrients was varied, coefficient variation (CV) ranged from 22.2% to 27.1%. Boys, compared to girls, spent almost twice as much time on physical activity.	–	–

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Table 3 (*continued*)

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
		Middle East	
El-Kassas & Ziade (2017)	Compared to the Dietary Guidelines for American Children and Adolescents 2015 and based on a semi-quantitative food frequency questionnaire, more than half were estimated to have inadequate daily intake of vegetables, fruit, and proteins compared to the recommendation. 94.8% consumed three meals per day. 20.5% of adolescents (≥10 years) reported meals did not satisfy appetite, compared to only 13% of children below 10 years, with no statistical significance between the two groups ($p = 0.480$). 45.1% of the studied sample revealed consumption of one snack per day; 49% consumed sweet and 19% consumed salty snacks on a regular basis. 82% of both age groups reported regular intake of breakfast. Inadequate protein intake (OR: 0.017, 95% CI [0.001–0.291]) was associated with statistically significant lower odds for being overweight and obese. Conversely, consumption of sweet snacks (OR: 6.492, 95% CI [1.124–37.512]) was associated with significantly higher odds for overweight and obesity.	–	Abnormal Hair Condition: 5.9% ($p = 0.736$) Abnormal Skin Condition: 26.1% ($p = 0.063$) Muscle Wasting: 2.6% ($p = 0.348$) Edema: 0% Bowing of legs or knocked knees: 2.6% ($p = 0.622$) Abnormal Mucus Membranes: 5.9% ($p = 0.014$) "Physical signs suggesting nutritional deficiencies were detected in about 25% of the sample."

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Table 3 (*continued*)

Author, year	Dietary analysis	Micronutrient status	Clinical signs/symptoms and infections
	South America		
Nunes et al. (1999)	–	Anemia: 3%	"High rates of infectious diseases in all the children." HIV: 9.4% Gastroesophageal reflux: 3% Parasites: 6% Skin infections: 10% Upper respiratory infection: 7.3% Conjunctivitis: 1.7%
	The Caribbean		
Nelson (2016)	Children living in both residential settings listed (1) carbohydrates and starches, (2) meat and (3) fruits and vegetables as the most commonly consumed food items. Significant difference in self-reports of foods consumed most often by CC and IBC (X2 (4, $N = 215$) =21.93, $P > 0.000$). CC were more likely than IBC to report meat as most often consumed food. Chi-square analyses revealed no significant differences in self-reports of foods consumed most often by IBC in the three orphanages. No significant differences in the food served at the three orphanages. No difference between physical activity between IBC and CC or between orphanages.	–	–

Notes.

Study population: IBC, Institution-based care; FBC, Family-based care (orphaned or abandoned children in community settings); CC, Community children (non-orphans); CLS, Children living on the street.

live in IBC and there are a multitude of factors and reasons why they may be affected by different types of malnutrition. The extent and direction of this has not been well studied nor is it currently being effectively monitored or assessed (*Petrowski, Cappa & Gross, 2017*). Representing an inherently high-risk population, there are many reasons why we would expect undernutrition to be common: this was indeed observed in our review. Conversely, there are some reasons why IBC may offer opportunities for good nutrition and access to services, such as better food security, more reliable funding sources and access to specialized therapy or treatment. These ideal factors may not be possible or available for families affected by different economic circumstances living in the same communities (*Braitstein et al., 2013*; *Panpanich et al., 1999*; *Whetten et al., 2014*).

Our review, which used a comprehensive search strategy, also notably highlights a lack of well reported and standardized evidence. Only 19 countries were represented in our findings, despite Petrowski and colleagues finding 140 countries with data on children in institutions and this limited our ability to determine trends or region-specific patterns and risk factors (*Petrowski, Cappa & Gross, 2017*).

Children with disabilities and children with low birth weight

A key observation is that few studies mentioned children with disabilities and only one included anthropometric analysis (Tables 1 and 2) (*Lewindon et al., 1997*). Children with disabilities are disproportionately present in institutionalized care settings. (*Baron, Baron & Spencer, 2001*; *The Children's Health Care Collaborative Study Group, 1994*; *The St Petersburg-USA Orphanage Research Team, 2005*). They are already at increased risk when they enter care centers because disabilities can increase the likelihood of being malnourished due to feeding challenges, malabsorption and/or intake needs. In addition, children with disabilities face the risk of their disabilities worsening in environments that do not meet their individual needs (*Groce et al., 2014*; *Kroupina et al., 2014*). Children with some types of disabilities may have higher caloric needs or require specialized diets or additional supports at mealtimes (*Groce et al., 2014*; *Johnson & Gunnar, 2011*; *Johnson et al., 2010*; *Kroupina et al., 2014*; *The Children's Health Care Collaborative Study Group, 1994*; *The St. Petersburg- USA Orphanage Research Team, 2008*).

Children in care or those who stay in care the longest may have more disabilities, more underlying diseases or more complex backgrounds—including a history of low birth weight (LBW), and therefore may require more focused care (*The Children's Health Care Collaborative Study Group, 1994*; *The St Petersburg-USA Orphanage Research Team, 2005*). Even when provided with adequate diet and medical care, these groups may be more dependent on caregivers for feeding, or need specialized approaches to feeding such as supportive seating and positioning, adaptive skill development and an extended time to eat (*Johnson & Gunnar, 2011*). When children enter into care they are often in poor health and those who stay the longest, such as some children with disabilities, are frequently in worse condition compared to children who are healthy at admission (*Groce et al., 2014*; *The St Petersburg-USA Orphanage Research Team, 2005*). These issues are important to highlight because becoming malnourished while living in an institution can also increase the risk of children developing a disability (*Groce et al., 2014*).

High prevalences of low birth weight infants were common within institutions; although child history, records or tracking were often limited (*Johnson et al., 2010*; *Kroupina et al., 2014*; *The Children's Health Care Collaborative Study Group, 1994*; *The St Petersburg-USA Orphanage Research Team, 2005*). Health status at birth was found to be a significant determinant of development. Growth trajectories and pre- and perinatal circumstances influence children's development in care: nutrition needs vary depending on individual growth rates and the presence of preexisting nutrition deficiencies (*Johnson et al., 2010*; *Kroupina et al., 2014*; *Martins et al., 2013*). *Johnson & Gunnar (2011)* and *Johnson et al. (2010)* found that during early rapid-growth phases, the effects of even modest nutritional deficits can become magnified. Age, age at admission and length of stay were other key factors identified that were associated with nutritional status (*Chowdhury et al., 2017*; *Kroupina et al., 2014*; *Martins et al., 2013*; *Panpanich et al., 1999*).

Gender and malnutrition

Gender is also important to consider because programs and policies should be evidence-based and equitable, offering support to those most in need (*Theobald et al., 2017*). However, our review found that only nine of the studies compared genders. Of these, two found that girls were more malnourished, three found boys were more malnourished than girls and another four found both groups had similarly high prevalence of malnutrition or no significant difference in nutritional status by gender. We thus have mixed and inconclusive evidence of malnutrition or risk of malnutrition being linked to gender of children in institutional care (Table 2). This may be a very context specific issue where social as well as biological factors play a role.

Anthropometrics

Frequently the prevalence of low birth weight, stunting, wasting, underweight, anemia, and overweight was higher in IBC compared to the global prevalence for children younger than 5 years old (*The World Bank Group, 2019*). Paralleling global trends, the triple burden of malnutrition (undernutrition, micronutrient deficiencies and overweight/ obesity) also needs to be examined in IBC (*Black et al., 2013*; *UNICEF, 2019*). Although only a few studies reported on overweight, when it was reported, the prevalence was high, especially for adolescents. Future studies should report on overweight as well as underweight and micronutrient deficiencies. A positive feature of the studies reviewed was that many had peer groups for comparison; this is helpful because many children in the surrounding community may also deviate from WHO growth standards and it is helpful to see the nutritional status of children in IBC in local as well as global context. Multiple studies found that children in IBC were more undernourished than community children (CC) or children living in family-based care (FBC) (Table 2). Six studies indicated that peers within the community were more likely to be malnourished than children living within IBC, although this varied a bit by age. This could be in part due to children in care receiving adequate nutrition, routine meals and health screenings, especially for children who have HIV, and/or it could reflect the challenges faced by families in those communities (*Braitstein et al., 2013*; *Panpanich et al., 1999*; *Sarma et al., 1991*; *Whetten et al., 2014*; *Whetten et al., 2009*; *Zahid & Karim, 2013*).

Clinical signs/symptoms, micronutrient status and infections

HIV prevalence was higher than global percentages for the few sites that reported it (*The World Bank Group, 2019*). HIV can be a significant risk factor for becoming malnourished and is also a contributing factor to children ending up in care (*Kotler, 1989*; *Leyenaar, 2005*). Another clear gap was that less than a third of the studies reported on micronutrient status and less than half reported on clinical signs/ symptoms or infections (Table 3). Micronutrient deficiencies were common with a prevalence of anemia higher than the global average in the majority of studies (*The World Bank Group, 2019*). The prevalence of micronutrient deficiencies in children in IBC is likely linked to their increased risk of sickness or morbidities (*Black et al., 2013*). *Hearst et al. (2014)* concluded that the growth-related indicators coincide with the high prevalence of low albumin, indicating generalized chronic undernutrition, and suggested macronutrient deficiencies could be due to inadequate diets, infections and/or inflammation, or impaired nutrient absorption or utilization secondary to the psychosocial stress of living in an institution.

Dietary diversity, intake and food security

Only eight (32%) studies included information on dietary intake and, of those, half found intake or diet diversity to be inadequate. Dietary diversity was reported to be low for children in IBC, especially in terms of fruits, vegetables and protein. Limited funding and reliance on donations for food were frequently mentioned issues, and resulted in diets high in starches and legumes (*Mwaniki, Makokha & Muttunga, 2014*). Dietary adequacy varied; in some IBC sites children received an adequate amount or more than recommended dietary allowances and in others they received below the recommendations. Interestingly, the one study which reported on food security found that children in a Kenyan orphanage had higher food security when compared to children in FBC (*Braitstein et al., 2013*). However, it is impossible to generalize from this one study to say anything more broadly about food security.

Limitations

We focused on nutritional status of children living in care but note that many other issues (e.g., development, cognition, puberty, catch-up growth, care practices, length of stay, age at admission, cause of institutionalization, illnesses, health of children who have been adopted or cultural practices) affect the demographics, health and well-being of children who are in institutions. It could be that all children coming into care are at risk due to the adverse events and trauma of being abandoned or orphaned (*Baron, Baron & Spencer, 2001*; *Martins et al., 2013*; *The Children's Health Care Collaborative Study Group, 1994*; *The St. Petersburg- USA Orphanage Research Team, 2008*). These wider factors were beyond the scope of this study (as well as infrequently reported in sufficient details in papers). Given biological links between poor nutrition and sub-optimal child development, evaluating these topics in more depth is critical in future work.

Although we found some research, there was limited recent information on this population of children. This may be because of practical or ethical considerations or it may reflect the desire to move away from institution-based care to family-based living situations for children (Kelley et al., 2016). This review also only analyzed data from research published in English from January 1990 to January 2019. The studies were of differing designs and types. The review did not find enough studies to be able to examine differences between IBC, FBC, CC and CLS (children living on the streets). Other weaknesses included the common use of non-standard reporting methods or lack of clarity around measurement methods, such as how studies assessed micronutrient status or clinical signs and symptoms or determined disability status. Many of the studies were examining other subjects and nutritional/anthropometric information was only supplementary. Furthermore, growth measurements may have been affected by measurement or other errors (e.g., incorrect birthdate estimates leading to incorrect z-score calculations for age-related indices). Additionally, children with some types of disabilities may be shorter or lighter not because of inadequacy of dietary intake but because of their specific underlying conditions (e.g., disabilities such as Down syndrome and many others are associated with non-standard growth and development). It is also possible that there is under-diagnosis or misdiagnosis of medical conditions, chronic diseases or disabilities in these settings, which can also impair the growth and development of children (Byass, Kahn & Ivarsson, 2011). Another consideration is the potential for healthy survivor bias and sampling bias: some of the most vulnerable children may have died prior to measurement; younger children and healthier children may more quickly leave institutions with the remaining older residents more likely to have deficiencies (van IJzendoorn et al., 2011; The St Petersburg-USA Orphanage Research Team, 2005).

Risk of bias was apparent in most of the studies. We had originally considered using a formal risk of bias tool to differentiate study quality but did not do so because it became apparent that all of the studies had a high risk of bias and could not be representative of all the institutions in the countries. Another concern was that many used convenience sampling. It is also plausible that the sites included in the research were better-off facilities, which welcomed researchers, who were looking to share positive results and good performance. These are unlikely to be representative of all sites; we speculate that the overall situation is likely worse at many facilities with higher prevalence of malnutrition indicators. There is also wide variation between different institutional care facilities (van IJzendoorn et al., 2011; Petrowski, Cappa & Gross, 2017; Whetten et al., 2014).

CONCLUSIONS

A key finding from this study was the limited amount of quality evidence-based data available on the nutritional status of children in institutions. Equally as important, our review found that where data was available, children living in institutionalized care were consistently at high risk of malnutrition, commonly experiencing undernutrition, overweight and/or micronutrient deficiencies. The implications for caregivers, clinicians, institutional administration and policy makers is that work is needed to ensure all children's basic rights to nutrition are met. Children living within care are at risk and require special attention. This is especially true for children with disabilities and low birth weight infants.

Although institutionalized care is not the ideal setting for children to grow up in, living within care continues to be a reality for many children. This study is in agreement with other papers and reports that support optimizing current institutional environments when alternative placements for orphaned or abandoned children are not available. These children have a right to good nutrition, both to maintain their health now and to allow them to grow into healthy adults. Interventions will need to be multifaceted to address all of the root causes of malnutrition faced by children living in care. The need for much more evidence as well as a commitment to monitoring and evaluation of nutritional status in all institutions, should be acknowledged and children supported through improved nutrition programming as part of broader policy and child rights initiatives.

ADDITIONAL INFORMATION AND DECLARATIONS

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Competing Interests

Emily DeLacey, Michael Quiring and Caryl Garcia are employed by Holt International.

Author Contributions

- Emily DeLacey and Marko Kerac conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the paper, and approved the final draft.
- Cally Tann conceived and designed the experiments, analyzed the data, authored or reviewed drafts of the paper, and approved the final draft.
- Nora Groce, Maria Kett, Michael Quiring, Ethan Bergman and Caryl Garcia analyzed the data, authored or reviewed drafts of the paper, and approved the final draft.

Data Availability

The following information was supplied regarding data availability:

The raw data in available in Tables 1–3.

Supplemental Information

Supplemental information for this article can be found online at http://dx.doi.org/10.7717/peerj.8484#supplemental-information.

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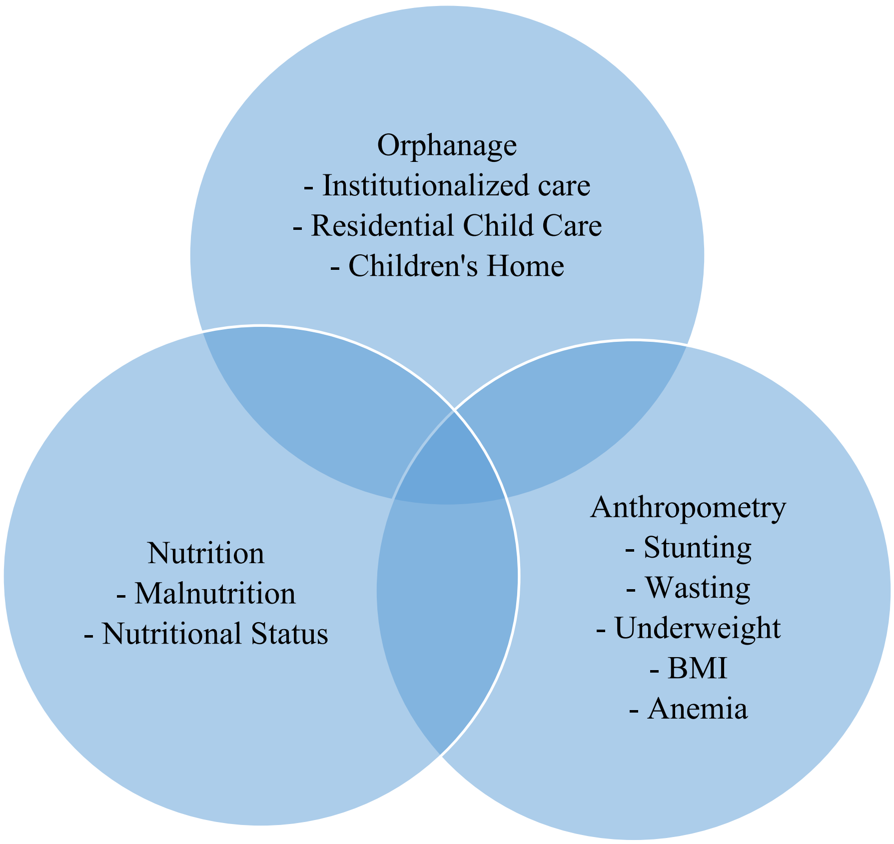
Appendix 1: Database Search Strategy and Acronyms

Database Search Strategy:



OVID Keyword Search: December 30th 2018 - Jan 6th, 2019

A. Orphanage or institutionalized care or residential child care or children's home
B. Nutrition or nutritional status (MeSH Term) or malnutrition (MeSH)
C. Anthropometry OR (length for age OR length-for-age OR LFA OR LAZ) OR linear growth OR stunted OR stunting OR malnutrition OR wasting OR wasted OR oedematous malnutrition OR edematous malnutrition OR kwashiorkor OR protein-energy malnutrition OR (SAM OR MAM OR GAM) OR weight-for-length OR weight for length OR WFL OR WLZ OR muac OR mid upper arm circumference OR mid-upper-arm-circumference and (low OR small) OR underweight OR thinness OR (weight-for-age OR weight for age OR WFA OR WAZ) OR Anemia OR Anaemia OR Hemglobin Levels OR BMI

Through Ovid, four electronic databases were searched; PubMed/ Medline 1950's to present, CINHAL PLUS 1937 to present, Global Health Database 1910 to 2018 Week 51 and Embase Classic+Embase 1947 to 2018 December 31.

Acronyms:

BMI: Body mass index

CC: Community children, children living with their biological families

CDC: Centers for Disease Control (USA)

CLS: Children living on the streets

FBC: Family-based care, orphaned, separated, or abandoned children living in family-based care settings like foster care or kinship care.

GAM: Global acute malnutrition

HAZ/ LFA/ LAZ: Height/length for age z-score

IBC: Institution-based care, children living in institutional care/ residential care facilities.

LBW: Low birth weight

MAM: Moderate acute malnutrition

MUAC: Mid-upper arm circumference

NCHS: National Center for Health Statistics (USA)

SAM: Severe acute malnutrition

WAZ/ WFA: Weight-for-age z-score

WHO: World Health Organization

WHZ/ WFL/ WLZ: Weight for height/length z-score

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	5
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	10
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	5
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	5

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	10
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	5
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	6
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	10
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Tables 1-3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	10
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Tables 1-3
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	8
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	10
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	12
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	13

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

Appendix 3: Studies excluded and reasons.

Author Year	Author
Johnson, 2018	Anthropometric information in a different study
Johnson, 2011	Anthropometric information in a different study
The St. Petersburg—USA Orphanage Research Team, 2008	Anthropometric information in a different study
Diamond, 2003	No breakout of IBC
He, 2007	No breakout of IBC
Adotey, 2011	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Adotey, 2011	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Al-Jobair, 2013	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Al-Maweri, 2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Ankita2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Archelli, 2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Arpita, 2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Aurpibul, 2010	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Bailey, 2013	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Baptista, 2018	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Baron, 2001	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Barroso Junior, 2006	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status

Blignaut, 2007	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Blignaut, 2007	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Boondit, 2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Boontanom, 2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Bos, 2009	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Carr, 2018	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Children's Health Care Collaborative Study Group, 1992	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Children's Health Care Collaborative Study Group, 1993	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Chizoba, 2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Culha, 2004	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Dixit, 2009	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
El-Wahab, 2015	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Freitas-Fernandes, 2002	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Golden, 2002	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Hersh, 1991	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Hong, 2011	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status

Huq, 2013	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Inabo, 2011	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Isenbarger, 1998	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Jagvir, 1997	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Kim, 2003	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Kim, 2003	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Kubiak, 2015	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
McCall, 2010	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Munoz-Hoyos, 2001	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Oh, 2010	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Oluboyo, 2017	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Onigbinde, 2017	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Ozkalp, 2010	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Pagornrat, 2009	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Pintong, 2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Pruksachatkunakorn, 2002	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status

Ramsha, 2017	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Rebello, 2011	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Ruta, 1999	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Sharma, 2014	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Shrestha, 2010	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Solarsh, 1996	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Stark, 2017	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Supriya, 2015	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Tande, 2009	Non-standard or insufficient Anthropometric measurements/measurements of nutrition status
Bischof, 2002	Population
Le Thanh, 2012	Population
Chakraborty, 2004	Population
Abe, 2000	Study Type
Cataldo, 2007	Study Type
Frank, 1996	Study Type
Martin, 1998	Study Type
McCall, 2018	Study Type
Al-Shibani, 2009	Unable to find full text
Beard, 2005	Unable to find full text
Bhuvaneswari, 2017	Unable to find full text
Blignaut, 2007	Unable to find full text
Kannan, 2018	Unable to find full text
Makhlouf,1994	Unable to find full text
Virk, 2012	Unable to find full text

Chapter 3: Nutritional Status of Children in IBC (Paper 2)

3.1 Scope of Chapter

This chapter presents the second research paper titled "The nutritional status of children living within institution-based care: A retrospective analysis with funnel plots and control charts for program monitoring".[6] This work was published in BMJ Open on Dec. 6, 2021 as an open access article under the Creative Commons Attribution Non Commercial License. Copyright: © 2021 DeLacey et al. Although the research was not funded, Holt International paid for publication costs to allow for open access of the research to improve the accessibility of the information to all audiences.

This paper describes the nutrition-related epidemiology of children living within institution-based care who participate in Holt International's Child Nutrition Program. The primary aim of this paper was to describe the nutritional status of children in care, taking into account both age, disability status and other variables in analysis. We utilized Shewhart control charts and funnel plots to explore and visualize inter-site and over-time variations in nutritional status for all children, those with disabilities and those without disabilities. The results from this paper helped to inform our subsequent paper on feeding practices and their relationship to nutritional status for this population.

3.2 List of figures

children without disabilities. Upper control limits (UCL) and lower control limits (LCL) are indicated by the dashed lines; WAZ, weight-for-age z-score.

Online Supplement Figures 2-6: Funnel plots of anthropometric proportions for all sites at baseline and 1 year.

Online Supplement Figures 7-10: Control charts of mean z-score change in anthropometric measurements from baseline to 2 years.

3.3 List of tables

Table 1: Description of population at baseline screening of children living within IBC in six countries.

Table 2: Total population mean anthropometric z-scores, malnutrition, and anemia prevalence at baseline.

Online Supplement 1: The Strobe Checklist.[44]

Online Supplement Table 11: Total population mean anthropometric z-scores and anemia prevalence over time by age and disability.

3.4 Citation

DeLacey E, Hilberg E, Allen E, et al Nutritional status of children living within institution-based care: a retrospective analysis with funnel plots and control charts for programme monitoring BMJ Open 2021;11:e050371. doi: 10.1136/bmjopen-2021-050371

3.5 Research Paper

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed <u>for each</u> research paper included within a thesis.

SECTION A – Student Details

Student ID Number	lsh1804647	**Title**	Ms
First Name(s)	Emily		
Surname/Family Name	DeLacey		
Thesis Title	The Nutritional and Feeding Status of Children Living within Institution-based Care and an Evaluation of Process of the Child Nutrition Program.		
Primary Supervisor	Marko Kerac		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?	BMJ Open https://bmjopen.bmj.com/content/11/12/e050371		
When was the work published?	Published December 30 2021.		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	N/A		
Have you retained the copyright for the work?*	**No**	Was the work subject to academic peer review?	**Yes**

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	

Stage of publication	Choose an item.

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	Emily DeLacey, Marko Kerac, Elizabeth Allen and Cally J Tann designed the study. Emily DeLacey, Marko Kerac, Evan Hilberg, Michael Quiring, Cally J Tann, Nora E Groce, Elizabeth Allen, Merzel Demasu-Ay, Hang T Dam, James Villus and Ethan Bergman contributed to specific areas of the methods, data analysis, statistics and quality control. Emily DeLacey, Marko Kerac, Michael Quiring and Evan Hilberg had access and verified the data. Emily DeLacey led the data analysis and writing of the first draft of the manuscript. Emily DeLacey, Marko Kerac, Evan Hilberg, Michael Quiring, Cally J Tann, Elizabeth Allen, Nora E Groce, Merzel Demasu-Ay, Hang T Dam, James Villus and Ethan Bergman contributed to the writing of the manuscript and agree with the manuscript's results and conclusions. All of the authors read and approved of the submitted manuscript. Emily DeLacey is the guarantor of this study.

SECTION E

Student Signature	Emily DeLacey
Date	June 6 2022

Supervisor Signature	Marko Kerac
Date	June 21, 2022

BMJ Open

Nutritional status of children living within institution-based care: a retrospective analysis with funnel plots and control charts for programme monitoring

Emily DeLacey ,[1,2,3] Evan Hilberg,[2] Elizabeth Allen,[1] Michael Quiring,[2] Cally J Tann,[3,4,5] Nora Ellen Groce,[6] James Vilus,[7] Ethan Bergman,[8] Merzel Demasu-Ay,[9] Hang T Dam,[2] Marko Kerac [1,3]

To cite: DeLacey E, Hilberg E, Allen E, *et al*. Nutritional status of children living within institution-based care: a retrospective analysis with funnel plots and control charts for programme monitoring. *BMJ Open* 2021;**11**:e050371. doi:10.1136/bmjopen-2021-050371

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-050371).

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Check for updates

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ABSTRACT

Objectives The aim of this study is to fill a key information gap on the nutrition-related epidemiology of orphaned and vulnerable children living within institution-based care (IBC) across six countries.

Design A retrospective analysis with Shewhart control charts and funnel plots to explore intersite and over time variations in nutritional status.

Setting We conducted a retrospective analysis of records from Holt International's Child Nutrition Programme from 35 sites in six countries; Mongolia, India, Ethiopia, Vietnam, China and the Philippines.

Participants Deidentified health records from Holt International's online nutrition screening database included records from 2926 children, 0–18 years old. Data were collected from 2013 to 2020 and included demographic and health information.

Results At initial screening, 717 (28.7%) children were anaemic, 788 (34.1%) underweight, 1048 (37.3%) stunted, 212 (12.6%) wasted, 135 (12%) overweight or obese and 339 (31%) had small head circumference. Many had underlying conditions: low birth weight, 514 (57.5%); prematurity, 294 (42.2%) and disabilities, 739 (25.3%). Children with disabilities had higher prevalence of malnutrition compared with counterparts without disabilities at baseline and 1-year screenings. There was marked intersite variation. Funnel plots highlight sites with malnutrition prevalence outside expected limits for this specific population taking into consideration natural variation at baseline and at 1 year. Control charts show changes in site mean z-scores over time in relation to site control limits.

Conclusions Malnutrition is prevalent among children living within IBC, notably different forms of undernutrition (stunting, underweight, wasting). Underlying risk factors are also common: prematurity, low birth weight and disability. Nutrition interventions should take into account the needs of this vulnerable population, especially for infants and those with disabilities. Using control charts to present data could be especially useful to programme managers as sites outside control limits could represent: problems to be investigated; good practices to be shared.

Strengths and limitations of this study

- ► The main strength of our study was the large sample size in both terms of individual children (including those with disabilities) and multiple centres across several countries.
- ► This study explored the utility of statistical process control charts and funnel plots to explore intersite and over time variations in malnutrition prevalence—these are established but under-used tools which might help managers monitor and ultimately improve programme outcomes.
- ► There were changes in the sample size over time.
- ► The sites included in this sample may not be representative of all similar institutions in all of the countries.

BACKGROUND

UNICEF estimates there are 140 million orphans worldwide who have lost either one or both parents.[1] Although most live with other family members, some live in institution-based care (IBC) or residential care facilities.[1] IBC is defined by the United Nations as residential care provided in any non-family-based group setting.[2] The UN Convention on the Rights of the Child requires that children in IBC are provided with standards of living that will support their full development. There are 3.18 million to 9.42 million children ages 18 years and younger who live in IBC globally.[3]

Malnutrition continues to affect many countries worldwide with millions of children having inadequate access to nutritious food.[4–6] Almost half of the deaths among children younger than 5 years old have undernutrition as an underlying factor.[4 6] Malnutrition also predisposes children to long-term impairments such as diminished cognition, disability, non-communicable diseases and suboptimal performance at school and work.[4 6] Dramatic worsening is anticipated as a result of the COVID-19 pandemic.[7 8]

A recent systematic review exploring the nutritional status of children living in IBC found few studies directly documenting the problem.[9] Where publications were available, 'data quality was often poor: as well as suboptimal reporting of anthropometry, few looked for or described disabilities, despite disability being common in this population and having a large potential impact on nutrition status.'[9] Disabilities in particular can be both a cause and a result of malnutrition.[10] Interpreting data can be difficult due to limited information about children's lives prior to entering IBC.[9 11–13] Pre-existing needs and adversities, including disabilities, low birth weight (LBW) or premature birth, or exposure to alcohol or drugs can impact nutritional status.[9 11 13 14]

Once children enter into IBC, facilities might only be able to address their basic needs due to limited staffing, time and fiscal constraints.[11 15–17] Children's nutritional status could be impacted by inadequate dietary diversity; inappropriate types of food; poor feeding practices; inadequate attention or stimulation; suboptimal hygiene and sanitation. These can further exacerbate preadmission vulnerabilities, with the net result of: reduced nutrient utilisation, worsening malnutrition and a vicious cycle of increased vulnerability to illnesses and in turn further nutritional decline.[9 13 16 18]

In this paper, we seek to help contribute to the current small body of data on nutritional status of children in IBC by analysing data on 2926 children from 35 sites in six countries. Our objectives were to:

1. Describe children's nutritional status, focusing on core anthropometric measures of growth (underweight, wasting, stunting, overweight) and anaemia.
2. Explore intersite variations and potential factors underlying those, notably disability.
3. Explore any changes in nutritional status over time in IBC.

Cross-cutting these objectives, we also explored the utility of control charts and funnel plots to present key data in a way that may be used to track, monitor and evaluate nutritional status and programmes.

METHODS

We reported according to the Strengthening the Reporting of Observational Studies in Epidemiology statement (online supplemental file 1).[19] A data use agreement was signed with Holt International for use of routinely collected data.

Study design

A retrospective analysis of nutrition screenings from a large multicountry nutrition programme.

Setting/study size

We used secondary data from Holt International's Child Nutrition Programme nutrition screening database. Holt International is a 65-year-old child welfare non-profit, which provides services to children and families in numerous countries around the world. Holt's Child Nutrition Programme currently supports 35 IBC sites in six countries: Mongolia, India, China, Philippines, Ethiopia and Vietnam. Study size was determined by the number of children and nutrition screenings at each site. Figure 1 is a flow chart of inclusion criteria leading to the final sample size.

Patient and public involvement

This study analysed secondary deidentified routine programme audit data and did not involve patients or public in development of the research. However, we intend to disseminate this research to the public and all relevant stakeholders on open access publication.

Participants

Screenings from children 0–18 years old residing in IBC between January 2013 and June 2020 were included. These health/nutrition screenings were routinely performed at each site based on age and specific health indicators (eg, anaemia). They are carried out monthly on children up to 2 years old; quarterly on children 2–5 years old and biannually thereafter. Each screening captures information on age, birth status, sex, disability status, time spent in care, episodes of illness, nutritional status as assessed by anthropometric measurements and anaemia as assessed by haemoglobin tests. Screenings and measurements were taken by trained staff using standardised equipment (Stadiometer (Seca 206 cm), standing scale (Seca model 469), baby scale (Health-O-metre model 553 kL), infant/child length/height measurement board (Shorrboard), Hb201 +Haemoglobin System (Hemocue)).

Variables

Health indicators analysed included prevalence of stunting (height-for-age z-score, HAZ), wasting (weight-for-height z-score, WHZ and mid-upper arm circumference-for-age z-score), underweight (weight-for-age z-score, WAZ), thinness/underweight (body mass index z-score, BMIZ), overweight (BMIZ), head circumference (head circumference-for-age z-score) and anaemia. Disabilities, as categorised by professionals in country, were grouped and tabulated by the primary disability listed. LBW and preterm birth were as noted in any preadmission health records.

Statistical analysis

Analysis was completed using Stata V.16.[20] Children's baseline and last screening within each 6-month period were selected for analysis. Child health characteristics are described in tables 1 and 2 with n (%) for categorical variables and means, SD, medians, and IQR for continuous variables. WHO diagnostic and data cleaning criteria for anthropometry and anaemia were used

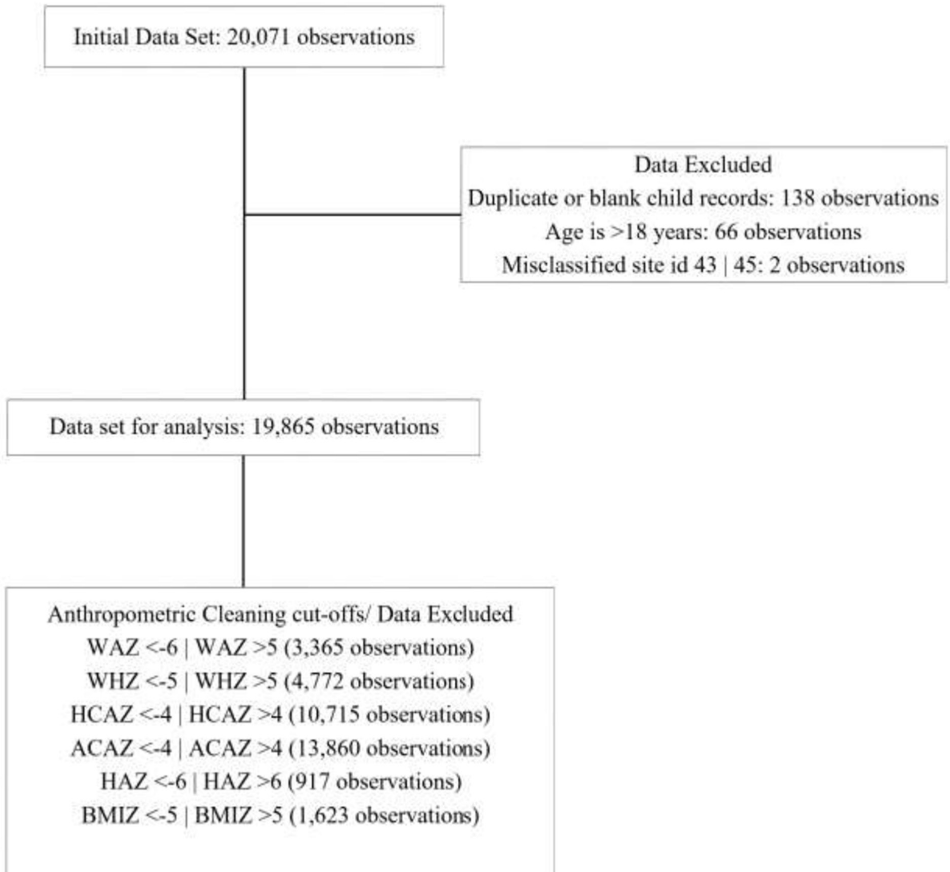

Figure 1 Data cleaning flow chart.[19] BMIZ, body mass index z-score; HAZ, height-for-age z-score; HCAZ, head circumference-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score; ACAZ, mid-upper arm circumference-for-age z-score.

(haemoglobin levels for ages 0–5 years: mild 10.0–10.9 g/dL, moderate 7.0–9.9 g/dL, severe, <7.0 g/dL; ages 5–11 years: mild 11.0–11.4 g/dL, moderate 8.0–10.9 g/dL, severe, <8.0 g/dL; ages 12–14 years: mild 11.0–11.9 g/dL, moderate 8.0–10.9 g/dL, severe, <8.0 g/dL; females aged 14+ years: mild 11.0–11.9 g/dL, moderate 8.0–10.9 g/dL, severe <8.0 g/dL and males aged 14+years: mild 11.0–12.9 g/dL, moderate 8.0–10.9 g/dL, severe <8.0 g/dL).[21–23] The time in programme is defined as the number of days from the registered admission date to exit and is censored at the date of the final observation for those remaining in care.

We used statistical process control (SPC) charts (Shewhart), which provide graphical representation of data and applies the statistical power of classical significance tests to analyse data chronologically while being easily interpreted and capable of identifying changes (figures 2 and 3, online supplemental annex 2–10).[24 25] The central line and upper and lower control limits (UCL and LCL) define the expected amount of variability assuming expected variability due to sampling. Historically, control charts were used to determine if manufacturing processes were within expected variability; however recently they've been used in healthcare and development settings to distinguish random variations from statistically significant variations which may require further exploration/analysis.[24 25] Here, we use the control charts to explore changes over time in key anthropometric indicators and monitor the health of children in individual sites. We hypothesise that ongoing use of control charts will enable sites to take action accordingly. Different types of control charts exist for different types of data. For our anthropometric data we use X-bar charts, plotting the mean anthropometric z-scores at each time point for an individual site along with the site UCL and LCL. These control charts were created using site level aggregated mean z-scores for the nutritional status indicators at different time points based on the children's last screening in each 6-month period after baseline. The central line is the arithmetic mean and our UCL and LCL were calculated based on the mean and SE of the mean (±3) of aggregated data from the site at baseline.

A funnel plot plots the outcome of interest against a measure of study precision with more data resulting in more precision and creating the funnel shape. We used funnel plots for outcomes measured as proportions, plotting IBC sites against the absolute number of occurrences of our health outcomes of interest (eg, stunting) while taking into account the amount of available data from each site and plotting sites by size (smallest to largest) against the proportion of interest. The plot's mean and limits of 2 and 3 SEs identify sites for whom the prevalence/

Table 1 Description of population at baseline screening of children living within IBC in six countries	
Population at baseline	**Total (n=2926)**
Age (%)	
Exact date of birth unknown	2639 (90.2)
Estimated or known date of birth	(n=2926)
0–6 months	746 (25.5)
6–12 months	245 (8.4)
12–24 months	282 (9.6)
24–59 months	427 (14.6)
5–18 years	1226 (41.9)
Sex (%)	(n=2926)
Female	1435 (49.0)
Disability (%)	(n=2926)
With one or more disabilities	739 (25.3)
Common disabilities (%)	(n=547)
Autism spectrum disorder	9 (1.6)
Cerebral palsy	100 (18.2)
Cleft lip/cleft palate	7 (1.3)
Cognitive impairment	34 (6.2)
Down syndrome	15 (2.7)
Hearing loss/deafness	8 (1.5)
Heart disease/defect	35 (6.4)
HIV/AIDS	10 (1.8)
Hydrocephaly	16 (2.9)
Microcephaly	6 (1.1)
Vision impairment and blindness	13 (2.4)
Speech/language delays	3 (0.6)
Other	291 (53.2)
Birth weight (%)	(n=2926)
Birth weight unknown	2031 (69.4)
Where birth weight known	(n=895)
Birth weight >2.5 kg	381 (42.6)
Low birth weight <2.5 kg	452 (50.5)
Very low birth weight <1.5 kg	55 (6.2)
Extremely low birth weight <1.0 kg	7 (0.8)
Birth status (%)	(n=2926)
Unknown birth status	2229 (76.2)
Where birth status known	(n=697)
Where known full term	403 (57.8)
Where known premature	294 (42.2)
Age at admission	(n=2926)
Median age in months (IQR)	10 (0.4–71.8)
Time since admission	(n=2926)
Median time in months since admission (IQR)	20.7 (8.9–49.2)
Exit status	(n=2926)

Continued

Table 1 Continued	
Population at baseline	**Total (n=2926)**
Total no exited	1489
Active children	1437
Exit status reasons (%)	(n=1489)
Family reunification	315 (21)
Foster care placement	29 (2)
Adoption (domestic)	517 (34.7)
Adoption(international)	281 (18.9)
Aged out of care	82 (5.5)
Transfer to a different centre	103 (6.9)
Death	40 (2.7)
Other	57 (4.1)
Programme closed	65 (4.4)

IBC, institution-based care.

outcome is unusually high or low. Together, these charts will allow us to assess individual site performance over time and enable appropriate targeted support.

RESULTS

We analysed data from 19 865 nutrition records from 2926 children at 35 sites in six countries.

Demographic characteristics

Table 1 shows baseline characteristics of 2926 children living within IBC. The largest age groups were children 0–6 months 746 (25.5%) and children older than 5 years of age 1226 (41.9%); 1435 (49%) were female; 739 (25.3%) had one or more disabilities. A range of disabilities were reported. Cerebral palsy was the most common disability identified (100 (18.2%)). However, 291 (53.2%) children with disabilities had a disability which did not fall into established categories. Of those with a known birth weight, 514 (57.5%) were born LBW. Of those children with a known gestational age, 294 (42.2%) were born prematurely. Children came into IBC at a median age of 10 months (IQR: 0.4–71.8 months) and resided in IBC for a median time of 21.7 months (IQR: 9.7–50.9 months).

Anthropometric characteristics

Table 2 and online supplemental annex table 11 show details of anthropometric status. At baseline the mean weight-for-age *z*-score for those 0–10 years old was −1.48±1.54. The mean HAZ was −1.74±1.67 for those 0–18 years old. For children 0–5 years old, the mean WHZ at baseline was −0.42±1.49. BMI *z*-score for children 5–18 years old at baseline was −0.44 (±1.34).

At baseline 788 (34.1%) of children younger than 10 years of old were underweight and 1048 (37.3%) of children ages 0–18 years were stunted. Of those children younger than 5 years old, 212 (12.6%) were wasted. Of children 5–18 years of age, 114 (10.2%) were too thin/

Table 2 Total population mean anthropometric z-scores, malnutrition and anaemia prevalence at baseline

Mean anthropometric baseline z-scores	z-score (±SD)
Weight-for-age z-score (0–10 years) (n=2308)	–1.48±1.54
Height-for-age z-score (0–18 years) (n=1686)	–1.74±1.67
Weight-for-height z-score (0–5 years) (n=1678)	–0.42±1.49
BMI z-score (0–18 years) (n=2733)	–0.62±1.45
Mid upper arm circumference-for-age z-score (6 months to 5 years) (n=426)	–0.33±1.20
Head circumference-for-age z-score (0–5 years) (n=1095)	–1.26±1.37
Malnutrition prevalence	n (%)
Underweight (WAZ) (0–10 years) (n=2308)	
Normal (≥2)	1520 (65.9)
Moderate (≥3 to ≤2)	443 (19.2)
Severe (<-3)	345 (15)
Stunting (HAZ) (0–18 years) (n=2812)	
Normal (≥2)	1764 (62.7)
Moderate (≥3 to ≤2)	560 (19.9)
Severe (≤3)	488 (17.4)
Wasted (WHZ) (0–5 years) (n=1678)	
Normal (≥2)	1466 (87.4)
Moderate (≥3 to ≤2)	137 (8.2)
Severe (≤3)	75 (4.5)
Overweight/thinness (BMIZ) (5–18 years) (n=1123)	
Obese (≥2)	17 (1.5)
Overweight (≥1 to <2)	118 (10.5)
Normal (≥2 to <1)	874 (77.8)
Thinness (≥3 to ≤2)	80 (7.1)
Severe thinness (≤3)	34 (3)
Head circumference (HCAZ) (0–5 years) (n=1095)	
Severe large (≥3)	7 (0.6)
Large (≥2 to <3)	10 (0.9)
Normal (≥2 to <2)	739 (67.5)
Small (≥3 to ≤2)	214 (19.5)
Severe small (≤3)	125 (11.4)
Anaemia (0–18 years) (n=2494)	
Normal	1777 (71.3)
Mild	413 (16.6)
Moderate	287 (11.5)
Severe	17 (0.7)

ACAZ, mid-upper arm circumference-for-age z-score; BMI, body mass index; HAZ, height-for-age z-score; HCAZ, head circumference-for-age z-score; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score.

underweight. For children ages 5–18 years old, 135 (12%) were overweight/obese. Of children ages 0–5 years old, 339 (31%) had a small head circumference.

Among those with disabilities who had anthropometric data available, at baseline 324 (57.6%) of those under 10 years old were underweight and 368 (56.3%) were stunted. Of children ages 5–18 years old, 38 (16.2%) were too thin/underweight and 38 (16.2%) were overweight/obese. For children with disabilities, 95 (53.7%) had a small head circumference.

At baseline, of the total population 717 (28.8%) had anaemia, with younger children more likely to have anaemia. Over time, anaemia severity and prevalence of anaemia reduced for most categories and age groups. Children younger than 5 years old and those younger than 5 years old

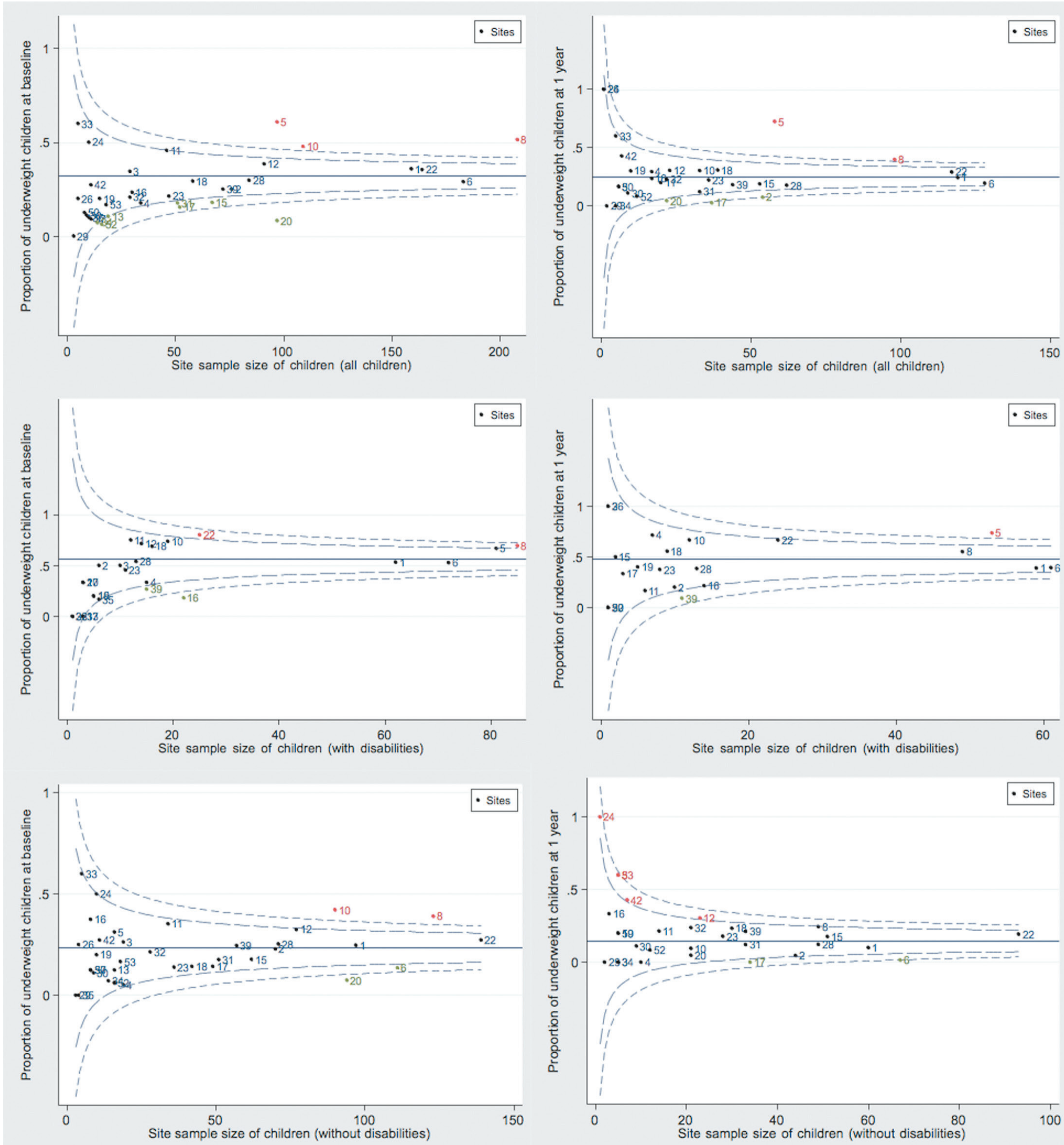

Figure 2 Funnel plots of the proportion of underweight children (WAZ), 0–10 years old at baseline screening (left side panels) and 1-year screening (right side panels). Top row includes all children, the middle row includes only those children with disabilities and the bottom row includes only those children without disabilities. Site identifiers above expected variation are in red, those within variation in black and those below expected variation in green. WAZ, weight-for-age z-score.

with a disability had similar anaemia prevalence; 461 (34.4%) and 131 (34.5%), respectively.

Funnel plots

Funnel plots (figure 2, online supplemental annex 2–6) show prevalence of anthropometric deficit in different sites over time and by disability status, identifying those sites which are outside of expected limits. Figure 2 shows weight-for-age prevalence. Sites 5 and 8 are outside the control limits with higher than expected prevalence of underweight children both baseline and 1 year. At 1 year, site 10 seems to have a higher proportion of underweight than would be expected compared with other sites. The mean prevalence of underweight is higher among children with disabilities than in those without. Online supplemental annex 2–6 show the same for other key anthropometric indicators—broad patterns are similar to underweight.

SPC charts

Figure 3 and online supplemental annex 7–10 show control charts for tracking site-level changes in anthropometric z-scores over time compared with total population UCL and LCL. Figure 3 shows mean WAZ change over time. Sites 1 and 6 illustrate sites with average (generally within the UCL and LCL) performance, respectively. Both sites have individual points outside of expected variation for children with disabilities, with a suggestion of a slight improvement in weight-for-age at 1 year for both sites, with site six maintaining the improvement over time.

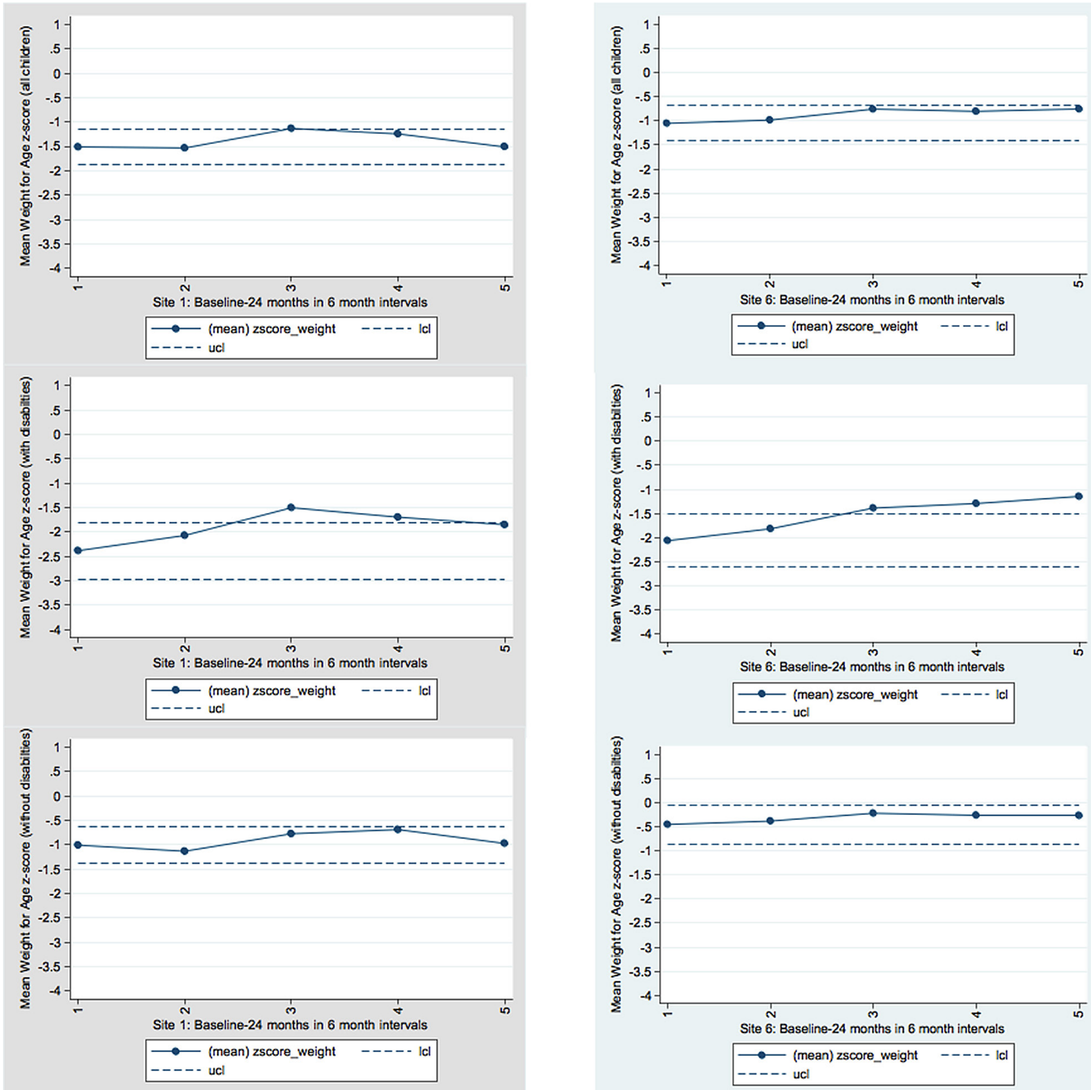

Figure 3 Individual site control charts showing the mean WAZ for children 0–10 years of age over time from baseline screening to 24-month screening. The top row includes all children; the middle row includes only those children with disabilities and bottom row includes only those children without disabilities. Upper control limits (UCL) and lower control limits (LCL) are indicated by the dashed lines; WAZ, weight-for-age z-score.

DISCUSSION

Our study presents comprehensive data on the nutritional status of children living within IBC and uses funnel plots and control charts to visualise intersite variations and progress over time in individual centres. Overall, children were at high risk of malnutrition, especially for those with disabilities.

Date of birth, birth weight, prematurity, age and length of stay

There is a paucity of information on children's birth history and this requires healthcare professionals or site staff to estimate date of birth which can lead to inaccuracies for other indicators (eg, WAZ). Such data gaps can occur when children are abandoned without connections to birth family, when records are not forwarded from hospitals or other healthcare facilities or when unavailable.[12] Aiming to receive available information is important and might be helped by improving transfer processes and by decreasing stigma for families placing children. Medical history matters because being born LBW or prematurely can increase children's risk of mortality, being stunted, wasted or developmentally delayed.[4] For those with records available, we found a notably high prevalence of LBW, 514 (57.5%) compared with the global prevalence of 14.6% and premature, 294 (42.2%) vs the global prevalence of prematurity 10.6% (table 1).[26 27] The high proportion of young children and the median age of admission means that a large proportion of children are entering IBC early in life, within the developmentally sensitive 'first 1000 days' of life.[4] The median length of stay indicates that children stay in care for around 2 years although some had lived within IBC for more than 13 years. This could indicate faster placement into families for young children or the challenge of finding homes for older children or those with the severest disabilities. This is important because the longer children stay within IBC, the more at risk they are for delayed development and malnutrition.[12 17]

Disability status

Over a quarter of this population had one or more disabilities (table 1). This is markedly higher than the global prevalence of 5.1% of children younger than 15 years of age and for those older than 15 years of age (14.9%).[28] Children with disabilities were significantly smaller than their peers without disability over multiple anthropometric indices and this continued over 2 years (table 2 and online supplemental annex table 11). Nutritional status of children with disabilities seems to improve for younger children over time but older children do not appear to improve, and in some cases worsen. It could be that children with more severe disabilities stay in IBC longer because of their high needs.

Anaemia

Almost a quarter of all children entered into the programme with anaemia, which was below the anaemia prevalence in low-income and middle income countries (LMICs) of 42.9% for children younger than 5 years old (table 2 and online supplemental annex table 11).[5] Anaemia can impact brain development, cognition and growth.[4] Children 0–6 months had the highest prevalence of anaemia, which is expected with the high prevalence of LBW and premature births in the population. Throughout the 2-year period, the prevalence of anaemia reduced and moderate and severe anaemia eliminated for some age groups. This could be a reflection of access to health services or routine meals that children can experience in IBC, which may not be accessible to all community families.[15 29]

Anthropometry

Being underweight, wasted, stunted or thin can increase children's risk of infectious diseases, delayed development, mortality and non-communicable diseases.[4] This can be especially serious for children with disabilities.[4 10] We found for most anthropometric measurements, the total population of children have mean z-scores below the WHO mean for age (table 2, online supplemental annex table 11).[22] Compared with the prevalence in LMIC there was a higher prevalence of malnutrition indicators, such as stunting, wasting and thin/underweight, with the one exception being overweight/obese children which was below global figures.[5] Children with disabilities had more severe anthropometric deficits than their peers without disabilities and their prevalence of malnutrition overall was higher. The high prevalence of stunting for young children is especially concerning. For those younger than 5 years of age, 725 (43%) and specifically those with a disability, 260 (61.5%) were stunted. Catch-up from early-life stunting can be limited, especially for those outside of the developmentally sensitive 'first 1000 days'.[4] Although children with some disabling conditions may be smaller or slighter than their peers without disabilities, stunting relevant to the normal growth potential of adequately nourished children with the same disabling conditions should not be overlooked.[30] Wasting among children with disabilities was also higher than their peers without disabilities (without disability: 100 (8%) vs children with disabilities: 112 (26.7%) vs 2020 prevalence in LMIC: 6.8%).[5] This could be related to a number of issues including difficulties swallowing/dysphagia, inadequate or poor nutrition, poor feeding practices, biological needs or caregiver practices or beliefs.[10 30] Children with disabilities who are wasted are at high risk of mortality and require specific care and inclusion in malnutrition treatment programmes.[31] It is also notable that nearly a third of children younger than 5 years and over half of those with disabilities had a small head circumference, which although associated with preterm birth or some disabilities, could be an indicator of impacted brain development.

Utility of control charts and funnel plots

Funnel plots capture all of the sites at a specific time point, allowing easy visualisation of a particular indicator (eg, prevalence of underweight children) and comparing sites with each other to highlight those inside versus outside of control limits. In the control charts, we see individual sites trends over time in comparison to the site's limits. Using these charts is an easy way of distinguishing normal inter-site variations from statistically significant variations which warrant site visits and in-depth consultations to explore possible reasons and potential extra need for support (figures 2 and 3, online supplemental annex 2–10).

Together these charts could help healthcare providers better track and monitor the nutritional needs of their individual sites with tools that provide expected limits and take into account the existence of natural variation. These charts will be added to Holt International's nutrition screening database to allow programme staff to evaluate the impact of programmes in a way that is easily understandable, interpretable and provides up-to-date information. These automated charts in tandem with tools and training provided by Holt's Child Nutrition Programme, will support sites to appropriately conduct targeted nutrition interventions when needed.

Limitations

There were several limitations in our study. First, though our sample was large both in terms of individual children and different centres across several countries, those may not be representative of all similar institutions within all of the countries. As a large global non-governmental organisation, Holt International offers support and resources that many locally-funded centres may not have and the nutritional status of the wider group of children in IBC is likely to be worse than our data suggest. The uniqueness of the children who come into IBC and the environments in IBC are also likely not reflective of wider local community populations. This is concerning since children arrive malnourished and high quality (and costly) nutrition and care is needed to optimise their chances of catch-up growth.

Other limitations included unknown prior history, stage of entry into care and length of stay in the programme—all of which could impact growth. For some, their first screening was their first day into IBC but for others, it occurred multiple years into living in IBC. Changes over time may be more impactful for different children depending on how long they are in IBC prior to their first screening. Potential biases include measurement error which could have occurred during anthropometric assessment as measurements can be especially difficult for children with disabilities.[30] Disabilities also, though diagnosed by qualified health professionals in all countries were not assessed by a standardised method, such as the 'Washington Group' questionnaire, which would enable a more comparative analysis.[31 32] Future analysis should include additional categorisation of many other disabilities, including physical disabilities. Although grouping those with and without disabilities does help understand intercentre variations, this simple split does not address the individual needs of children. Children with some types of disabilities may be small or underweight for age based on clinical sequelae related to their specific disability. These disabilities may impede their ability to feed themselves, digest food or be associated with conditions that would reflect in lower height or weight. Another limitation was a decrease in sample sizes over time and some small site sample sizes. This decrease may introduce biases as some children exit the programme, such as those who are healthier being placed into family-based care at a higher rate and those needing more support staying in care longer.

CONCLUSION

Malnourished children in IBC are at risk of not fulfilling their growth potential and are thus more vulnerable to serious illness, becoming disabled or exacerbating existing disabilities. We found a high prevalence of children who are malnourished or at risk for malnutrition. Many were born LBW, prematurely or have an underlying disability. Those with disabilities were found to have a higher prevalence of malnutrition than children without disabilities. Control charts could be a valuable tool to track and monitor children's growth and inter-centre variations. Future research should aim to understand the reasons for intercentre variations in more detail and also formally explore the utility of control charts over more standard methods of presenting key data. The nutritional needs of close to 10 million children in IBC around the world are likely high and worthy of greater global attention. Children have a basic human right to grow and fully develop regardless of where they received care early in their lives.

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Supplement 1:

STROBE Checklist

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

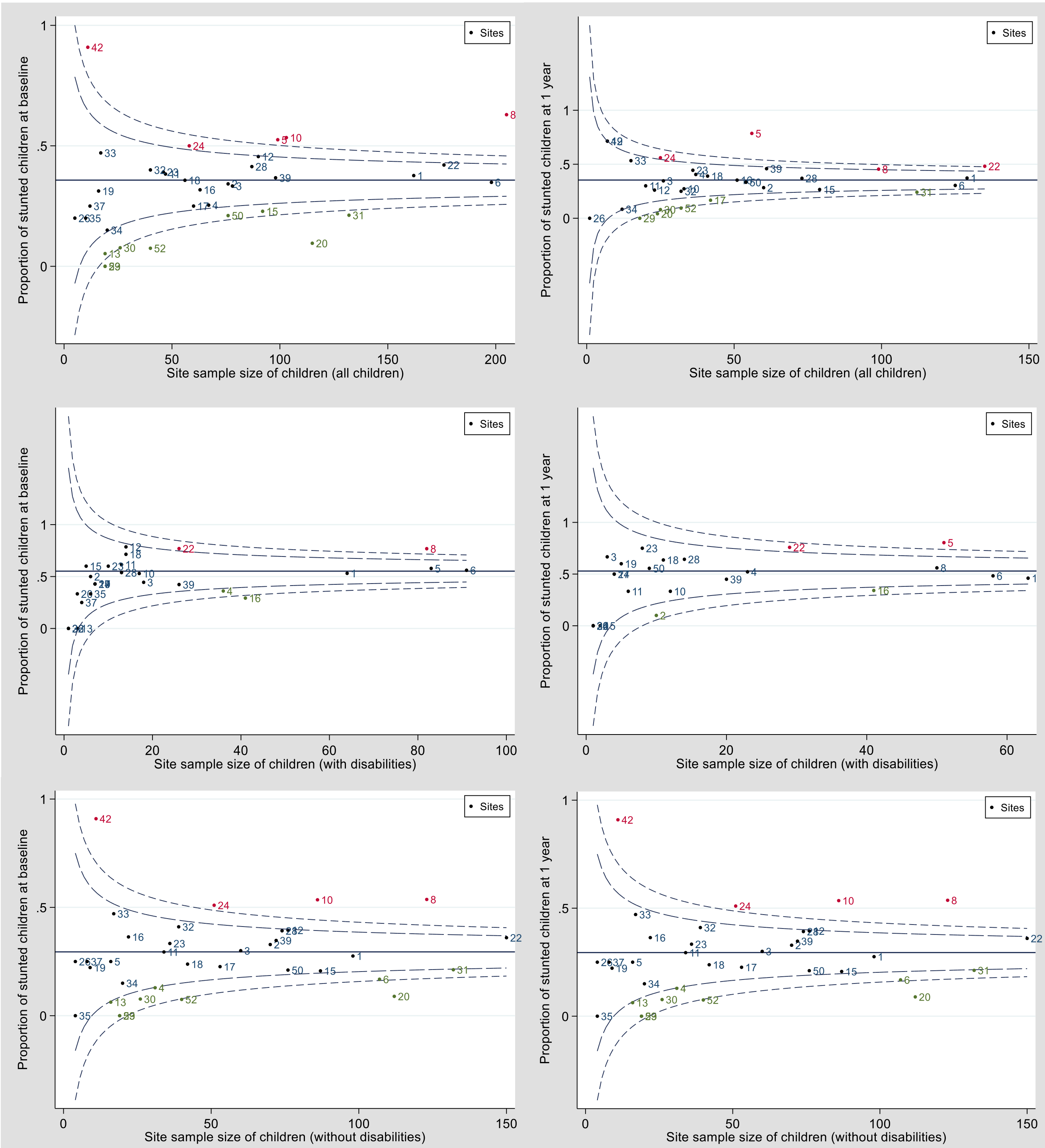
	Item No	Recommendation	Page located
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5, Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6

		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5, 11
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	5-6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	7, Figure 1
		(b) Give reasons for non-participation at each stage	7, Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-16, Table 1 & 2, Annex Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Tables 1 & 2
		(c) Summarize follow-up time (e.g., average and total amount)	Figures 2, 3 and Annex Figures 1-9
Outcome data	15*	Report numbers of outcome events or summary measures over time	8-16, Tables 1, 2 and Figures 2,3 and Annex Table 1, Annex Figures 1-9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6, Tables 1, 2 and Figures 2,3 and Annex Figures 1-9
		(*b*) Report category boundaries when continuous variables were categorized	Tables 1, 2 and Figures 2,3 and Annex Table 1, Annex Figures 1-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses	Tables 1, 2 and Figures 2,3 and Annex Table 1, Annex Figures 1-9
Discussion			

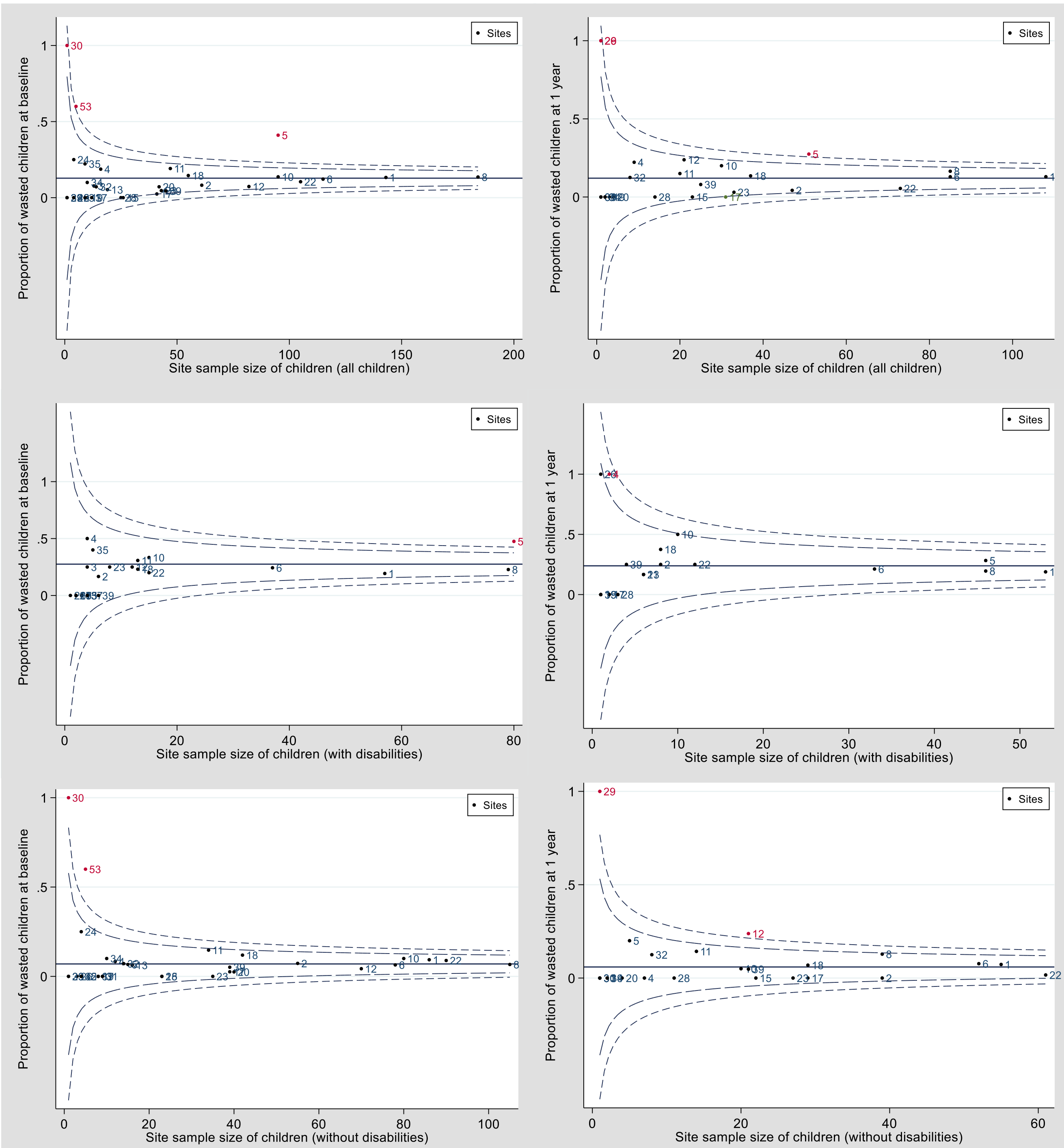
Key results	18	Summarize key results with reference to study objectives	17-19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-19
Generalizability	21	Discuss the generalizability (external validity) of the study results	17-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2, 20

*Give information separately for exposed and unexposed groups.

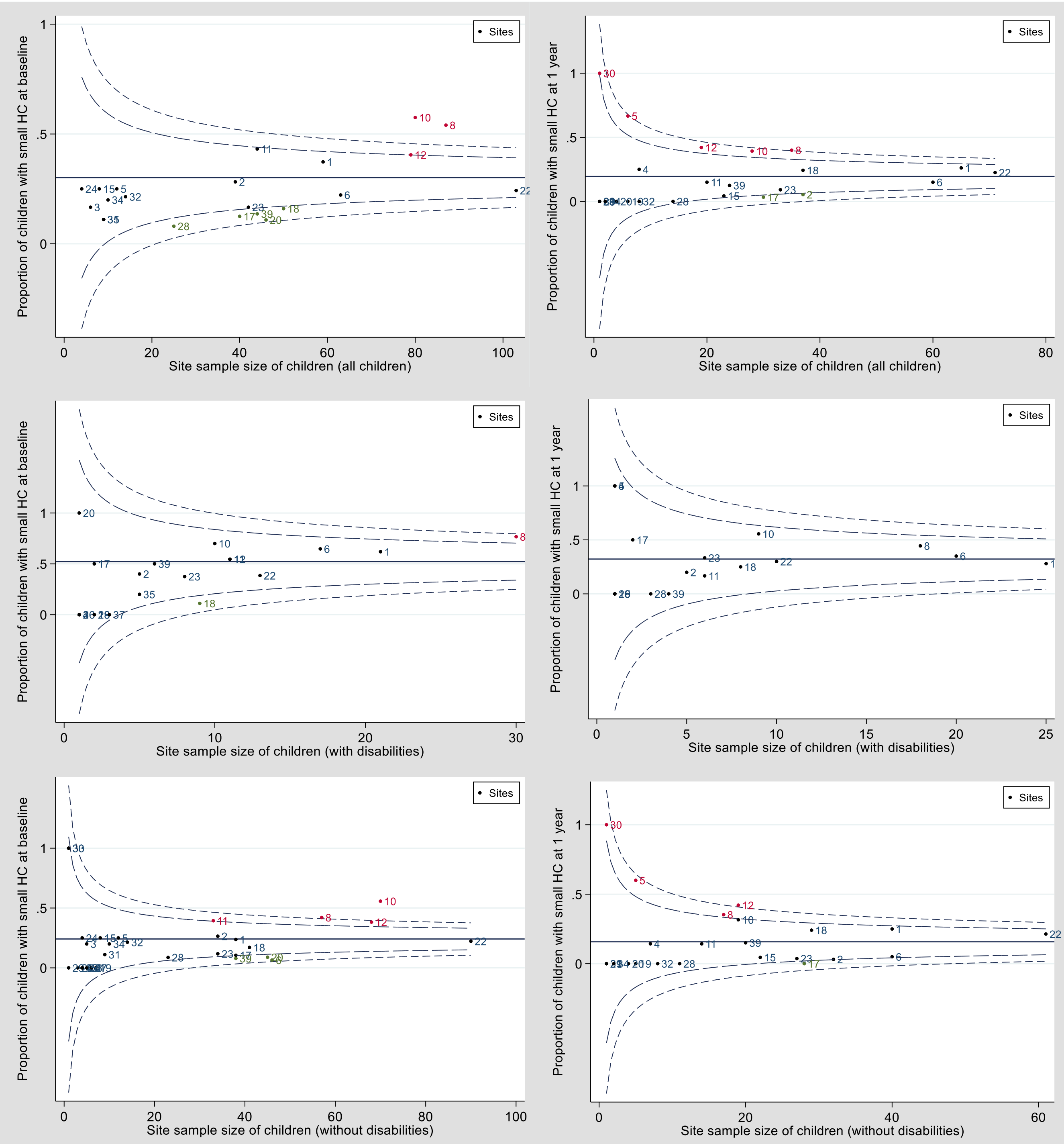
Online Supplement Figure 2. Funnel plots of proportion of children stunted (HAZ), 0-18 years at baseline (left side panels) and 1 year (right panels) for all children (top row), children with a disability (middle row) and those without disability (bottom row).



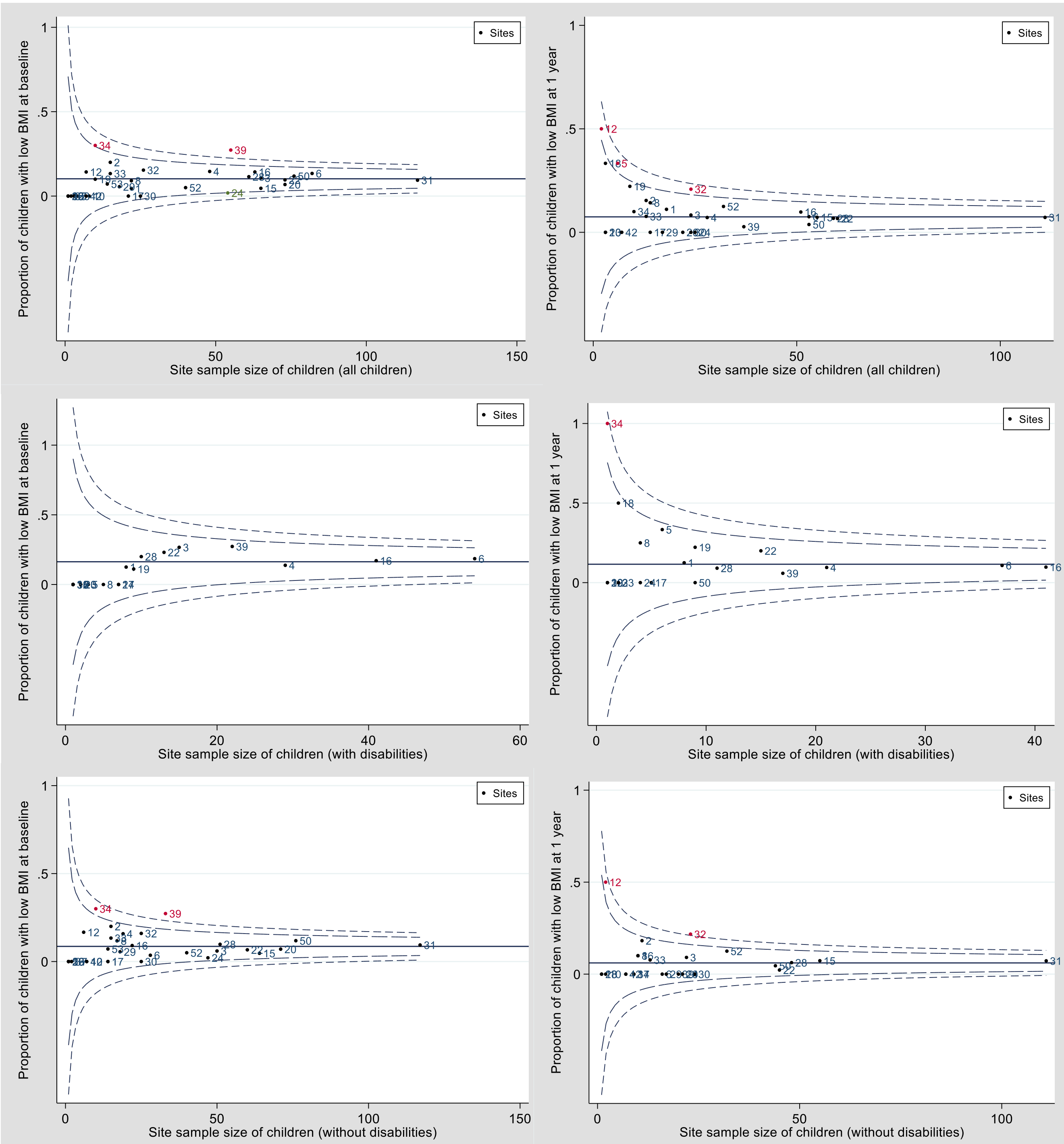
Online Supplement Figure 3. Funnel plots of proportion of total children wasted (WHZ), 0-5 years at baseline (left side panels) and 1 year (right panels) for all children (top row), children with a disability (middle row) and those without disability (bottom row).



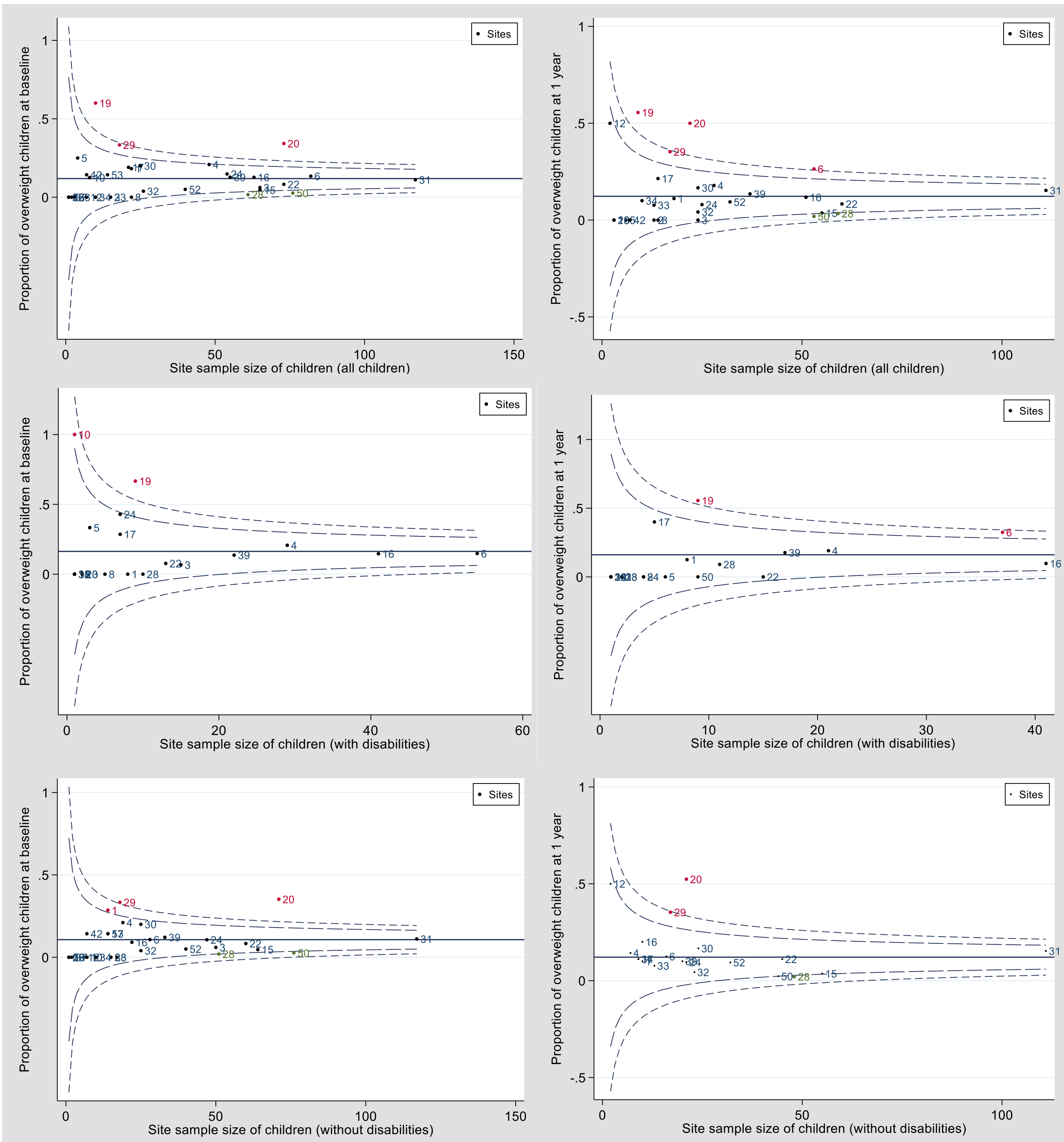
Online Supplement Figure 4. Funnel plots of proportion of total children with small head circumference (HCAZ), 0-5 years at baseline (left side panels) and 1 year (right panels) for all children (top row), children with a disability (middle row) and those without disability (bottom row).



Online Supplement Figure 5. Funnel plots of proportion of total children underweight/ thinness (BMIZ), 5-18 years at baseline (left side panels) and 1 year (right panels) for all children (top row), children with a disability (middle row) and those without disability (bottom row).

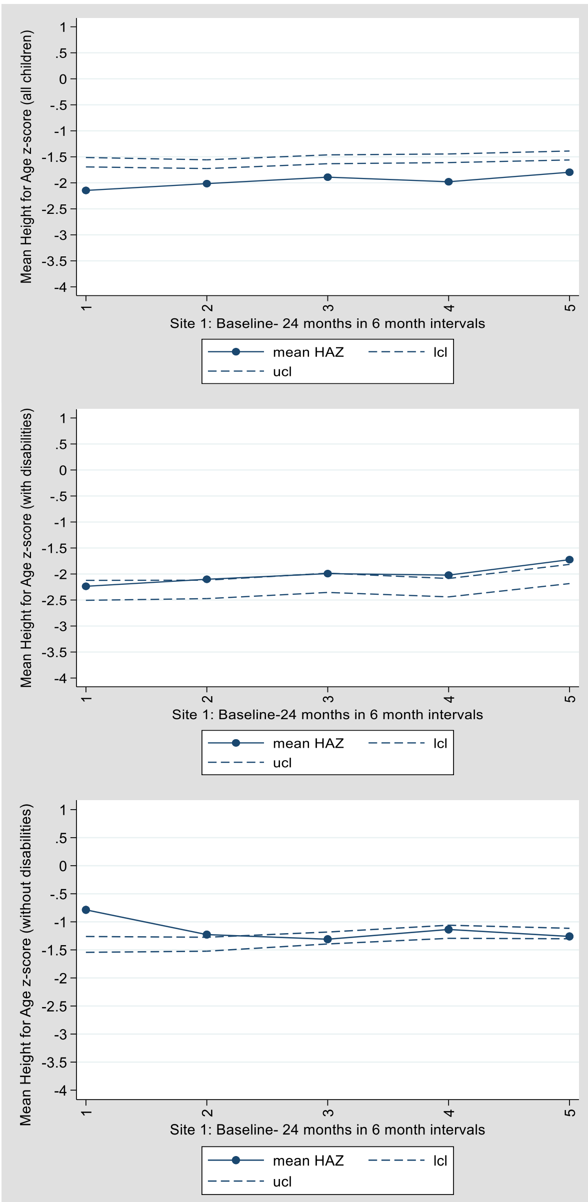


Online Supplement Figure 6. Funnel plots of proportion of all children with overweight (BMIZ), 5-18 years at baseline (left side panels) and 1 year (right panels) for all children (top row), children with a disability (middle row) and those without disability (bottom row).

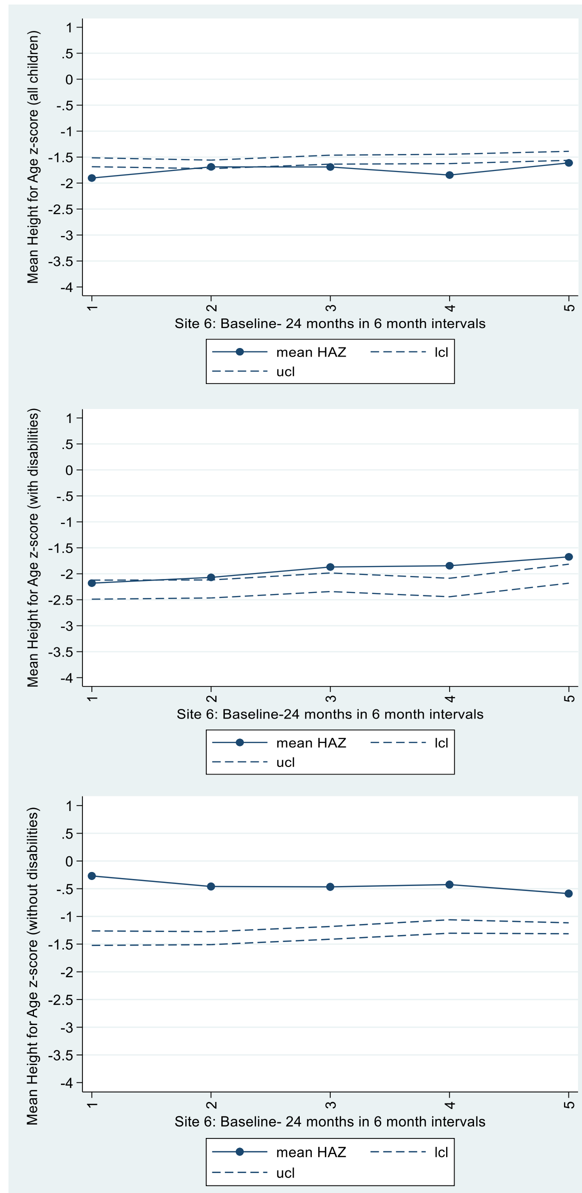


Online Supplement Figure 7. Individual site control charts show mean HAZ for children 0-18 years of age over time. The top row shows all children; the middle row shows those with disability; and the bottom row shows those without disability.

Site 1:

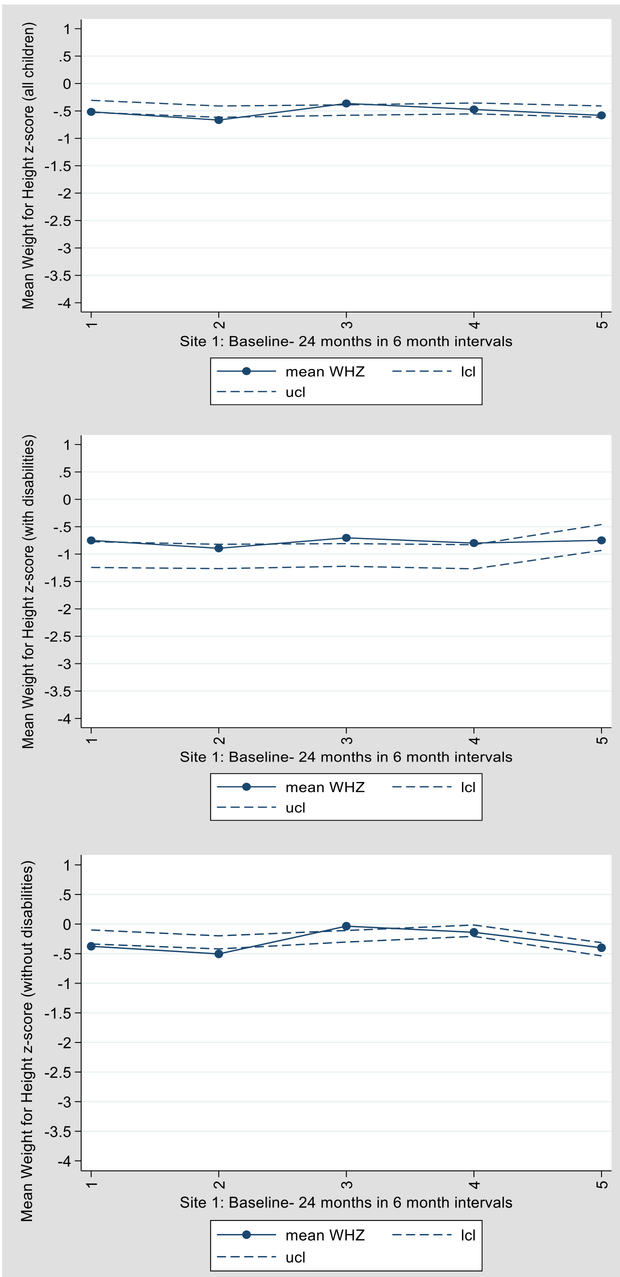


Site 6:

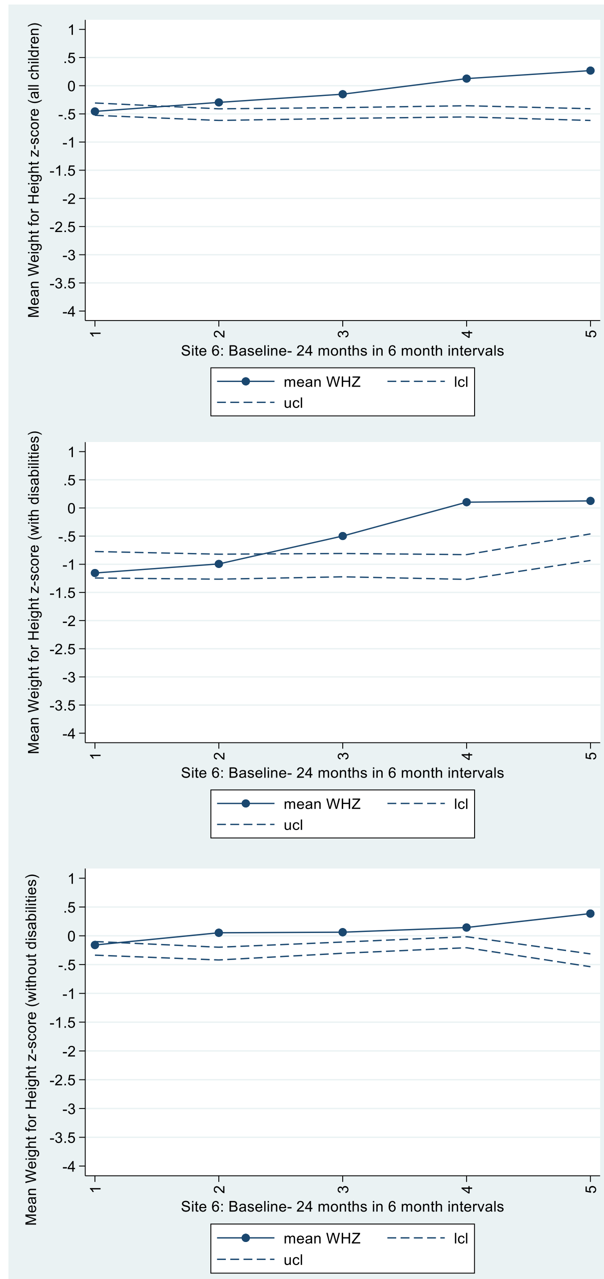


Online Supplement Figure 8. Individual site control charts show mean WHZ for children 0-5 years of age over time. The top row shows all children; the middle row shows those with disability; and the bottom row shows those without disability.

Site 1:



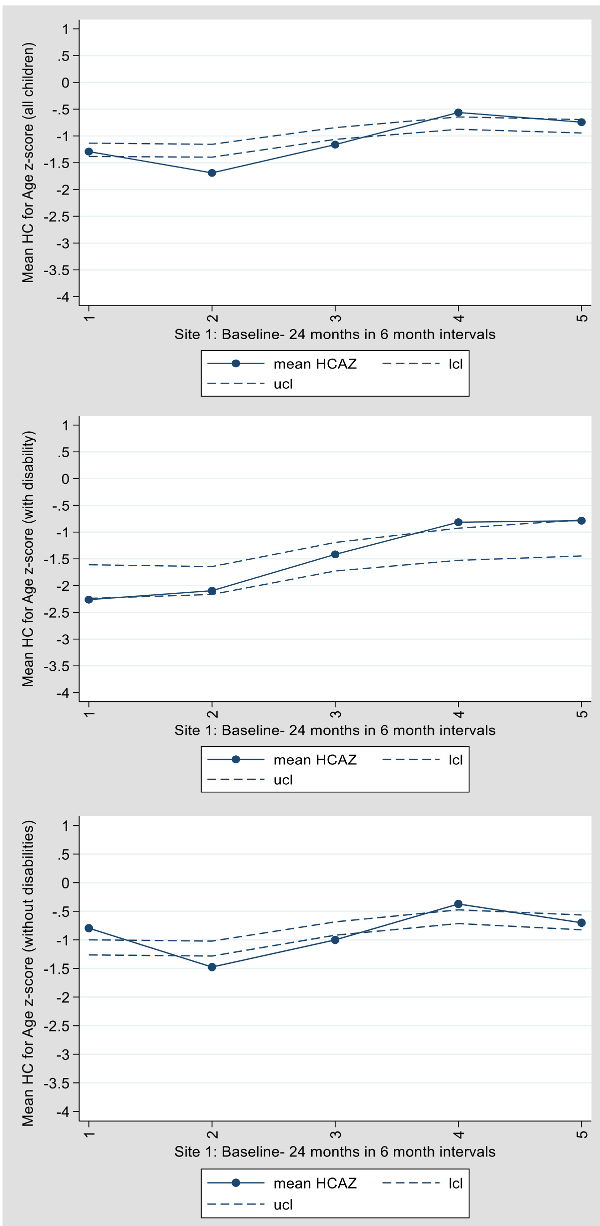
Site 6:



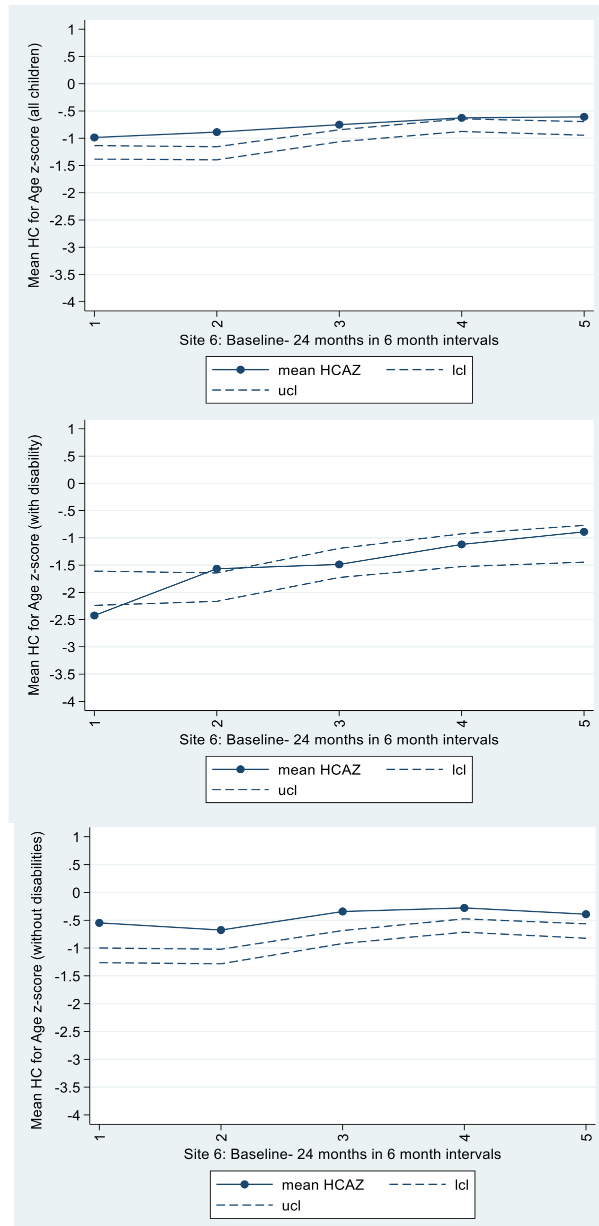
DeLacey E, *et al. BMJ Open* 2022; 11:e050371. doi: 10.1136/bmjopen-2021-050371

Online Supplement Figure 9. Individual site control charts show mean HCAZ for children 0-5 years of age over time. The top row shows all children; the middle row shows those with disability; and the bottom row shows those without disability.

Site 1:

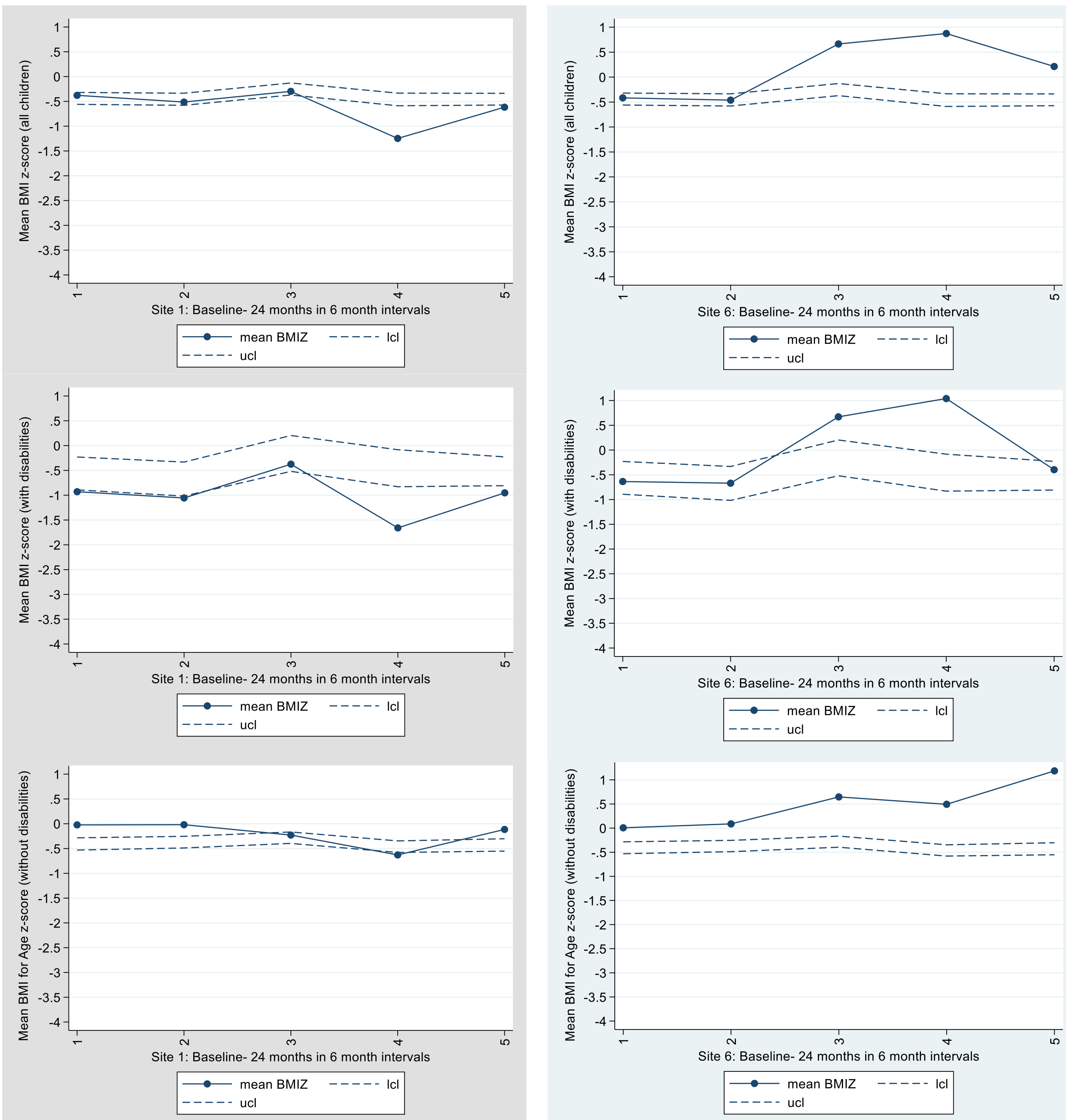


Site 6:



Online Supplement Figure 10. Individual site control charts shows mean BMIZ for children 5-18 years of age over time. The top row shows all children; the middle row shows those with disability; and the bottom row shows those without disability.

Site 1: **Site 6:**



DeLacey E, *et al. BMJ Open* 2022; 11:e050371. doi: 10.1136/bmjopen-2021-050371

Annex Table 11: Total population mean anthropometric z-scores and anemia prevalence at baseline, 6 months, 12 months, 18 months and 24 months by age category and disability status.

All countries (Mean z-score, (± SD))																				
	Baseline Screening					6 month screening					12 month screening				18 month screening			24 month screening		
Age at screening	0-≤6 months	>6-≤12 months	>12-≤24 months	>24-≤59 months	>5-≤18 years	0-≤6 months	>6-≤12 months	>12-≤24 months	>24-≤59 months	>5-≤18yrs	>6-≤12 months	>12-≤24 months	>24-≤59 months	>5-≤18 years	>12-≤24 months	>24-≤59 months	>5-≤18 years	>12-≤24 months	>24-≤59 months	>5-≤18 years
Children without disabilities																				
N:	727	108	142	307	469	294	322	133	218	263	81	250	170	282	180	125	178	39	165	170
Weight for age z-score (0-10 years)	-1·48 ± 1·46	-1·04 ± 1·27	-0·69 ± 1·26	-1·09 ± 1·17	-0·99 ± 1·36	-1·48 ± 1·14	-1·13 ± 1·31	-0·76 ± 1·08	-1·12 ± 1·34	-1·07 ± 1·22	-0·77 ± 1·35	-0·79 ± 1·19	-1·02 ± 0·99	-0·97 ± 1·22	-0·67 ± 1·08	-0·96 1·05	-0·88 ± 1·25	-050 ± 0·98	-1·19 ± 1·40	-0·90 ± 1·34
N:	713	105	142	303	895	294	320	133	218	447	80	249	170	599	181	125	373	39	164	300
Height for age z-score (0-18 years)	-1·54 ± 1·73	-1·04 ± 1·62	-1·38 ± 1·46	-1·60 ± 1·29	-1·23 ± 1·24	-1·58 ± 1·48	-1·13 ± 1·46	-1·45 ± 1·34	-1·66 ± 1·19	-1·31 ± 1·25	-0·84 ± 1·41	-1·41 ± 1·36	-1·51 ± 1·11	-1·24 ± 1·21	-1·15 ± 1·42	- 1·51 ± 1·16	-1·06 ± 1·19	-1·10 ± 1·00	-1·57 ± 1·25	-1·05 ± 1·22
N:	707	105	142	303	286	295	321	133	218	170	80	249	170	168	180	124	98	39	165	79
Weight for height z-score (0-5 years)	-0·20 ± 1·51	-0·48 ± 1·34	-0·03 ± 1·24	-0·25 ± 1·19	-0·47 ± 1·23	-0·19 ± 1·58	-0·54 ± 1·23	-0·78 ± 1·08	-0·26 ± 1·09	-0·45 ± 1·14	-0·36 ± 1·26	-0·13 ± 1·21	-0·24 ± 0·99	-0·41 ±1·10	-0·10 ± 1·21	-0·12 ± 1·00	-0·40 ± 1·20	0·05 ± 1·07	-0·54 ± 1·34	-0·39 ± 1·16
N:	643	102	137	287	888	248	288	128	209	447	69	225	159	599	164	121	375	37	161	304
BMI z-score (0-18 years)	-0·84 ± 1·39	-0·56 ± 1·38	0·21 ± 1·25	-0·05 ± 1·22	-0·41 ± 1·23	-0·70 ± 1·33	-0·58 ± 1·26	0·17 ± 1·13	-0·06 ± 1·10	-0·38 ± 1·16	-0·23 ± 1·20	0·14 ± 1·21	-0·09 ± 1·01	-0·28 ± 1·14	0·16 ± 1·21	0·03 ± 1·03	-0·46 ± 1·157	0·23 ± 1·10	-0·35 ± 1·27	-0·43 ±1·24
N:	N/A	60	88	223	N/A	N/A	196	87	155	N/A	53	160	119	N/A	113	93	N/A	21	83	N/A
Mid upper arm circumference for age z-score (6 months- 5 years)	N/A	-0·20 ± 1·19	-0·16 ± 1·21	-0·37 ± 1·14	N/A	N/A	-0·61 ± 1·05	0·11 ± 1·07	-0·29 ± 1·06	N/A	-0·41 ± 0·97	-0·04 ± 1·11	-0·29 ± 1·06	N/A	0·06 ± 0·98	-0·14 ± 1·08	N/A	0·19 ± 0·85	-0·10 ± 1·04	N/A
N:	483	77	111	247	N/A	206	264	115	190	N/A	67	217	148	N/A	157	102	N/A	N/A	143	N/A
Head circumference for age z-score (0-5 years)	-1·41 ± 1·41	-0·75 ± 1·33	-0·65 ± 1·12	-0·92 ± 1·23	N/A	-1·74 ± 1·24	-1·30 ± 1·26	-0·48 ± 1·27	-0·72 ± 1·09	N/A	-1·31 ± 1·19	-0·71 ± 1·21	-0·71 ± 1·09	N/A	-0·53 ± 1·19	-0·69 ± 1·25	N/A	-0·69 ± 1·29	-0·69 ± 1·32	N/A
Anemia (N)	467	89	125	281	897	201	153	77	200	376	37	113	154	580	86	103	312	18	112	306
Normal Absolute (%)	264 (56·5)	59 (66·3)	90 (72)	219 (77·9)	709 (79)	155 (77·1)	124 (81·1)	61 (79·2)	164 (82·0)	280 (74·5)	32 (86·5)	96 (85·0)	133 (86·4)	502 (86·6)	76 (88·4)	90 (87·4)	274 (87·8)	13 (72·2)	101 (90·2)	273 (89·2)
Mild Absolute (%)	125 (26·8)	23 (25·8)	26 (20·8)	50 (17·8)	97 (10·8)	32 (15·9)	26 (17·0)	12 (15·6)	30 (15·0)	65 (17·3)	4 (10·8)	11 (9·7)	19 (12·3)	57 (9·8)	8 (9·3)	12 (11·7)	27 (8·7)	4 (22·2)	11 (9·8)	24 (7·8)
Moderate Absolute (%)	78 (16·7)	7 (7·9)	9 (7·2)	11 (3·9)	87 (9·7)	14 (7·0)	3 (2·0)	4 (5·2)	6 (3·0)	31 (8·2)	1 (2·7)	6 (5·3)	2 (1·3)	21 (3·62)	2 (2·3)	1 (1·0)	11 (3·5)	1 (5·6)	0	9 (2·9)
Severe Absolute (%)	0	0	0	1 (0·4)	4 (0·5)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Children with disabilities																				
N:	199	43	55	132	138	50	152	59	112	106	25	135	100	110	102	74	104	17	85	82
Weight for age z-score (0-10 years)	-2·82 ± 1·57	-2·45 ± 1·66	-2·03 ± 1·44	-2·26 ± 1·57	-1·96 ± 1·57	-2·60 ± 1·27	-2·07 ± 1·58	-2·25 ± 1·30	-2·45 ± 1·56	-1·96 ± 1·57	-2·00 ± 1·22	-1·52 ± 1·60	-2·48 ± 1·45	-1·79 ± 1·50	-1·42 ± 1·51	-2·61 1·58	-2·18 ± 1·54	-0·55 ± 1·79	-1·79 ± 1·81	2·02 ± 1·44
N:	192	45	54	132	231	47	152	58	112	172	26	136	99	186	104	75	151	17	82	135
Height for age z-score (0-18 years)	-2·68 ± 1·73	-2·34 ± 1·85	-2·18 ± 1·31	-2·43 ± 1· 62	-1·98 ± 1·47	-3·00 ± 1·35	-1·87 ± 1·57	-2·72 ± 1·18	-2·60 ± 1·41	-2·13 ± 1·47	-2·38 ± 1·51	-1·84 ± 1·66	-2·73 ± 1·48	-2·07 ± 1·38	-1·86 ± 1·64	-3·03 ± 1·39	-2·16 ± 1·41	-1·14 ± 1·88	-2·15 ± 1·57	-2·02 ± 1·53
N:	189	46	55	130	114	49	152	59	112	94	26	137	98	82	105	71	82	17	79	64
Weight for height z-score (0-5 years)	-0·66 ± 1·61	-1·35 ± 1·72	-1·32 ± 1·33	-1·26 ± 1·58	-0·79 ± 1·63	0·03 ± 1·75	-1·06 ± 1·33	-1·17 ± 1·38	-1·43 ± 1·51	-0·91 ± 1·61	-1·06 ± 1·28	-0·87 ± 1·47	-1·21 ± 1·36	-0·78 ± 1·58	-0·80 ± 1·46	-1·41 ± 1·50	-1·05 ± 1·59	0·51 ± 1·65	-0·86 ± 1·57	-0·84 ± 1·71
N:	210	46	55	129	235	50	142	57	111	177	21	131	96	202	98	67	161	14	77	134
BMI z-score (0-18 years)	-1·79 ± 1·51	-1·63 ± 1·74	-1·04 ± 1·34	-0·92 ± 1·62	-0·56 ± 1·69	-0·94 ± 1·69	-1·23 ± 1·32	-0·82 ± 1·46	-1·10 ± 1·50	-0·67 ± 1·75	-0·67 ± 1·00	-0·60 ± 1·44	-0·95 ± 1·44	0·16 ± 1·85	-0·45 ± 1·44	-1·05 ± 1·51	-0·45 ± 1·91	0·33 ± 1·56	-0·59 ± 1·57	-0·52 ± 1·48
N:	N/A	9	11	34	N/A	N/A	52	11	22	N/A	14	58	28	N/A	54	18	N/A	9	47	N/A
Mid upper arm circumference for age z-score (6 months- 5 years)	N/A	-0·35 ± 1·58	-0·70 ± 1·74	-0·73 ± 1·18	N/A	N/A	-0·93 ± 1·17	-0·59 ± 1·48	-1·10 ± 1·07	N/A	-1·04 ± 0·90	-0·46 ± 1·23	-0·77 ± 1·19	N/A	- 0·53 ± 1·37	-0·80 ± 1·40	N/A	-0·11 ± 1·31	-0·68 ± 1·35	N/A
N:	102	18	13	44	N/A	24	85	16	28	N/A	17	81	33	N/A	75	17	N/A	13	64	N/A
Head circumference for age z-score (0-5 years)	-2·36 ± 1·22	-2·09 ± 1·24	-0·82 ± 1·22	-1·18 ± 1·43	N/A	-2·58 ± 0·77	-1·86 ± 1·16	-1·50 ± 1·19	-1·70 ± 1·22	N/A	-1·89 ± 0·92	-1·39 ± 1·22	-1·41 ± 1·20	N/A	-1·18 ± 1·41	-1·42 ± 0·96	N/A	0·06 ± 1·47	-1·34 ± 1·39	N/A
Anemia (N)	156	39	53	132	255	38	94	50	110	180	14	77	95	222	48	75	172	8	57	152
Normal Absolute (%)	79 (50·6)	29 (74·4)	41 (77·4)	100 (75·8)	187 (73·3)	22 (57·9)	71 (75·5)	40 (80·0)	93 (84·6)	136 (75·6)	11 (78·6)	69 (89·6)	79 (83·2)	182 (82·0)	36 (75)	64 (85·3)	140 (81·4)	7 (87·5)	52 (91·2)	127 (83·6)
Mild Absolute (%)	34 (21·8)	6 (15·4)	8 (15·1)	22 (16·7)	22 (8·6)	11 (29·0)	16 (17·0)	4 (8·0)	9 (8·2)	18 (10·0)	2 (14·3)	6 (7·8)	9 (9·5)	18 (8·1)	5 (10·4)	8 (10·7)	16 (9·3)	1 (12·5)	3 (5·3)	12 (7·9)
Moderate Absolute (%)	40 (25·6)	3 (7·7)	4 (7·6)	7 (5·3)	41 (16·1)	5 (13·2)	7 (7·5)	6 (12·0)	6 (5·5)	25 (13·9)	1 (7·1)	2 (2·6)	6 (6·3)	21 (9·5)	7 (14·6)	1 (1·3)	16 (9·3)	0	2 (3·5)	11 (7·2)
Severe Absolute (%)	3 (1·9)	1 (2·6)	0	3 (2·3)	5 (2·0)	0	0	0	2 (1·8)	1 (0·6)	0	0	1 (1·1)	1 (0·5)	0	2 (2·7)	0	0	0	2 (1·3)

Chapter 4: Feeding Status of Children in IBC (Paper 3)

4.1 Scope of Chapter

This chapter presents the third research paper titled "Feeding practices of children within institution-based care: A retrospective analysis of surveillance data". This work was published in Maternal and Child Nutrition on Mar. 22, 2022 as an open access article under the Creative Commons Attribution Non Commercial License. Copyright: © 2022 DeLacey et al. Although the research was not funded, funding was provided by an agreement between LSHTM and Wiley Publishing.

This paper describes the feeding-related epidemiology of children living within institution-based care who participate in Holt International's Child Nutrition Program. The primary aim of this paper was to describe the feeding practices and status of children in care, considering both age, disability status and other variables in analysis. This paper helped to support information from the first two papers to present an inclusive summary of the nutrition and feeding status of children living within IBC. This summary provides a foundation to the needs of children in IBC and why programs to support their nutrition and feeding practices — such as Holt International's Child Nutrition Program — need to be examined.

4.2 List of figures

4.3 List of tables

Table 4: Feeding and positioning behavior observations for children with disabilities at baseline and evaluation

4.4 Citation

DeLacey, E., Allen, E., Tann, C., Groce, N., Hilberg, E., Quiring, M., Kaplan, T., Smythe, T., Kaui, E., Catt, R., Miller, R., Gombo, M., Dam, H., & Kerac, M. (2022). Feeding practices of children within institution-based care: A retrospective analysis of surveillance data. Maternal & Child Nutrition, e13352. https://doi.org/10.1111/mcn.13352

4.5 Research Paper

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed for each research paper included within a thesis.

SECTION A – Student Details

Student ID Number	lsh1804647	**Title**	Ms
First Name(s)	Emily		
Surname/Family Name	DeLacey		
Thesis Title	The Nutritional and Feeding Status of Children Living within Institution-based Care and an Evaluation of Process of the Child Nutrition Program.		
Primary Supervisor	Marko Kerac		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?	Maternal and Child Nutrition https://onlinelibrary.wiley.com/doi/full/10.1111/mcn.13352		
When was the work published?	Published March 22 2022		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	N/A		
Have you retained the copyright for the work?*	**No**	Was the work subject to academic peer review?	**Yes**

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	

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SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	Emily DeLacey, Marko Kerac, Elizabeth Allen and Cally Tann designed the study. Emily DeLacey, Marko Kerac, Tracey Smythe, Michael Quiring, Cally Tann, Nora Groce, Elizabeth Allen and Evan Hilberg contributed to specific areas of the methods, data analysis, statistics, and quality control. Emily DeLacey, Marko Kerac, Evan Hilberg and Michael Quiring had access and verified the data. Emily DeLacey led the data analysis and wrote the first draft of the manuscript. Emily DeLacey, Marko Kerac, Michael Quiring, Cally Tann, Nora Groce, Elizabeth Allen, Tracy Kaplan, Erin Kaui, Rachael Catt, Raeanne Miller and Evan Hilberg contributed to the writing of the manuscript and agree with the manuscript's results and conclusions. All of the authors have read and approved the submitted manuscript.

SECTION E

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Feeding practices of children within institution-based care: A retrospective analysis of surveillance data

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Abstract

There is limited information on the feeding practices of 9.42 million children living within institution-based care (IBC) worldwide. Poor feeding practices can predispose or exacerbate malnutrition, illness and disability. Here we describe the feeding practices of children living within IBC based on a retrospective analysis of records from 3335 children, 0–18 years old, participating in Holt International's Child Nutrition Program (CNP), from 36 sites in six countries. Data analysed included demographic information on age, sex, feeding practices, disabilities and feeding difficulties. Descriptive statistics were produced. A generalised linear model explored associations between feeding difficulties and disability and 2 × 2 tables examined feeding difficulties over time. An additional set of feeding observations with qualitative and quantitative data was analysed. At baseline, the median age of children was 16 months (0.66–68 months) with 1650/3335 (49.5%) females. There were 757/3335 (22.7%) children with disabilities; 550/984 (55.9%) were low birth weight; 311/784 (39.7%) were premature; 447/3113 (14.4%) had low body mass index and 378/3335 (11.3%) had feeding difficulties. The adjusted risk of having a feeding difficulty was 5.08 ([95% confidence interval: 2.65–9.7], $p \leq 0.001$) times greater in children with disabilities than those without. Many children saw their feeding difficulties resolve after 1-year in CNP, 54/163 (33.1%) for children with disabilities and 57/106 (53.8%) for those without disabilities. Suboptimal hygiene, dietary and feeding practices were reported. In conclusion, feeding difficulties were common in IBC, especially among children with disabilities. Supporting safe interactive mealtimes for children living within IBC should be prioritised, to ensure overall health and development.

KEYWORDS
children, disability, epidemiology, feeding, institution-based care, nutrition, orphanages

1 | INTRODUCTION

It is estimated that anywhere from 3.18 million to 9.42 million children younger than 18 years old live in institution-based care (IBC) globally (Desmond et al., 2020). IBC is defined by the United Nations as residential care provided in any nonfamily-based group setting, such as places for emergency care and all other short- and long-term residential care facilities (United Nations General Assembly, 2009; United Nations Human Rights Office of the High Commissioner, 1990). The UN Convention on the Rights of the Child requires that children in IBC are provided with standards of living, such as adequate nutrition, health care services and education, which support their full social integration and individual development (Richter et al., 2019; United Nations Human Rights Office of the High Commissioner, 1990). A focus on supporting children in IBC is important to ensure their full development. Substantial progress has been made in the last two decades in saving the lives of children younger than 5 years old globally (Victora et al., 2021). However, many children in IBC, especially those with disabilities have been excluded (DeLacey et al., 2020; Ernst et al., 2021). The UN Convention on the Rights of Persons with Disabilities defines persons with disabilities as ‘All persons with disabilities including those who have long-term physical, mental, intellectual or sensory impairments which, in interaction with various attitudinal and environmental barriers, hinders their full and effective participation in society on an equal basis with others’ (United Nations, 2006).

These vulnerable children can be especially at risk for malnutrition. Malnutrition impacts millions of children worldwide who have limited access to nutritious food or the resources and support needed to safely and successfully eat. Nutritional intake is especially important throughout childhood because of critical periods of growth and development, during which unaddressed malnutrition can have long-term consequences to children's development (Black et al., 2013; DeLacey et al., 2021; Yang, 2017). Feeding practices are an especially important factor in children's nutritional intake, and are defined as the interactions between a child and caregiver during mealtimes and can be influenced by various factors, such as socioeconomic status or a child's ability, age or cultural beliefs and practices (Reilly, 1996; B. N. S. Silva et al., 2017; Yang, 2017). Some children experience difficulty with feeding, impacting their ability to consume nutritious food. Feeding difficulties is a term that encompasses feeding issues or challenges, regardless of severity, aetiology or effects. It includes any difficulties that affect the process of providing food to the child or the child consuming the meal (Yang, 2017). Feeding difficulties affect up to 80% of children with disabilities and 25%–45% of those without (Benjasuwantep et al., 2013; Reif et al., 1995; Reilly et al., 1996; Yang, 2017). Feeding difficulties and malnutrition predispose children to long-term impairments, such as diminished cognition, disability, suboptimal school performance and adult noncommunicable diseases (Black et al., 2013; UNICEF Producer, 2019; Victora et al., 2021).

Children in IBC, especially young children and those with disabilities, are particularly at risk for infections, illnesses, anaemia, micronutrient deficiencies and malnutrition (Black et al., 2013; DeLacey et al., 2020; DeLacey et al., 2021; The World Bank Group Producer, 2019; UNICEF Producer, 2019; Victora et al., 2021).

Key points

- Feeding difficulties are common among children living in institution-based care (IBC), particularly but not exclusively among those children with disabilities.
- Suboptimal feeding practices were common in IBC and encompassed inadequate hygiene, limited support for self-feeding, reading children's feeding cues (especially around pacing and satiety), addressing feeding difficulties, such as difficulty chewing or swallowing. These should be prioritised in training and supervision for caregivers.
- Addressing the needs of this vulnerable group should include support for safe feeding techniques. These should be prioritised to help ease the transition into eventual family-based care if we are to move towards deinstitutionalizing children and strengthening families.

A recent systematic review exploring the nutritional status of children living in IBC found few studies directly documenting the problem (DeLacey et al., 2020). One exemption, the St. Petersburg-USA Orphanage Research Team found malnutrition in IBC related to inadequate dietary diversity; inappropriate types or textures of food or fluids; poor feeding and positioning practices; inadequate attention or stimulation and suboptimal hygiene and sanitation (The St. Petersburg-USA Orphanage Research Team, 2005, 2008). These can result in increased frequency of illnesses or reduce nutrient utilisation (DeLacey et al., 2020; Frank et al., 1996; van IJzendoorn et al., 2011; The St. Petersburg-USA Orphanage Research Team, 2008). The COVID-19 pandemic threatens to exacerbate malnutrition in IBC for children already at risk due to their emotional, physical and social vulnerabilities (Goldman et al., 2020; Victora et al., 2021). This could include increasing their risk of social isolation or of immunodeficiencies, which make them more susceptible to COVID-19 or even disruptions in food systems making nutritious food unavailable. (Goldman et al., 2020; Headey et al., 2020; Victora et al., 2021). Headey and coworkers suggest there could be a 14.3% increase in the prevalence of wasting among children younger than 5 years due to COVID-19 (Headey et al., 2020). Concerns of increasing numbers of children being abandoned or separated from families due to COVID-19 could lead to increased numbers in IBC (Goldman et al., 2020).

Children in IBC might be at risk for the following reasons. Firstly, facilities might only be able to address children's basic needs due to limited staffing, time and fiscal constraints (Frank et al., 1996; D. E. Johnson & Gunnar, 2011; The Children's Health Care Collaborative Study Group, 1994; Whetten et al., 2014). Often caregivers do not receive any information on developmental stages, caregiving, feeding practices or the needs of children of different ages or abilities (Richter et al., 2019; The St. Petersburg-USA Orphanage Research Team, 2005). This is compounded by caregivers experiencing competing priorities for their time, resulting in interactions with children that are limited to routine and perfunctory caregiving (The St. Petersburg-USA Orphanage Research Team, 2005, 2008). These competing priorities around mealtimes are of particular concern as feeding and mealtimes make up as much as 50% of the time a caregiver may spend with a child during the day and are key opportunities for interaction, learning and skill development (G. A. Silva et al., 2016; The St. Petersburg-USA Orphanage Research Team, 2005). Additionally, caregivers are also responsible for other variables that impact feeding behaviour, such as sleep schedules, environment, activity time or access to appropriate feeding utensils and seating (Birch & Doub, 2014; The St. Petersburg-USA Orphanage Research Team, 2005).

These challenges can be all the more severe for children with disabilities who comprise up to 25% of all children in IBC (DeLacey et al., 2020; DeLacey et al., 2021; Ernst et al., 2021). Disabilities are especially prevalent among children in low and middle-income countries where IBC is common and malnutrition is the leading cause of childhood mortality (Black et al., 2013; Hume-Nixon & Kuper, 2018; Victora et al., 2021). Children with disabilities often need additional time, support and assistance to safely, successfully and comfortably eat. With an estimated 93 million children (close to 1 in every 20 children worldwide) living with moderate to severe disabilities—this is an issue with far-reaching implications (Groce et al., 2014; Hume-Nixon & Kuper, 2018; Kuper et al., 2015; World Health Organization, 2011b). For some children, poor nutrition can also worsen their disabilities and make recovery more difficult if not impossible (Groce et al., 2014; Hume-Nixon & Kuper, 2018; Victora et al., 2021).

This paper describes the current feeding practices of children living within IBC in a large multicountry nutrition programme. Our key objectives are to:

1. Describe the children's feeding methods, practices and associated difficulties.
2. Explore potential factors underlying these practices and difficulties, notably disability.
3. Explore any changes in feeding difficulties over time in IBC.

2 | METHODS

2.1 | Study design

This is a retrospective analysis of routine health records and programme audit data of feeding practices, dietary intake and feeding difficulties from a large multicountry IBC nutrition programme.

2.2 | Setting/study size

Qualitative and quantitative data were collected from secondary data consisting of health records and routine programme audit behaviour observations of Holt International's Child Nutrition Program (CNP). Holt International is a nonprofit child welfare organization supporting children and families in multiple countries. Holt International's CNP is currently implemented in six countries: Vietnam, India, China, Mongolia, Philippines and Ethiopia. Within these countries, CNP is implemented in 53 community, foster care, day care and IBC sites, of which 36 IBC programmes were used for this study. Sample size was constrained by available programme data rather than determined by a priori calculation.

2.3 | Participants and variables

Deidentified secondary data were used from the nutrition screening records of children aged 0–18 years old residing in IBC sites participating in the CNP. Nutrition screenings are routinely performed at each site. They are carried out monthly for children aged 0–2 years old; quarterly for those 2–5 years old and biannually thereafter. Each screening captures information on age, birth status, sex, disability status, episodes of illness, anthropometry, feeding methods and difficulties. Additionally, a smaller data set of deidentified feeding behaviour observations, completed by Holt's feeding experts during routine programme audits, were analysed from CNP baseline and evaluation reports. All included data are from January 2013 to May 2021.

2.4 | Data management and analysis

Quantitative data were managed and analysed using Stata (16.1, StataCorp LLC). Data from each child's baseline and 1-year screening were used for analysis. Children's records were provided by Holt International to the primary author (E. D.) in a deidentified CSV file. Data extracted from children's records included age, sex, prematurity, disability status, episodes of illness, anthropometry, feeding methods, dietary intake and feeding difficulties. Disability status was further grouped by the primary disability listed, as categorised by health professionals in the country. Low birth weight and preterm birth were added to children's records when available from any preadmission hospital records. However, birth status information was limited as many children were abandoned. Feeding variables included data on dietary intake, food supplements, feeding difficulties and vitamin/mineral supplementation. Different types of feeding difficulties were predefined by feeding specialists and could be recorded on a child's health record where present. Time since admission into IBC was a continuous variable defined as the number of days from the registered admission date to their exit date or to the date of the data export for those still in IBC. World Health Organization (WHO) diagnostic and data cleaning criteria were used based on age and gender thresholds for body mass index (BMI) and anaemia (World Health Organization, 2017, 2007, 2006). Haemoglobin levels for ages 0–5 years: mild 10.0–10.9 g/dl, moderate 7.0–9.9 g/dl, severe <7.0 g/dl; ages 5–11 years: mild 11.0–11.4 g/dl, moderate 8.0–10.9 g/dl, severe <8.0 g/dl; ages 12–14 years: mild 11.0–11.9 g/dl, moderate 8.0–10.9 g/dl, severe, <8.0 g/dl; females aged 14+ years: mild 11.0–11.9 g/dl, moderate 8.0–10.9 g/dl, severe <8.0 g/dl and males aged 14+ years: mild 11.0–12.9 g/dl, moderate 8.0–10.9 g/dl, severe <8.0 g/dl. BMI-for-age (BMIZ) outlier data cleaning cut-offs: <−5 standard deviation (SD) and >+5 SD. *Z*-score categories: risk of overweight/overweight: >+1 SD, normal weight: <+1 SD to >−2 SD, thinness/underweight: −2 SD to −3 SD, severe thinness/underweight: >−3 SD (World Health Organization, 2011a, 2007, 2006).

The smaller set of secondary routine programme audit data of behaviour observations of infant feeding, young child feeding and feeding of children with disabilities was completed by expert feeding specialists during baseline and evaluation assessments. These behaviour observations include quantitative and qualitative data. Quantitative data were from standard questions about specific practices; qualitative data were from comments on witnessed feeding practices, environment and hygiene practices. Qualitative data were managed and analysed using Microsoft Excel (2013).

2.5 | Statistical methods/analysis

Descriptive statistics were produced for categorical and continuous variables. These are frequency and percent for categorical variables and mean (with SD) for normally distributed data, and median (with interquartile ranges [IQRs]) for nonnormally distributed data that were continuous variables.

The association between feeding difficulties and disability status was explored. For analysis of feeding difficulties over time, we cross-tabulated those with and without feeding difficulties at 1-year based on disability status and feeding difficulties at baseline. A generalised linear model with a log link was fitted to assess the association of feeding difficulties with disability status at children's baseline screening after adjusting for preidentified potential confounders age, and sex. Robust standard errors were used to allow for clustering by site. Statistical significance was taken as 5%.

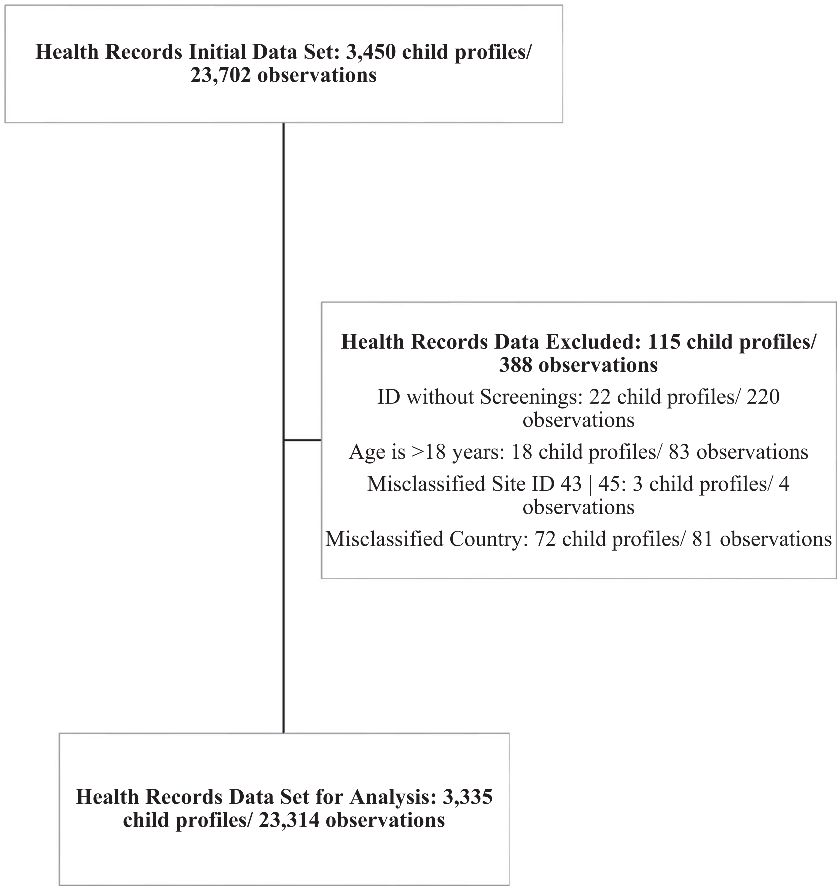
For the quantitative data from behaviour observations, the frequency and percent of desired feeding behaviours at baseline and evaluation time points were calculated and then tested for nonrandom association using Fisher's exact test. Qualitative data from the feeding behaviour observations were summarised by grouping different comments into overarching themes (e.g., 'child fed laying down', 'child fed with head back unable to safely swallow', 'child fed on lap without support and poor head positioning') were all summarised as 'inappropriate positioning'. The summary sought to identify categories and subcategories that appeared to be important in the experience and observation of feeding specialists. Themes were identified by most frequently recorded comments on observed practices. A narrative synthesis of findings was also undertaken.

3 | RESULTS

3.1 | Population demographics

Figure 1 shows inclusion criteria leading to the final sample size. Table 1 shows baseline characteristics of all 3335 children living within IBC in six countries. There were many infants (0–6 months) (1041 [31.2%]) and children aged 5 years and older (1270 [38.1%]) in the programme. There were similar numbers of females and males. There were 757 (22.7%) children with one or more disabilities. Of these, cerebral palsy was the most commonly identified; however, in less than half (44.3%) of the children with a disability, the type of disability was not specified. Only 29.5% (985) of children had recorded birth information; among these low birthweight and prematurity were common, and both were more common among those with a disability when compared to those without (Table 1). Children entered into IBC at a median age of 16 months (IQR: 0.66–68 months) and stayed for a median time of 22.7 months (IQR: 8.8–48.8 months).

FIGURE 1 Data cleaning flow chart for health records data set



3.2 | Feeding and health characteristics

Table 2 describes feeding characteristics of all children at their baseline and 1-year screening by disability status. See Table A1 for fuller details. With regard to feeding characteristics, feeding difficulties were common especially for children with disabilities. For those with feeding difficulties, the most common were difficulty feeding self for children older than 1 year, poor appetite and difficulty chewing. Of the total population at baseline, 225/3335 (6.8%) were taking food supplements and 1626/3335 (48.8%) were taking vitamin or mineral supplements, of which vitamin C, D, calcium and iron were the most common. Cough or colds were the most common illnesses experienced by children in the month before their last screening. Anaemia was prevalent at baseline (763/2828 [27%]) and at 1 year (97/1511 [6.4%]) and more prevalent among children with disabilities at both time points. At baseline, 447/3113 (14.4%) of children had low BMI.

3.3 | Feeding difficulties over time

Table 3 shows the change in feeding difficulties after 1 year in the CNP for those with and without disabilities. For those with a disability and no feeding difficulties at baseline, 279/315 (88.6%) continue to not have feeding difficulties and 36/315 (11.3%) develop feeding difficulties after 1 year. For those children with a disability and a feeding difficulty at baseline, 54/163 (33.1%) see their feeding difficulties resolve and 109/163 (66.9%) continue to have feeding difficulties.

For children without disabilities and without feeding difficulties at baseline, after 1 year 1276/1325 (96.3%) continue to not have a feeding difficulty and 49/1325 (3.7%) develop a feeding difficulty. For those without disabilities and with feeding difficulties at baseline, 57/106 (53.8%) see their feeding difficulties resolve and 49/106 (46.2%) see their feeding difficulties continue after 1 year in the CNP.

3.4 | Feeding difficulties and disability status

At baseline, 153/2578 (5.9%) children without disabilities had a feeding difficulty present; in contrast, 225/757 (29.7%) of children with a disability had feeding difficulties at baseline. A generalised linear model with a log link was fitted to explore the association between disability at baseline and feeding difficulties at baseline. We found an adjusted risk ratio of 5.08 (95% confidence interval [CI]: 2.65–9.7, $p \leq 0.001$). This represents significantly increased risk of having a feeding difficulty among those with disabilities.

TABLE 1 Characteristics of children living within IBC in six countries at baseline screening

	All children	Children without disabilities	Children with disabilities
Population at baseline screening, *n* (%)	3335 (100.0)	2578 (77.3)	757 (22.7)
Total number exited	1795 (53.8)	1316 (51)	479 (63.3)
Active children	1540 (46.2)	1262 (49)	278 (36.7)
Exact date of birth unknown	3033 (90.9)	2344 (90.9)	689 (91)
Age based on the estimated or known date of birth			
0–6 months	1041 (31.2)	807 (31.3)	234 (30.9)
6–12 months	173 (5.2)	125 (4.9)	48 (6.3)
12–24 months	220 (6.6)	161 (6.3)	59 (7.8)
24–59 months	631 (18.9)	481 (18.7)	150 (19.8)
5–9 years	670 (20.1)	525 (20.4)	145 (19.2)
10–14 years	484 (14.5)	382 (14.8)	102 (13.5)
15–18 years	116 (3.5)	97 (3.8)	19 (2.5)
Sex: female, *n* (%)	1650 (49.5)	1306 (50.7)	344 (45.4)
Common disabilities, *n* (%)	-	-	n = 589
Autism spectrum disorder	-	-	12 (2.0)
Cerebral palsy	-	-	107 (18.2)
Cleft lip/cleft palate	-	-	8 (1.4)
Cognitive impairment	-	-	53 (9.0)
Down syndrome	-	-	21 (3.6)
Hearing loss/deafness	-	-	13 (2.2)
Heart disease/defect	-	-	43 (7.3)
HIV/AIDS	-	-	13 (2.2)
Hydrocephaly	-	-	16 (2.7)
Microcephaly	-	-	8 (1.4)
Vision impairment and blindness	-	-	23 (3.9)
Speech/language delays	-	-	6 (1.0)
Missing limbs/digits	-	-	3 (0.5)
Kidney disease or defect	-	-	2 (0.3)
Other	-	-	261 (44.3)
Birth weight unknown	2350 (70.5)	1878 (72.9)	472 (62.4)
Birth weight known, *n* (%)	*N* = 984	*N* = 699	*N* = 285
Birth weight > 2.5 kg	434 (44.1)	354 (50.6)	80 (28.1)
Low birth weight < 2.5 kg	452 (45.9)	305 (43.6)	147 (51.6)
Very low birth weight < 1.5 kg	81 (8.2)	33 (4.7)	48 (16.8)
Extremely low birth weight < 1.0 kg	17 (1.7)	7 (1.0)	10 (3.5)
Gestational age unknown, *n* (%)	2551 (76.5)	2042 (79.2)	509 (67.2)
Where birth prematurity status known, *n* (%)	*N* = 784	*N* = 536	*N* = 248
Full term	473 (60.3)	400 (74.6)	73 (29.4)
Premature	311 (39.7)	136 (25.4)	175 (70.6)

TABLE 1 (Continued)

	All children	Children without disabilities	Children with disabilities
Median age (IQR) (months)	*N* = 3315	*N* = 2562	*N* = 753
	16 (0.66–68)	22.7 (0.66–72.5)	6.7 (0.7–48)
Median time since admission into IBC (IQR) (months)	*N* = 3209	*N* = 2499	*N* = 710
	22.7 (8.8– 48.8)	20.1 (7.9–40.7)	36.3 (15.6–75.8)

Abbreviations: IBC, institution-based care; IQR, interquartile range.

3.5 | Feeding and positioning behaviour observations

Table 4 summarises the positioning and feeding behaviour observations for children with disabilities. From baseline to evaluation, a change was observed in behaviours of children receiving modified liquid or food textures. Additionally, observations of appropriately sized spoons or food offerings indicated a significant difference from baseline to evaluation. Observations indicate that meals frequently did not include all five food groups, handwashing was often skipped, children did not feed themselves and were often incorrectly positioned for mealtimes. Positive caregiver interaction with the child during meal times was also observed, such as smiling and making eye contact with children. Suboptimal feeding practices, poor hygiene practices, inadequate fluid and dietary intake were commonly observed. Putting cereal in formula bottles with cut nipples for children of all ages was noted. Further details are in Tables A2 and A3 on infant and young child feeding behaviour observations.

4 | DISCUSSION

This study explored the feeding practices, behaviours, difficulties and outcomes among children living within IBC. Key findings from this study indicate that feeding difficulties were common among children living within IBC with the most common being difficulty self-feeding. Disability was a major factor underlying this challenge, with children having an increased risk of feeding difficulties if a disability is present. Overtime in the CNP, some feeding difficulties resolve for those with and without disabilities, although many children continue to experience feeding difficulties. Suboptimal feeding practices were observed, such as poor positioning, limited handwashing and inappropriate pacing of meals. These findings have rarely been described in this population and might explain the increased prevalence of malnutrition in this population (DeLacey et al., 2020; DeLacey et al., 2021; Ernst et al., 2021).

4.1 | Feeding difficulties

Oral feeding is an important component of children's nutritional growth and development. When feeding difficulties are present it can limit physical, behavioural and cognitive development, increase risks for illness, disease and cause or exacerbate existing disabilities (Benjasuwantep et al., 2013; DeLacey et al., 2020; DeLacey et al., 2021; Ernst et al., 2021; Reif et al., 1995). Providing support for children with feeding difficulties at their baseline screening should be prioritised (Manikam & Perman, 2000; Reif et al., 1995). By addressing feeding issues early and effectively with training and resources for caregivers, long-term feeding difficulties, malnutrition and delayed development could be minimised or avoided (Perry, 2005). Over 40% of those with feeding difficulties did not have a disability and are still at risk of becoming malnourished, even though not having a disability may not make their risk as obvious. Notably, many children saw their feeding difficulties resolve after 1 year in the CNP, 54/163 (33.1%) for children with disabilities and 57/106 (53.8%) for children without disabilities. It is likely that the programme had an impact on improving the feeding of children, even though some feeding difficulties resolve with age.

Moreover, the impact of how children are fed can lead to long-term positive or negative associations with feeding (Reif et al., 1995). Diagnostic and Statistical Manual of Mental Disorders (DSM-5) diagnosis for paediatric feeding disorders indicates that children can be experiencing fear and pain during the feeding process and this could lead to negative associations with mealtimes (Perry, 2005; American Psychiatric Association, 2016). However, caregivers often work long hours, receive very little training, maintain social-emotional detachment and interaction is not considered a key function of their roles (The St. Petersburg-USA Orphanage Research Team, 2005). Limited staffing and support can lead to limited time to engage and fully support each child (The St. Petersburg-USA Orphanage Research Team, 2005).

4.2 | Feeding practices

Mealtimes can be opportunities for positive interactive learning or stressful events with suboptimal feeding practices (G. A. Silva et al., 2016; The St. Petersburg-USA Orphanage Research Team, 2005). Mealtimes are important because modelling desired behaviours by caregivers can teach children about eating practices or contexts of meals (Birch & Doub, 2014). What children learn during mealtimes from caregivers has an impact on their lifelong eating habits, nutritional status, cognitive and social development (Richter et al., 2019). Learning new feeding skills

TABLE 2 Description of feeding practices and health variables of children living within institution-based care in six countries at baseline and 1-year screening

Feeding profile	All children at baseline	All children at 1 year	Children without disabilities at baseline	Children without disabilities at 1 year	Children with disabilities at baseline	Children with disabilities at 1 year
Feeding method, *n* (%)[a]	*N* = 3335	*N* = 1909	*N* = 2578	*N* = 1385	*N* = 757	*N* = 524
Fed with bottle	1398 (41.9)	525 (27.5)	1028 (39.9)	327 (23.6)	370 (48.9)	198 (37.8)
Self-fed[b]	1727 (51.8)	1046 (54.8)	1469 (57)	830 (59.9)	258 (34.1)	216 (41.2)
Fed with cup	930 (27.9)	650 (34.1)	804 (31.2)	504 (36.4)	126 (16.6)	146 (27.9)
Spoon fed	1123 (33.7)	957 (50.1)	811 (31.5)	628 (45.3)	312 (41.2)	329 (62.8)
Fed with adaptive utensils	32 (1.0)	21 (1.1)	15 (.6)	2 (0.1)	17 (2.3)	19 (3.6)
Breastfed	9 (0.3)	1 (0.1)	7 (0.3)	1 (0.1)	2 (0.3)	0
Feed type, *n* (%)[a]						
Formula	1488 (44.6)	467 (24.5)	1108 (43)	316 (22.8)	380 (50.2)	151 (28.8)
Solid foods	1993 (59.8)	1314 (68.8)	1578 (61.2)	951 (68.7)	415 (54.8)	363 (69.3)
Animal milk	803 (24.1)	584 (30.6)	659 (25.6)	402 (29.0)	144 (19.0)	182 (34.7)
Rice cereal	445 (13.3)	534 (28)	306 (11.9)	339 (24.5)	139 (18.4)	195 (37.2)
Breast milk	11 (0.3)	1 (0.1)	9 (0.4)	1 (0.1)	2 (0.3)	0
Special diet[c]	77 (2.3)	53 (2.8)	38 (1.5)	19 (1.4)	39 (5.2)	34 (6.5)
Feeding difficulty, *n* (%)						
Feeding issue present	378 (11.3)	243 (12.7)	153 (5.9)	83 (6.0)	225 (29.7)	160 (30.5)
Aspiration	14 (0.4)	11 (0.6)	0	2 (0.1)	14 (1.9)	9 (1.7)
Difficulty sucking	27 (0.8)	16 (0.8)	4 (0.2)	0	23 (3.0)	16 (3.1)
Cough/chokes during feeding	57 (1.7)	25 (1.3)	17 (0.7)	0	40 (5.3)	25 (4.8)
Difficulty feeding self (>1 year)	119 (3.6)	103 (5.4)	8 (0.3)	18 (1.3)	111 (14.7)	85 (16.2)
Reflux/heartburn	6 (0.2)	5 (0.3)	2 (0.1)	0	4 (0.5)	5 (1.0)
Poor appetite	111 (3.3)	82 (4.3)	72 (2.8)	47 (3.4)	39 (5.2)	35 (6.7)
Frequent vomiting/ spitting up	19 (0.6)	8 (0.4)	7 (0.3)	1 (0.1)	12 (1.6)	7 (1.3)
Difficulty drinking from a cup (> 1 year)	53 (1.6)	43 (2.3)	2 (0.1)	3 (0.2)	51 (6.7)	40 (7.6)
Difficulty swallowing	63 (1.9)	50 (2.6)	3 (0.1)	0	60 (7.9)	50 (9.5)
Difficulty chewing	91 (2.7)	82 (4.3)	8 (0.3)	1 (0.1)	83 (11.0)	81 (15.5)
Picky eater	69 (2.1)	44 (2.3)	35 (1.4)	19 (1.4)	34 (4.5)	25 (4.8)
Food allergy/ intolerance	14 (0.4)	8 (0.4)	10 (0.4)	5 (0.4)	4 (0.5)	3 (0.6)
Bad teeth (> 1 year)	22 (0.7)	24 (1.3)	9 (0.4)	4 (0.3)	13 (1.7)	20 (3.8)
Other	5 (0.2)	1 (0.1)	2 (0.1)	0	3 (0.4)	1 (0.2)
Supplements, *n* (%)[a]						
Currently taking food supplements	225 (6.8)	42 (2.2)	157 (6.1)	15 (1.1)	68 (9.0)	27 (5.2)
Currently taking mineral/vitamin supplements	1626 (48.8)	847 (44.4)	1176 (45.6)	572 (41.3)	450 (59.5)	275 (52.5)

TABLE 2 (Continued)

Feeding profile	All children at baseline	All children at 1 year	Children without disabilities at baseline	Children without disabilities at 1 year	Children with disabilities at baseline	Children with disabilities at 1 year
Illnesses/symptoms, *n* (%)[a]						
Fever	438 (13.1)	193 (10.1)	295 (11.4)	121 (8.7)	143 (18.9)	72 (13.7)
Constipation	40 (1.2)	13 (0.7)	22 (0.9)	0	18 (2.4)	13(2.5)
Diarrhoea	172 (5.2)	40 (2.1)	116 (4.5)	23 (1.7)	56 (7.4)	17 (3.2)
Nausea/vomiting	163 (4.9)	32 (1.7)	111 (4.3)	20 (1.5)	52 (6.9)	12 (2.3)
Cough/cold	722 (21.6)	395 (20.7)	489 (19.0)	222 (16.2)	233 (30.8)	173 (33.0)
Hospitalisation	135 (4.0)	45 (2.4)	64 (2.5)	26 (1.9)	71 (9.4)	19 (3.6)
Anaemia status, *n* (%)	*N* = 2828	*N* = 1511	*N* = 2167	*N* = 1101	*N* = 661	*N* = 410
None	2065 (73.0)	1314 (87.0)	1604 (74.0)	969 (88.0)	461 (69.7)	345 (84.2)
Mild	438 (15.5)	136 (9.0)	346 (16.0)	102 (9.3)	92 (13.9)	34 (8.3)
Moderate	307 (10.9)	59 (3.9)	212 (9.8)	30 (2.7)	95 (14.4)	29 (7.1)
Severe	18 (0.6)	2 (0.1)	5 (0.2)	0	13 (2.0)	2 (0.5)
Body mass index for age *z*-score *n* (%)	*N* = 3113	*N* = 1790	*N* = 2408	*N* = 1312	*N* = 705	*N* = 478
Overweight (>+1 SD)	361 (11.6)	226 (12.6)	286 (11.9)	172 (13.1)	75 (10.6)	54 (11.3)
Normal weight (−2 to +1 SD)	2305 (74.0)	1404 (78.4)	1882 (78.2)	1051 (80.1)	423 (60.0)	353 (73.9)
Underweight (<−2 to −3 SD)	291 (9.4)	119 (6.7)	175 (7.3)	73 (5.6)	116 (16.5)	46 (9.6)
Severely underweight (<−3 to ≥−5 SD)	156 (5.0)	41 (2.3)	65 (2.7)	16 (1.2)	91 (12.9)	25 (5.2)

[a]Not mutually exclusive variables.

[b]Self-fed/self-feeding is defined as when children feed themselves using their own fingers, utensils and cups. It is the process of setting up, arranging and bringing food and liquid from a plate, bowl or cup to their mouth. Self-feeding using the fingers typically begins around 6–7 months old when children start eating solid foods. Typically by 12–14 months old, children take on more of an active role using spoons and cups on their own to feed themselves. Age-appropriate self-feeding is considered an important developmental skill (Holt International; Kaplan, 2019).

[c]Special diets include diets for certain food allergies/intolerances or chronic conditions, such as diabetes, epilepsy or kidney disease. They also include therapeutic diets, such as modified texture diets like pureed, soft or liquid diets.

from peers or other children may also be limited because children in IBC are typically grouped by disability status or age regardless of developmental level or needs (Perry, 2005; The St. Petersburg-USA Orphanage Research Team, 2005, 2008). Quantitative and qualitative data from the behaviour observations in our study indicate that caregivers need on-going support to carry out optimal feeding for infants, young children and for those with disabilities.

Interactions during mealtimes varied widely between caregivers and sites—from no interaction to highly engaged. Positive interaction is essential for children's development and positive relationships can mitigate children's trauma (Perry, 2005). Despite this, suboptimal feeding practices and limited response to feeding cues, especially for infants and children with disabilities, were commonly noted. The St. Petersburg-USA Orphanage Research Team findings that feeding regimes were often limited in interaction, with bottle propping, scraping of children's faces, refeeding of spilled food back into the child's mouth and children fed lying down were prevalent practices in all observation sites in this study (The St. Petersburg-USA Orphanage Research Team, 2005, 2008). Additional poor feeding practices in our study included inappropriate pacing, positioning, limited interaction, forced feeding, lack of awareness of feeding cues, limited opportunities for self-feeding and skill advancement, restrictive feeding schedules and limited offering of fluids. The pace of meals being fed to children was often reported to be rapid, and similar to the findings by The St. Petersburg-USA Orphanage study which observed rapid feeding, with some children receiving as many as 30 spoonfuls per minute (Reilly et al., 1996; The St. Petersburg-USA Orphanage Research Team, 2008).

Additionally, poor hygiene and sanitation practices were prevalent and should be addressed as a preventable route for illness and malnutrition. Specifically, handwashing was not frequently observed among caregivers or children. Other concerning feeding practices included feeding children cereal in their bottles and cutting bottle nipples to increase flow rate, which can increase the risk of aspiration as well as reduce nutrient intake. Also, inappropriate feeding utensils,

TABLE 3 2 × 2 tables of the change in feeding difficulties after 1 year in the CNP for those with and without disabilities

	Without feeding difficulties at 1 year	With feeding difficulties at 1 year	Total
With disabilities	333 (69.7%)	145 (30.3%)	478 (100%)
Without feeding difficulties at baseline	279 (88.6%)	36 (11.3%)	315 (100%)
With feeding difficulties at baseline	54 (33.1%)	109 (66.9%)	163 (100%)
Without disabilities	1333 (93.2%)	98 (6.9%)	1431 (100%)
Without feeding difficulties at baseline	1276 (96.3%)	49 (3.7%)	1325 (100%)
With feeding difficulties at baseline	57 (53.8%)	49 (46.2%)	106 (100%)

Note: Missing data excluded.

such as spoons too large for children's mouths, poor seating options or inappropriate nipples and bottles for premature infants were noted. Some observed feeding practices were positive, such as the use of altered textures for food and liquids for children with disabilities, positive interaction during mealtimes, improved positioning, changes to serving sizes and appropriate environments for mealtimes but this varied by the feeder and site. Support for positive practices, such as good positioning, adequate fluid and dietary intake, food texture modifications, adaptive equipment and environmental modifications should be prioritised (Reilly et al., 1996).

4.3 | Children with disabilities

We found disability status to be strongly related to feeding difficulties. Compared with children without disabilities, those with disabilities had a higher prevalence of feeding difficulties at their baseline and 1-year screening. Children with disabilities had more than five times the risk, in adjusted analysis, of having a feeding difficulty at their baseline screening compared to children without disabilities. Feeding difficulties, such as difficulty self-feeding, chewing, drinking from a cup and sucking, in addition to coughing or choking and difficulty swallowing were higher for children with disabilities. Similarly, Kuper and co-workers, found that children with disabilities were more likely to experience feeding difficulties compared to their neighbours (OR = 1.9, 95% CI: 1.2–3.1) and are more likely to have difficulty self-feeding (Kuper et al., 2015). Many children with disabilities have challenges feeding themselves or eating (DeLacey et al., 2020; Groce et al., 2014; Hume-Nixon & Kuper, 2018). Teaching children with disabilities to feed themselves often takes additional time, resources and is often not done. This is a lost opportunity. Allowing additional time and resources as needed to teach these children to feed themselves, will create greater self-efficacy, increase social participation and independence for the rest of their lives. It should be considered a long-term investment in their futures (Groce et al., 2014; Hume-Nixon & Kuper, 2018; Reilly, 1996).

Screening for feeding difficulties early could help with the identification of children who need additional support and feeding interventions to enable safe mealtimes and support growth (S. Johnson et al., 2016; Manikam & Perman, 2000). Identifying feeding difficulties could point to underlying oral-motor problems related to neurological immaturity, delays or disabilities, which result in poor developmental outcomes (S. Johnson et al., 2016; Manikam & Perman, 2000).

Children with disabilities in IBC are at increased risk of malnutrition for a variety of reasons (DeLacey et al., 2020; DeLacey et al., 2021; Ernst et al., 2021). Poor fluid and dietary intake were noted for this group, which could lead to dehydration, malnutrition, feeding difficulties and illnesses (DeLacey et al., 2021).

4.4 | Illnesses, supplementation and anthropometry

Children within IBC were commonly found to have been ill within the last month in IBC, with children with disabilities having a higher proportion of illnesses compared to those without a disability. The most common illnesses reported were a cough or cold (722/3335 [21.6%]). This could be related to a number of factors, including poor hygiene, inadequate dietary intake and other suboptimal feeding practices putting them at increased risk for illness (Victora et al., 2021). Anaemia is common in this population (DeLacey et al., 2021; Ernst et al., 2021). Frequent illnesses or anaemia can have consequences for children's development and impact brain functioning (Black et al., 2013; Victora et al., 2021). Notably, anaemia resolves for many children after 1 year in CNP, likely related in part to screening and treatment components of the programme. In this population, supplementation was common with nearly half of all children receiving a supplement at baseline. Mineral, vitamin and food supplementation was more prevalent among children with disabilities. This could raise a concern that the challenge of feeding children with disabilities is resulting in them being given supplements in lieu of teaching caregivers or children themselves feeding skills. Chronic poor dietary intake, frequent illnesses, micronutrient deficiencies and feeding practices could lead to poor growth. Children with disabilities are more likely to have lower anthropometric measurements compared to siblings and peers without disabilities (DeLacey et al., 2020; DeLacey et al., 2021; Ernst et al., 2021; Myatt et al., 2018). Our paper found nearly 30% of children with disabilities

TABLE 4 Feeding and positioning behaviour observations for children with disabilities at baseline and evaluation

Feeding and positioning behaviour observations for children with disabilities	22 observations	29 observations	Fisher's exact (two-sided) *p*-value	Qualitative summary
	Baseline *n*/*N* (%)	Evaluation *n*/*N* (%)		Length of feeding: 5–60 min
Child's body positioned upright and feet supported	5/17 (29.4)	17/27 (62.9)	0.062	Inappropriate positioning; limited handwashing observed; limited or no fluids offered; limited self-feeding; inappropriate feeding utensils; inadequate interaction; inadequate dietary intake; food textures are modified; children fed only on a schedule; hunger cues are not observed; fast pacing of meals; caregivers are attentive to children; environments were calm, quiet and appropriately lit
Child's hands cleaned before mealtime	0/9 (0)	2/9 (20)	0.471	
Child feeds self	2/21 (9.5)	0/28 (0)	0.179	
The caregiver interacts during mealtime	18/22 (81)	23/26 (88.5)	0.687	
The child receives altered food and/or liquid textures	9/22 (40.9)	25/28 (89.3)	0.001	
The caregiver is responsive to hunger cues and fullness cues	4/16 (25)	10/22 (45)	0.309	
The child does not cough when consuming liquids	2/8 (25)	3/12 (25)	1	
The meal include all of the five food groups	1/14 (7.1)	3/21 (14.3)	0.635	
The spoon or size of food offered is appropriate	2/15 (13)	16/22 (72)	0.001	
The caregiver allows ample time for the child to appropriately and safely eat/swallow each bite	No observations completed	3/6 (50)	--	
The caregiver appropriately feeds the child at the child's pace	7/9 (80)	4/12 (40)	0.080	
The caregiver cleans/assists with cleaning children's hands after mealtime (yes = desired)	1/6 (16)	5/8 (62.5)	0.138	

to have a low BMI, which may be related to the third of children who presented feeding difficulties (DeLacey et al., 2020; DeLacey et al., 2021; Ernst et al., 2021; Kuper et al., 2015).

4.5 | Limitations

There were some limitations in our study. Although this study was from a large multicountry sample, this sample may not be representative of all IBC facilities in these countries since data were collected only from those participating in Holt International's CNP. Holt partnerships provide resources that many other institutions may not regularly have access to, including organisational and financial support for education, healthcare, nutrition and other child welfare needs.

Additionally, when analysing these data it is important to consider that some children's first screening was their first day in IBC, and for others, their first screening occurred after multiple years in IBC. Time in IBC for children still in care is censored at the final data pull date. Changes in feeding practices vary based on children's age, skill level and how long they are in IBC. Holt's CNP provides definitions and training around age- and disability-appropriate feeding practices but we acknowledge that perceptions of child needs and abilities may have an element of subjectivity. For example, some Holt feeding specialists and trainers are from Western backgrounds/training and details of appropriate feeding practices vary by age or culture (e.g., although self-feeding is an important part of development, in many cultures, caregivers feeding children is a sign of care). More objective tools could be used in the future.

Furthermore, disabilities were diagnosed by specialists within the countries but not all countries or specialists diagnose disabilities the same way. In the future, a standardised diagnostic tool could be used for more comparative analysis. However, grouping children, both those without disabilities and those with disabilities, do not fully address the individual needs of children. Children with some types of disabilities may be small or underweight for age based on clinical sequelae related to their specific disability. These disabilities may impede their ability to self-feed, manipulate food in the mouth, safely swallow, digest food or be associated with conditions that would reflect in lower height or weight. Additionally, there are potentially unobserved variables that might confound the relationship observed, such as prenatal substance exposure, which could be related to both disability status and feeding difficulties that we were unable to include in the analysis. Finally, change in sample sizes over time and missing data could impact these interpretations. For example from the original data set, there was more missing data at 1 year of both children with and without disabilities who did not have a feeding problem. This could indicate that those who have fewer difficulties may be able to be placed into family-based care more easily than those with feeding difficulties. Survival bias may also be present considering those who are sicker or with more severe disabilities that impact their ability to eat, may not live as long. Therefore results should be taken with some caution as the population of children with baseline to 1-year screenings may differ from those who stay in IBC the longest and the overall effect of these biases is unknown. Future prospective studies may help understand their relative effects.

4.6 | Recommendations

In light of many global issues, such as food insecurity, climate change and the COVID-19 pandemic, the risk to vulnerable children is heightened, as is the risk of abandonment (Goldman et al., 2020; Headey et al., 2020; Victora et al., 2021). With the global goal of deinstitutionalizing children and strengthening families, addressing the needs of children and their caregivers, especially those with disabilities, is essential (DeLacey et al., 2021; Ernst et al., 2021; Goldman et al., 2020; Headey et al., 2020; Manikam & Perman, 2000; United Nations Human Rights Office of the High Commissioner, 1990; Victora et al., 2021). It is important to consider how to support and strengthen individual caregivers and families in communities who may lack the support, supervision and resources present in IBC (DeLacey et al., 2020; DeLacey et al., 2021; Ernst et al., 2021; Whetten et al., 2014). Future research needs to examine how best to support caregivers in different countries and cultures to provide high-quality feeding practices, especially around quality interaction, children's feeding cues, pacing, satiety and feeding difficulties, such as aspiration (Perry, 2005; Reilly, 1996; Reilly et al., 1996). This could improve child health outcomes and nutritional status.

In light of how common feeding issues are, we recommend all caregivers who work in IBC receive training on child feeding and nutrition. Given the potential bias in this study, follow-up with future cohorts prospectively would address some of the limitations in this paper and could focus on the needs of specific ages or those with or without disabilities as important subgroups. There could be more formal intervention research exploring the impact of feeding support programmes such as that run by Holt; more targeted research could also focus on specific elements of the programme, such as the use of Holt International's Feeding and Positioning Manual (Holt International et al., 2019).

5 | CONCLUSION

As the global community works towards the deinstitutionalization of children, addressing the feeding needs of those living within IBC is a top priority. Poor feeding practices are common in IBC and can put children at risk for illnesses, malnutrition and can cause or exacerbate existing disabilities. Disabilities and feeding issues are strongly linked. Feeding and mealtimes offer not just the opportunity for good nutrition but are part of critical development and connections for children. Supporting each child's individual needs should be prioritised, with a focus on safe, positive and engaging meals. Caregivers play a critical role and should receive the resources to understand and provide support to children during mealtimes. Feeding regimes for all children living in IBC need to be routinely reviewed and evaluated; appropriate feeding for children with disabilities, in particular, needs to be carefully and consistently implemented. Based on the findings from this study, we believe this is a critically important and currently largely overlooked component of improving the health and well-being of millions of children currently living in IBC.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

ETHICS STATEMENT

London School of Hygiene and Tropical Medicine's Ethics Committee (ref: 22822). This study did not involve patients or the public in its development. We intend to disseminate this study through open access publication to the public and all stakeholders. Holt International has given consent for the publication.

AUTHOR CONTRIBUTIONS

Emily DeLacey, Marko Kerac, Elizabeth Allen and Cally Tann designed the study. Emily DeLacey, Marko Kerac, Tracey Smythe, Michael Quiring, Cally Tann, Nora Groce, Elizabeth Allen and Evan Hilberg contributed to specific areas of the methods, data analysis, statistics, and quality control. Emily DeLacey, Marko Kerac, Evan Hilberg and Michael Quiring had access and verified the data. Emily DeLacey led the data analysis and wrote the first draft of the manuscript. Emily DeLacey, Marko Kerac, Michael Quiring, Cally Tann, Nora Groce, Elizabeth Allen, Tracy Kaplan, Erin Kaui, Rachael Catt, Raeanne Miller and Evan Hilberg contributed to the writing of the manuscript and agree with the manuscript's results and conclusions. All of the authors have read and approved the submitted manuscript.

DATA AVAILABILITY STATEMENT

Data are available upon request after approval process from Holt International. STATA code available upon request from Holt International.

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APPENDIX A

STROBE Statement—Checklist of items that should be included in reports of cohort studies (von Elm et al., 2007)

	Item no	Recommendation	Page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State-specific objectives, including any pre-specified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up and data collection	7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	8
		(b) For matched studies, give matching criteria and number of exposed and unexposed	-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8[a]	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8
Bias	9	Describe any efforts to address potential sources of bias	17
Study size	10	Explain how the study size was arrived at	Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8
		(b) Describe any methods used to examine subgroups and interactions	8
		(c) Explain how missing data were addressed	8/17
		(d) If applicable, explain how loss to follow-up was addressed	8
		(e) Describe any sensitivity analyses	-
Results			
Participants	13[a]	(a) Report numbers of individuals at each stage of study—for example, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10/Figure 1
		(b) Give reasons for nonparticipation at each stage	Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14[a]	(a) Give characteristics of study participants (e.g., demographic, clinical and social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	Noted in each table
		(c) Summarise follow-up time (e.g., average and total amount)	13
Outcome data	15[a]	Report numbers of outcome events or summary measures over time	10–14
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10–14
		(b) Report category boundaries when continuous variables were categorised	10
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—for example, analyses of subgroups and interactions, and sensitivity analyses	10–14
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15–17

(Continues)

	Item no	Recommendation	Page #
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies and other relevant evidence	15–17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15–19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	2

TABLE A1 Full Table 2: Description of feeding practices and health variables of children living within institution-based care in six countries at baseline and 1-year screening

Feeding profile	All children at baseline	All children at 1 year	Children without disabilities at baseline	Children without disabilities at 1 year	Children with disabilities at baseline	Children with disabilities at 1 year
Feeding method, *n* (%)[a]	*N* = 3335	*N* = 1909	*N* = 2578	*N* = 1385	*N* = 757	*N* = 524
Fed with bottle	1398 (41.9)	525 (27.5)	1028 (39.9)	327 (23.6)	370 (48.9)	198 (37.8)
Selfâ€fed	1727 (51.8)	1046 (54.8)	1469 (57)	830 (59.9)	258 (34.1)	216 (41.2)
Fed with cup	930 (27.9)	650 (34.1)	804 (31.2)	504 (36.4)	126 (16.6)	146 (27.9)
Spoon fed	1,123 (33.7)	957 (50.1)	811 (31.5)	628 (45.3)	312 (41.2)	329 (62.8)
Tube fed	0	0	0	0	0	0
Fed with adaptive utensils	32 (1.0)	21 (1.1)	15 (.6)	2 (0.1)	17 (2.3)	19 (3.6)
Breastfed	9 (0.3)	1 (0.1)	7 (0.3)	1 (0.1)	2 (0.3)	0
Feed type, *n* (%)[a]						
Formula	1488 (44.6)	467 (24.5)	1108 (43)	316 (22.8)	380 (50.2)	151 (28.8)
Solid foods	1993 (59.8)	1314 (68.8)	1578 (61.2)	951 (68.7)	415 (54.8)	363 (69.3)
Animal milk	803 (24.1)	584 (30.6)	659 (25.6)	402 (29.0)	144 (19.0)	182 (34.7)
Rice cereal	445 (13.3)	534 (28)	306 (11.9)	339 (24.5)	139 (18.4)	195 (37.2)
Breast milk	11 (0.3)	1 (0.1)	9 (0.4)	1 (0.1)	2 (0.3)	0
Special diet	77 (2.3)	53 (2.8)	38 (1.5)	19 (1.4)	39 (5.2)	34 (6.5)
Feeding difficulty, *n* (%)						
Feeding issue present	378 (11.3)	243 (12.7)	153 (5.9)	83 (6.0)	225 (29.7)	160 (30.5)
Aspiration	14 (0.4)	11 (0.6)	0	2 (0.1)	14 (1.9)	9 (1.7)
Difficulty sucking	27 (0.8)	16 (0.8)	4 (0.2)	0	23 (3.0)	16 (3.1)
Cough/chokes during feeding	57 (1.7)	25 (1.3)	17 (0.7)	0	40 (5.3)	25 (4.8)
Difficulty feeding self (>1 year)	119 (3.6)	103 (5.4)	8 (0.3)	18 (1.3)	111 (14.7)	85 (16.2)
Reflux/heartburn	6 (0.2)	5 (0.3)	2 (0.1)	0	4 (0.5)	5 (1.0)
Poor appetite	111 (3.3)	82 (4.3)	72 (2.8)	47 (3.4)	39 (5.2)	35 (6.7)
Frequent vomiting/ spitting up	19 (0.6)	8 (0.4)	7 (0.3)	1 (0.1)	12 (1.6)	7 (1.3)
Difficulty drinking from a cup (>1 year)	53 (1.6)	43 (2.3)	2 (0.1)	3 (0.2)	51 (6.7)	40 (7.6)

TABLE A1 (Continued)

Feeding profile	All children at baseline	All children at 1 year	Children without disabilities at baseline	Children without disabilities at 1 year	Children with disabilities at baseline	Children with disabilities at 1 year
Difficulty swallowing	63 (1.9)	50 (2.6)	3 (0.1)	0	60 (7.9)	50 (9.5)
Difficulty chewing	91 (2.7)	82 (4.3)	8 (0.3)	1 (0.1)	83 (11.0)	81 (15.5)
Picky eater	69 (2.1)	44 (2.3)	35 (1.4)	19 (1.4)	34 (4.5)	25 (4.8)
Food allergy/ intolerance	14 (0.4)	8 (0.4)	10 (0.4)	5 (0.4)	4 (0.5)	3 (0.6)
Bad teeth (> 1 year)	22 (0.7)	24 (1.3)	9 (0.4)	4 (0.3)	13 (1.7)	20 (3.8)
Other	5 (0.2)	1 (0.1)	2 (0.1)	0	3 (0.4)	1 (0.2)
Supplements, *n* (%)[a]						
Currently taking food supplements	225 (6.8)	42 (2.2)	157 (6.1)	15 (1.1)	68 (9.0)	27 (5.2)
Currently taking mineral/vitamin supplements	1626 (48.8)	847 (44.4)	1176 (45.6)	572 (41.3)	450 (59.5)	275 (52.5)
Complete multivitamin	219 (6.6)	232 (12.2)	164 (6.4)	177 (12.8)	55 (7.3)	55 (10.5)
Vitamin A	231 (6.9)	192 (10.1)	148 (5.7)	123 (8.9)	83 (11)	69 (13.2)
Vitamin B_{12}	191 (5.7)	123 (6.4)	132 (5.1)	64 (4.6)	59 (7.8)	59 (11.3)
Zinc	206 (6.2)	89 (4.7)	168 (6.5)	56 (4.0)	38 (5.0)	33 (6.3)
Lysine	30 (0.9)	15 (0.8)	30 (1.2)	14 (1.0)	0	1 (0.2)
Iron	271 (8.1)	109 (5.7)	242 (9.4)	83 (6.0)	29 (3.8)	26 (27.1)
Vitamin C	960 (28.8)	517 (27.1)	733 (28.4)	324 (23.4)	227 (30.0)	193 (36.8)
Vitamin B complex	247 (7.4)	146 (7.7)	166 (6.4)	72 (5.2)	81 (10.7)	74 (14.1)
Calcium	801 (24.0)	213 (11.2)	542 (21.0)	117 (8.5)	259 (34.2)	96 (18.3)
Fish oil/omega 3/EPA/DHA	1 (0.03)	3 (0.2)	0	3 (0.2)	1 (0.03)	0
Vitamin D	775 (23.2)	264 (13.8)	512 (19.9)	161 (11.6)	263 (34.7)	103 (19.7)
Folate	102 (3.1)	101 (5.3)	84 (3.3)	49 (3.5)	18 (2.4)	52 (9.9)
Probiotics	12 (0.4)	5 (0.3)	12 (0.5)	5 (0.4)	0	0
Other	238 (7.1)	147 (7.7)	196 (7.6)	104 (7.5)	42 (5.6)	43 (8.2)
Illnesses/symptoms, *n* (%)[a]						
Fever	438 (13.1)	193 (10.1)	295 (11.4)	121 (8.7)	143 (18.9)	72 (13.7)
Constipation	40 (1.2)	13 (0.7)	22 (0.9)	0	18 (2.4)	13 (2.5)
Diarrhoea	172 (5.2)	40 (2.1)	116 (4.5)	23 (1.7)	56 (7.4)	17 (3.2)
Nausea/vomiting	163 (4.9)	32 (1.7)	111 (4.3)	20 (1.5)	52 (6.9)	12 (2.3)
Cough/cold	722 (21.6)	395 (20.7)	489 (19.0)	222 (16.2)	233 (30.8)	173 (33.0)
Hospital	135 (4.0)	45 (2.4)	64 (2.5)	26 (1.9)	71 (9.4)	19 (3.6)

(Continues)

TABLE A1 (Continued)

Feeding profile	All children at baseline	All children at 1 year	Children without disabilities at baseline	Children without disabilities at 1 year	Children with disabilities at baseline	Children with disabilities at 1 year
Anaemia status, *n* (%)	*N* = 2828	*N* = 1511	*N* = 2167	*N* = 1101	*N* = 661	*N* = 410
None	2065 (73.0)	1314 (87.0)	1604 (74.0)	969 (88.0)	461 (69.7)	345 (84.2)
Mild	438 (15.5)	136 (9.0)	346 (16.0)	102 (9.3)	92 (13.9)	34 (8.3)
Moderate	307 (10.9)	59 (3.9)	212 (9.8)	30 (2.7)	95 (14.4)	29 (7.1)
Severe	18 (0.6)	2 (0.1)	5 (0.2)	0	13 (2.0)	2 (0.5)
Body mass index for age *z*-score, *n* (%)	*N* = 3113	*N* = 1790	*N* = 2408	*N* = 1312	*N* = 705	*N* = 478
Risk of overweight or obesity (>+1 SD to ≤5)	361 (11.6)	226 (12.6)	286 (11.9)	172 (13.1)	75 (10.6)	54 (11.3)
Normal weight (−2 to +1 SD)	2305 (74.0)	1404 (78.4)	1882 (78.2)	1051 (80.1)	423 (60.0)	353 (73.9)
Thin/underweight (<−2 to −3 SD)	291 (9.4)	119 (6.7)	175 (7.3)	73 (5.6)	116 (16.5)	46 (9.6)
Severe thinness/underweight (<−3 to ≥−5 SD)	156 (5.0)	41 (2.3)	65 (2.7)	16 (1.2)	91 (12.9)	25 (5.2)

[a]Not mutually exclusive variables.

TABLE A2 Young children feeding behaviour observations at baseline and evaluation

Young children feeding behaviour observations	15 observations	32 observations	Fisher's exact (two-sided) *p*-value	Qualitative summary
	Baseline	Evaluation		Length of feeding: 5–30 min
	n/*N* (%)	*n*/*N* (%)		
Cleans hands before feeding using hand sanitiser or hot, soapy water	4/10 (40)	8/15 (53)	0.688	Limited handwashing observed; feeding on only organization's schedule; feeding cues not observed by caregivers; multiple children fed at the same time; force feeding; limited self-feeding; caregivers are attentive to children; environments were calm, quiet and appropriately lit
Cleans/assists with cleaning young children's hands before mealtime	4/11 (36)	6/14 (42.9)	1	
Caregiver does not leave young children unattended during mealtimes	14/14 (100)	29/31 (93.5)	1	
Caregiver supervises and assists young children (<3 years) with using a spoon or cup	11/12 (91.6)	15/24 (62.5)	0.115	
Caregiver allows older children (>3 years) to feed themselves with minimal assistance	10/11 (90)	12/14 (85.7)	1	
Caregiver feeds when the child is showing signs of hunger	8/9 (80)	22/27 (81.4)	1	
Caregiver stops feeding infants when showing signs of fullness	11/12 (91.6)	25/29 (86.2)	1	
Caregiver allows young children to decide how much they will eat	6/12 (50)	5/17 (29.4)	0.438	
Caregiver feeds one child at a time	6/12 (50)	10/21 (47.6)	1	
Caregiver does not allow multiple children to use the same spoon, cup or dish	5/6 (83)	9/14 (64.3)	0.613	
Caregiver cleans hands after mealtime using hand sanitiser or hot, soapy water	6/10 (60)	10/14 (71.4)	0.673	
Caregiver cleans/assists with cleaning young children's hands after mealtime	6/11 (54)	16/22 (72)	0.437	
The caregiver allows ample time for the child to appropriately and safely eat/swallow each bite	No observations completed	3/6 (50)	-	
The caregiver appropriately feeds the child at the child's pace	7/9 (80)	4/12 (40)	0.080	
The caregiver cleans/assists with cleaning children's hands after mealtime (yes = desired)	1/6 (16)	5/8 (62.5)	0.138	

TABLE A3 Infants bottle-feeding behaviour observations at baseline and evaluation

Bottle-feeding behaviour observations	11 observations	33 observations	Fisher's exact (two-sided) *p*-value	Qualitative summary
	Baseline	Evaluation		Length of feeding: 5–30 min
	n/*N* (%)	*n*/*N* (%)		
Caregiver cleans hands before feeding using hand sanitiser or hot, soapy water	0/4 (0)	5/19 (26.3)	0.539	Limited handwashing observed; frequent bottle propping of infants; frequent cut nipples on bottles; cereal or porridge added to bottles; limited adaptive bottles or bottles for premature infants; feeding on only schedule; hunger cues not observed by caregivers; multiple children fed at the same time; limited or no burping observed and children laid down after meals; environments were calm, quiet and appropriately lit
Caregiver properly positions infant in a semi-upright/upright position in their arms for feeding	5/8 (45.5)	14/19 (73.7)	0.658	
Caregiver offers only formula or milk in the bottle	9/11 (81)	30/33 (90)	0.586	
Caregiver does not mix rice cereal and formula in the bottle	7/10 (70)	26/29 (89.7)	0.049	
Caregiver does not cut large holes in bottle nipples	7/10 (70)	25/29 (86.2)	3.44	
Caregiver uses adaptive bottles when appropriate	2/6 (30)	4/11 (36)	1	
Caregiver feeds infant on demand	9/10 (90)	7/16 (43.8)	0.037	
Caregiver checks milk temperature before feeding an infant	6/7 (85.7)	13/22 (59)	0.367	
Caregiver feeds one infant at a time	8/11 (72)	24/31 (77.4)	1	
Caregiver does not share bottle or formula among multiple infants	8/10 (80)	26/26 (100)	0.071	
Caregiver burps infant before lying down or keeps an infant in a semi-upright/upright position for at least 15 min following feeding	6/8 (75)	11/27 (40.7)	0.121	
Caregiver cleans hands after feeding using hand sanitiser or hot, soapy water	2/5 (40)	1/15 (6)	0.140	

Chapter 5: Evaluation of the Process of the Implementation of CNP (Paper 4)

5.1 Scope of Chapter

This chapter presents the fourth research paper titled "Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process." This work is published in Children. We will publish this paper as an open access article under the Creative Commons Attribution Non-Commercial License. Although the research was not funded, research was no cost because of discounts from the journal.

This paper describes the implementation of Holt's Child Nutrition Program. This is a nutrition and feeding intervention program aimed to address the needs of vulnerable children and their caregivers through training, resources and support. The primary aim of this paper is to describe the implementation process of CNP in Mongolia and the Philippines, two countries which have seen substantial growth in the program but operate in different contexts.

5.2 List of figures

5.3 List of tables

Table 3: Summary of key elements needed for implementation at a site level and a country level and multinational implementers level from KIIs. This checklist provides guidance to implementers at each level of key elements needed for program implementation.

Annex Table 1: Prevalence of Desired Answers of Knowledge, Attitude and Practice Surveys (KAPS) from Pre-training and Post-training in Mongolia. Knowledge Questions are Yellow, Attitude Questions Red and Practice Questions Green.

Annex Table 2: Prevalence of Desired Answers of Knowledge, Attitude and Practice Surveys (KAPS) from Pre-training and Post-training in the Philippines. Knowledge Questions are Yellow, Attitude Questions Red and Practice Questions Green.

Annex Table 3: Summary of the Implementation Process of the Child Nutrition Program based on the WHO's Health System's Framework and Monitoring and Evaluation of Health Systems.

Supplement 1: TREND Statement

Supplement 2: Interview Question Outline

5.4 Citation

DeLacey, E.; Tann, C.; Smythe, T.; Groce, N.; Quiring, M.; Allen, E.; Gombo, M.; Demasu-ay, M.; Ochirbat, B.; Kerac, M. Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process. Children 2022, 9, 1965. https://doi.org/10.3390/children9121965

5.5 Research Paper

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed <u>for each</u> research paper included within a thesis.

SECTION A – Student Details

Student ID Number	lsh1804647	**Title**	Ms
First Name(s)	Emily		
Surname/Family Name	DeLacey		
Thesis Title	The Nutritional and Feeding Status of Children Living within Institution-based Care and an Evaluation of Process of the Child Nutrition Program.		
Primary Supervisor	Marko Kerac		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?	Children https://www.mdpi.com/2227-9067/9/12/1965		
When was the work published?	December 14th, 2022		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	Open access	Was the work subject to academic peer review?	Yes

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	Emily DeLacey, Cally Tann, Tracey Smythe, Nora Groce, Michael Quiring, Elizabeth Allen, Maijargal Gombo, Merzel Demasu-Ay, Batbayar Ochirbat, Marko Kerac

Stage of publication	**Published**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	Emily DeLacey, Marko Kerac and Cally Tann designed the study. Emily DeLacey, Marko Kerac, Tracey Smythe, Elizabeth Allen, Michael Quiring, Cally Tann, Nora Groce, Maijargal Gombo, and Merzel Demasu-Ay contributed to specific areas of the methods, data analysis, statistics and quality control. Emily DeLacey, Michael Quiring, Merzel Demasu-Ay, Maijargal Gombo had access and verified the data. Emily DeLacey led the data analysis and writing of the first draft of the manuscript. Emily DeLacey, Marko Kerac, Tracey Smythe, Michael Quiring, Cally Tann, Nora Groce, Batbayar Ochirbat, Merzel Demasu-Ay, Elizabeth Allen and Maijargal Gombo contributed to the writing of the manuscript and agree with the manuscript's results and conclusions. All of the authors have read and approved of the submitted manuscript.

SECTION E

Student Signature	Emily DeLacey
Date	June 6 2022

Supervisor Signature	Marko Kerac
Date	June 21, 2022

children

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Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process

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Abstract: Nutrition and feeding interventions are important for children's growth and development. Holt International's Child Nutrition Program (CNP) is a child nutrition and feeding intervention. This study aims to describe and explore the implementation of CNP in Mongolia and the Philippines using mixed methods including qualitative and quantitative data analysis. The analysis framework was guided by the WHO's Monitoring the Building Blocks of Health Systems. Key informant interviews (KIIs) were conducted, transcribed, translated and coded. Knowledge, Attitude and Practice Surveys (KAPS) and pre-/post-tests from routine program audit data were analyzed. Analysis of nutrition (Mongolia: 95% CI: 7.5-16.6 ($p = < 0.0001$), Philippines: 95% CI: 7.6-15.7 ($p = < 0.0001$)) and feeding (Mongolia: 95% CI: 11.7-23.9 ($p = < 0.0001$), Philippines: 95% CI: 6.6-16.9 ($p = < 0.0001$)) tests indicate improvement post-training in both countries. KAPS indicate changes in desired practices from pre-training to post-training. Thematic analysis of KIIs highlight essential components for program implementation and effectiveness, including strong leadership, buy-in, secure funding, reliable supply chains, training and adequate staffing. This evaluation of program implementation highlights successful strategies and challenges in implementing CNP to improve the health of children in Mongolia and the Philippines. Lessons learned from the implementation of CNP can inform growth of the program, scaling strategies and provide insights for similar interventions.

Keywords: child nutrition; caregivers; intervention programming; training of trainers; implementation; service and outcomes; child health; disease prevention

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1. Introduction

Millions of children around the world continue to suffer from malnutrition for reasons including inadequate access to nutritious food, feeding practices and poor hygiene and sanitation [1–4]. Nearly half of the deaths among children younger than 5 years old have undernutrition as a primary factor [1,3]. Malnutrition predisposes children to long-term impairments such as disability, impaired cognition, non-communicable diseases and suboptimal performance at school [1,3]. How children are fed can be just as impactful as what they are being fed because both nutrition and feeding difficulties can heighten children's malnutrition risk, especially for infants and children with disabilities [4–7]. Caregivers often need additional support to address children's individual nutrition and feeding needs, especially if the needs and strategies to support the child are unfamiliar to the caregiver [8,9]. There is need for interventions which support children's development and these programs need to be inclusive of children with disabilities and provide support to caregivers [6,8–10]. Evaluation of the implementation of such programs could provide insights into ways to enhance programs to better the outcomes for children and their caregivers [10–12].

Holt International is a 67-year-old child welfare non-profit working in 15 countries. In 2012, Holt identified that many of the children participating in its programs globally were at risk for malnutrition or experiencing malnutrition. Motivated to address this issue, Holt developed the Child Nutrition Program (CNP). The CNP works to address the critical nutrition, feeding, health and development needs of vulnerable children who are most at risk of malnutrition by providing training, resources and support for caregivers and sites providing care for children [13]. The program aims to improve individual and site level care practices. This program uses a Training of Trainers (ToT) approach in combination with formal assessment, monitoring and evaluation methods. Trained trainers who lead program implementation are considered CNP champions. The training enables caregivers and sites to conduct targeted interventions to address and prevent the causes of malnutrition, including undernutrition, overnutrition and micronutrient deficiencies for children, especially ages 0–5 and those with disabilities [14]. Training topics include child nutrition, feeding and positioning, hygiene and sanitation, growth monitoring, common illnesses, anemia screening, micronutrient deficiencies, disabilities and other development topics. The training is typically 5 days with a practicum and participants are selected by their sites and include staff from all positions. This program is implemented in community-based settings, foster care systems, health centers and institution-based care (IBC) [15]. After an initial site assessment, training is provided to site staff and caregivers followed by an evaluation and ongoing refreshment training and support from country level CNP teams. Training curriculum is standardized with some variations for context, such as maternal health and breastfeeding in community settings and formula feeding in IBC.

This study follows two retrospective analyses on the nutritional and feeding status of children who participate in the CNP [4,7]. This study aims to identify and explore key factors for program implementation through a mixed methods evaluation of process of the CNP in two countries—Mongolia and the Philippines.

Objectives

1. Describe and assess the implementation of the CNP in Mongolia and the Philippines;
2. Identify and describe the barriers, disruptions, enablers and solutions for implementation at a caregiver, site, country, multinational implementers and policy level;
3. Explore key factors important for implementation and growth of the CNP.

2. Materials and Methods

2.1. Ethics Approval

Ethical approval was obtained from the London School of Hygiene and Tropical Medicine (ref: 22865). The National Center of Public Health of Mongolia approved the research methodology/protocol and ethical approval was obtained from the Medical Ethics

Control Committee of the Mongolian Ministry of Health (ref: 230). Ethical approval was obtained from the St. Cabrini Medical Center-Asian Eye Institute Ethics Review Committee (SCMC-AEI) Ethics Review Committee in the Philippines (ref: 2021-002). We have reported according to the TREND statement (Supplementary Materials S1) [16]. A data use agreement was signed with Holt International for use of routinely collected de-identified program audit data. Both qualitative and quantitative data will be held indefinitely on Holt International's server.

2.2. Study Design

This study uses mixed methods to examine the implementation of a large multi-country nutrition and feeding intervention program. This study was designed by ED, MK, CT and TS and uses primary data collected by the principal investigator (PI), ED, and the CNP champions in Mongolia and the Philippines, in addition to secondary data from routine program audits of which all available data were used. The framework developed for this evaluation of process utilized a health systems approach guided by the WHO's Monitoring the Building Blocks of Health Systems: A Handbook of Indicators and their Measurement Strategies [17–19].

2.3. Setting/Study Size

The CNP currently operates in eight countries at 68 sites serving over 7500 children. Countries include China, India, Mongolia, the Philippines, Ethiopia, Uganda, Vietnam and Haiti. The program operates in community-based settings, foster care systems, health care facilities and IBC. Mongolia began program implementation in 2016 and the Philippines in 2017. In the Philippines, there are seven sites consisting of five IBC and two foster care programs. In Mongolia, there are 13 sites including 4 health centers, 3 IBC, 5 schools/daycare sites and 1 facility with IBC, in-patient and outpatient services. Mongolia and the Philippines were selected for analysis because of logistics and data availability.

2.4. Participants

This study utilized primary and secondary data. Participants in the primary data collection included key informants (KIs) who participated in key informant interviews (KIIs). KIs were selected using purposive sampling of one interviewee per site and per country program. The secondary data were collected during routine program audits. This data consisted of KAPS and nutrition and feeding pre-/post-training tests completed by staff at sites participating in the CNP as part of program implementation. These data components were analyzed using quantitative and qualitative methodologies and the findings were then combined to provide a broader synthesis of the CNP implementation.

2.5. Nutrition and Feeding Tests

The nutrition and feeding pre-/post-training tests were routine program audit data collected between 2016 and 2020 in Mongolia and the Philippines. The tests consist of questions on child nutrition and feeding information and practices which are covered in the CNP curriculum and training. The nutrition and feeding tests are repeated over time to identify areas of change and topics for future training for the program. The nutrition and feeding tests were analyzed from four collection time points: pre-training, post-training, six-months post-training/implementation and 1.5-years post-training/implementation, using descriptive statistics. Independent-samples *t*-tests were conducted comparing the unmatched pre-training and post-training tests (Table 1).

Table 1. Comparison of Unmatched Nutrition and Feeding Test Scores from Pre-training to Post-training, 6-month Post-training and 1.5-year Post-training using an Independent Samples *t*-test.

Mongolia														
	Nutrition							**Feeding**						
	Summary Statistics				**Independent Samples *t*-Test**			**Summary Statistics**				**Independent Samples *t*-Test**		
	N	Mean	Median	Mean Difference (%)	df	*p*-value	95% CI	N	Mean	Median	Mean Difference (%)	df	*p*-value	95% CI
Pre-training (Reference)	45	70.8	70	REF	REF	REF	REF	39	62.9	66.7	REF	REF	REF	REF
Post-training	42	82.9	85	12	85	<0.0001	7.5–16.6	34	80.7	83	17.8	71	<0.0001	11.7–23.9
6 Month Post-training	12	65.3	66.7	5.5	55	0.151	−13.2–2.1	12	55.6	58.3	7.3	49	0.185	−18.3–3.6
1.5 Year Post-training	39	74.8	73.9	4	82	0.143	−1.4–9.2	39	65.2	66.7	2.3	76	0.505	−4.5–9.1

Philippines														
	Nutrition							**Feeding**						
	Summary Statistics				**Independent Samples *t*-test**			**Summary Statistics**				**Independent Samples *t*-test**		
	N	Mean	Median	Mean Difference(%)	df	*p*-value	95% CI	N	Mean	Median	Mean Difference (%)	df	*p*-value	95% CI
Pre-training (Reference)	63	66.4	68.2	REF	REF	REF	REF	63	68.1	73.3	REF	REF	REF	REF
Post-training	58	78	80	11.7	119	<0.0001	7.6–15.7	57	79.9	86.7	11.8	118	<0.0001	6.6–16.9
6 Month Post-training	29	82.7	82.6	16.4	90	<0.0001	10.9–21.8	29	77.5	80	9.3	90	0.004	3.1–15.6
1.5 Year Post-training	19	82.1	84.8	15.7	80	<0.0001	9.9–21.5	20	77.3	83.3	9.2	81	0.019	1.5–16.8

2.6. *Knowledge Attitude and Practice Surveys*

The knowledge, attitude and practice surveys (KAPS) were collected during routine program audits prior to the site being trained in the CNP and after sites were trained between 2016 and 2020 in Mongolia and the Philippines. The KAPS were completed by staff of all levels at sites participating in the CNP. The surveys provide feedback to the program about participants knowledge, attitudes and practices in key programmatic areas. The surveys are routinely completed as part of program monitoring and evaluation systems and are used to track changes over time and inform trainers of key areas for training, as well as areas to support site implementation. The KAPS included respondent demographics and questions about nutrition, feeding, health, growth monitoring, disability, child development, hygiene and sanitation. There were a total of 25 questions; 11 knowledge-based questions, 5 attitude-based questions and 9 practice-based questions. As some of the questions reflected participants' views and there were not "correct" answers, we summarized the KAPS using the program's previously identified "desired" answers out of the total number of responses (Tables 2, A1 and A2). Each question is color coded by its domain: knowledge questions in yellow, attitude questions in red and practice questions in green. The "desired" answer is specified in parentheses following the question (Tables A1 and A2).

Table 2. Change in Desired Answers of Knowledge, Attitude and Practice Surveys Between Pre-training and Post-training Using a Fisher's Exact Test.

Mongolia			
Knowledge, Attitude and Practice Survey			
	Observations Pre-training (n/N)	Observations Post-training (n/N)	Two-sided Fisher's Exact test
Knowledge	73.8% (107/145)	67.9% (57/84)	$p = 0.749$
Attitude	70.2% (40/57)	60% (24/40)	$p = 0.742$
Practice	58.6% (75/128)	81.9% (59/72)	$p = 0.170$

Table 2. *Cont.*

Mongolia			
Knowledge, Attitude and Practice Survey			
Overall	67.2% (222/330)	71.4% (140/196)	$p = 0.673$
Philippines			
Knowledge, Attitude and Practice Survey			
	Observations Pre-training (n/N)	Observations Post-training (n/N)	Two-sided Fisher's Exact test
Knowledge	70.1% (499/712)	72.5% (116/160)	$p = 0.839$
Attitude	61.8% (170/275)	66.1% (43/65)	$p = 0.826$
Practice	69.9% (356/509)	81.5% (97/119)	$p = 0.318$
Overall	68.5% (1025/1496)	74.4% (256/ 344)	$p = 0.380$

2.7. Key Informant Interviews

The semi-structured KIIs were designed and pretested by the PI (ED) and the two CNP champions who are lead trained trainers and manage the program in the Philippines and Mongolia (Supplementary Materials S2). The in-depth interviews consisted of open-ended questions on program implementation at the site or country level depending on interviewee (approximately 25–30 questions with prompts). Key informants were identified for participation by the CNP champions because they were site directors or lead staff who oversee the CNP implementation at their sites. The KIs had preexisting professional relationships with the CNP champions related to program participation. One informant from each site was identified for interview by the CNP champion in their respective countries.

The CNP champions received interview training and practice prior to conducting interviews. All interviewees were provided and signed participant information and consent forms via DocuSign (DocuSign, Inc., San Francisco, CA, USA 2021) prior to the interviews. Interviews were conducted via password protected Zoom (Version 5.9.6, 2021). Interviews were transcribed, de-identified and then translated and shared with the PI (ED). The PI (ED) interviewed the two CNP champions on country level implementation. ED is the director of CNP, a lead trainer, has trained in all implementing countries and maintains relationships at the country level and site level.

2.8. Statistical Analysis

2.8.1. Quantitative Methods

All quantitative statistical analyses were conducted using Stata (16.1, StataCorp LLC, College Station, TX, USA) and Microsoft Excel (2013). Independent-samples *t*-tests were used to compare the independent nutrition and feeding pre-training and post-training tests (Table 1 and Figure A1). A bar graph is used to notate the mean and confidence intervals for nutrition and feeding tests at pre-training, post-training, 6-month post-training/implementation and 1.5-years post training/implementation time points (Figure A1).

Descriptive statistics were produced to summarize the independent KAPS. Respondent demographics and the frequency and percent of desired answers prior to training and after training are presented. A two-sided Fisher's Exact test was used to assess whether there was any difference in the domains (knowledge, attitude and practice) from pre-training compared to post-training (Table 2).

Demographic information of key informants who participated in the KIIs is presented.

2.8.2. Qualitative Methods

The qualitative data from semi-structured interviews were analyzed with descriptive coding for thematic content using NVivo 21 (released March 2020) and following the COREQ checklist [20]. The coding framework was developed to examine the KIIs with a health systems approach, which was guided by the WHO's Monitoring the Building Blocks of Health Systems and its monitoring and evaluation of health systems strengthening [17]. The coding framework helped to process and systematically categorize qualitative data to identify themes and patterns in the interviews related to the process of implementation of the CNP. Defining and naming themes and grouping themes into categories were done by the PI with review by other co-authors. Codes were categorized and sub-codes were created. As key themes emerged, codes were consolidated.

Following the WHO's monitoring and evaluation of health systems strengthening inputs, processes, outputs, outcomes and impact were summarized by each of the six building blocks (Table A3). Additionally, a qualitative conceptual framework analysis of responses on barriers/disruptions and facilitators/solutions to implementation of the CNP was created by adapting the socioecological model produced by Rao et al., with areas identified by the analysis guided by the WHO's health systems framework and building blocks (Figure 1) [21]. The information was further organized based on five levels: caregiver, site, country, multinational implementer and policy levels. For each level, facilitators/solutions and barriers/disruptions for implementing the CNP were identified.

Figure 1. Synthesis of Barriers/Disruptions and Analysis of Facilitators/Solutions to the Implementation of CNP from the KIIs According to Levels of Conceptual Framework.

3. Results

In both Mongolia and the Philippines, the CNP was implemented at sites following standard program implementation starting with a formal assessment followed by a training and evaluation. After the evaluation, country level CNP staff provided ongoing support to sites and caregivers with additional training, resources and monitoring and evaluation systems. There were two main differences in context between Mongolia and the Philippines—the types of sites and who is trained. In Mongolia, many of the sites are health centers and daycares or schools for children with disabilities, which engage children's caregivers, including mothers and fathers, and teachers or health center staff in training. In the Philippines, there are more IBC and foster care programs than in Mongolia, therefore training participants are primarily foster care parents or IBC staff.

3.1. Nutrition and Feeding Tests

Analysis of the unmatched nutrition (Mongolia: 95% CI: 7.5–16.6 ($p \leq 0.0001$), Philippines: 95% CI: 7.6–15.7 ($p \leq 0.0001$)) and feeding (Mongolia: 95% CI: 11.7–23.9 ($p \leq 0.0001$), Philippines: 95% CI: 6.6–16.9 ($p \leq 0.0001$) tests suggest an improvement in knowledge and practices in both countries between the pre- and post-training (Table 1 and Figure A1). Additionally, there was a difference from the Philippines nutrition pre-training test to the 6-month post-training (95% CI: 10.9–21.8, $p \leq 0.0001$) and 1.5-year post-training (95% CI: 9.9–21.5, $p \leq 0.0001$). Differences at other test points may be due to chance, possibly related to changes in sample size or that the tests takers at different time points may not be the same.

3.2. Knowledge Attitude and Practice Surveys

In total, 98 KAPS were analyzed. From the Philippines, there were 60 pre-training and 15 post-training KAPS from five sites. From Mongolia, there were 15 pre-training and 8 post-training KAPS collected from one site. Of the respondents from both countries, 96/98 (98%) were women and 65/98 (66%) had attended a university, graduate or professional school (Tables A1 and A2). For Mongolia, the median age of respondents was at pre-training 42 years (IQR: 37–49 years) and post-training 43.5 years (IQR: 32–45.5 years). The majority of respondents in Mongolia had worked for more than 6 years (10/15, 66.7%) at pre-training and post-training the majority had worked for less than 6 years (6/8, 75%). In the Philippines, the median age of respondents was at pre-training 44 years (IQR: 32–50 years) and post-training 44 years (IQR: 37–49 years). The majority of respondents in the Philippines had worked for more than 6 years (35/60, 58.3%) at pre-training and post-training the majority had worked for less than 6 years (9/15, 60%).

There was an increase in desired answers from the practice domain and overall from the pre-training to post-training for both countries consistent with a positive change in implementation of practices. (Table 2). The Philippines saw an increase in desired answers from all three KAPS domains from pre-training to post-training. However, there were no statistically significant differences in KAPS outcomes after the training. This may be due to limitations of the samples such as change in sample size and the independences of the pre-training and post-training samples. Analysis of the KAPS in this study indicate that caregivers may need additional training and reinforcement, which is supported by the KIIs, which mention frequent training and retraining and integration of practices as essential to maintaining a high level of standardized program implementation.

3.3. Key Informant Interviews

In Mongolia, 13 site directors or key staff and one CNP champion were invited to participate in KIIs, of which 10 staff from different sites and one CNP champion were interviewed. In the Philippines, eight individuals were invited to participate of which six agreed to participate. The six KIIs were conducted with individuals from five different sites and one interview was conducted with the CNP champion of the Philippines. All of the KIs were female. Of the types of sites, seven were from IBC facilities, six were community-based programs, such as schools for children with disabilities, one was a health center and a final site was a hospital that offers IBC, day-care/community services and inpatient/out-patient clinical services for children. KIs had participated in the CNP a median time of three years (IQR: 2–5 years) and their sites had participated for a median of four years (IQR: 2–5 years). The CNP champion in Mongolia has led the CNP for six years and the champion in the Philippines for four years.

Analysis of the KIIs identified key barriers/ disruptions, facilitators and solutions to implementation (Figure 1). Key barriers identified included inadequate funding, insufficient supply chains, limited staffing and technology limitations. Key facilitators included partnerships, support, training, program buy-in from government officials and staff, secure supply chains, integration of practices and collaboration. The full analysis of the KIIs on the implementation is included in Table A3 [17]. The data were summarized and presented with guidance by the WHO's health systems framework and building blocks. Additionally, key elements identified as essential for implementation at site, country and multinational implementers levels emphasize the need for clear communication, including memorandums of agreement or contracts with sites and partners (Tables 2 and A3). Strong relationships and frequent training were also identified as essential elements at all levels. KIs recommended that for the CNP to be successful, sites and CNP program managers need to leverage sites' commitment and success to advocate for growth through regional government leaders, as invested sites can share the value of the program and its impact. Sites sharing about the program could create traction for buy-in or interest from regional government leaders, translating into program growth at sites and buy-in to engage new sites in implementing the CNP.

3.3.1. Training and Behavior Change

Frequent training and retraining for all staff at the sites were the most frequently mentioned factors for sustained standardized program implementation over time. Training was reported as driving behavior change at a caregiver and site level.

> *"Since they were able to attend training and they know what its benefit is, I feel like the house parents can be encouraged to really do the practice,"—CNP Site Director*

> *"Our employees' passion and care for children, especially special needs [children with disabilities], have increased and changed positively. We learned to feed a child with swallowing and chewing difficulties. Children with disabilities, especially CP [Cerebral palsy], were fed with only very thin "liquidish" pureed food by bottles when they lay on their back. Now, we all use proper positioning as possible as their physical condition lets and feed them with proper food texture using cut out cups or maroon spoons adjusted with their abilities. We used to tell our children to sit quietly during meal times, but now we encourage them to communicate and interact with each other and our teachers improved their intention to interact with special needs kids,"—CNP Site Director*

3.3.2. Technology and Health Screenings

Technology, such as lack of access to the internet or computers, was identified as a key barrier to implementation. As part of implementing the CNP, sites are supported with supplies and access to the internet when needed and provided an electronic nutrition screening database. Use of the nutrition screening database was reported as an essential piece for implementation for both sites and country level implementers. The database allows sites to track and monitor children's health and growth through analysis of health records. Participants frequently reported database use as a valuable tool in making other parts of their roles easier. Informants mentioned valuing the database due to its simplicity for monitoring and reporting of nutrition and health data which improves user experience and supports sites' ability to easily report information to local government systems.

> *"We realize and see many positive changes in children's health and development since implementing CNP at our site. We never had such [a] monitoring system and methods before. Now we can see the growth and nutrition progresses using CNP database. Children's nutrition intakes and feeding quality were much improved and so their health condition became better,"—CNP Site Director*

3.3.3. Program Understanding and Buy-in

Buy-in was also frequently noted as a key element to implementation. Buy-in and understanding of the program and its value to children is needed at all levels, including for caregivers, site staff, site leadership and other key stakeholders, such as local government. To achieve this, KIs suggested sharing of success from already existing programs, engagement of other stakeholders in training (i.e., parents or government officials or other organizations) and ensuring participatory training is part of the onboarding process for all of the new staff.

"We try to organize some CNP trainings in extended scope and we intend to introduce the CNP to every one of the whole organization and we try to involve all level staff, including directors and also executive staff, also the children's parents who have disabled children. We try to involve everyone who participates in taking care of the children. So I think it's very important to make them understand of CNP,"—CNP Champion

"Maybe we can best achieve that [buy-in] by also, although we've done that already. We've sought help of the center head so it's the sites' leadership, so whenever we go to the regional director, we have center head with us, so that it's not just KBF or Holt going to the regional office but also the center head. The sites and the sites' center head goes along with us and shows that the site really has the need. So it goes two ways I think—so we connect the higher officials with the senior leadership and then we seek the support of the center head, so that we can have the center head share about the need and then she or he is able to go to the senior leadership and then say that, 'Yeah this program is needed [at the site], and we really need it and that's why we're here to seek your support as well, so that whenever we need something we can ask you and can request anything from the senior leadership [government].' Yeah, so I think that's one way,"—CNP Champion

3.3.4. Alignment of Program with Site and Country Goals

KIs identified that the aims and objectives for nutrition programs or other services for children need to fit within sites and countries goals.

"CNP complies with our organization's medium-term strategic plan and the organization's child protection policy by identifying barriers to learning, development and quality of life for every child with a disability that will have a positive impact on the child's development and growth. It is also in line with the Mongolian Government policy for 2020-2024 program, 'Vision-2050′—Mongolia's long-term development policy, State Education Policy for 2014-2024 programs, the Convention on the Child Rights, the Child Protection Law and government resolutions,"—CNP Champion

3.3.5. Diversification of Funding

Funding was identified as necessary to implementation with a lack of diverse or secure funding being a key barrier. Often, funding or gifts-in-kind did not match site priorities. For example, sites received cookies instead of needed diapers, fruits or vegetables.

"We found that it's good to have partnership[s] with outside entities. We don't want to be too dependent on one— because it's very constricting. We're boxed into the budget we receive,"—CNP Site Director

"When there are donors, it's like—more on, not really for the kitchen or stocks, especially diapers, things like that. That's the priority of the institution. Diapers, milk—things like that,"—CNP Site Director

3.3.6. Partnerships and Agreements

In both countries, implementation of this program worked top down from government relationships and bottom up from site level partnerships. KIIs reported a high value in signing agreements with clear expectations of all parties, including government agencies, suppliers and sites. Quality implementation and sustainability of the program correlated with government support, site partnerships and quality relationships with key stakeholders. Some of the sites have received recognition/awards from the government for their overall center quality, which included implementation of the CNP. This was reported to help to reinforce site commitment to the program.

"We have reached not only the center head of the site, but also the regional directors so we conducted meetings with them and then we've made memorandum of agreement with them, though there's like it's not implemented right to the right for every word for word that's in there but we have to be flexible, with what the site needs, but I think the partnership is there and in trusting each other to conduct this together and troubleshoot

or whenever there's like this needed help/there's needed assistance, we can support each other in a way on how to make CNP doable for everyone,"—CNP Champion

3.3.7. Dissemination and Growth

Dissemination and raising awareness about the program and its benefits was identified as essential for program growth. Sites that requested the program were noted to have high levels of implementation. These sites often referred new sites to the country level CNP staff to utilize the program based on the impact it has on children's development at their site. KIs suggested engaging site directors from currently implementing sites into meetings with government officials, new potential sites and other stakeholders to share about program operation and impact. Additionally, the need for advocacy and awareness of the program was identified with suggestions to develop a focused media strategy and better share about research on the program with wider audiences.

"And I think one step for that, aside from the ongoing attempt to expand this to [new CNP sites], we plan also for gathering existing current champions and creating a best practices manual or anything that can be shared to anyone to see how CNP has been successful here. So I think my vision is something like that, so we can easily inform other people and other sites about CNP so that acceptance of the program can be easier," —CNP Champion

"I think it will be very helpful to involving some of those Public Health National Center and also Health Ministry and Educational Ministry and Social Welfare Ministry people for their attention because you know, Mongolia has like straight line managing system, so those ministries are the most upper level supervising and managing and also developing strategy and policies for those sites, so I think their involvement would be helpful to scaling our program because CNP has lots of benefits for those vulnerable population," —CNP Champion

"Maybe we can find someone who can somehow make nice about the CNP and really put CNP out there. Really make it popular somehow or make it really known to most people because, like when we think of businesses, when we think of important information we've been to like make it like trending or sensationalize . . . to put it out there, to really make it known in a way. Like maybe have someone who's good at communication [or] publishing. And maybe for this research as well. If this research goes well and it finishes, then we can publish it further and then share with the scientific bodies, the experts and then show them [the value of the CNP],"—CNP Champion

4. Discussion

Exploration of the implementation of the CNP in Mongolia and the Philippines provides key insights that have the potential to increase the sustainability of the CNP interventions and improve implementation. The goal of this research was to be relevant and practical for implementers of CNP and potentially inform wider nutrition and feeding interventions. This research informs CNP staff, partners and similar programs on implementation strategies, as well as areas for future research.

Interviews with CNP champions and lead site staff provided key insights for implementation in the different contexts in which the CNP operates (Figure 1, Tables 3 and A3). They identified many commonalities of barriers/disruptions regarding funding, staffing, dependence on donations, supply chains, COVID-19, reinforcement of site-wide practices and behavior change (Figure 1). In both countries, many KIs reported frequent training, integration of practices into site systems, incentives, strong local government relationships and strong oversight of implementation were facilitators/solutions to implementation at their sites. Securing diverse funding, strong partnerships, frequent communication, appropriate technology, routine monitoring and evaluation systems helped to mitigate disruptions related to staffing or leadership turnover, COVID-19, inflation and inadequate supply systems. Similarly to other research on implementation, we found the quality of implementation and sustainability of the program was related to strong leadership, frequent oversight, quality relationships, clear partnerships, training and government support, which are congruent with recommendations from the World Health Organization [11,22,23]. For the CNP, implementation of the program in different site types (community, foster-care, health centers and IBC) and country contexts highlights the adaptability of the program and the universal value of core nutrition and feeding training and education for caregivers [10]. KIs reported some of the success of CNP in their countries was due to the program fitting within the country's goals for child nutrition and development, which made it easier to promote with local and regional governments [24,25].

Table 3. Summary of key elements needed for program implementation at the site level, the country level and the multinational implementers level identified from the KIIs.

Key Elements Needed for Implementation of the CNP
Multinational Implementers Level
• Strong relationships with partners, country programs and other key stakeholders • Secure and adequate funding in addition to identification of new funding or partnerships for growth opportunities • Organizational buy-in • Integration of research • Strong and clear program communication • Accountable and informative multi-level monitoring and evaluation systems • Strategic plans for advocacy and awareness efforts
Country Level
• Strong relationships with partners, local government, and other key stakeholders • Clear memorandum of agreements with sites • Secure and adequate funding • Appropriate technology • Identification of new opportunities for growth of program • Frequent communication and refresher trainings for sites • Access to strong in-country supply systems • Strong implementation of monitoring and evaluation systems
Site Level
• Access to reliable supply chains • Frequent training and retraining for staff • Buy-in from site leadership • Adequate staffing and integration of program into staff onboarding • Internet and technology resources are available • Secure and adequate funding and diversification of funding • Integration of program into site practices and workflow • Clear guidance and support for staff • Frequent review and oversight of sitewide behavior change and practices

Our findings show that successful sustained implementation of the CNP requires behavior change at both a caregiver level and a site-wide level. At both levels, behavior change was strongly linked to frequent training, hands-on practicums, clear roles and responsibilities, support, access to resources and adequate staffing. Similar to other programs, such as Ubuntu, Baby Ubuntu and Juntos, the CNP is structured to provide participatory training, resources and support to caregivers [12,26,27]. Training for caregivers can have a substantial impact on their behaviors, practices and feelings of support [5,8,10]. Participatory training, such as the CNP, can result in improved quality of life for caregivers and support them to improve practices and keep children healthy [10]. These findings are comparable to those reported by other programs, such as Ubuntu/Getting to Know Cerebral Palsy (CP), which found that with support and training, caregivers can have positive changes in their attitudes toward the children they care for and an improved understanding of children's needs [8,10,12]. Similar to findings from Ubuntu, we found that caregivers can make significant gains in their knowledge and confidence in caring for children from participating in the CNP [8,10,12]. Building confidence in abilities for caregivers or staff at all levels was suggested by KIs as a key factor in implementation success [8,10,12,23]. Participating in the CNP also added value to caregivers' personal lives in terms of use of practices at home, in the community and in their professional careers. As program managers move through the building blocks of the program health systems, they need to consider how behavior change methods can be integrated into their inputs and processes to achieve desired outcomes and improve impact [17,22,23].

Taking into consideration the results from the KIIs, KAPS, and nutrition and feeding pre-/post-training tests, behavior change and maintaining high quality implementation and integration takes ongoing support, frequent training and reinforcement (Table 2) [8]. Using insights from this research, currently implementing CNP sites and countries can review their implementation strategy for areas of reinforcement or improvement. This research indicates that for other similar nutrition and feeding programs, frequent training, building buy-in, support structures, involvement of key stakeholders, strong monitoring and evaluation need to be included in their program implementation.

Next steps will be to use this information to explore different contexts and to investigate how best to scale up the CNP in countries where it currently operates, as well as future countries (Table 2). Involving other key stakeholders in the process, including children, caregivers, community members and government officials, will be essential [11]. The next steps in growing the CNP could look to using scaling frameworks, such as the WHO's Nine Steps for Developing a Scaling-up Strategy, to determine how best to increase the range of impact of this program at both national and international levels [28]. Determining a scaling-up strategy could provide pertinent insights for expansion of the CNP and other similar programs.

Strengths and Limitations

This study adds to limited evidence on implementation of nutrition and feeding intervention programs. We used a mixed-methods health systems approach to provide a more comprehensive evaluation of the process of implementing the CNP. The research practices were built upon strong existing relationships and took cultural protocols into consideration. Using mixed methods and analysis of different aspects of implementation enabled the research methods to complement each other to understand a complex implementation process more fully. This study included data and interviews from KIs in two countries of the eight where the CNP is implemented. These countries were selected because of data availability and logistics, but future research could look at implementation in all the countries were CNP is implemented. Conducting remote KIIs enabled this research to be efficient and less time consuming for our research team and interviewers although there is potential sampling and recruitment bias, as not all KIs were able to participate. Responder bias could also be present, as these KIs work at sites that benefit from support from Holt. Additionally, the principal investigator and some of the co-authors on this research are trainers or CNP champions who lead this program and whilst this can potentially introduce some influence, it also allows for enhanced analysis of the data because of a deep understanding of program operations and relationships with sites. Future research could consider using other methods such as use of control groups or independent evaluators to address the potential bias in this paper.

As KAPS and nutrition and feeding pre-/post-training test samples were independent and there were smaller sample sizes at different time points, this could impact analysis of the results. These tests were conducted as part of routine program operations with unknown validity. Future research could further examine these tools. This research was also impacted by the COVID-19 pandemic because implementation of the CNP adapted as sites navigated through changes in public health restrictions. Other limitations included the fact that KIIs did not include other important stakeholders including children, caregivers, community members, families or government partners.

5. Conclusions

The implementation of the CNP in Mongolia and the Philippines provides insights for implementation in other countries and for other similar nutrition and feeding interventions, in addition to areas for future research. With appropriate inputs, processes and implementation methods to address barriers and facilitators, programs such as the CNP could have the potential for substantial impact and growth. Strong partnerships and relationships with local government, secure funding, buy-in at all levels, adequate staffing, frequent training, support systems and adequate supply chains were identified as essential to implementation. As malnutrition continues to impact millions of children, programs that address the needs of caregivers and children, such as the CNP, should be prioritized. Applying scaling frameworks to future research on the CNP could provide additional information on how to scale-up programs to reach more children globally.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/children9121965/s1, S1: TREND Statement [16]; S2: Interview Question Outline.

Author Contributions: E.D., M.K. and C.T. designed the study. E.D., M.K., T.S., E.A., M.Q., C.T., N.G., M.G. and M.D.-a. contributed to specific areas of the methods, data analysis, statistics and quality control. E.D., M.Q., M.D.-a. and M.G. had access to and verified the data. E.D. led the data analysis and writing of the first draft of the manuscript. E.D., M.K., T.S., M.Q., C.T., N.G., B.O., M.D.-a., E.A. and M.G. contributed to the writing of the manuscript and agreed with the manuscript's results and conclusions. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsink and approved by the London School of Hygiene and Tropical Medicine's Ethics Committee (ref: 22865). Additionally, this study received approval from the National Center for Public Health of Mongolia for the research methodology/protocol and ethical approval from the Medical Ethics Control Committee of the Mongolian Ministry of Health (ref: 230). Ethical approval was obtained from the St. Cabrini Medical Center-Asian Eye Institute Ethics Review Committee (SCMC-AEI) Ethics Review Committee in the Philippines (ref: 2021-002).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the participants(s) to publish this paper.

Data Availability Statement: Some data is available upon request after an approval process from Holt International.

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Appendix A

Table A1. Prevalence of Desired Answers of Knowledge, Attitude and Practice Surveys (KAPS) from Pre-training and Post-training in Mongolia. Knowledge Questions are Yellow, Attitude Questions Red and Practice Questions Green.

Mongolia					
Knowledge, Attitude, Practice Survey					
	Respondent Demographics	**n = 15**	**Pre-Training**	**n = 8**	**Post-Training**
1	Median Age (IQR)	15	42 years (37–49 years)	8	43.5 years (32–45.5 years)
2	Have Attended Training (%)		No response		No response
3	Gender (Female), n (%)	15	15 (100%)	8	8 (100%)

Table A1. *Cont.*

	Mongolia				
	Knowledge, Attitude, Practice Survey				
	Respondent Demographics	**n = 15**	**Pre-Training**	**n = 8**	**Post-Training**
4	Highest Level of Education n (%)	15	Never attended: 0 Primary (1–5 years): 0 Secondary (6–11 years): 1 (6.7%) Post-secondary (12+ years): 7 (46.7%) Uni./Grad./Prof. School: 7 (46.7%)	8	Never attended: 1 (12.5%) Primary (1–5 years): 0 Secondary (6–11 years): 0 Post-secondary (12+ years): Uni./Grad./Prof. School: 7 (87.5%)
5	Years in Role	15	<1 year: 0 1–3 years: 3 (20%) 4–6 years: 2 (13.3%) 7–9 years: 2 (13.3%) 10+ years: 8 (53.3%)	8	<1 year: 2 (25%): 1–3 years: 2 (25%) 4–6 years: 1 (12.5%) 7–9 years: 0 10+ years: 3 (37.5%)
	Survey Questions (Desired Answer)	n = 15		n = 8	
6	I allow infants to take a bottle while lying on their own. (Never)	15	Not Applicable: 0 Always: 2 (13.3%) Sometimes: 13 (86.7%) Never: 0	8	Not Applicable: 0 Always: 0 Sometimes: 0 Never: 8 (100%)
7	If a child is coughing while eating, I lay him down. (Never)	15	Not Applicable: 1 (6.7%) Always: 0 Sometimes: 2 (13.3%) Never: 12 (80%)	8	Not Applicable: 0 Always: 0 Sometimes: 0 Never: 8 (100%)
8	I make sure children with disabilities are positioned upright or slightly reclined for feedings. (Always)	15	Not Applicable: 2 (13.3%) Always: 11 (73.3%) Sometimes: 2 13.3%) Never: 0	8	Not Applicable: 0 Always: 8 (100%) Sometimes: 0 Never: 0
9	I make sure a child finishes his entire meal when he is sick. (Never)	15	Not Applicable: 0 Always: 4 (26.7%) Sometimes: 8 (53.3%) Never: 3 (20%)	8	Not Applicable: 0 Always: 0 Sometimes: 3 (37.5%) Never: 5 (62.5%)
10	I boil bottles in hot water before every use. (Always)	15	Not Applicable: 0 Always: 15 (100%) Sometimes: 0 Never: 0	8	Not Applicable: 0 Always: 7 (87.5%) Sometimes: 1 (12.5%) Never: 0
11	If a child with a disability is having difficulty swallowing, I spoon liquid into his mouth. (Never)	15	Not Applicable: 1 (6.7%) Always: 13 (86.7%) Sometimes: 1 (6.7%) Never: 0	8	Not Applicable: 0 Always: 2 (25%) Sometimes: 4 (50%) Never: 2 (25%)
12	Children with disabilities are always smaller and thinner than children without disabilities. (Disagree)	15	Not Applicable: 2 (13.3%) Agree: 8 (53.3%) Disagree: 4 (26.7%) Unsure: 1 (6.7%)	8	Not Applicable: 0 Agree: 6 (75%) Disagree: 1 (12.5%) Unsure: 1 (12.5%)
13	Feeding a child with a disability is a stressful experience for me. (Disagree)	15	Not Applicable: 1 (6.7%) Agree: 6 (40%) Disagree: 6 (40%) Unsure: 2 (13.3%)	8	Not Applicable: 0 Agree: 3 (37.5%) Disagree: 3 (37.5%) Unsure: 2 (25%)
14	Good nutrition helps the body fight illness and infections. (Agree)	15	Not Applicable: 1 (6.7%) Agree: 14 (93.3%) Disagree: 0 Unsure: 0	8	Not Applicable: 0 Agree: 100% Disagree: 0 Unsure: 0
15	Repeated episodes of diarrhea cause malnutrition. (Agree)	15	Not Applicable: 1 (1.7%) Agree: 12 (80%) Disagree: 2 (13.3%) Unsure: 0	8	Not Applicable: 0 Agree: 8 (100%) Disagree: 0 Unsure: 0

Table A1. *Cont.*

	Mongolia				
	Knowledge, Attitude, Practice Survey				
	Respondent Demographics	**n = 15**	**Pre-Training**	**n = 8**	**Post-Training**
16	I can tell if water is safe for drinking and making formula just by looking at it. (Disagree)	15	Not Applicable: 0 Agree: 8 (53.3%) Disagree: 5 (33.3%) Unsure: 2 (13.3%)	8	Not Applicable: 0 Agree: 4 (50%) Disagree: 1 (12.5%) Unsure: 3 (37.5%)
17	The way I interact with infants during feeding can affect their brain development. (Agree)	15	Not Applicable: 1 (6.7%) Agree: 13 (86.7%) Disagree: 1 (6.7%) Unsure: 0	8	Not Applicable: 0 Agree: 7 (87.5%) Disagree: 0 Unsure: 1 (12.5%)
18	Some children with disabilities need more food to grow compared to children without disabilities. (Agree)	15	Not Applicable: 2 (13.3%) Agree: 8 (53.3%) Disagree: 1 (6.7%) Unsure: 4 (26.7%)	8	Not Applicable: 1 (12.5%) Agree: 3 (37.5%) Disagree: 4 (50%) Unsure: 0
19	The best source of iron comes from animal milk and yogurt. (Disagree)	15	Not Applicable: 0 (6.7%) Agree: 3 (20%) Disagree: 7 (46.7%) Unsure: 4 (26.7%)	8	Not Applicable: 3 (37.5%) Agree: 1 (12.5%) Disagree: 2 (25%) Unsure: 2 (25%)
20	If an infant does not finish his formula milk, it is OK to give it to another child. (Disagree)	15	Not Applicable: 2 (13.3%) Agree: 0 Disagree: 12 (80%) Unsure: 1 (6.7%)	8	Not Applicable: 0 Agree: 1 (12.5%) Disagree: 6 (75%) Unsure: 1 (12.5%)
21	Children living in the orphanage receive better nutrition than children living in the community. (Agree)	15	Not Applicable: 1 (6.7%) Agree: 14 (93.3%) Disagree: 0 Unsure: 0	8	Not Applicable: 0 Agree: 8 (100%) Disagree: 0 Unsure: 0
22	A child will cough every time they have inhaled food or liquid into their lungs. (Disagree)	15	Not Applicable: 1 (6.7%) Agree: 6 (40%) Disagree: 7 (46.7%) Unsure: 1 (6.7%)	8	Not Applicable: 0 Agree: 8 (100%) Disagree: 0 Unsure: 0
23	It is OK to mix cereal, sugar or fruit juice with formula in a bottle when feeding an infant. (Disagree)	15	Not Applicable: 1 (6.7%) Agree: 4 (26.7%) Disagree: 10 (66.7%) Unsure: 0	15	Not Applicable: 0 Agree: 0 Disagree: 8 (100%) Unsure: 0
24	It is OK for a 3-month-old infant to have food other than formula milk. (Disagree)	15	Not Applicable: 1 (1.7%) Agree: 3 (20%) Disagree: 11 (73.3%) Unsure: 0	8	Not Applicable: 0 Agree: 0 Disagree: 8 (100%) Unsure: 0
25	I can tell if a child is healthy by just looking at him. (Disagree)	14	Not Applicable: 1 (6.7%) Agree: 8 (53.3%) Disagree: 2 (13.3%) Unsure: 3 (20%)	8	Not Applicable: 0 Agree: 6 (75%) Disagree: 0 Unsure: 2 (25%)
26	Cutting larger holes in the nipple on a bottle is one way to make feeding easier for an infant with difficulty sucking. (Disagree)	15	Not Applicable: 0 Agree: 2 (13.3%) Disagree: 12 (80%) Unsure: 1 (6.7%)	8	Not Applicable: 0 Agree: 1 (12.5%) Disagree: 7 (87.5%) Unsure: 0
27	Animal milk like cow/goat/buffalo milk is better than formula for children younger than 1-year-old. (Disagree)	15	Not Applicable: 0 Agree: 2 (13.3%) Disagree: 13 (86.7%) Unsure: 0	8	Not Applicable: 0 Agree: 1 (12.5%) Disagree: 6 (75%) Unsure: 1 (12.5%)
28	Washing hands with only hot water is enough to properly clean hands. (Disagree)	15	Not Applicable: 0 Agree: 1 (1.7%) Disagree: 13 (86.7%) Unsure: 0	8	Not Applicable: 0 Agree: 0 Disagree: 7 (87.5%) Unsure: 1 (12.5%)
29	It is important for children younger than 2 years old to be able to touch their food as they learn how to self-feed. (Agree)	4	Not Applicable: 0 Agree: 4 (100%) Disagree: 0 Unsure: 0	8	Not Applicable: 0 Agree: 7 (87.5%) Disagree: 1 (12.5%) Unsure: 0

Table A1. *Cont.*

	Mongolia				
	Knowledge, Attitude, Practice Survey				
	Respondent Demographics	**n = 15**	**Pre-Training**	**n = 8**	**Post-Training**
30	The only reason children with disabilities cry during meals is because they are misbehaving. (Disagree)	4	Not Applicable: 1 (1.7%) Agree: 1 (1.7%) Disagree: 1 (1.7%) Unsure: 1 (1.7%)	8	Not Applicable: 0 Agree: 1 (12.5%) Disagree: 7 (87.5%) Unsure: 0
31	List three signs of hunger for an infant younger than 12 months old (most frequent answers)	4	1. Crying 2. Losing weight 3. Looking for something to eat.	8	1. Crying 2. Suck fingers, lips. 3. Make noises, sucking and feeding noises.
32	List three causes of diarrhea (most frequent answers)	15	1. Food 2. Dirty hands/ utensils/environment 3. Infection or Digestion Disorder	8	1. Dirty Hands/ Bottles/Environment 2. Antibiotics 3. Poor Food Quality/Safety

Table A2. Prevalence of Desired Answers of Knowledge, Attitude and Practice Surveys (KAPS) from Pre-training and Post-training in the Philippines. Knowledge Questions are Yellow, Attitude Questions Red and Practice Questions Green.

	Philippines				
	Knowledge, Attitude and Practice Survey				
	Respondent Demographics	**n = 60**	**Pre-Training**	**n = 15**	**Post-Training**
1	Median Age (IQR)	59	44 years (32–50 years)	14	44 years (37–49 years)
2	Have Attended Training (%)	38	Yes: 29 (76.3%) No: 9 (23.7%)	12	Yes: 12 (100%)
3	Gender (Female), n (%)	58	50 (86.2%)	15	13 (86.7%)
4	Highest Level of Education	60	Never attended: 0 Primary (1–5 years): 0 Secondary (6–11 years): 4 (6.7%) Post-secondary (12+ years): 16 (26.7%) Uni./Grad./Prof. School: 40 (66.7%)	13	Never attended: 0 Primary (1–5 years): 0 Secondary (6–11 years): 0 Post-secondary (12+ years): 2 (15.4%) Uni./Grad./Prof. School: 11 (84.6%)
5	Years in Role	60	<1 year: 11 (18.3%) 1–3 years: 11 (18.3%) 4–6 years: 3 (5%) 7–9 years: 10 (16.7%) 10+ years: 25 (41.67%)	15	<1 year: 1 (6.7%) 1–3 years: 6 (40%) 4–6 years: 2 (13.3%) 7–9 years: 0 10+ years: 6 (40%)
	Survey Questions (Desired Answers)	n = 60		n = 15	
6	I allow infants to take a bottle while lying on their own. (Never)	60	Not Applicable: 1 (1.7%) Always: 5 (8.3%) Sometimes: 28 (46.7%) Never: 26 (43.3%)	14	Not Applicable: 5 (35.7%) Always: 1 (7.1%) Sometimes: 1 (7.1%) Never: 7 (50%)
7	If a child is coughing while eating, I lay him down. (Never)	60	Not Applicable: 0 Always: 2 (3.3%) Sometimes: 22 (36.7%) Never: 36 (60%)	15	Not Applicable: 1 (6.7%) Always: 0 Sometimes: 1 (6.7%) Never: 13 86.7%)

Table A2. *Cont.*

	Philippines				
	Knowledge, Attitude and Practice Survey				
	Respondent Demographics	**n = 60**	**Pre-Training**	**n = 15**	**Post-Training**
8	I make sure children with disabilities are positioned upright or slightly reclined for feedings. (Always)	60	Not Applicable: 1 (1.7%) Always: 55 (91.7%) Sometimes: 2 (3.3%) Never: 2 (3.3%)	15	Not Applicable: 0 Always: 15 (100%) Sometimes: 0 Never: 0
9	I make sure a child finishes his entire meal when he is sick. (Never)	38	Not Applicable: 1 (1.7%) Always: 3 (7.9%) Sometimes: 18 (47.4%) Never: 16 (42.1%)	14	Not Applicable: 0 Always: 0 Sometimes: 3 (37.5%) Never: 6 (42.9%)
10	I boil bottles in hot water before every use. (Always)	60	Not Applicable: 1 (1.7%) Always: 56 (93.3%) Sometimes: 2 (3.3%) Never: 1 (1.7%)	15	Not Applicable: 2 (13.3%) Always: 13 (86.7%) Sometimes: 0 Never: 0
11	If a child with a disability is having difficulty swallowing, I spoon liquid into his mouth. (Never)	60	Not Applicable: 2 (3.3%) Always: 24 (40%) Sometimes: 19 (31.7%) Never: 15 (25%)	15	Not Applicable: 0 Always: 11 (73.3%) Sometimes: 3 (20%) Never: 1 (6.7%)
12	Children with disabilities are always smaller and thinner than children without disabilities. (Disagree)	60	Not Applicable: 1 (1.7%) Agree: 23 (38.3%) Disagree: 31 (51.7%) Unsure: 5 (8.3%)	14	Not Applicable: 7 (50%) Agree: 6 (42.9%) Disagree: 1 (7.1%) Unsure:
13	Feeding a child with a disability is a stressful experience for me. (Disagree)	60	Not Applicable: 2 (3.3%) Agree: 15 (25%) Disagree: 39 (65%) Unsure: 4 (6.7%)	14	Not Applicable: 0 Agree: 3 (21.4%) Disagree: 10 (71.4%) Unsure: 1 (7.1%)
14	Good nutrition helps the body fight illness and infections. (Agree)	60	Not Applicable: 0 Agree: 59 (98.3%) Disagree: 1 (1.67%) Unsure: 0	15	Not Applicable: 0 Agree: 15 (100%) Disagree: 0 Unsure: 0
15	Repeated episodes of diarrhea cause malnutrition. (Agree)	60	Not Applicable: 1 (1.7%) Agree: 48 (80%) Disagree: 7 (11.7%) Unsure: 4 (6.7%)	15	Not Applicable: 0 Agree: 15 (100%) Disagree: 0 Unsure: 0
16	I can tell if water is safe for drinking and making formula just by looking at it. (Disagree)	60	Not Applicable: 1 (1.7%) Agree: 9 (15%) Disagree: 47 (78.3%) Unsure: 3 (5%)	15	Not Applicable: 1 (6.7%) Agree: 3 (20%) Disagree: 11 (73.3%) Unsure: 0
17	The way I interact with infants during feeding can affect their brain development. (Agree)	60	Not Applicable: 1 (1.7%) Agree: 56 (93.3%) Disagree: 3 (5%) Unsure: 0	15	Not Applicable: 0 Agree: 10 (66.7%) Disagree: 4 (26.7%) Unsure: 1 (6.7%)
18	Some children with disabilities need more food to grow compared to children without disabilities. (Agree)	60	Not Applicable: 0 Agree: 34 (56.7%) Disagree: 24 (40%) Unsure: 2 (3.3%)	15	Not Applicable: 0 Agree: 9 (60%) Disagree: 6 (40%) Unsure: 0
19	The best source of iron comes from animal milk and yogurt. (Disagree)	60	Not Applicable: 0 Agree: 13 (21.7%) Disagree: 35 (58.3%) Unsure: 12 (20%)	15	Not Applicable: 0 Agree: 4 (26.7%) Disagree: 9 (60%) Unsure: 2 (13.3%)
20	If an infant does not finish his formula milk, it is OK to give it to another child. (Disagree)	60	Not Applicable: 0 Agree: 1 (1.7%) Disagree: 59 (98.3%) Unsure: 0	15	Not Applicable: 1 (6.7%) Agree: 0 Disagree: 13 (86.7%) Unsure: 1 (6.7%)
21	Children living in the orphanage receive better nutrition than children living in the community. (Agree)	60	Not Applicable: 0 Agree: 33 (55%) Disagree: 20 (33.3%) Unsure: 7 (11.7%)	15	Not Applicable: 0 Agree: 5 (33.3%) Disagree: 10 (66.7%) Unsure: 0

Table A2. *Cont.*

	Philippines				
	Knowledge, Attitude and Practice Survey				
	Respondent Demographics	**n = 60**	**Pre-Training**	**n = 15**	**Post-Training**
22	A child will cough every time they have inhaled food or liquid into their lungs. (Disagree)	60	Not Applicable: 1 (1.7%) Agree: 39 (65%) Disagree: 14 (23.3%) Unsure: 6 (10%)	14	Not Applicable: 0 Agree: 9 (64.3%) Disagree: 5 (35.7%) Unsure: 0
23	It is OK to mix cereal, sugar or fruit juice with formula in a bottle when feeding an infant. (Disagree)	60	Not Applicable: 2 (3.3%) Agree: 16 (26.7%) Disagree: 39 (65%) Unsure: 3 (5%)	15	Not Applicable: 0 Agree: 0 Disagree: 15 (100%) Unsure: 0
24	It is OK for a 3 month-old infant to have food other than formula milk. (Disagree)	60	Not Applicable: 2 (3.3%) Agree: 3 (5%) Disagree: 52 (86.7%) Unsure: 3 (5%)	14	Not Applicable: 0 Agree: 0 Disagree: 14 (100%) Unsure: 0
25	I can tell if a child is healthy by just looking at him. (Disagree)	60	Not Applicable: 0 Agree: 12 (20%) Disagree: 46 (76.7%) Unsure: 2 (3.3%)	14	Not Applicable: 0 Agree: 0 Disagree: 14 (100%) Unsure: 0
26	Cutting larger holes in the nipple on a bottle is one way to make feeding easier for an infant with difficulty sucking. (Disagree)	60	Not Applicable: 1 (1.7%) Agree: 5 (8.3%) Disagree: 54 (90%) Unsure: 0	15	Not Applicable: 0 Agree: 0 Disagree: 14 (93.3%) Unsure: 1 (6.7%)
27	Animal milk like cow/goat/buffalo milk is better than formula for children younger than 1-year-old. (Disagree)	60	Not Applicable: 1 (1.7%) Agree: 4 (6.7%) Disagree: 48 (80%) Unsure: 7 (11.7%)	14	Not Applicable: 0 Agree: 2 (13.3%) Disagree: 12 (93.3%) Unsure: 0
28	Washing hands with only hot water is enough to properly clean hands. (Disagree)	60	Not Applicable: 1 (1.7%) Agree: 6 (10%) Disagree: 53 (88.3%) Unsure: 0	14	Not Applicable: 0 Agree: 0 Disagree: 14 (100%) Unsure: 0
29	It is important for children younger than 2 years old to be able to touch their food as they learn how to self-feed. (Agree)	60	Not Applicable: 0 Agree: 53 (88.3%) Disagree: 6 (10%) Unsure: 1 (1.7%)	15	Not Applicable: 0 Agree: 15 (100%) Disagree: 0 Unsure: 0
30	The only reason children with disabilities cry during meals is because they are misbehaving. (Disagree)	38	Not Applicable: 0 Agree: 15 (39.5%) Disagree: 21 (55.3%) Unsure: 2 (5.3%)	15	Not Applicable: 0 Agree: 1 (6.7%) Disagree: 13 (86.7%) Unsure: 1 (6.7%)
31	List three signs of hunger for an infant younger than 12 months old (most frequent answers)	38	1. Crying 2. Irritable 3. Thumb suck	14	1. Crying 2. Irritable 3. Asking for food or gesturing to food or putting things in mouth.
32	List three causes of diarrhea (most frequent answers)	60	1. Unsafe Water or Food or Environment 2. Teething or Indigestion 3. Nonsterile bottles or changing formula	15	1. Contaminated water, food, environment 2. In appropriate bottle sterilization or formula preparation 3. Indigestion or overfeeding.

Table A3. Summary of the Implementation Process of the Child Nutrition Program based on the WHO's Health System's Framework and Monitoring and Evaluation of Health Systems [2].

Summary of the Implementation Process of the Child Nutrition Program					
Building Blocks	**Inputs**	**Processes**	**Outputs**	**Outcomes**	**Impact**
Service Delivery	• Adequate and developmentally appropriate food • Feeding equipment • Anthropometric equipment • Resource, training and operations manuals provided in appropriate languages • Identification of key areas for practice improvement • Buy-in from leadership • Identify CNP Champions • Review country level guidelines • Complete an assessment of the site their needs • Assess site environment needs for successful implementation (e.g., are handwashing stations too high for children? Are there handwashing stations in every room?)	• Program training and practicum • Integration of program implementation into facility workflow • Retraining is frequent • Ensure training and training curriculum is provided and accessible for all staff • Support change in environments to support site's needs. • Support from leadership for changing practices • Train CNP Champions on implementation processes for site or country level • Place CNP Champions in regions across the country • Monitoring and evaluation processes • Adapt program for community, foster care or IBC • Integrate country guidelines into programming • Reinforce positive behaviors • Integration of program into research	• Increased staff knowledge and skills • Sites choose more nutrient dense foods, appropriate textures and feeding methods • Sites standardize practices and support systems • Staff understand the need for changes in practices • Staff are skilled in practices • CNP Champions support sites to implement programs • Disseminate information to other caregivers, staff and families • Increased quality interaction with children • CNP Champions identify potential additional sites • Sites are able to frequently retrain staff	• Improved dietary intake of children • High quality program implementation • Malnutrition is identified and treated • Staff practice new behaviors and receive support • Staff support other staff • Strong relationships with CNP champions and sites • Children's growth • Increased number of participating sites • Programming supports overall government goals for health services for children • CNP is integrated into site workflow	• Improved health outcomes for children • Program sustainability • Malnutrition is prevented • Sitewide behavior change is sustained • CNP Champions identify areas for program growth

Table A3. *Cont.*

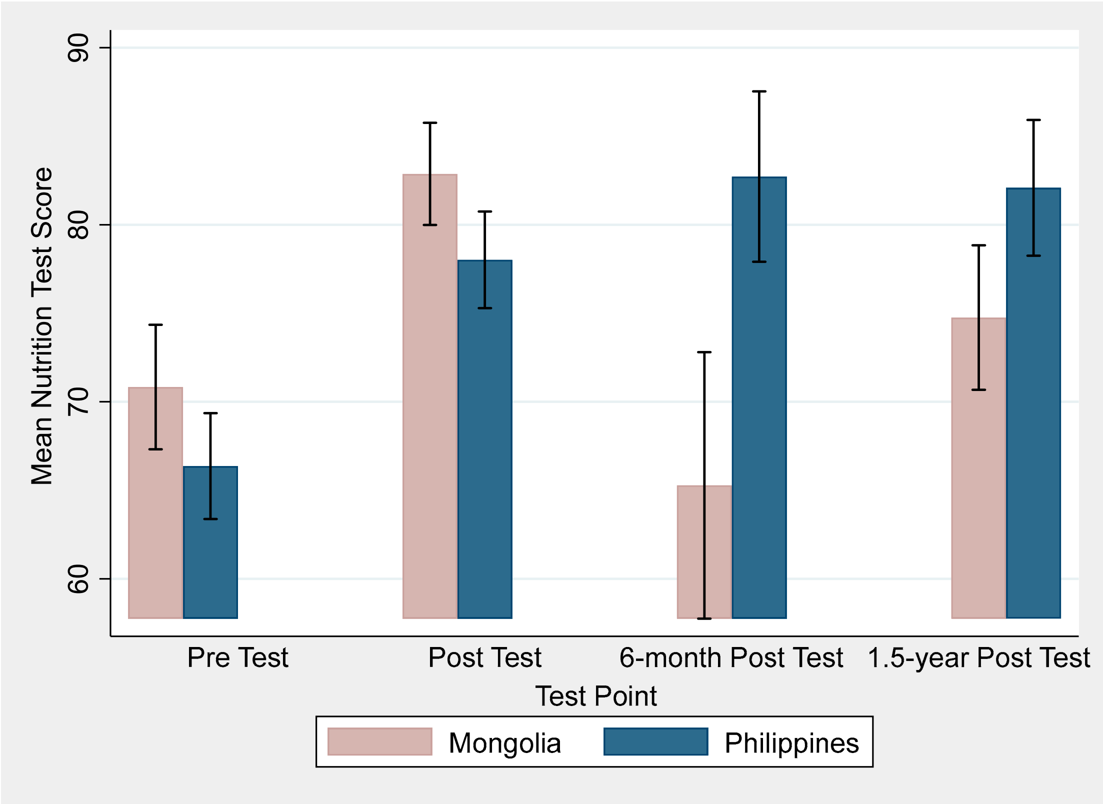
Summary of the Implementation Process of the Child Nutrition Program					
Building Blocks	**Inputs**	**Processes**	**Outputs**	**Outcomes**	**Impact**
Health Workforce	• Adequate staffing • Development of site level clear guidance and integration into staffing job descriptions and work expectations • Hire staff at site level and country level to support program implementation • Clear guidance for staff to implement program and reporting systems • Identify areas for staffing needs such as during mealtimes • Skilled therapists/trainers identified to provide support to sites	• Provide training and retraining for staff, including onboarding training and practicum for new staff • Provide opportunities for staff professional development • Adequate coverage to allow staff to attend training • Engagement with local therapists • Staff have clear guidance on integration of best practices into workflow and job duties • Supervision, support and reinforcement of staff • Shift site schedules/responsibility to meet staffing demands, such as all staff go to feed children during mealtimes • Frequent review of staff performance	• Trained trainers • Skilled staff • Children receive more therapeutic services • Staff have clear guidance and support to accomplish duties • Child welfare is prioritized and staff are assigned appropriate duties	• Increased standardization of practices • Staff have the ability to provide peer support • Increased staff satisfaction with job • In-house technical expertise • Increased staff confidence in abilities • Staff maintain skills and practices • Capacity strengthening • Staff duties are accomplished and staff feel supported	• Improved care for children • Improved staff retention • Highly skilled workforce • In-country technical experts and reduced reliance on international trainers
Health Information Systems	• Access to internet • Provision of supplies such as laptops and printers to complete health screenings • Identify staff to be trained on health screenings and data entry • Provide resources and screening schedule	• Training on how to use the nutrition screening database • Staff complete health screenings and enter data into database • Children are routinely screened according to schedule.	• Staff skilled in use of nutrition screening database • Health screenings completed, and data recorded • Staff have consistent access to resources for program implementation	• Children are routinely screened, and their health tracked over time • Data used to improve programming and monitoring and evaluation systems • Systems are integrated into site workflow	• Improved health outcomes for children • Improved program outcomes and feedback systems

Table A3. *Cont.*

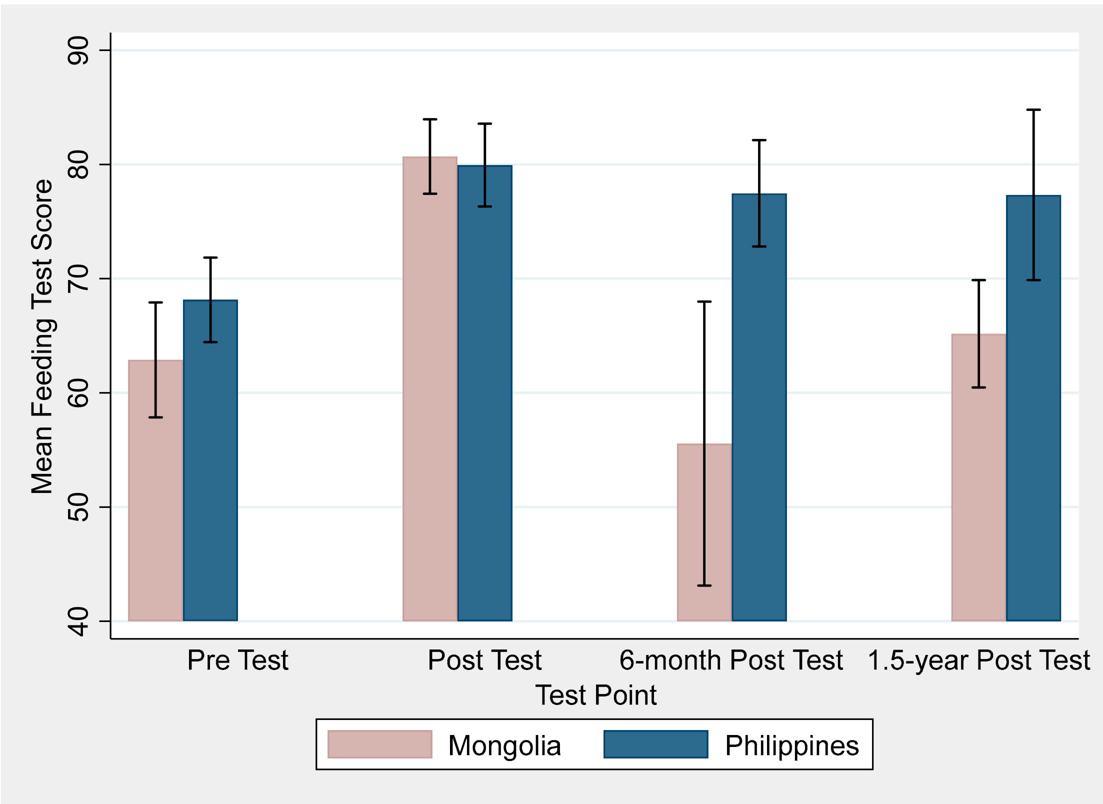
Summary of the Implementation Process of the Child Nutrition Program					
Building Blocks	**Inputs**	**Processes**	**Outputs**	**Outcomes**	**Impact**
Access to Essential Medicines and Services	• Identify needed supplies and services, prioritize when necessary • Identify access to clean safe water • Identify potential local therapists and health care providers • Research local markets and suppliers • Include supply needs in annual planning • Identify potential government procurement systems to support supply chain • Identify environments or equipment that need to be improved to maintain supplies (e.g., kitchen equipment) • Provide sites with initial supplies required to start program	• Connect facilities with local government supply chains or health systems • Identify secure supply chains • Sign memorandum of agreement to provide essential supplies such as hemoglobin testing kits • Train local therapists to provide specialized services to children and support to staff • Create processes to ensure supplies are taken care of and accounted for • Secure and adequate supply chains • Support sites with how discuss with donors donations to prioritize • Create system to keep track of expiration dates	• Ability to conduct health screenings • Government able to contribute to support children and sites • Children receive ongoing specialized support • Supplies remain in good condition and accounted for • Children receive adequate meals, supplements and services • Reduced supply loss	• Health screenings and work happens on schedule • Secure supply chains • Children are well-nourished and growing • Cost savings related to buying in bulk and reduced supply loss	• Improved health outcomes for children • Sustainable and diverse supply systems • Improved program outcomes

Table A3. *Cont.*

Summary of the Implementation Process of the Child Nutrition Program					
Building Blocks	**Inputs**	**Processes**	**Outputs**	**Outcomes**	**Impact**
Financing	• Secure and adequate funding • Provide sites with financial incentives for staff to do data entry • Budget annual program implementation costs and define accountability systems • Identify ongoing costs associated with CNP	• Provision of financial support, supplies and resources • Provide financial incentives for staffing • Sites are provided funding for implementation • Add CNP costs into annual budget and proposals to donors • Purchase and distribute necessary supplies for implementation	• Sites or country level offices purchase supplies, food and resources needed to implement program • Staff are committed to accomplishing work and data entry • Necessary supplies are available • Sites have adequate funding for staffing, supplies and services	• Programming implementation may reduce costs associated with illnesses, specialty doctors and hospitalizations. • Program is implemented to a high level • Reduced staff costs associated with turnover • Work gets completed on time	• Financial accountability • Program implementation is sustained • Sites operate with some independence • Sites utilize funding for program sustainability • Improved program outcomes
Leadership and Governance	• Identify site and government leadership with interest for supporting programming • Identification of partnerships with government and other stakeholders • Identify key stakeholders to communicate about program • Meet with local, regional and national government officials	• Develop relationships with site leadership and local governments • Sites sign memorandum of agreements with partners and government • Raise awareness of CNP, program outcomes and opportunities • Coordinate program growth and expansion with local, regional and national government • Engagement of local government officials in training	• Strong relationships with site leadership and government officials, developed understanding of program value and importance. • Sites and partners fulfill their obligations as identified in agreements • New stakeholders are aware of program and opportunities at local, regional and national levels • Government officials see value in programming	• Site leadership and government partners have buy-in for program success • Program implementation is sustainable and supported • New sites start CNP • Increased awareness and advocacy for vulnerable populations globally • Government officials	• Strong program implementation leadership by site leadership and government partners • Improved program outcomes • Increased growth of program • Policy makers include vulnerable populations in decision making



(**A**)



(**B**)

Figure A1. Mean Nutrition (**A**) and Feeding (**B**) Test Scores at Pre-training, Post-training, 6-month Post-training and 1.5-year Post-training. Error bars show 95% confidence intervals.

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Supplement S1: TREND Statement Checklist

Paper Section/ Topic	Item No	Descriptor	Reported? ✓	Pg #
Title and Abstract				
Title and Abstract	1	• Information on how unit were allocated to interventions	✓	1
		• Structured abstract recommended	✓	1
		• Information on target population or study sample	✓	1
Introduction				
Background	2	• Scientific background and explanation of rationale	✓	3
		• Theories used in designing behavioral interventions	✓	3
Methods				
Participants	3	• Eligibility criteria for participants, including criteria at different levels in recruitment/sampling plan (e.g., cities, clinics, subjects)	✓	5
		• Method of recruitment (e.g., referral, self-selection), including the sampling method if a systematic sampling plan was implemented	✓	5
		• Recruitment setting	✓	5
		• Settings and locations where the data were collected	✓	5
Interventions	4	• Details of the interventions intended for each study condition and how and when they were actually administered, specifically including:	✓	7
		○ Content: what was given?	✓	7
		○ Delivery method: how was the content given?	✓	7
		○ Unit of delivery: how were the subjects grouped during delivery?	✓	7
		○ Deliverer: who delivered the intervention?	✓	7
		○ Setting: where was the intervention delivered?	✓	5
		○ Exposure quantity and duration: how many sessions or episodes or events were intended to be delivered? How long were they intended to last?	✓	7
		○ Time span: how long was it intended to take to deliver the intervention to each unit?	✓	7
		○ Activities to increase compliance or adherence (e.g., incentives)	✓	7
Objectives	5	• Specific objectives and hypotheses	✓	4
Outcomes	6	• Clearly defined primary and secondary outcome measures	✓	7
		• Methods used to collect data and any methods used to enhance the quality of measurements	✓	7
		• Information on validated instruments such as psychometric and biometric properties	✓	8
Sample Size	7	• How sample size was determined and, when applicable, explanation of any interim analyses and stopping rules	✓	7
Assignment Method	8	• Unit of assignment (the unit being assigned to study condition, e.g., individual, group, community)	✓	7
		• Method used to assign units to study conditions, including details of any restriction (e.g., blocking, stratification, minimization)	✓	7
		• Inclusion of aspects employed to help minimize potential bias induced due to non-randomization (e.g., matching)	✓	7

Supplement S1: TREND Statement Checklist

Blinding (masking)	9	• Whether or not participants, those administering the interventions, and those assessing the outcomes were blinded to study condition assignment; if so, statement regarding how the blinding was accomplished and how it was assessed.	✓	7
Unit of Analysis	10	• Description of the smallest unit that is being analyzed to assess intervention effects (e.g., individual, group, or community)	✓	5
		• If the unit of analysis differs from the unit of assignment, the analytical method used to account for this (e.g., adjusting the standard error estimates by the design effect or using multilevel analysis)	✓	7
Statistical Methods	11	• Statistical methods used to compare study groups for primary methods outcome(s), including complex methods of correlated data	✓	7
		• Statistical methods used for additional analyses, such as a subgroup analyses and adjusted analysis	✓	7
		• Methods for imputing missing data, if used		N/A
		• Statistical software or programs used	✓	7, 8
Results				
Participant flow	12	• Flow of participants through each stage of the study: enrollment, assignment, allocation, and intervention exposure, follow-up, analysis (a diagram is strongly recommended)	✓	9
		○ Enrollment: the numbers of participants screened for eligibility, found to be eligible or not eligible, declined to be enrolled, and enrolled in the study	✓	12-14
		○ Assignment: the numbers of participants assigned to a study condition	✓	12-14
		○ Allocation and intervention exposure: the number of participants assigned to each study condition and the number of participants who received each intervention	✓	12-14
		○ Follow-up: the number of participants who completed the follow-up or did not complete the follow-up (i.e., lost to follow-up), by study condition	✓	12-14
		○ Analysis: the number of participants included in or excluded from the main analysis, by study condition	✓	12-14
		• Description of protocol deviations from study as planned, along with reasons	✓	26
Recruitment	13	• Dates defining the periods of recruitment and follow-up	✓	7
Baseline Data	14	• Baseline demographic and clinical characteristics of participants in each study condition	✓	9-23
		• Baseline characteristics for each study condition relevant to specific disease prevention research	✓	9-23
		• Baseline comparisons of those lost to follow-up and those retained, overall and by study condition	✓	9-23
		• Comparison between study population at baseline and target population of interest	✓	9-23
Baseline equivalence	15	• Data on study group equivalence at baseline and statistical methods used to control for baseline differences	✓	9-23

Supplement S1: TREND Statement Checklist

Numbers analyzed	16	• Number of participants (denominator) included in each analysis for each study condition, particularly when the denominators change for different outcomes; statement of the results in absolute numbers when feasible	✓	9-23
		• Indication of whether the analysis strategy was "intention to treat" or, if not, description of how non-compliers were treated in the analyses		N/A
Outcomes and estimation	17	• For each primary and secondary outcome, a summary of results for each estimation study condition, and the estimated effect size and a confidence interval to indicate the precision	✓	9-23
		• Inclusion of null and negative findings	✓	9-23
		• Inclusion of results from testing pre-specified causal pathways through which the intervention was intended to operate, if any	✓	9-23
Ancillary analyses	18	• Summary of other analyses performed, including subgroup or restricted analyses, indicating which are pre-specified or exploratory	✓	9-23
Adverse events	19	• Summary of all important adverse events or unintended effects in each study condition (including summary measures, effect size estimates, and confidence intervals)	✓	26
DISCUSSION				
Interpretation	20	• Interpretation of the results, taking into account study hypotheses, sources of potential bias, imprecision of measures, multiplicative analyses, and other limitations or weaknesses of the study	✓	24
		• Discussion of results taking into account the mechanism by which the intervention was intended to work (causal pathways) or alternative mechanisms or explanations	✓	24
		• Discussion of the success of and barriers to implementing the intervention, fidelity of implementation	✓	25
		• Discussion of research, programmatic, or policy implications	✓	25
Generalizability	21	• Generalizability (external validity) of the trial findings, taking into account the study population, the characteristics of the intervention, length of follow-up, incentives, compliance rates, specific sites/settings involved in the study, and other contextual issues	✓	24-25
Overall Evidence	22	• General interpretation of the results in the context of current evidence and current theory	✓	27

From: Des Jarlais, D. C., Lyles, C., Crepaz, N., & the Trend Group (2004). Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: The TREND statement. *American Journal of Public Health*, 94, 361-366. For more information, visit: http://www.cdc.gov/trendstatement/

Supplement S2: Interview Question Outline

Site Key Informant Interview Guide- Site Level

Name of Interviewer:	Date of Interview:
Person being interviewed:	Position:
Site:	

Intro

Explain purpose, what will happen with info

Consent

Guiding Questions

1. Please can you describe your role to me? Prompt: What are your job functions at this site?

2. How long has your site been participating in the Child Nutrition Program?

3. Can you describe the how CNP operates at your site?

Program Implementation

4. Please can you describe to me how you are involved in the program implementation of CNP? (Prompt: List any management roles, activities or other actions you are a part of; Management, activities, actions)

5. Have you participated in trainings/ learning activities offered by CNP? If so, which type?

6. What were your overall impression of these trainings/services? What was successful? What challenges did you experience?

7. Have you changed the way you perform your job duties after attending the CNP Training? If so, what specifically has changed?

8. Has your site implemented any of the practices learned in the training? If yes, what practices or tools?

9. What are some practices that your site has found challenging to implement or don't use? Why were they challenging or not useful?

Screening, Tracking Progress (Database), Interventions

10. Please can you describe to me the current processes used at your organization to track and screen all children, including children with disabilities and special needs?

    a. Does your organization use the database to track children's progress? If so, are there specific people designated to use and manage this data?

11. What progress have you seen in child nutrition and growth monitoring at your site since CNP began? Please give examples. Is this what you expected? Any lessons learned?

Relevance of Project to Children's Needs

12. Can you explain how the program meets the needs of children? (If it does not meet the needs of children, can you explain why?) Is the program design relevant to the current situation of children? If not, what is challenge?

13. Does CNP fit with, or meet, the priorities of your organization/government?

14. Have you seen any changes in children's health since implementing practices from the Child Nutrition Program? If yes, what changes? If no, what do you think may help you to see changes?

Successes and Challenges

15. In your opinion, do you think the program implementation gone as planned? What have you planned to by this point that you have not been able to do?

16. What were the biggest successes of the project? (Skip questions if previously covered)

17. What are the biggest challenges?

18. I would like to discuss with you now about working with Holt – Can you describe your experience working with Holt. What has worked well in your opinion? and what could be better?

Other impacts

19. Has CNP been sustainable at your site? Have any of its practices become standard across your organization? If so, explain.

20. What additional resources might you need to sustain the CNP at your site long-term?

21. How have you adapted the Child Nutrition Program to be relevant at your site?

22. Have you used anything you learned from the Child Nutrition Program in your own home or in your community?

Recommendations

23. Do you have future recommendations for the program? Advice for future sites interested in taking on the program?

24. What are some ways that the program could better support your organization? Has the support been adequate? (Financial, technical, training)

25. Would you recommend this program to other sites? Why or why not?

26. What do you think the Child Nutrition Program would need to do to grow within the country where you work? What do you think it would take to get there?

Closing

27. Is there anything else you would like to tell me about the Child Nutrition Program?

28. Is there other information you think is important for us to know?

Thank you for your time. You can reach out to me at any point with any additional information.

Site Key Informant Interview Guide- Country Level

Name of Interviewer:	Date of Interview:
Person being interviewed:	Position:
Site:	

Intro

Explain purpose, what will happen with info

Consent

Guiding Questions

1. Please can you describe your role and job functions.

2. How long have you been a Child Nutrition Program implementor/ Champion?

3. Describe the growth of CNP in your county.

Program Implementation Questions

4. How does CNP implementation vary between institutions, community programs and foster care?

5. Why has CNP been successful in your country?

6. In your opinion, what factors are critical in terms of organizational, process, technical factors?

7. Do you think CNP be simplified without undermining its effectiveness? Which elements of CNP are essential?

8. How have you adapted the program to specifically to your country/ programs?

9. Is there anything special or unique about the social or political context, or general circumstances of the program in your country that would need to be present for CNP to be successfully implemented or replicated? (e.g., cultural, ethnic, or religious values/characteristics; distribution of power; homogeneity; economic conditions)

Program Growth and Expansion

10. Do you think your country program have the desire and organizational capacity to expand its operations and deliver services on a substantially larger scale? If yes/ no, explain.

11. Should the scaling up effort include policy change by the government or rely exclusively on voluntary adoption of the program by private or non-governmental organizations?

12. Do relevant stakeholders, potential partners, and intended beneficiaries perceive a need for this kind of program?

13. As the program grows, what could CNP do to maintain its effectiveness?

14. Are there any procedures for documenting the progress, lessons learned, and implementation of CNP to inform growth?

15. How can program characteristics that were key to the outcomes achieved be replicated or enlarged? (ToT, more training opportunities)

16. What is your vision for CNP in your country? Does the plan include a clear description of proposed actions, timetables, roles, responsibilities, and resources available?

17. How can we best achieve buy-in from the leadership and staff at potential implementing organizations?

18. What additional human, institutional, and financial resources will be needed to support the process of expanding CNP in your country?

19. What human, institutional, and financial resources will be needed for operating at a bigger scale?

20. What new partnerships will need to be established to grow CNP, if any?

21. What success factors do you think need to be in place at sites expected to implement CNP? Can you expand on this?

22. Are action plans and budgets in place for growth of CNP? If not, what more needs to be done?

23. What are the most effective networks and alliances for carrying out advocacy for the growth of CNP? How can they be most efficiently mobilized and organized?

Closing

24. Overall, what are some of the biggest challenges faced by your organization (KBF/ Holt Mongolia) in daily work? Why are they challenges?

25. Is there anything else you would like to tell me about the Child Nutrition Program?

26. Is there other information you think is important for us to know?

Chapter 6: Discussion

6.1 Scope of this chapter

In the preceding chapters, this thesis presented the results of four studies and discussed how they contribute to the existing evidence base. This chapter summarizes the findings from the PhD and the implication for children living within institution-based care.

6.2 Main findings of this PhD

The overall aim of this PhD was to generate evidence to improve future nutritional and feeding services for children living within IBC globally. The first objective of this PhD examined currently available data on nutritional status of children living within IBC globally. Limited evidence was found on this population and the data suggests children living within IBC are commonly malnourished: affected by undernutrition, overnutrition and micronutrient deficiencies, especially young children and those with disabilities.[38] The second objective described and evaluated the nutritional status of children living within IBC who participate in Holt International's CNP. These children were found to have a higher prevalence of prematurity, low birth weight, disabilities and malnutrition when compared to global prevalence of these issues.[6] Children with disabilities were more malnourished than those without disabilities. Control charts and funnel plots were used to look at changes in malnutrition indicators over time at both a program and site level. The third objective described and evaluated the feeding practices and difficulties of children living with IBC who participate in CNP. The study found suboptimal dietary, hygiene and feeding practices were reported in IBC and feeding difficulties were common in IBC, especially for those with disabilities.[7] Using a generalized linear model, the adjusted risk of having a feeding difficulty was higher for children with disabilities than those without, although over time many children, both those with and without disabilities, saw their feeding difficulties resolve after participation in CNP. The fourth objective described and evaluated key factors underlying successful program implementation of Holt's Child Nutrition Program in Mongolia and the Philippines. Essential elements to program implementation included frequent and routine training, adequate staffing, strong relationships and buy-in by local government or the governing municipality.[45]

Ideally children would not live in IBC but rather with secure and loving families. However, for millions of children, this ideal is currently out-of-reach.[19,25,27,46,47] Deinstitutionalization of children requires multi-faceted long term strategies, involving many different stakeholders at all levels of a child's social ecological environment [27,48] This research agrees with other papers and reports that support optimizing current IBC environments when alternative placements for orphaned or abandoned children are not available.[49,50] There are still many children living within IBC who need as good of an environment and support as possible. Especially for children with disabilities, placements into families may present more hurdles and they may reside in IBC for longer than desired. Furthermore, when children with disabilities are placed into families, their families may need ongoing support to care for them. This research provides important insights on how to support children and their caregivers. Children in IBC have a right to good nutrition, optimal feeding practices and quality care, both to maintain their health now and to enable them to grow into healthy adults. Interventions will need to be multifaceted to address the root causes of malnutrition faced by children living in IBC. The need for more evidence, as well as a commitment to the monitoring and evaluation of nutrition and feeding practices of children in IBC, and of nutrition and feeding interventions such as CNP, should be acknowledged. Supporting children through improved nutrition and feeding services needs to be part of a broader policy and child rights initiatives.

6.3 Demographics of Children in Institution-based Care and Pre-existing Conditions

Children enter into IBC for a variety of reasons including economic, social, and cultural reasons, or the loss of one or more parents.[14,23,27,46,51] When children enter into care they have often faced many adversities prior to admission including trauma, neglect, malnutrition and/or substance exposure.[21,23,51] This research found that upon entry, many have pre-existing developmental, medical, nutrition and neurological conditions that may be impacting their development.[6,7,22,23,51] Many children enter into care with disabilities, HIV, or were born low birth weight or prematurely or with other issues — all of which could impact their health and development. [6,7,38,51,52] Although our research is unable to provide insights into why these children entered into care and their lives before IBC, we are able to describe the demographics and some insights into the lives of children who live in IBC and participate in CNP.

Our research found that there is a similar prevalence of males and females in IBC. The largest age groups of children were children 0-6 months (25.5%) and those 5-18 years old (41.9%).[7,37] Children came into IBC at a median age of 10 months and had resided in IBC for around two years although some had lived within IBC for more than 13 years. The wide ranges of length of stay in IBC could be related to a desire of adoptive families for infants and/or potentially the challenge of finding families for older children, those with disabilities or those with higher levels of needs. This is important because other research on the development of children living in care indicates that the longer children stay within IBC, the more at risk they are for delayed development and malnutrition, which is supported by our findings.[23,43,53-56] Although fewer children were placed into foster care, 35% of children who left CNP were domestically adopted and another 19% were adopted internationally. Additionally, the median age at which children enter into IBC and the high proportion of young children in IBC indicate that a large number of children are living within care during the developmentally sensitive "first 1,000 days" of their lives.[6,8,54]

Children often came into care without much known about their birth or prior health which was similarly reported in other research on children who have been orphaned or abandoned.[7,23,25,37,51,54,57] Often this can occur when children are abandoned without connections to birth family or when children's birth records or medical history are not forwarded from other facilities, hospitals or child records.[23] We found 2350/3335 (70.5%) of children to have an unknown birth weight, and 2551/3335 (76.5%) had an unknown gestational age. Of those with known birth weights and gestational ages, there was a notably high prevalence of prematurity and low birth weight with 311/784 (39.7%) of children were born prematurely and 550/984 (55.9%) were born low birth weight.[6] Both of which are substantially higher than the global prevalence of 14.6% low birth weight and 10.6% prematurity.[58,59] Health status at birth can be an important determinant of children's development and growth.[25,54,56] The limited information on children's prior health can lead to estimates by site staff or health care professionals, which can lead to imprecisions in growth measurements and medical interventions. The St. Petersburg-USA Orphanage Research team suggested that unknown birth circumstances makes it difficult to untangle the contributions of poor prenatal or perinatal circumstances and the environment within orphanages in relationship to poor health, delays or disabilities.[23]

Disabilities were common among children in IBC with a quarter of children in care having one or more disabilities. This is higher than the global prevalence of 5.1% of children younger than 15 years old and 14.9% of those older than 15 years having a disability.[33] Of those children participating in CNP, we found cerebral palsy, cognitive impairment, heart disease or defect, hydrocephaly, vision impairment or blindness, Down syndrome, cleft lip/ palate, HIV and autism to be common.[7,37] HIV prevalence in IBC was higher than global prevalence and this is important because HIV can significantly increase children's risk for becoming malnourished and can also be a contributing factor to children entering into IBC.[6,7,60-62] The St. Petersburg-USA Orphanage research team found that 8% of the children entering into IBC were considered to have a disability, although through use of a functional abilities index, they considered 21% of the children in IBC to have a disability which is closer to our finding of 25.3% of children in IBC having a disability.[6,22]

6.4 Malnutrition and Institution-based Care

Our research found children in IBC to be at high risk for malnutrition.[6,7,63] There were many challenges experienced by IBC facilities including staffing constraints, funding issues, poor supply chains and limited knowledge among staff on nutrition and feeding best practices for children which were similar to findings from other researchers.[6,7,27,38,43,45,50,51] Within the sites, there was commonly inadequate dietary diversity, inappropriate types of food for children of different stages and abilities, poor feeding practices, inadequate attention or stimulation and suboptimal hygiene and sanitation.[6,7,22,27,63,64] These are important findings because conditions in IBC can exacerbate the pre-admission vulnerabilities children have, resulting in reduced nutrient utilization, increased risk of malnutrition and a cycle of increased vulnerability to illnesses and nutritional decline.[22,27,63,64] Hearst et al. concluded that there was a relationship between growth-related indicators and low albumin, a nutritional biomarker, which suggested children in IBC were experiencing chronic malnutrition which could be related to inadequate diet, infections and/or inflammation or impaired nutrient absorption or utilization secondary to the psychosocial stress of living in IBC.[57]

A primary finding from this body of research was the limited amount of quality evidence-based data available on the nutritional status and feeding practices of children in IBC.[37,38] This thesis adds value because of the paucity of research and data available. Where data were found, children living within IBC were consistently at high risk of malnutrition — commonly experiencing undernutrition, overnutrition and/or micronutrient deficiencies.[6,63] Even modest nutritional deficits can have serious consequences and during periods of rapid growth, such as in early childhood, which can become magnified.[8,25,43] With the high proportion of infants and young children in IBC during the developmentally sensitive “first 1,000 days” of their lives, the malnutrition status of young children is a key concern and further reinforces the need for nutrition and feeding programs and optimal care while children reside in IBC.[6,8,54]

The risk of malnutrition for children in IBC becomes amplified if a child has a disability.[30,33,38] We found few studies which mentioned children with disabilities and their nutritional status, despite children with disabilities being disproportionately present in IBC, which has been a common finding among several research groups including UNICEF’s Division of Data, Analytics, Planning and Monitoring.[20,21,37,48,63,65] Their recent publication highlights the need to use data to shed light on the well-being of children with disabilities.[20] When children enter into IBC they are often already at an increased risk for malnutrition because of any challenges they may face with feeding, absorption or intake related to their disability or an unaccommodating environment.[7,30,31,34,66] Children with some types of disabilities may need additional time or support during meals or have higher caloric needs or need specialized diets.[30-32,66-69] Additionally, children with disabilities are often highly dependent on their caregivers for feeding, routine care, stimulation and engagement.[22,25] Our retrospective analysis found that the children who stay the longest in care are often children with disabilities and that they experience more malnutrition than children without disabilities.[37] We found that the nutritional status of children with disabilities seems to improve for younger children over time but older children do not appear to improve and, in some cases, worsen.[6] Disability can be a cause of malnutrition and malnutrition can also be a cause of disability — when children are malnourished they have an increased risk of developing a disability. [8,66] This is a key area of concern for children who live in IBC: for those who are at risk of malnutrition; for those who are malnourished; and for those whose malnutrition puts them at risk of exacerbating their disabilities

6.4.1 Anthropometric Data

Being stunted, wasted, underweight or overweight can increase children's risk of infectious diseases, poor development, non-communicable diseases and mortality. [8,70] In the retrospective analysis of children's nutritional status, we found that children in IBC are commonly stunted (1,048/2812, 37.3%), wasted (212/1678, 12.6%), underweight (788/2308, 34.1%) and overweight/obese (135/1123, 12%).[6] Additionally, children with small head circumference were prevalent (339/1095, 31%) which could be evidence of impacted brain development.[6,7,63] For most anthropometric measurements, children in IBC have z-scores far below the WHO's mean-for-age.[71,72] Compared to the global prevalence and the prevalence in LMICs, the prevalence of stunting, wasting and underweight was higher among children in IBC. The only exception was the prevalence of overweight children was lower than the global prevalence or the prevalence in LMICs.[60] Young children were found to have a high prevalence of stunting.[6] This is especially concerning because catch-up from stunting in early-life can be limited, especially for those children outside of the developmentally sensitive "first 1,000 days".[8] Furthermore, we found that children with disabilities were more likely to be stunted, wasted and underweight than their peers without disabilities and far below the WHO's growth standards and references.[71,72] Although children with disabilities may have clinical sequelae that impacts their growth, having a disability should not presume malnutrition or poor growth.[33,66] Suboptimal growth and anthropometric deficits could be related to a number of issues. Possible causes suggested by our research include poor feeding practices, varying biological needs, inadequate nutrition, feeding difficulties and caregiver beliefs and practices.[6,7,30,63] Children in IBC, especially those with disabilities, are at high risk of mortality and may require specific care and inclusion into programs to treat malnutrition.[33,66] Inclusion into programs often requires nutritional assessments which include the use of anthropometric indicators. Our systematic review of MUAC use among children with disabilities found that inadequate and non-standardized reporting of anthropometry is a widespread issue.[73] Groce et al.'s call to action highlights the need for inclusive nutrition programs for those with disabilities and the consequences to individuals if their basic needs continue to not be met.[68]

Although we found children in IBC to be more undernourished than the global prevalence and the prevalence in LMICs, children within the same communities as these facilities may also be at high risk for malnutrition. We found several studies that indicate peers in the community were more likely to be malnourished than children in IBC, although the risk varied by age.[38,49,50] Key informants and caregivers in our research also reported they thought children in IBC received better nutrition than children in the surrounding communities.[6,7,45] This could reflect some of the challenges faced by families in the community. Many families place their children into IBC to ensure they have access to routine nutritious meals, education, specialized care for those with disabilities or HIV and access to health care.[49,50,55,74-76] This is an important piece of information as sites, organizations and governments work to deinstitutionalized children and place them into families in local communities.

6.4.2 Dietary Intake, Diet Diversity and Micronutrient Deficiencies

Data from our systematic review and retrospective analyses of nutrition and feeding practices, found that few studies reported on children's dietary intake, dietary diversity or micronutrient status.[6,7,37,38] Of the studies that reported on dietary intake, half of them found dietary diversity to be inadequate.[38] Sites participating in the CNP reported that insufficient funding, inadequate supply chains and reliance on donations were limiting factors in their ability to provide nutritious foods to children.[45] Access to basic foods such as fruits, vegetables and milk was limited for many sites, often due to funding constraints or reliance on donations.[6] Diets in IBC were generally found to be high in starches and dietary adequacy varied with few facilities providing the recommended dietary allowances, although many were below the recommendations.[6,38]

Our systematic review and retrospective analyses found that some of the most common micronutrient deficiencies included low vitamin D, iodine, zinc, albumin, vitamin A, vitamin B and anemia.[6,7,38] We found that almost a third of children in IBC are anemic with younger children and those with disabilities more likely to be anemic.[6] Children 0-6 months old had the highest prevalence of anemia which is likely related to the high prevalence of LBW and prematurity.[6] Measuring anemia is a part of the CNP child health screenings. Sites are provided with equipment to track, treat and monitor children's anemia status at their facilities.[45] When children are anemic, there can be consequences to their cognition, brain development and growth. Globally, this is a common problem with 42.9% of children in low- and middle-income countries (LMICs) experiencing anemia.[8,60] Over time in IBC, the prevalence of anemia was reduced and this is likely related to the routine health screenings and training on how to treat anemia.[6] Additionally, the reduction in anemia could be a reflection of increased access to other health services, routine meals and improved sanitation, which may not be accessible to some families in the community. Whetten et. al and Panpanich et. al also identified these as a possible reasons why children in IBC may have better health than those in the community.[8,50,55] Addressing micronutrient deficiencies should be prioritized because when children are malnourished in IBC, they are at increased risk for illness, infections and morbidities.[8,57,70] Although micronutrient deficiencies were common, so was supplementation, with nearly half of children in IBC receiving a mineral or vitamin supplement (1626/3335, 48.8%).[7] An additional 225/3335 (6.8%) of children were taking food supplements. Supplementation of both food and mineral/vitamin supplements were more prevalent among children with disabilities.[7] This could raise a concern that challenges with feeding children with disabilities is resulting in them being given supplements in lieu of support to ensure they are receiving diverse adequate diets, provided in ways that allow them to safely eat and absorb the nutrition. This is a concern that has been raised by other disability researchers including Groce et al.[31,33,66]

6.4.3 Illnesses and Infections

Few of the papers in the systematic review reported information on the types and prevalence of illnesses and infections experienced by children in IBC. Through the systematic review and analysis of the CNP data, we found illnesses and infections to be common in IBC with many children experiencing fevers, cough/cold, diarrhea, constipation or hospitalization.[7,38] Many children were found to be ill within the last month of their stay in IBC and those with disabilities were found to have a higher proportion of illnesses compared to those without disabilities.[7] Although data on illnesses can be difficult to interpret, the frequency of illnesses could be related to the conditions in IBC including poor hygiene and sanitation, suboptimal feeding practices and inadequate diet diversity.[6,7] Frequent illnesses can have consequences to children's brain functioning and development.[8,12] Together, the high prevalence of illnesses and infections in addition to micronutrient deficiencies and inadequate dietary intake could lead to malnutrition and suboptimal growth among children in IBC. As described by Black et al., this could further trap children into a cyclical interaction between malnutrition and infections which could affect their feeding, intake and growth.[8]

6.4.4 Monitoring and Tracking of Nutritional Indicators

One of the most valued parts of the CNP was the ability for sites to track and monitor the health and growth of the children at their sites using an electronic nutrition screening system.[45] The CNP implementation engages caregivers and site staff in a participatory training of trainers (ToT) styled training where they learn how to conduct nutrition and feeding interventions. This training helps caregivers and staff develop the skills to identify, treat and prevent malnutrition for children of all ages and abilities.[45] They build skills to accurately complete anthropometric measurements and growth screenings and learn how to test and treat children with micronutrient deficiencies.[45] One key feature of the database is a dashboard that allows sites and country-level program managers to see the current demographics and nutritional status of children at a site level or country level. Through our research we found that utilizing funnel plots, provides useful visualization of nutrition indicators such as the prevalence of underweight children in relationship to other sites: this could be beneficial for country level program managers.[45] Additionally, for site level monitoring, the use of control charts enables sites to see trends in their site's nutritional indicators over time in comparison to the site's limits. Together these charts can help implementation by providing sites and country level program managers a way to distinguish normal inter-site variations from statistically significant variations which would warrant follow up. [45] Through future integration of these types of charts into the CNP nutrition screening system's dashboard, staff can track and monitor the nutritional needs of sites with charts that provide expected limits for children in IBC accounting for the existence of natural variation. In tandem with the tools and training provided by the CNP, these charts provide an added tool for program staff to monitor and evaluate program implementation with up-to-date easily understandable data visualizations.[45]

6.5 Feeding and Institution-based Care

Children's nutritional intake is important because childhood presents critical periods of growth, learning and development.[70] Although the causes of malnutrition are multi-faceted, we found that an area of high concern for children living within IBC are feeding practices.[7] How children are being fed can be just as impactful as what children are being fed.[40,66,69]

6.5.1 Feeding Practices

Our retrospective analysis on feeding found feeding practices to vary between sites and caregivers but were commonly poor or unsafe or inadequate to meet children's needs.[7] Feeding practices are the interactions which happen between caregivers and children during mealtimes. How children are fed can change based on context and other factors such as a child's age, ability or socio-economic status of the site or family and cultural practices or beliefs.[3,40,77] The limitations of IBC in terms of staffing, time and fiscal constraints can also impact how children are being fed.[27,43,51] We found that the level and frequency of interactions between caregivers and children varied greatly by site and by caregiver. Our key informants reported that caregivers working within IBC often do not receive any information or training on the nutritional or feeding needs of children, developmental stages or optimal caregiving practices which is a similar to findings by the St. Petersburg-USA Orphanage Research Team.[22,23,45,47] This lack of training and resources is compounded by competing work demands of caregivers, which limit their time to just address children's basic needs.[22,23] These competing priorities can limit the amount of engagement a caregiver has with a child, which is of particular concern in regard to mealtimes because mealtimes can make up as much as 50% of the time a caregiver will spend with a child during the day.[23,40] Mealtimes and interaction with caregivers are an important part of a child's development and provide key opportunities for children to learn and practice new skills — skills which impact their lifelong eating habits, nutritional status and both social and cognitive development.[3,40,78] Some CNP sites had environments and structures which allowed for more interaction with children. However, we found mealtimes were often short and perfunctory, and caregivers were not always responsive to children's feeding cues, which are similar to findings by the St. Petersburg-USA Orphanage Research Team.[7,22,23] Additionally, other research on practices within orphanages indicates that interaction may not be considered a key function of caregivers roles in IBC and sometimes even an environment of emotional detachment is encouraged.[23,51,54,57] This is important because it is through these essential interactions that children learn from their caregivers desired feeding practices and the context of meals. Our research further found that learning new skills from peers was also limited in IBC because during mealtimes children at CNP sites were typically grouped by age or disability status, regardless of their needs or development level which was a practice similarly reported in other research on orphanages.[7,22,23,79]

In addition to suboptimal interaction, poor feeding practices were common across all the sites examined in this PhD. Forced feeding, limited opportunities for self-feeding and skill development, inadequate dietary diversity, limited feeding schedules, cutting bottle nipples, inappropriate utensils or bottles, cereal in bottles, inadequate offering of fluids and inappropriate pacing and positioning were all commonly observed.[7] Poor hygiene practices around mealtimes, such as the lack of handwashing or sanitizing of bottles, were prevalent. Inadequate fluids, poor positioning, inappropriate utensils and poor dietary diversity were noted as key problems for children with disabilities. The St. Petersburg-USA Orphanage Research Team also found similar suboptimal feeding practices through its research on practices and populations within government funded baby homes within the Russian Federation, which operate similarly to some of the IBC facilities participating in CNP.[22,23] Together, these poor feeding practices have the potential create preventable routes to illness, dehydration, infections and cause malnutrition.[8,31,32,69] Poor feeding practices can be especially impactful for infants and young children who are within the nutritionally sensitive "first 1,000 days" of their lives and need the attention and stimulation of quality caregiving to grow.[3,8,80] As many of the children in IBC are premature or born low birth weight, these children can require individualized feeding support and are they are particularly vulnerable to diarrhea, dehydration and infections.[8,40,78] Children with disabilities also often require additional support to safely and enjoyably eat and participate in mealtimes.[7,30,31,33,66,69]

How children are fed can lead to long-term negative or positive associations with eating and mealtimes.[81] The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) has a diagnosis for pediatric feeding disorders. This diagnosis is used to indicate that children experiencing fear and pain during the feeding process could have negative associations with feeding and develop difficulties with feeding.[79,82] By providing training to caregivers on safe feeding practices, there is the potential to avoid some consequences of poor feeding practices.[67,83] Caregivers of children in IBC, especially caregivers of infants and those with disabilities, play a critical role and should receive frequent training and resources to understand children's needs and provide appropriate support.[33,45] Feeding methods for all children living in IBC need to be routinely reviewed and evaluated sitewide for consistency of implementation as children age and develop. Based on the findings from this PhD, feeding is a critically important and currently largely overlooked component of improving the health and well-being of millions of children living in IBC. Training on how to support safe, positive and engaging mealtimes should be prioritized. Feeding and mealtimes provide opportunities for good nutrition, essential skill development and connections for children.[7,32,45,83]

6.5.2 Feeding Difficulties

Feeding difficulties is a term that is used to describe the feeding challenges and issues children have during mealtimes. This term encompasses all difficulties during the process of providing food to the child or the child eating the meal, regardless of etiology, effects or severity.[3,40] We found that feeding difficulties were pervasive across all the sites included in this research.[7] Feeding difficulties impacted children of all ages and abilities. Some of the most common feeding difficulties identified included difficulty chewing, difficulty feeding self (>1-year-old), coughing or choking during meals, difficulty swallowing, poor appetite, aspiration, reflux/heartburn, frequent spitting up or vomiting, difficulty drinking, bad teeth, food allergies/intolerances and picky eating. In general populations, feeding difficulties affect 25-45% of children without disabilities and up to 80% of children with disabilities.[3,39,77,81] We found that feeding difficulties were present in 378/3335 (11.3%) of all children in IBC including 153/2578 (5.9%) of children without disabilities and 225/757 (29.7%) of children with disabilities. When children have feeding difficulties it can put them at increased risk for malnutrition, illnesses, diseases, diminished cognitive and behavioral development, suboptimal performance at school and work, non-communicable diseases and cause or exacerbate existing disabilities.[6,8,10,12,38,39,81] It is notable that of the children with disabilities participating in CNP over 40% of them have an unspecified disability, which could limit practitioners ability to determine root causes or treatment plans for those with feeding difficulties. Early screening for feeding difficulties when children come into IBC could help with the identification of those who need additional support — potentially helping children who have undiagnosed disabilities or underlying oral motor issues which could impact their development.[84,85]

A notable finding from this research was that many of the children no longer had feeding difficulties after one year in the CNP.[7] Of those with disabilities 54/164 (33.1%) saw their feeding difficulties resolve after one year in the CNP. Similarly for children without disabilities, 57/106 (53.8%) no longer had feeding difficulties after one year. Some feeding difficulties may resolve with age, but it is likely that training caregivers on how to identify feeding difficulties and best feeding and positioning practices for children may have had some impact on reducing feeding difficulties.[7,31,45,67,83] When feeding issues are addressed early and effectively with resources and training for caregivers, consequences such as malnutrition and delayed development could be minimized or prevented.[30,31,40,67,79] We found that disability status was strongly related to feeding difficulties for children. Children with disabilities had more than five times the risk, in adjusted analysis, of having a feeding difficulty compared to those without disabilities. Some feeding difficulties were higher for children with disabilities such as coughing or choking during meals and having more difficulties with swallowing, chewing, drinking, sucking or self-feeding. Similarly, Kuper et. Al found that children with disabilities were more likely to have feeding difficulties compared to their neighbors without disabilities (OR= 1.9, 95% CI 1.2-3.1).[31] Difficulty with safely eating could increase a child's risk of aspiration, upper respiratory infections and mortality.[31,69] Our research and the research done by Kuper et al. found that ability and support to self-feed among children with disabilities is low.[30-32,38] Caregivers often do not know that many children with disabilities can learn to feed themselves if given the chance, time and support to learn. This is a lost opportunity for both the children and their caregivers. By providing additional time and resources to teach children to feed themselves, caregivers enable children to have greater self-efficacy, increase social participation and develop independence that will benefit them for the rest of their lives. Taking the time to help children develop new skills around feeding should be considered a long-term investment in their futures.

6.6 Nutrition and Feeding Interventions

A core connecting piece of this body of research was Holt's Child Nutrition Program. This program gave us insights into areas of need for children in IBC and data to explore the nutritional needs and feeding practices of children in IBC. The data collected indicates that site participation in CNP has the potential to improve feeding practices, nutritional outcomes and hygiene and sanitation at sites.[6,7,45] We found that examination of the implementation of CNP provides key insights which can potentially help increase the sustainability of CNP interventions and inform wider nutrition and feeding interventions.[45]

6.6.1 Training and Behavior Change

One of the most challenging and important parts of program interventions is working to change behavior. While there are many theories and frameworks around social behavior change for programming, generally behavior change theories take into account the interaction between individuals and their environments, behaviors and personal factors.[86-89] Behavior change at individual and site levels require multi-faceted approaches.[87] Similar to USAID's Advancing Nutrition Social and Behavior Change competencies for Multi-Sectoral Nutrition, we found that securing buy-in, clear communication of programming, use of evidence-based content, utilization of data to inform programming, clear guidance, strong monitoring and evaluation systems, engagement with stakeholders, program adaptability, resources and tools were all essential factors for implementation.[87,88] Additionally, this research found the factors influencing program implementation were similar to USAID's Advancing Nutrition findings and included a number of barriers and facilitators.[87,88] These factors included cost, time, technical skills, staffing, supportive policies of sites, site infrastructure, financial support, integration of practices, enforcement of changes, perceived value, and understanding of the information and value of the program.[87,88] We found that for sustained implementation of nutrition and feeding interventions overtime, behavior change had to occur at both a caregiver and site-wide level. At both levels, behavior change was related to frequent training and retraining with hands-on practicums, support from site directors and country level staff, clear staff roles and responsibilities, adequate staffing and resources accessible to all staff.[45]

Specifically for site staff and caregivers, participatory training, support and resources are essential to program implementation. Similar to findings from other programs, such as Ubuntu, Baby Ubuntu and Juntos, we found that training for caregivers has a substantial impact on their behaviors, practices, engagement, and feelings of support.[83,90,91] When caregivers change their behaviors, the resulting improved practices have the potential to improve children's developmental outcomes.[31,67,91] Our findings are comparable to other programs, including Ubuntu/ Getting to Know Cerebral Palsy (CP), which found that caregivers can experience positive changes in their attitudes toward children they care for, have an improved understanding of children's needs and confidence to care for them.[83,91] In addition to gains in the knowledge of caregiving practices, with support and training caregivers can build confidence in their abilities and this acquisition of confidence, knowledge and skills can provide added value to caregivers' personal and professional lives.[31,83,88,91]

6.6.2 Sustained Program Implementation and Growth

Utilizing tools and resources such as the World Health Organization's Monitoring the Building Blocks of Health Systems handbook to guide interventions and program implementation can add value by ensuring the building blocks of programs and systems desired outcomes are met and sustained.[92,93] Sustaining high quality program implementation can be a challenge, especially as programs grow and scale up. The CNP has grown from two pilot sites to over 60 sites in the span of 9 years and the growth occurred in large part because of the value sites have seen in the program and the impact sites see in terms of children's development. Our research found clear barriers and facilitators to implementing the CNP. Many of the program barriers identified were related to funding, inadequate staffing, dependence on donations, poor supply chains, staffing or leadership turnover, inflation and inappropriate technology. The facilitators included integration of practices into site systems, frequent training, incentives for staff such as extra pay, diverse funding, strong partnerships, frequent communication with key stakeholders, appropriate technology, routine monitoring and evaluation systems and peer support. Specifically, we found that high quality sustained program implementation of CNP required ongoing support, frequent oversight, quality relationships, clear partnership expectations with local and national government systems, strong leadership and engagement of key stakeholders.[92,93] Sustained program implementation over many years is the goal for CNP and the insights gained from this research will support strategies for ensuring high-quality sustained implementation is maintained by sites and country programs.

Next steps for CNP implementation will be to take the learnings from this research and apply them to programs, determine potential strategies for scaling up the program and growth within the sites and countries where CNP is already operating. Our research identified that to grow and scale programs, interventions need to be adaptable to different contexts and the individual needs of implementing sites, while fitting within the country's overall agenda in terms of child nutrition and health.[45,83,92,94,95] Additionally, a plan for dissemination of the program and outcomes with key stakeholders and wider audiences is essential to finding opportunities for growth. Utilizing tools such as the WHO's Nine Steps for Developing a Scaling-Up Strategy will allow program managers to create strategies to increase the range of impact of this program at both national and international levels.[92,96] Engaging other key stakeholders such as children, caregivers, community members and officials in this will context and guidance for next steps.[45,96] Combined with information from evaluating the process of implementing CNP, scaling up strategies could provide insights for similar nutrition and feeding interventions.[45]

6.7 Strengths and Limitations of this PhD

There were several strengths and limitations to the research included in this PhD. One main strength of this research was the use of large, multi-site, multi-country data sets with substantial numbers of children. The data varied in terms of countries included, different types of centers, and the number of children of all ages and abilities. While the samples included may not be representative of all institutions or the entire profile of children living in IBC, it does provide insights into care centers of various types in low to upper-middle-income countries. With the limited research available, this diversity is a strength of this research and can provide a more global view of the challenges faced in IBC.

However, it is important to note the data included in this research is from sites and children's health records who participate in CNP and often other Holt programs. As a large global non-profit, Holt International has worked with and supported many of these sites for years. Often the sites receive support for education, food, staffing, health and medical services, systems strengthening and other items to support the well-being of children at their facilities, in addition to programs such as CNP. The data included in this body of research is subject to sampling bias and likely the wider group of IBC facilities are not as well-resourced as these sites. Additionally, the strong relationships with these sites may have influence on their buy-in and implementation of CNP. But the integration and nesting of this research into existing programmatic data collection methods and relationships with sites enabled more targeted and relevant questions which can provide direct feedback into programming and allow adjustments to be made more quickly and easily.

Although there are insights from some of this research which could inform wider local community populations, such as the need for support and training for caregivers of children, any general conclusions should be taken with consideration of the differences between care centers and the children who come into care from the general community. Many children who come into IBC have experienced numerous adversities prior to care and may have pre-existing risk factors for malnutrition. Care centers are often better resourced than families in the same communities for managing malnutrition.

Specifically for the data from children's health records, there are some limitations which could impact growth trajectories or influence analysis such as unknown prior history (i.e. substance exposure prematurity, age, low birth weight). Additionally, for some children their first screening as part of the CNP was their first day in IBC but for others, it occurred multiple years into living in IBC and the length of stay in care could impact children differently as children age and develop their nutrition and feeding needs change. There could be potential measurement bias in the data sets, especially for the children with disabilities for whom anthropometric measurements can be difficult to conduct.[20,66,73]

Another limitation of this research, although a strength in terms of numbers of children with disabilities and the different types of disabilities included, disabilities were diagnosed by health professionals in their countries, not assessed by a standardized method, such as the Washington Group questionnaire.[37,38,97] Using a standardized tool such as the Washington Group questionnaire would allow for a more comparative analysis and potentially identify additional children in IBC who have functional difficulties or undiagnosed disabilities.[97] Disabilities can result in some children being small or underweight for their age based on clinical sequelae.[30,33,45,68,69] These disabilities may impede their feeding ability, digestion or other conditions that could result in a lower weight or height. [67,73,7431] Additionally, this research grouped children with disabilities together for comparison with children without identified disabilities in IBC. Although this allows for some comparative analysis, it does not address the individual needs of children.

Other limitations include that this research utilized routine surveillance audit data and over time there was a decrease in sample sizes of children and some small site samples. As children exit CNP, this could introduce additional biases, such as those needing more care stay in IBC longer and those who are healthier are able to be transitioned to family-based care. Cultural and social considerations and context should also be considered when reviewing this research.

Although I worked to include our field staff and partners in each of the research papers, this research was lead and completed by a Western researcher, using data from a program designed by a multinational non-profit which may not fully consider the cultural contexts and perceptions of children's needs in each of the countries where the CNP operates. Additionally, myself and some of the co-authors of this research are trainers or CNP Champions who help to lead this program. This introduces a potential bias and completely independent observers may have interpreted the same results differently. Overall, however, this was a strength because it allowed for much deeper analysis and understanding of the data because of the direct and full knowledge understanding of the CNP methodology and relationships with sites, field staff and partners.

This research was also impacted by the COVID-19 pandemic. There were delays in ethics reviews, interviews, publications, in addition to travel and in-person interviews not being possible. Although completing some of this research remotely did allow for efficiencies the research team. Additionally, how sites implemented CNP changed as they navigated public health restrictions. Another limitation was minimal engagement with important stakeholders, such as children, caregivers, community members, families, or government partners in the design and analysis of this research due to the types of data available and used.

Chapter 7: Recommendations, Implications for Research and Conclusions

7.1 Scope of this Chapter

This PhD has produced a body of work which describes the nutrition and feeding status of children living in IBC and the implementation of a nutrition and feeding intervention program which addresses the needs of children in IBC. In this final chapter, I use the findings from this PhD to provide recommendations for programs, policy and future research in this area.

7.2 Recommendations for policy and programs

In line with UNICEF's goals to reach every child and the Sustainable Development Goals (SDGs) to reduce malnutrition among children, these recommendations address programs and policies related to the nutrition and feeding needs of children in IBC in line with global development goals.[20,35]

Table 7.1: Summary of recommendations for policy and programs for children in IBC

	Recommendations for policy and programs
Individual level (Children, Caregivers)	• Address the developmental needs of children in care today. • Prioritize training opportunities for caregivers around nutrition and feeding best practices for children, including those with disabilities. • Integrate support systems for caregivers into nutrition and feeding interventions. • Raise awareness around the value and impact of safe and engaging nutritious mealtimes for children. • Ensure nutrition and health screenings of children in facilities are routinely completed.
Site Level (Program managers, site administrators)	• Integrate nutrition and feeding interventions into organization and workflow. • Provide frequent support and training for staff. • Assess, track and monitor the nutrition and health of children within sites and evaluate at a site level.

	• Analyze nutrition and feeding interventions to improve program implementation. • Consideration of inclusion of standardized methods of disability. identification such as use of the Washington Group questionnaire.[97]
Country level (e.g. Ministry of Health, Holt country offices)	• Identify and raise awareness about the needs of children in care within countries and promote scale up of programs addressing their needs. • Strengthen nutrition and health systems for children and integrate services for children with disabilities across all levels of care. • Ensure engagement with local, regional and national government and other local stakeholders.
Multinational implementer level (e.g. NGOs, Holt)	• Advocate and raise awareness about the needs of children. • Provide support for programs, such as CNP, which address the nutrition and health needs of children in care, including for those with disabilities. • Include children in care, especially those with disabilities, in research that could help to address their needs.
Policy level (e.g. WHO, UNICEF)	• Develop evidence-based guidelines addressing the nutrition and feeding needs of children in IBC. • Promote scale-up of nutrition and feeding interventions in all countries, with inclusion of children with disabilities at all levels. • Take actions to further scientific understanding of the nutrition and feeding needs of children, as well as how best to support their caregivers.

7.2.1 Individual level

Children

While it is not ideal that children live in IBC because of the potential risks to their physical, emotional, intellectual well-being and development, millions of children are living in care today and their needs cannot be ignored.[19,25,27,46,47] Children have a right to live in conditions that provide standards of living that will support their full and adequate development.[17] As the global community works towards strengthening families and deinstitutionalizing children, the children currently in IBC need to be included in the conversation, including young children and those with disabilties.[12,48,98] Children in IBC are at high risk of not developing to their full potential.[55] Despite the environmental limitations of IBC, sites should work to not just meet the basic needs of children but aim for a holistic approach to support children's full development. Sufficient and quality dietary intakes, quality engaged caregiving, stimulation and engagement, routine health screenings, and support for safe feeding are all key areas identified as necessary to the development of children.[6,7,38,54] Infants and children with disabilities present with an even higher risk for malnutrition and delayed development within IBC.[6,7,20,22,38,54] Often these children are not able to fully convey their needs and rely on their caregivers to help them meet their basic needs. They need extra attention and support and should be a key part of improving available services in IBC. By better understanding the needs of this unique population, more can be done to ensure that children reach their full potential, regardless of where they reside in their early lives.

Caregiver

One of the most important factors in a child's development is the support, engagement and relationship they share with their caregivers.[22,23,47,83] When staff are not well supported, it becomes harder to meet children's needs. Supporting staff in IBC with resources, training, peer networks, and clear guidance needs to be prioritized.[7,45] Caregivers without support can often have increased stress, resulting in negative consequences for children.[30,47,91] This is especially true for caregivers of children with disabilities who often need extra resources and training to care for children appropriately.[30,47,91] Key priorities should be to raise awareness with caregivers around the value of good nutrition practices and safe and engaging mealtimes and provide training opportunities for caregivers around the nutrition and feeding best practices for children, including those with disabilities. Additionally, all nutrition and feeding interventions should have an integrated support system for caregivers. Within these interventions, caregivers should have clear guidance on the best practices and how and when to complete routine health screenings for children. We suggest that screening children early for things like feeding difficulties, disabilities or malnutrition could help with identification of those who might need additional support and interventions to ensure positive developmental outcomes, which is similar to recommendations from Manikam & Perman and Johnson et al.[84,85]

7.2.2 Site Level

As sites care for children and implement nutrition and feeding interventions such as the Child Nutrition Program, sites should complete a full assessment of how best to integrate programs in a sustainable and standardized way throughout their entire facilities. By integrating nutrition and feeding interventions into their organizational workflow, they can work to ensure systems support staff with frequent training and clear guidance on expectations. Sites should create systems of accountability to ensure they are consistently and routinely assessing, tracking and monitoring the nutrition and health of both individual children and the site as a whole. Routine monitoring and evaluation of their programs will allow them to make changes to improve implementation of these programs. Utilization of monitoring and evaluation tools such as Shewhart control charts and funnel plots could provide sites with added insights into the trends and changes in children's health at their sites.

7.2.3 Country level

There is a great need for programs such as CNP in IBC, foster care systems and other community-based services. Country level teams should work to identify the needs of children within their local contexts, especially for children in IBC or those with disabilities. Integration of disability inclusive services should be part of program frameworks and design. As they implement, support and lead nutrition and feeding interventions ensuring collaboration with local, regional and national government, as well as other key stakeholders, should be prioritized.[45] Through these relationships, country-level teams can work to strengthen nutrition and health services across all levels of care and partner sites. As these relationships develop, opportunities for growth and scale-up of programs to meet the needs of more children, sites, families and communities should be identified collectively. Advocacy efforts to fund programs which address the needs of children, sites and programs are often effective from country-level teams.

7.2.4 Multinational Implementers Level

International non-profits, such as Holt International, are in a unique position to advocate for the needs of vulnerable groups and support the nutrition and health services for children.[1,41] The successful implementation of CNP is one example of a nutrition and health program which has the capacity to work in multiple countries and different types of sites. Through evaluation of implementation of programs such as CNP, multinational implementers can play a key role in the growth and scale-up of such programs. Additionally, multinational implementers also often have funding or access to resources to support the implementation of programs. At this level, many organizations have the capacity to conduct research which could provide further insights into the needs of children. Any research conducted should include those with disabilities. Research provides a great opportunity to examine practices in a way which provides peer-review and has the potential to reach global audiences. Relationships and influence with policy level stakeholders could be developed in efforts to further advocacy efforts for the world's most vulnerable populations.

7.2.5 Policy Level

Policy-level stakeholders play an important role in children's health and development. Guidance and recommendations have the potential to impact millions of children at this level. By developing clear, inclusive, and evidence-based guidelines for children, including those in IBC, policy makers have the opportunity to improve the services provided to children and their developmental outcomes. At this level, policy makers also can direct funding and resources where they are needed most and provide guidance on best practice methods. They also can both lead and fund research to further the scientific understanding of the nutrition and feeding needs of children, as well as how best to support their caregivers. The research in this PhD could help to inform better decision making among policy makers and child welfare professionals on the nutrition and health needs of children in IBC, especially those with disabilities, as they work toward deinstitutionalization and global reforms in child welfare practices. Governments need to have plans for deinstitutionalization which include monitoring, evaluating and sustaining the desired reforms, while ensuring they are linked to broader changes across all sectors and that action plans are child focused and disability inclusive. Work needs to be done to increase political will for prioritizing the development of all children, ensuring child welfare systems address the needs of all children, funding for family strengthening programs to reduce child abandonment and putting into place strategies to expand family-based care for children who are in IBC.[48,70]

7.3 Implications for Research

Table 7.2: Summary of implications for future research

	Additional research questions to address evidence gaps
Description	Describe the prevalence of malnutrition and feeding difficulties in foster care, family-based care, children with their birth families and those in IBC, including for those with disabilities.
	Describe the challenges and needs of caregivers in IBC.
	Describe the impact of early nutrition and feeding interventions for children of different ages and disability types in IBC.
	By utilizing the Washington Group Questionnaire, describe the differences in disability identification in IBC and foster care.
Understanding	Examine inter center variations in child health outcomes in IBC and how that can inform program adaptation.
	Explore the utility of control charts over more standard methods of presenting key nutrition and health outcomes of children.
	Examine how children's nutrition and feeding status impacts deinstitutionalization strategies.
	Explore how nutrition and feeding interventions impact caregivers.
Implementation	Evaluate the differences between different implementation strategies, including cost-effectiveness of services, to inform nutrition and feeding intervention programming.
	Adapt and evaluate how nutrition and feeding interventions for caregivers can be adapted for different communities, countries, contexts and how that changes caregiver's outcomes.
	Examine how nutrition and feeding services for children with disabilities can be integrated into routine child health services.
	Create and evaluate a scaling-up strategy for CNP.
	Examine implementation of CNP or the roll out of new training strategies or tools by utilizing methods such as a stepped-wedge trial design or other type of randomized control trial.

7.3.1 Description

To achieve the global goal of deinstitutionalizing children and strengthening families, addressing the needs of children and their caregivers, including those with disabilities, is essential.[7,12,15,16,38,45,48] It will be of key importance to consider how best to strengthen and support individual caregivers, children and families who may lack resources and support.[31,67,91]

Describing the needs and challenges of caregivers in IBC, as well as those in foster care or the community will be an important part of future research. An important step to support more targeted programs and services will be to better describe the variations in malnutrition and feeding difficulties for children in foster care and community-based care compared to those in IBC. This will be especially important for children with disabilities. Exploring how nutrition and feeding interventions at different time points (i.e. short-term early intervention vs. long term supported interventions) for children of different ages and abilities will help to inform services. Utilizing tools such as the Washington Group questionnaire will create a more standardized method of identifying disabilities and enable enhanced description of the differences in needs of children in IBC, foster care and community-based care.[97]

7.3.2 Understanding

To better understand the needs of children in IBC, further examination of how the variations of sites and contexts interact with program outcomes. Beneficial or consequential variations between sites could inform program adaptations and address any gaps which might exist within the CNP implementation model. Examining monitoring and evaluation tools could also provide better insights into program outcomes and implementation strategies. Specifically, examining the use of control charts and funnel plots in tandem with more standard methods of presenting key data should be analyzed further. Deinstitutionalization strategies for children, especially those with disabilities, will require further understanding of how children's individual needs, such as how their nutritional and feeding needs are related to the ability to place children into families both domestically and internationally.[48,99,100] As we work toward placing children with families, understanding the needs of caregivers in terms of nutrition and feeding interventions and how those interventions impact caregivers will be of core importance.[31,67,83,91] Supporting caregivers is of key importance to children's development.

7.3.3 Implementation

Scaling up programs that improve children's health outcomes, such as CNP, require further investigation.[93,96,101] Creating and evaluating a scaling strategy for CNP could provide guidance for how Holt can continue to grow the program and how potentially other stakeholders could implement the program at all levels. Additionally, it will be important for future research to look at the differences between implementation strategies, including the cost effectiveness of different strategies and programs, is needed to inform high quality programming. Gaining insights into how different strategies for both caregivers and sites can be adapted to different communities, contexts and countries is valuable. Another key area for future research on implementation will be to examine how nutrition and feeding services for children with disabilities can be integrated into routine child health services. Disability-inclusive programming, such as CNP or Ubuntu, could offer valuable information to learning how to better meet the needs of all children.[1,102] Examining CNP implementation or the roll out of new training, tools or resources to sites by utilizing more rigorous research methods such as a stepped-wedge trial design or other type of randomized control trial would be another valuable area for future research. This would help to reduce the biases and limitations of observational studies and potentially provide more insights into true impact of interventions.

7.4 Conclusions

Up to 9.4 million children live within IBC globally. But despite this being a large population of vulnerable children, this group is often not included in research, nutrition programming, health services or policy decisions. An overarching key finding from this research was the substantial gap in the amount of available recent literature on this population. In an ideal world, children would never reside in IBC but rather in the love and care of their stable families. However, for so many children, including many infants and children with disabilities, living in IBC is a reality that they face. Without acknowledging the vulnerabilities and needs of this population, the global community does a disservice to these children by ignoring their present reality and needs. Collectively working toward the deinstitutionalization of children is the ultimate goal but in the immediate future, there is an urgent need to address the nutrition and feeding needs of children in care today.

Children in IBC are commonly malnourished and at risk of not reaching their full growth potential. They are often underweight, overweight, stunted, wasted or experiencing micronutrient deficiencies at prevalence higher than the global prevalence. The prevalence of being born low birth weight, prematurely, having a feeding difficulty or having a disability is also higher for children in IBC than for the wider global population of children. Additionally, children in IBC also experience several other factors which can increase their risk of suboptimal nutrition and growth such as, poor feeding practices, increased illnesses and infections, lack of adequate dietary diversity and intake, inadequate stimulation and engagement with caregivers and poor hygiene and sanitation practices. Infants and children with disabilities are at an even higher risk of malnutrition and feeding difficulties. These factors combined play a significant role in children's risk for malnutrition and poor development.

Research on programs targeting the nutrition and feeding needs of vulnerable children, such as those in IBC could help to inform wider interventions targeting children. Nutrition and feeding interventions including strong partnerships with local government, secure funding, stakeholder engagement and buy-in, adequate staffing, frequent training, and support systems have the potential to positively impact the lives of children and their caregivers. The implications for caregivers, clinicians, governments, multinational implementers and policy makers is that work is needed to ensure all children's basic rights are met. Children living IBC are at risk and require special attention, especially for infants and those with disabilities. Children have a basic human right to grow and develop to their full potential, regardless of where they receive care in their lives.

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Annex

A. Contributions by Candidate and Co-Authors to the Work Presented in this Thesis
B. Publication on the Nutritional Status of International Adoptees (Paper 5)
C. Research on the Use of MUAC for Children with Disabilities (Paper 6)
D. Supplementary Materials for Paper 1: Nutritional Systematic Review
E. Supplementary Materials for Paper 2: Nutritional Retrospective Analysis
F. Supplementary Materials for Paper 3: Feeding Retrospective Analysis
G. Supplementary Materials for Paper 4: Evaluation of Process

A. Contributions by the Candidate and Co-authors to the Work Presented in this Thesis

Annex Table A.1: Contributions by candidate and co-author to the work presented in this thesis

Chapter		**Activity**	**Responsibility**	**Additional Input**
Chapter 1	Introduction, Rationale, Aims and Objectives, Structure, Description, Ethics and Funding	Conceptualization and writing	**Emily DeLacey**	Marko Kerac, Cally Tann, Elizabeth Allen
Chapter 2	The nutritional status of children living within institutionalized care: A systematic review (Paper 1)	Conception and design	**Emily DeLacey,** Marko Kerac, Cally Tann	
		Analyzed the data	**Emily DeLacey**	Marko Kerac, Cally Tann, Maria Kett, Michael Quiring, Ethan Bergman, Caryl Garcia
		Drafting of manuscript	**Emily DeLacey**	
		Review of drafts and approval of final paper	All authors	
Chapter 3	Nutritional status of children living within institution-based care: A retrospective analysis with funnel plots and control charts for programme monitoring (Paper 2)	Conceptualization of paper	**Emily DeLacey,** Marko Kerac, Cally Tann, Elizabeth Allen	
		Contributions to methods or quality control	**Emily DeLacey**	Marko Kerac, Evan Hilberg, Michael Quiring, Cally Tann, Elizabeth Allen, Hang Dam, Ethan Bergman, James Vilus, Nora Groce, Merzel Demasu-ay
		Analyzed the data	**Emily DeLacey**	Evan Hilberg, Elizabeth Allen
		Drafting of manuscript	**Emily DeLacey**	
		Review of drafts and approval of final paper	All authors	

Chapter 4	Feeding practices of children within institution-based care: A retrospective analysis of surveillance data (Paper 3)	Conceptualization of paper	**Emily DeLacey,** Marko Kerac, Elizabeth Allen and Cally Tann	
		Contributions to methods or quality control	**Emily DeLacey**	Marko Kerac, Tracey Smythe, Michael Quiring, Cally Tann, Nora Groce, Elizabeth Allen, Evan Hilberg
		Analyzed the data	**Emily DeLacey**	Evan Hilberg
		Drafting of manuscript	**Emily DeLacey**	
		Review of drafts and approval of final paper	All authors	
Chapter 5	Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process (Paper 4)	Conceptualization of paper	**Emily DeLacey,** Marko Kerac and Cally Tann	
		Contributions to methods or quality control	**Emily DeLacey**	Marko Kerac, Tracey Smythe, Elizabeth Allen, Michael Quiring, Nora Groce, Cally Tann, Maijargal Gombo, Merzel Demasu-ay
		Analyzed the data	**Emily DeLacey**	Elizabeth Allen, Michael Quiring
		Drafting of manuscript	**Emily DeLacey**	
		Review of drafts and approval of final paper	All authors	
Chapter 6	Discussion	Conceptualization and writing	**Emily DeLacey**	Marko Kerac, Cally Tann
Chapter 7	Recommendations, Implications and Conclusions	Conceptualization and writing	**Emily DeLacey**	Marko Kerac, Cally Tann
Annex	B. The Nutritional Status of Individuals Adopted Internationally as Children: A Systematic Review (Paper 5)	Conceptualization of paper	**Emily DeLacey,** Marko Kerac	
		Contributions to methods or quality control	Richard Ivey, **Emily DeLacey**	Marko Kerac
		Analyzed the data	Richard Ivey, **Emily DeLacey**	

		Drafting of manuscript	Richard Ivey, **Emily DeLacey**	
		Review of drafts and approval of final paper	All authors	
	C. Mid-upper arm circumference (MUAC) measurement usage among children with disabilities: a systematic review (Paper 6)	Conceptualization of paper	**Emily DeLacey,** Marko Kerac and Cally Tann	
		Contributions to methods or quality control	Julia Hayes, **Emily DeLacey**	Cally Tann, Nora Groce, Tracey Smythe, Michael Quiring, Zerihun Gultie, Lydia Nyesigomwe
		Analyzed the data	Julia Hayes, **Emily DeLacey** and Michael Quiring	
		Drafting of manuscript	**Emily DeLacey,** Julia Hayes	
		Review of drafts and approval of final paper	All authors	
	Supplementary Materials for Papers 1-4	Writing	**Emily DeLacey**	Marko Kerac, Cally Tann

B. Publication on the Nutritional Status of International Adoptees (Paper 5)

B.1.1 Scope of this Paper

This research is titled "The Nutritional Status of Individuals Adopted Internationally as Children: A Systematic Review".[99] This work was published in Nutrients on January 16th, 2021 as an open access article under the Creative Commons Attribution License. Copyright: © 2021 Ivey et al. Although the research was not funded, Holt International paid for publication.

This paper presents the findings of a systematic review of literature on the nutritional status of children adopted internationally as children. This research was part of an LSHTM MSc summer project where I was the main supervisor.

B.1.2 Citation

Ivey, R., Kerac, M., Quiring, M., Dam, T., Doig, S., & DeLacey, E. (2021). The Nutritional Status of Individuals Adopted Internationally as Children: A Systematic Review. Nutrients, 13(1), 245. https://doi.org/10.3390/nu13010245

B.1.3 Ethics

Ethical approval was not determined to be needed by LSHTM. This study did not involve patients or the public in its development. This study is available through open access publication to the public and all stakeholders. This paper followed PRISMA guidelines[103] throughout the study and a PROSPERO registration was completed prior to the start of the study (PROSPERO 2020: CRD42020186825 https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=186825).

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed for each research paper included within a thesis.

SECTION A – Student Details

Student ID Number	lsh1804647	**Title**	Ms
First Name(s)	Emily		
Surname/Family Name	DeLacey		
Thesis Title	The Nutritional and Feeding Status of Children Living within Institution-based Care and an Evaluation of Process of the Child Nutrition Program.		
Primary Supervisor	Marko Kerac		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

SECTION B – Paper already published

Where was the work published?	Nutrients https://www.mdpi.com/2072-6643/13/1/245		
When was the work published?	Published January 16 2022		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion	N/A		
Have you retained the copyright for the work?*	**No**	Was the work subject to academic peer review?	**Yes**

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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
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Stage of publication	Choose an item.

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	Conceptualization, Emily DeLacey and Marko Kerac; methodology, Richard Ivey, Emily DeLacey Marko Kerac, Hang T Dam, Michael Quiring, and Susie Doig; validation, Richard Ivey, Marko Kerac and Emily DeLacey; formal analysis, Richard Ivey, Marko Kerac and Emily DeLacey; writing—original draft preparation, Richard Ivey, Emily DeLacey and Marko Kerac; writing—review and editing, Richard Ivey, Emily DeLacey, Marko Kerac, Hang T Dam, Michael Quiring and Susie Doig. All authors have read and agreed to the published version of the manuscript..

SECTION E

Student Signature	Emily DeLacey
Date	June 6 2022

Supervisor Signature	Marko Kerac
Date	June 21,2022

nutrients

MDPI

Review

The Nutritional Status of Individuals Adopted Internationally as Children: A Systematic Review

Richard Ivey [1,2,*], Marko Kerac [1,2], Michael Quiring [3], Hang T. Dam [3], Susie Doig [3] and Emily DeLacey [1,2,3]

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Abstract: Since 1955, international adoption has been a way of finding homes for children who have been orphaned or abandoned. We aimed to describe the nutritional status of individuals adopted internationally and their long-term nutritional and health outcomes. We searched four databases for articles published from January 1995 to June 2020, which included information on anthropometric or micronutrient status of children adopted internationally (CAI). Mean Z-scores on arrival to adoptive country ranged from −2.04 to −0.31 for weight for age; −0.94 to 0.39 for weight for height; −0.7 to 0 for body mass index; −1.89 to −0.03 for height for age; −1.43 to 0.80 for head circumference for age. Older children, those adopted from institutionalized care or with underlying disability, were more likely to be malnourished. Though long-term data was scarce, mean Z-scores post-adoption ranged from −0.59 to 0.53 for weight for age; −0.31 to 1.04 for weight for height; 0.39 to 1.04 for body mass index; −1.09 to 0.58 for height for age; −0.06 to 1.23 for head circumference for age. We conclude that though CAI are at high risk of malnutrition at baseline, marked catch-up growth is possible, including for those older than two years of age on arrival. This has implications not only for CAI but for the wider population of malnourished children worldwide. Research on how to optimize catch-up growth is a priority.

Keywords: international adoption; children; nutritional status; malnutrition; growth

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1. Introduction

Globally, there are some 140 million children worldwide who are orphans, defined as those aged younger than 18 who have lost "one or both parents to any cause of death" [1]. There are also an estimated 60 million children living on the streets worldwide and 10 million more living in institutions [2], which is defined by the United Nations as residential care that is provided in any non-family-based group setting [3,4].

UN international adoption began in 1955 as a response to post-World War II societal destruction and continues to be a method to find homes for children who have been orphaned or abandoned. Detailed statistics are difficult to find, but one 2007 review described "a silent global movement of about 30,000 children per year moving between about 100 different countries" [5]. Children often move from low- and middle-income countries to high-income countries, primarily the United States, Spain, France and Italy [6].

Adopted children are by definition vulnerable and often experience medical issues such as growth faltering and developmental delay related to their difficult early childhood and suboptimal pre-adoption quality of care [7]. International adoption aims to provide them with a safe, family-based environment, where the quality of care, attachment, interaction and nutrition experienced often improves [8]. The better-quality environment is crucial to improving the child's health because many CAI have been legally relinquished for adoption by one or both birth parents (South Korea, Thailand, Ethiopia, etc.) who are still living, while others are removed from caregivers due to severe abuse and neglect, and, as a result, are at high risk of malnutrition at baseline on arrival to their adoptive country [9].

1.1. Malnutrition Epidemiology

In 2019, 144 million (21.3%) children younger than 5 years old worldwide were stunted (i.e., too short for their age, commonly interpreted as a marker of chronic undernutrition), 47 million (6.9%) were wasted (too thin, commonly interpreted as a marker of acute undernutrition), and 38.3 million were overweight or obese [10]. Undernutrition is particularly concerning short term since is it associated with 45% of deaths among children younger than 5 years old [10].

1.2. Malnutrition and Disability at Pre-Adoption Baseline

Many children who are adopted internationally arrive into their adoptive country with specific and sometimes extensive medical needs. These include underlying infectious disease, inadequate nutrition, histories of low birth weight and psychological deprivation [11–13]—all of which are associated with delayed growth and cognition [12,13]. Disabilities are also common, particularly among those who arrive from institutionalized care [14,15]. Since disability and malnutrition often intersect [16], those with disabilities can become even more at risk of malnutrition and malnutrition in turn can exacerbate and lead to new disabilities [16]. For example, 90% of children with cerebral palsy have difficulty feeding, which can lead to inadequate intake of nutrients [17].

1.3. Malnutrition Post-Adoption

There is currently little research describing the long-term health outcomes following international adoption. As well as being of direct relevance to adoptees, this is of interest to those working in severe malnutrition in resource-poor and humanitarian settings [18]. Whilst the traditional focus of treatment and prevention programs has been on averting short-term malnutrition-associated mortality, there is increasing realization of adverse long-term consequences including a higher risk of chronic diseases in adulthood [19–22]. This relates to the "thrifty phenotype" hypothesis which arises from observations that reduced fetal growth, caused by maternal malnutrition, is strongly associated with several chronic health conditions later in life [23]. In contrast, some other authors find that early growth restriction does not increase the risk of metabolic syndrome if they have a healthy post-natal nutritional environment [24]. Examining outcomes for CAI may shed further light on key factors and mechanisms which are also relevant to the wider population of children recovering from any type of early life malnutrition. This is because CAI typically relocate from rural to urban settings or from low-income countries with traditional diets to high-income countries with obesogenic environments and Western diets with excess calories, fats and carbohydrates [24]. This mirrors the similar but longer-term changes within all countries with increasing urbanization and dietary changes.

1.4. Research Gap

Though there have been two reviews to date synthesizing evidence on growth in CAI, both are now more than 10 years old and there is need for an update [25,26]. There is also need for a more direct approach: Mason and Narad, for example, focused on the underlying causes of delayed growth in CAI but had insufficient on-arrival and post-adoption anthropometric data, which limited their ability to describe catch-up growth [26].

This review aims to describe and understand the baseline and long-term nutritional (anthropometric and micronutrient) status of individuals who were adopted as children, with particular emphasis on understanding factors influencing that, namely:

- Pre-adoption factors, e.g., early life clinical and nutritional history; underlying disability.

- Peri-adoption factors, e.g., age at adoption; length of stay in any institutional care before adoption.
- Post-adoption factors, e.g., socioeconomic and nutritional environment into which children are adopted.

2. Materials and Methods

We conducted a systematic review with narrative synthesis to understand baseline (at adoption) and longer-term post-adoption nutritional status of children adopted internationally.

2.1. Protocol and Registration

We followed PRISMA guidelines [27] throughout the study (List S1) and completed PROSPERO registration prior to the start of the study (PROSPERO 2020: CRD42020186825 https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=186825) [28].

2.2. Eligibility Criteria

We used the following PICO:

Population: Individuals who were adopted internationally as children (aged younger than 18 years).

Intervention: Our exposure was "international adoption".

Comparator: Due to likely paucity of data on our target population, we considered all types of studies, including those with a comparator group.

Main outcomes: Nutritional status as assessed by:

- Anthropometric data, including weight for age, weight for height, height for age, head circumference for age and body mass index. Our main focus was on standardized values using WHO growth standards, but we also considered other growth references (e.g., CDC, NCHS growth references) and non-standard reports (e.g., unadjusted height or weight).
- Micronutrient status: either laboratory-measured values or clinical status if applicable (e.g., clinically obvious rickets suggesting vitamin D deficiency).

Studies were eligible if they met the following criteria:

- Peer-reviewed studies.
- Written in English.
- Include at least one measurement of nutritional status, either micronutrient status or anthropometric data through standardized tools, such as WHO Growth Standards [29] or Centers of Disease Control growth charts [30].
- Published from January 1995 to July 2020.

We chose studies published after 1995, which is both the baseline for the Millennium Development Goals and also when the Hague Convention on the Protection of Children and Co-operation in Respect of Intercountry Adoption entered into force. This is an international treaty that provides necessary safeguards to protect the best interests of children, birth parents and adoptive parents who are involved in intercountry adoptions, especially in respect to protecting children from corruption, abuses and exploitation [31].

Studies were excluded if:

- They reported on individuals adopted at the age of 18 years or older.
- They focused on domestic adoption placements.
- Study reports were not peer reviewed.
- They used non-standardized anthropometric growth measurements.

2.3. Information Sources and Search Strategy

We searched four electronic databases through OVID between 15 June and 30 June 2020: Medline, Embase, Global Health Database and CINHAL Plus. Lead researcher RI conducted the initial title/abstract screen. Uncertainties about which items to include in the final tables were discussed with other co-authors, with EDL making the final decision about any discordant records. The electronic search strategy used for Medline is attached in Supplementary Materials (List S2).

2.4. Data Extraction

We extracted data on gender, age of adoption, standardized anthropometric measurements, micronutrient status, disability status, country of birth and adoption and entered them into Excel tables.

2.5. Quality Assessment

The NICE quality assessment tool was used to measure the risk of bias of individual studies. There are five sections in this appraisal tool. Section 1 aims to assess external validity, while Sections 2–4 assess the critical criteria for determining the study's internal validity [32]. The NICE quality assessment results can be found in Table 1 and greater detail in the Supplementary Material Table S2.

Table 1. Description of studies included in the review.

Author, Year	Study Design	Country	Study Population	NICE Quality Assessment Score: Internal Validity/ External Validity Score	Timing of Nutritional Assessments	Sex
Fuglestad et al., 2016 [33]	Prospective cohort	Multi country ➔USA	*N*: 58 children. Participants included children aged 8–18 months.	+/+	Arrival and 6 months post-adoption	Females: 32 (55%)
Gustafson, Eckerie et al., 2013 [34]	Prospective cohort	Multi country ➔USA	*N*: 160 patients. Aged 4 months to 17.8 years.	+/−	Within 6 months of adoption	Females: 83 (52%)
Park, Bothe et al., 2011 [9]	Prospective cohort	Multi country ➔USA	*N*: 58 children. Mean age on arrival: 17.6 months. Children evaluated within 19 days.	−/−	On arrival	Females: 34 (58%)
Bortone, Totaro et al., 2019 [14]	Prospective cohort	Multi country ➔Italy	*N*: 422 children. Median age at arrival: 6.5 years. Adopted from Europe (29.9%), Asia (26.8%), Africa (23.9%) and Latin America (19.4%).	+/−	Median 75 days after arrival	Females: 171 (40.5%)
Fuglestad et al., 2008 [11]	Prospective cohort	Multi country ➔USA	*N*: 37 children. Children adopted from orphanages or hospitals. Low birth weight: 32%.	−/−	On arrival and 6 months post-adoption	Females: 22 (59%)
Martinez Ortiz, Dominguez Pinilla et al., 2015 [35]	Retrospective cohort	Ethiopia ➔Spain	*N*: 251 children. Mean age of arrival: 7 months. 124 (49.4%) aged ≤ 6 months.	−/+	Pre-adoption	

Table 1. *Cont.*

Author, Year	Study Design	Country	Study Population	NICE Quality Assessment Score: Internal Validity/ External Validity Score	Timing of Nutritional Assessments	Sex
Palacios, Roman et al., 2011 [36]	Retrospective cohort	Multi country ➔Spain	*N*: 289 children. Mean age on arrival: 34.9 months. Children from institutionalized care. Parents reported the results (approximately 38 months after arrival) of their child's on arrival medical tests.	+/+	On arrival and 3 years post-adoption	
Pomerleau et al., 2005 [37]	Prospective cohort	China, Vietnam, Taiwan, Thailand, South Korea, Cambodia, Russia and Belarus ➔Canada	*N*: 123 evaluated. All children were adopted before 18 months of age. Adopted from orphanage, family-setting and some children had experience in both living situations. Assessed within one month of arrival (mean: 19.1 days).	−/−	On arrival, 3 months post-adoption and 6 months post-adoption	Females: 87 (70%)
Le Mare and Audet, 2006 [38]	Prospective cohort	Romania ➔Canada	*N*: 36 evaluated. Lived in an orphanage for a minimum of nine months (9 to 53 months, mean = 24 months). Mean age at arrival: 23.9 months. Mean time in institution: 22.7 months.	+/−	11 months post-adoption, 4.5 years of age and 10.5 years of age	Females: 19 (53%)
Buonsenso, Graffeo et al., 2019 [39]	Retrospective cohort	Multi country ➔Italy	*N*: 584 evaluated, (82.19%) lived in institutions. Mean age at arrival: 5 years and 9 months.	+/+	On arrival	

Table 1. *Cont.*

Author, Year	Study Design	Country	Study Population	NICE Quality Assessment Score: Internal Validity/ External Validity Score	Timing of Nutritional Assessments	Sex
Salerno, Ceccarelli et al., 2018 [40]	Retrospective cohort	Multi country →Italy	*N*: 873 children. Children were adopted from Europe and Russian federation (256, 29.8%), Latin America (231, 26.9%), Asia and Indian subcontinent (223, 26.0%), and Africa (149, 17.3%). Mean duration of institutionalization: 3 years.	+/+	On arrival	Females: 376 (43.8%)
Miller, Chan et al., 2005 [41]	Retrospective cohort	Guatemala →USA	*N*: 103 children. Mean age on arrival: 16 months. Before adoption, 25 children resided in orphanages, 56 in foster care, and 22 in mixed-care settings (time living with birth family, foster care and orphanage).	+/+	On arrival	Females: 48 (47%)
Ulijaszek and Schwekendiek 2013 [42]	Retrospective cohort	Korea →United States and Europe	Mean age when evaluated: 28.65 to 31.87 years old. Children adopted to America (52%) and Western Europe (44%). Adults self-reported their weight and height.	+/−	Post-adoption (mean age: males 30.46 years, females 28.65)	Females: 172 (66%)
Cataldo and Viviano 2007 [43]	Cross sectional	Multi country →Italy	*N*: 36 children. Mean age at arrival: 78.5 months. Referred within 2–6 weeks of arrival.	−/−	Pre-adoption medical records and on arrival	Females: 62 (46%)
Chiappini, Vierucci et al., 2016 [44]	Cross sectional	Multi country →Italy	Median age at arrival: 5.47 years 962 adopted from Africa (18.09%), South America (21.41%), Asia (16.32%), Europe (44.18%).	+/−	Median 72 days after arrival	Females: 381 (39.60%)

Table 1. *Cont.*

Author, Year	Study Design	Country	Study Population	NICE Quality Assessment Score: Internal Validity/ External Validity Score	Timing of Nutritional Assessments	Sex
Johansson-Kark, Rasmussen et al., 2002 [45]	Cross sectional	Multi country ➔Sweden	275,026 were included in study. 2400 adults who were international adoptees were evaluated. Mean age at adoption was 1.7 years. 64% adopted before age 2.	+/+	Post-adoption (17 years old)	Males: 275,026 (100%)
Miller and Hendrie 2000 [46]	Cross sectional	China ➔USA	*N*: 452 children. The clinic group age at arrival: 2 months to 12 years and 4 months. Age at clinic visit: 3 months to 151 months. Children evaluated within 1.3 months.	−/+	1 week to 17 months of arrival	Females: 443 (98%)
Van Kesteren and Wojciechowski 2017 [47]	Retrospective study	Ethiopia ➔Belgium	*N*: 315 children. Mean age on arrival: 3 years old.	+/+	On arrival	Females: 151 (48%)
Johnson, Bruce et al., 2011 [48]	Cross sectional	Multi country ➔USA	*N*: 120 children. Mean age on arrival: 6.85 years. Three groups: Post-institutionalized children, children from foster care and non-adopted children raised in the US.	+/−	On arrival	All three groups had: Male: 10 Female: 30
Miller, Spratt et al., 2015 [49]	Cross sectional	Russia ➔USA	*N*: 60 children. Age ranged from 3–10 years old. Three groups of children: previously institutionalized international adoptees, children with a history of neglect born in the USA, and controls.	−/+	Post-adoption (mean age 6.1 years old)	
Miller, Tseng et al., 2008 [50]	Cross sectional	Ethiopia/Eritrea ➔USA	*N*: 50 children. 62% were less than 4 years old. Mean age on arrival: 3 months to 15 years. Mean age at clinic visit: 51.12 months.	−/+	On arrival	

Table 1. *Cont.*

Author, Year	Study Design	Country	Study Population	NICE Quality Assessment Score: Internal Validity/ External Validity Score	Timing of Nutritional Assessments	Sex
Tirella and Miller 2011 [51]	Cross sectional	Multi country ➔USA	*N*: 387 children. Mean age on arrival: 14.0 months. 86% of the children were evaluated within 2 months and 91% evaluated within 5 months of arrival.	−/−	On arrival	Females: 254 (66%)
Reeves, Bachrach et al., 2000 [52]	Case study	Soviet Union ➔USA	Case 1: Age 2 years and 5 months, Case 2: Age 3 years and 3 months, Case 3: Age 2 years and 10 months.	−/+	On arrival	Females: 2 (66%)
Albers, Johnson et al., 1997 [53]	Case study	Russia➔USA	*N*: 56 adoptees from East Europe. Median age at arrival: 26 months.	+/+	Pre-adoption medical records and on arrival	Females: 30 (54%)

2.6. Summary Measures

We summarized the results by describing the range of mean on arrival and post-adoption anthropometric Z-scores. Ranges of the mean prevalence of malnutrition indicators and micronutrient deficiencies were recorded and compared with arrival and post-adoption data.

3. Results

3.1. Study Selection

Our search terms identified a total of 4939 papers. After 1518 duplicates were removed, 3421 papers were screened by title/abstract, of which 62 were potentially eligible. Of these 62, we were unable to locate the full text for four studies, which is partly because many journals do not have online access. A total of 12 studies had insufficient or non-standard anthropometric data and 6 included those not within our pre-determined population. This left us with a final 24 papers which met the inclusion criteria.

3.2. Study Characteristics

The 24 papers included were published between 1997 and 2019 and eight (33%) were published in the past five years. Studies included various countries to which children were adopted; 13 were to USA (54%), five were to Italy (20%), two were to Spain (8%), two were to Canada (8%) and two were to other European countries (8%). All were reports of observational studies, of which nine (37%) were cross-sectional studies and 13 (54%) were cohort studies. Anthropometric and micronutrient data was reported in three studies pre-adoption (12%), 20 on arrival (83%) and nine post-adoption (37%). On arrival anthropometric and micronutrient data was measured within one week to seven months after arrival.

Our study flow chart is shown below in Figure 1. Studies excluded are listed in Table S1.

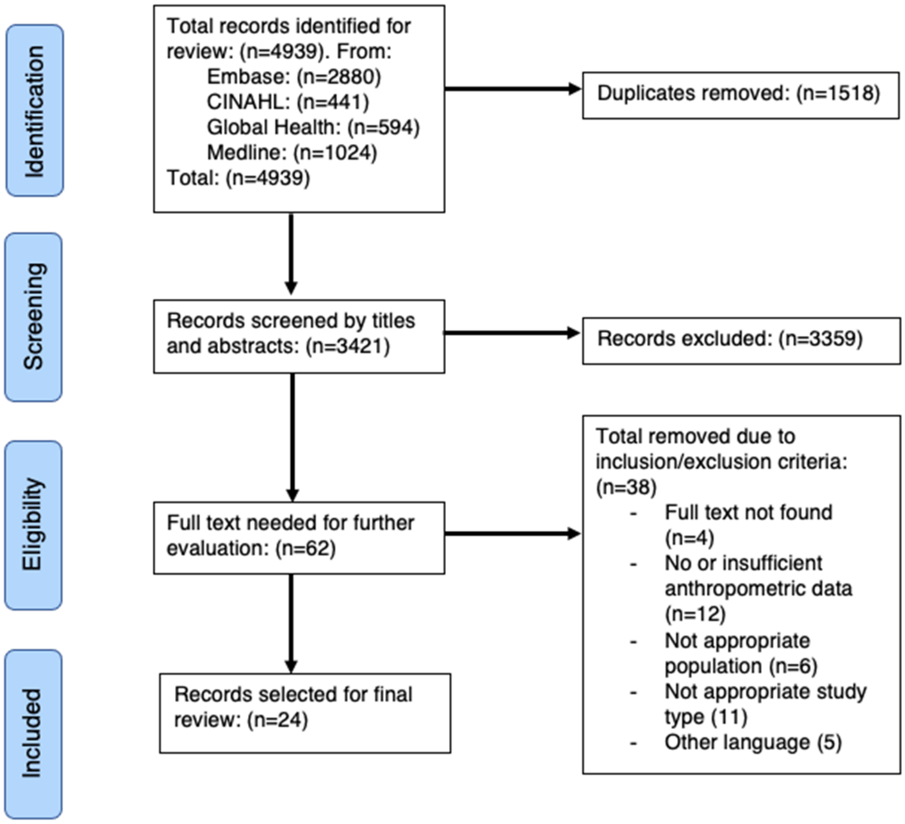

Figure 1. Flow diagram of study selection.

3.3. Anthropometric Data

Eighteen studies (75%) in Table 2 reported anthropometric data using World Health Organization (WHO) growth standards/references, Centre of Disease Control (CDC) standards or North American norms. The prevalence of underweight, wasting, stunting, overweight and microcephaly was reported in six (25%), six (25%), nine (37%), one (4%) and six (25%) studies, respectively. One study reported weight and height measurements as percentiles of the WHO growth charts/references [35]. Of the 24 studies, three (12%) reported anthropometric information pre-adoption, 16 (66%) on arrival, and nine (37%) post-adoption.

Table 2. Anthropometric measurements and results.

Author, Year	Growth Reference	Weight for Age (WAZ)	Weight for Length/Height (WHZ)	Length/Height for Age (HAZ)	Body Mass Index (BMI) for Age	Head Circumference for Age (HCAZ)	Other Observations
Albers, Johnson et al., 1997 [53]	WHO growth standards	Prevalence of WAZ pre-adoption <−1: 44% Mean WAZ baseline: −1.05 (SD ± 1.06) (range −3.15 to 1.26)		Prevalence of HAZ < −1 pre-adoption: 68% Mean HAZ on arrival: −1.41 (SD ± 1.37) (range −4.52 to 1.79)		Prevalence of HCAZ < −1 pre-adoption: 43% Mean HCAZ on arrival: −1.25 (SD + 1.00) (range, −3.7 to 0.62)	Growth delay in height (68%). Growth delay in head circumference (43%). Delay in linear growth directly correlated with the amount of time living in an orphanage ($p < 0.001$).
Bortone, Totaro et al., 2019 [14]	WHO growth standards	Underweight prevalence baseline: 13.2%. Mean WAZ baseline: −0.4, −0.6 (above age 5)	Wasting prevalence baseline: 4.3%. Mean WHZ: −0.5, −0.9 (above age 5)	Stunting prevalence baseline: 12.9%			Stunting common in children < 5 years and in those with a disability. Disability in 72/422 (17.1%).
Cataldo and Viviano 2007 [43]	WHO growth standards	Mean WAZ baseline: −0.97 (−3.97 to 2.27)	Wasting prevalence baseline: 18.4%	Mean HAZ baseline: −1.30 (–5.98 to 2.17) Stunting prevalence baseline: 19.1%		Mean HCAZ baseline: −0.58 (−2.1 to 3.3) HCAZ <−2: 8.8%	Total Iron deficiency anemia: 74. Total rickets: 21. Total delayed bone age: 17.
Fuglestad, Kroupina et al., 2016 [33]	WHO growth standards	Post-Soviet States: Mean WAZ Baseline: −0.31 (SD 1.05) 6 months follow up: 0.23 (SD 0.87)	Mean WHZ Baseline: 0.39 (SD 1.01) 6 months follow up: 0.66 (SD 1.04)	Mean WHZ Baseline: 0.39 (SD 1.01) 6 months follow up: 0.66 (SD 1.04)		Mean HCAZ Baseline: 0.05 (SD 1.31) 6 months follow up: 0.31 (SD 1.03)	Nutritional deficiencies were not eliminated at follow up. Significant growth improvements from baseline to follow up in HAZ, ($p < 0.001$), WAZ, ($p < 0.001$), WHZ, ($p < 0.001$), and OFCZ ($p < 0.001$).
		Ethiopia: Mean WAZ Baseline: −0.89 (SD 0.93). 6 months follow up: 0.26 (SD 0.91)	Mean WHZ Baseline: 0.17 (SD 0.84) 6 months follow up: 1.04 (SD 1.10)	Mean HAZ Baseline: −1.89 (SD 1.34) 6 months follow up: −1.09 (SD 1.23)		Mean HCAZ Baseline: 0.20 (SD 1.15) 6 months follow up: 1.23 (SD 1.14)	
		Mean WAZ Baseline: −0.56 (SD 0.80) 6 months follow up: 0.02 (SD 0.96)	Mean WHZ Baseline: −0.14 (SD 0.84) 6 months follow up: 0.39 (SD 1.01)	Mean HAZ Baseline: −0.93 (SD 1.30) 6 months follow up: 0.58 (SD 0.96)		Mean HCAZ Baseline: −0.37 (SD 0.92) 6 months follow up: −0.06 (SD 1.17)	
Fuglestad, Lehmann et al., 2008 [11]	Centers for Disease Control (CDC), 2000	Mean WAZ Baseline: −1.73 6 months follow up: 0.53	Mean WHZ Baseline: −0.63 6 months follow up: −0.02 (WHZ)	Mean HAZ Baseline: −1.24 6 months follow up: −0.49		Mean HCAZ Baseline: −0.67 6 months follow up: 0.11	Mean serum ferritin concentration lower than the US population at follow up. Children with giardia lamblia at baseline had worse iron status at baseline and follow up.

Table 2. *Cont.*

Author, Year	Growth Reference	Weight for Age (WAZ)	Weight for Length/Height (WHZ)	Length/Height for Age (HAZ)	Body Mass Index (BMI) for Age	Head Circumference for Age (HCAZ)	Other Observations
Johansson-Kark, Rasmussen et al., 2002 [45]	WHO growth standards				BMI range: 20.68 to 23.93 Overweight prevalence: 8.8–28.6% Overweight prevalence: 14.1% for non-adopted participants		1.36 (1.03–1.80) increase in the odds of becoming overweight in adulthood for those who arrived in their adoptive country at a young age (0–1 year old) compared to those adopted after the age of 2.
Martinez Ortiz, Dominguez Pinilla et al., 2015 [35]	WHO growth standards	49% of children <3rd percentile for weight at baseline		40% of children <3rd percentile for height at baseline			151 (65%) had malnutrition (details not specified). Low weight for height was related to age at adoption.
Miller and Hendrie 2000 [46]	WHO growth standards	Weight: −3.77 to −2.4 (mean, SD: −1.17, 1.00)	Wasting prevalence baseline: 18%	Height: −8.64 to −2.9 (mean, SD: −1.51, 1.4), 39% stunted		Microcephaly prevalence: 28%	The amount of time living in a orphanage in months was proportional to the linear growth lag ($r = 0.90$; $p = 0.0001$) for 192 Chinese adoptees. For every 2.86 months of stay in an orphanage, children lost 1 month of height age.
Palacios, Roman et al., 2011 [36]	WHO growth standards 1995	Mean WAZ Baseline: −1.48 Follow up: 0.09 Difference: ($p < 0.001$)		Mean HAZ Baseline: −1.46 Follow up: −0.1 Difference: ($p < 0.001$)		Mean HCAZ Baseline: −0.71 Follow up: −0.46 Difference: ($p < 0.001$)	No significant relationship between length of institutionalization or age at arrival and growth indicators. A longer stay in orphanages was related with greater height delays ($p < 0.05$). Less than 7 months in orphanage, there was a negative relationship between orphanage duration and head circumference ($p < 0.05$).
Park, Bothe et al., 2011 [9]	WHO growth standards 2006 and CDC 2000 (for those older than 5)	Underweight prevalence baseline: 10% Mean WAZ baseline: −1.4	Wasting prevalence baseline: 28% Mean WHZ baseline: −0.5	Stunting prevalence baseline: 17% Mean HAZ baseline: −1.1		Microcephaly prevalence baseline: 16% Mean HCAZ baseline: −0.8	Growth Z-scores less than zero at baseline: HCAZ (77%), HAZ (79%), WHZ (64%) and WAZ (90%). No significant relationship between age of participants at baseline and all growth Z-scores.

Table 2. *Cont.*

Author, Year	Growth Reference	Weight for Age (WAZ)	Weight for Length/Height (WHZ)	Length/Height for Age (HAZ)	Body Mass Index (BMI) for Age	Head Circumference for Age (HCAZ)	Other Observations
Salerno, Ceccarelli et al., 2018 [40]	WHO growth standards				Mean BMI baseline: 16		No significant difference between 25(OH)D mean values for the different BMI groups ($p = 0.47$).
Ulijaszek and Schwekendiek 2013 [42]	WHO growth standards				Adult BMI: USA: Males: mean BMI 25.85. Females: mean BMI 22.18. Europeans: Males: mean BMI 22.77. Females: mean BMI 21.67. USA over 25 BMI = 25.6% Europe over 25 BMI = 14.3%		Males had greater BMI than females ($p < 0.001$). Adoptees in Europe had lower BMI than those in the US ($p < 0.001$).
Van Kesteren and Wojciechowski 2017 [47]	WHO growth standards		Wasting prevalence baseline: 8.6%	Stunting prevalence baseline: 28.9% Severe stunting prevalence baseline: 11%			Microcephaly was uncommon. Moderate microcephaly in 8 (3.3%) children. Severe microcephaly in 2 (0.8%) children.
Johnson, Bruce et al., 2011 [48]	CDC, 2000	Mean WAZ baseline: −2.04 (post-institutionalized). Mean WAZ baseline: −0.23 (foster care).	Mean WHZ baseline: −0.94 (post-institutionalized) Mean WHZ baseline: −0.35 (foster care)	Mean HAZ baseline: −1.54 (post-institutionalized) Mean HAZ baseline: −0.03 (foster care)			For CAI linear growth delay was related with greater DSA and a more dysregulated diurnal cortisol rhythm.
Miller, Spratt et al., 2015 [49]	CDC, 2000	Mean WAZ post-adoption: −0.59	Mean WHZ post-adoption: −0.31	Mean HAZ post-adoption: −0.5			Three groups recruited: previously institutionalized CAI, US born children with history of neglect and control. Mean height growth was different ($p < 0.05$). Head circumference was significantly smaller ($p < 0.05$) in CAI.
Miller, Tseng et al., 2008 [50]	CDC, 2000	Mean WAZ baseline: −0.59 Underweight prevalence baseline: 8%		Mean HAZ baseline: −0.64 Stunting prevalence baseline: 12%		Microcephaly prevalence baseline: 6% Mean HCAZ baseline: −0.09	WHZ increased with age at adoption. Growth measurement Z-scores not related with age at arrival. Children from Ethiopia/Eritrea had significantly better anthropometric status at arrival than adoptees from China, Guatemala, or Russia.

Table 2. *Cont.*

Author, Year	Growth Reference	Weight for Age (WAZ)	Weight for Length/Height (WHZ)	Length/Height for Age (HAZ)	Body Mass Index (BMI) for Age	Head Circumference for Age (HCAZ)	Other Observations
Miller, Chan et al., 2005 [41]	CDC, 2000	Mean WAZ baseline: −1.0 Underweight prevalence baseline: 20%		Mean HAZ baseline: −1.04 Stunting prevalence baseline: 16%		Microcephaly prevalence baseline: 17% Mean HCAZ baseline: −1.08	Children who resided in orphanages had significantly lower Z-scores for all height, weight and head circumference. Children younger than 2 years at arrival, Z-scores for growth measurements related inversely with age at arrival.
Tirella and Miller 2011 [51]	CDC, 2000	Mean WAZ baseline: −1.17 Underweight prevalence baseline: 27%		Mean HAZ baseline −0.74 Stunting prevalence baseline: 13%		Microcephaly prevalence baseline: 14% Mean HCAZ baseline: 0.8	Children from Guatemala had greater delays in height ($p = 0.007$) and head circumference ($p = 0.01$) than those from the other countries, although these results are not significant after the Bonferroni correction.
Pomerleau et al., 2005 [37]	North American norms, 1979 (ANOVA: time, group)	Mean weight percentile baseline: 61.55 ($p < 0.001$)	Mean weight/height percentile baseline: 14.43 ($p < 0.001$)	Mean height percentile baseline: 8.44 ($p < 0.001$) Mean height/age percentile baseline: 7.35 ($p < 0.001$)		Mean head circumference percentile: 12.26 ($p < 0.001$)	On arrival, children from East Asia had higher percentiles for weight and height than Chinese or Russian children. Age at arrival was significantly associated with weight/height, height/age, head circumference percentile and weight percentile on arrival growth. Age at arrival was not associated with any growth indicators 6 months post-adoption.
Le Mare and Audet, 2006 [38]	CDC, 2006	Mean weight percentile (11 months post-adoption): 7.85 Mean weight percentile (4.5 years of age): 43.6 Mean weight percentile (10.5 years of age): 59.9		Mean height percentile (4.5 years of age): 36.98 Mean height percentile (10.5 years of age): 48.8			By phase 2 (4.5 years of age), children demonstrated almost complete weight catch up with only 3 (8.6%) children below the third percentile. By phase 3 (10.5 years of age), only 1 (2.8%) child had a weight score below the fifth percentile.

3.4. Weight

On arrival to their adoptive country, the mean WAZ score ranged from −2.04 to −0.31, compared with −0.59 to 0.53 post-adoption (see Table 2). On arrival, WHZ score ranged from −0.94 to 0.39, compared to −0.31 to 1.04 post-adoption. One study reported 123 children (49%) weighted below the third percentile [35]. Prevalence of wasting ranged from 0% to 18.4% on arrival, which is almost three times greater than the global prevalence of 6.9% [10]. Post-adoption, for those adopted, Fuglestad et al. did not find adoptees to be wasted [33]. Studies reported BMI as BMI for age Z-score and the mean BMI. On arrival, BMI for age Z-scores ranged from −0.7 to 0, compared to 0.39 to 1.04 post-adoption. Mean BMI on arrival was 16 to 23.93, compared to 21.67 to 25.85 post-adoption. Johansson-Kark et al. reported an overweight prevalence of 8.4% to 28.6% for adults who were adopted internationally as children [45].

3.5. Height

Prevalence of stunting from arrival to post-adoption; 12% to 39%, compared to 17% post-adoption. On arrival, mean HAZ ranged from −1.89 to −0.03 and post-adoption HAZ ranged from −1.09 to 0.58. One study reported 40% of children were below the third percentile for height on arrival [35].

3.6. Head Circumference

On arrival, mean HCAZ ranged from −1.43 to 0.80 and post-adoption HCAZ ranged from −0.06 to 1.23. The prevalence of microcephaly (HCAZ < −2) at baseline ranged from 5% to 17%, compared to 4% post-adoption.

3.7. Micronutrient Status

Of the 24 studies reviewed, 10 (41%) reported micronutrient data. Table 3 shows that iron deficiency ranged from 15% to 25% at baseline. Fuglestad et al. found that children adopted from Eastern Europe to the USA had a 9 percentage point reduction in iron deficiency from arrival to 6 months; however, this reduction was determined to not be statistically significant [11]. The prevalence of anemia on arrival ranged from 9.6% to 54.4%. No studies reported the prevalence of anemia post-adoption. The prevalence of vitamin D deficiency on arrival ranged from 9% to 85.1% (Table 3). Three studies reported mild, moderate and severe vitamin D deficiency, of which the prevalence ranged from 32.1% to 33.6%; 38.4% to 40.5%; and 9.6% to 12.5%, respectively. Only one study reported a prevalence of vitamin D deficiency post-adoption which found no significant improvement from baseline [33]. Two studies reported information on rickets, with a prevalence of 15.4% and 100%; the latter study was specifically regarding three cases of rickets [43,52]. Fuglestad et al. reported that 68% of CAI had at least one abnormal nutritional biochemical marker on arrival to their adoptive country [33]. The most common deficiencies they reported were low retinol-binding protein (33%), zinc deficiency (29%), vitamin D insufficiency/deficiency (21%) and iron deficiency (15%).

Table 3. Micronutrient status and clinical signs results.

Author, Year	Country	Micronutrient Status (On Arrival/Pre-Adoption)	Micronutrient Status (Post-Adoption)	Clinical Signs
Bortone, Totaro et al., 2019 [14]	Multi country ➔Italy	Total vitamin D deficiency: 188/416 (45.2%).		Total anemia: 40/417 (9.6%). Anemia not a risk factor for stunting ($p = 0.285$).
Buonsenso, Graffeo et al., 2019 [39]	Multi country ➔Italy	Total vitamin D deficiency: Moderate: 224 (38.4%) to mild: 196 (33.6%). Intestinal parasitic infections associated with vitamin D deficiency ($p < 0.05$).		

Table 3. *Cont.*

Author, Year	Country	Micronutrient Status (On Arrival/Pre-Adoption)	Micronutrient Status (Post-Adoption)	Clinical Signs
Cataldo and Viviano 2007 [43]	Multi country ➔Italy			Total anemia: 74 (54.4%). Total rickets: 21 (15.4%).
Chiappini, Vierucci et al., 2016 [44]	Multi country ➔Italy	Median 25(OH)D level: 22.0 ng/mL. 73.8% of had hypovitaminosis D. Children >6 years old had an adjusted odds ratio of vitamin D deficiency and hypovitaminosis 1.87 ($p < 0.01$) and 2.50 ($p < 0.01$) times higher than children <6 years old. Age at arrival to Italy was significantly associated with both with 25-hydroxyvitamin D mean values ($p < 0.01$) and Vitamin D status ($p < 0.01$). Sex, country of origin and BMI-z-score < −2 were not associated with vitamin D status.		
Fuglestad, Kroupina et al., 2016 [33]	Multi country ➔USA	Low retinol-binding protein (33%). Zinc deficiency (29%). Vitamin D insufficiency/deficiency (21%). Iron deficiency (15%).	No significant change in micronutrient at baseline and follow up.	
Gustafson, Eckerie et al., 2013 [34]	Multi country ➔USA	Total vitamin D deficiency: 7%. Total vitamin D insufficiency: 27%.		
Park, Bothe et al., 2011 [9]	Multi country ➔USA	Total anemia: 6 (11.5%).		
Reeves, Bachrach et al., 2000 [52]	Soviet Union ➔USA	Total vitamin D deficiency: 3 (100%).		Total rickets: 3 (100%).
Salerno, Ceccarelli et al., 2018 [40]	Multi country ➔Italy	A statistically significant difference was found for skin color ($p = 0.011$), season at first blood draw ($p < 0.001$), the age at the first blood draw ($p < 0.001$) and Vitamin D status. Time from the arrival to initial evaluation was not significantly related with 25(OH)D mean values ($p = 0.388$) and Vitamin D Status ($p = 0.912$). Female children had increased risk of severe vitamin D deficiency.		
Fuglestad, Lehmann et al., 2008 [11]	Multi country ➔USA	Total iron deficiency at baseline: 25%. Children with giardia lamblia had worse iron status at baseline and follow up. Growth rate was negatively related with change in serum ferritin concentrations between baseline and follow up ($p < 0.05$).	Total iron deficiency at follow up: 16%.	
Miller, Chan et al., 2005 [41]	Guatemala ➔USA			Total anemia: 30%.

3.8. Age of Adoption

On arrival, the mean age ranged from 11 months to 5.31 years. A total of 10 (41%) studies reported an association between age of adoption and anthropometric or micronutrient data. Four studies reported an inverse correlation between age of adoption and height [14,36,41,48]. Johnson et al. reported that HAZ was inversely associated with the age of adoption for those who previously lived in institutionalized care ($p = 0.01$), meanwhile, they found no association between HAZ and age of adoption for children who lived in foster care before adoption ($r = -0.15$, $N = 26$, ns) [48]. Miller et al. reported for children younger than two years at arrival, age at arrival was inversely associated with height ($p < 0.01$), weight ($p < 0.01$) and head circumference ($p < 0.02$), regardless of the location of residence before adoption [41]. Conversely, three studies found no association between age at adoption and delay in growth for either height, weight or head circumference on arrival to the adoptive country [9,48,50]. Pomerleau et al. found no significant association between age of adoption and growth indicators when they measured weight, height and head circumference six months post-adoption [37]. Interestingly, Palacios et al. reported no significant relationship between the age at adoption and anthropometric indicators three years post-adoption, except for head circumference ($r = 0.13$, $p < 0.05$) [36].

4. Discussion

4.1. Summary of Evidence

The study findings found that CAI were commonly malnourished when they arrived in their adoptive families. The majority of these children are affected by multiple forms of undernutrition and micronutrient deficiencies. The prevalence of undernutrition was comparable regardless of their country of origin and sex; however, CAI from institutionalized care had significantly more delays in weight, height and head circumference than those adopted from other care settings. Children adopted at an older age were also more malnourished than younger children, regardless of their prior living situation. There is some evidence on the nutritional status of CAI on arrival, but less is known about to what extent international adoption impacts long-term health and growth. In our review, only a few studies described the nutritional status of CAI post-adoption, but those that did suggest that substantial catch-up growth is possible for all CAI in weight, height and head circumference [11,33,36].

4.2. Pre-Adoption Factors, Country of Origin and Adoption

Data sources were limited, but there were no obvious patterns of anthropometric deficit varying by country of origin in most studies. Miller et al., however, found that children from Ethiopia/Eritrea had significantly better growth at arrival than international adoptees from China, Guatemala and Russia [50]. One study also reported post-adoption, the country of origin is significantly related to differences in weight and head circumference [36]. Only two studies reported information on nutritional status after three years of arrival, and both included anthropometric data on adults who were previously adopted internationally [42,45]. Both papers concluded that adulthood weight of individuals previously adopted internationally varied by the country of adoption [42,45]. There could many underlying reasons for this, including early life epigenetic changes or diversity in susceptibility to being overweight [54,55]. However, the limited available data means we are unable to quantify associations or infer causality and distinguish pre- and peri-adoption factors from post-adoption environments, diets and lifestyles. Future research measuring the nutritional status of adults who were adopted internationally as children is needed to understand the association between international adoption and risk of becoming overweight or obese in adulthood.

4.3. Micronutrient Status

Micronutrient deficiencies were prevalent in CAI on arrival, which is attributable to poor nutrition and infections [11]. The prevalence of anemia was similar to the global average for children younger than 5 years old, which is likely to be contributing to delayed linear growth and weight gain [56,57]. Multiple studies found no statistically significant difference in the prevalence of iron deficiency at arrival and follow up for all CAI (p = 0.37) [11,33]. Fuglestad et al. reported that this association was virtually unchanged when controlling for daily iron intake at baseline and iron intake did not predict changes in serum ferritin [11]. The insufficient change in iron deficiency may partly be due to the negative correlation between growth rate and change in serum ferritin concentrations between baseline and follow up ($p < 0.05$) [11]. Further, anemia was not tracked post-placement in any of the studies. Fuglestad et al. additionally reported no statistically significant difference in the prevalence of iron deficiency and zinc deficiency at baseline and at follow up [33]. Iron deficiency was associated with lower cognitive scores ($p < 0.03$) and slower speed of processing ($p < 0.02$); meanwhile, there was an association between zinc deficiency and compromised memory functioning ($p < 0.01$) [33]. The prevalence of micronutrient deficiencies did not improve significantly post-adoption, except for an increase in serum zinc concentrations ($p < 0.01$) [33].

Vitamin D deficiency was common for CAI, with the prevalence peaking at 53% on arrival. Only one (4%) study measured the prevalence of vitamin D deficiency on arrival and post-adoption [33], from which they reported vitamin D insufficiency was significantly higher in children from the post-Soviet states ($p < 0.01$) compared to Ethiopia and China. The variance may be because the children adopted from the post-Soviet states were from the northern-most latitude in their sample and spent the most time in institutionalized care, which limited their sun exposure and vitamin D synthesis. There was no significant difference in vitamin D deficiency at arrival and at follow up, despite participants being treated with 2000 IU vitamin D daily for eight weeks. Adoptees with a lower BMI and longer time in institutionalized care were more likely to be vitamin D deficient after adjusting for age [34]. CAI commonly live in institutionalized care before adoption; therefore, it is plausible to assume these children may have increased prevalence of vitamin D deficiency because of their lack of sun exposure or limited diets [34].

These results highlight the need to consider the possibility of micronutrient deficiencies in CAI and where appropriate formally measure micronutrient status. Interventions that provide nutritional supplements to young children can have both short-term and long-term benefits, such as treating anemia [58] and improved reading scores and non-verbal cognitive ability tests in adulthood [59].

4.4. Age at Adoption

The age at which children are adopted is also an important factor which may affect the nutritional status of CAI at baseline/on arrival and catch-up growth post-adoption. In our review, six papers reported an association between age of adoption and anthropometric data at baseline/on arrival [9,14,36,41,48,50]. This data is important to understand which peri-adoption factors contribute to delayed growth in CAI. Overall, the results in our review were inconsistent and contradict previous research, which found that the age of adoption was not significantly related to weight, height and head circumference Z-scores on arrival [25].

The age at which children are adopted, and begin to experience improved WASH practices, nutrition and psychological support could also affect catch-up growth in CAI. The first 1000 days of life are highlighted in current global health policy as offering a key window of opportunity for growth and development which will affect the health of individuals throughout their life [60]. In the short term, as much as 70% of linear growth deficit at 60 months is due to faltering during the first 1000 days [61]. The importance of growth and development in the first 1000 days is well established. However, children are often adopted internationally after this period. Therefore, previous studies have adjusted for age of adoption when analyzing the nutritional status of CAI to understand to what extent catch-up growth is possible after the child turns 2 years old. Children adopted at an older age experience longer exposure to negative risk factors such as inadequate nutrition and psychological deprivation, which may increase their growth delays, especially for children who lived in institutionalized care prior to international adoption [43].

In our review, the insufficient number of long-term studies describing catch-up growth in CAI limited our ability to describe the association between age of adoption and catch-up growth. Despite this, one study in our review that followed children for three years post-adoption found no significant association between age of adoption and catch-up growth for weight and height; however, they found a significant inverse association between age of adoption and head circumference catch up [36]. This association is probably due to the increased duration of psychosocial deprivation, which is associated with reduced head growth, even in the absence of subpar nutrition [62]. Our findings are in contrast with previous research which found that later age at arrival was associated with less complete catch up of height and weight [25,63]. The age at which children arrive to their adoptive family may also impact their health in the long term. For example, children adopted after the age of 2 have increased odds of becoming overweight in adulthood compared to those adopted before their first birthday [45].

4.5. Institutionalized Care and Orphanages

Similar to a previous review, we found limited data regarding the association between institutionalized care and growth indicators for CAI. The papers that did include this data support the existing literature that suggests that children who live in institutionalized care prior to being adopted internationally have significantly more delays in weight, height and head circumference on arrival to their adoptive country [25,26], particularly for those with a more extended stay in institutionalized care [43,46,53]. Linear growth faltering in these children reflects long-term chronic difficulties [64], which include inadequate nutrition, psychological care and impacts to growth hormones related to stressful early childhood experiences [65]. Children residing in orphanages who experience inadequate care have abnormal and high cortisol levels [65,66]. CAI have also demonstrated a relationship between the length of time spent in an orphanage and high cortisol levels when cortisol was measured 6.5 years after adoption [67]. Despite increased delays in growth on arrival and the potential long-term adverse health consequences, CAI who lived in institutionalized care prior to adoption demonstrate significant catch-up growth for weight, head circumference and height [36]. One study in our review reported that as much as 65% of children demonstrated catch-up growth (>0.5 change in Z-score) in length from arrival to follow up [11].

Although there was limited data, our review suggests that catch-up growth for children who have resided in institutionalized care is potentially comparable to that of all CAI. Future research with longer follow-up periods is needed to fully describe the post-adoption nutritional status of CAI from institutionalized care.

4.6. Sex and Nutrition Status

Sex is an essential factor to consider because females and males may not receive a similar quality of care before adoption, as well as the physiological differences between females and males [68]. In our review, no studies reported a significant association between sex and weight, height and head circumference growth on arrival. There was also limited anthropometric data post-adoption regarding differences in sex. This is an important area of international adoption research considering the growing evidence that suggests that CAI are at higher risk of developing precocious puberty [69]. Teilmann et al. followed CAI during 39,978 person-years at risk and reported 45 girls and six boys developed precocious puberty; girls adopted internationally had a 10 to 20 times greater risk of developing precocious puberty compared to girls who had a Danish background [69]. The earlier pubertal maturation has been hypothesized to be caused by the stressful psychosocial factors which adoptees experience during infancy. When central precocious puberty is not treated at an early stage, individuals can experience compromised final adult height [70].

Early menarche may also increase a person's risk of metabolic syndromes such as adulthood obesity, cardiovascular disease and diabetes [71].

Notably, only one (4%) study measured the relationship between anthropometric data and sex, post-adoption and found that Korean-born adult males had consistently greater BMI than females ($p < 0.01$). However, this may have been related to high BMI in male adults who lived the USA compared to Europe [42]. Increased prevalence of micronutrient deficiencies was not associated with sex, except one study which found that females had a significantly worse vitamin D status ($p < 0.05$) [40]. However, they found no significant difference between mean 25-hydroxyvitamin D values in females and males ($p = 0.59$). Further analysis determined that sex was significantly associated with vitamin D status only when testing a severe versus a moderate vitamin D deficiency, with female children having an increased risk of developing severe vitamin D deficiency compared to male children (OR 0.55, 95% CI: 0.36–0.86) [40]. In contrast, Chiappini et al. found no association between sex and vitamin D status for children adopted to Italy [44].

4.7. Disability and Nutritional Status

There is a high prevalence of children with disabilities living in out-of-home care or available for adoption due to economic and social constraints faced by families in low-income countries [72]. Families that adopt children domestically also often request to be placed with children who are young and healthy, which contributes to the high prevalence of children with disabilities remaining in institutions available for international adoption [73]. These children are some of the most vulnerable children during the international adoption process due to their increased risk of malnutrition, which is attributable to their disability status and increased time living in institutionalized care [14,43]. In our review, only one paper measured the nutritional status of children with disabilities, which amplifies the need for more research to allow families to understand the needs of their child better.

4.8. Strengths and Limitations

This review has many strengths which improve the understanding of the nutritional status of CAI throughout all stages of the adoption process. This study supports previous reviews that found that the majority of CAI are at high risk of malnutrition on arrival, especially those who previously lived in institutionalized care and those adopted at an older age. Our review also found that all CAI can experience catch-up growth, despite their country of origin, sex and previous living situation. In contrast to previous reviews, we found significant improvements in head circumference post-adoption. We have also highlighted the potential association between the country of origin, the adoptive country and an increased risk of becoming overweight. However, gaps in the literature were also identified, such as the need to describe the long-term health impacts of international adoption, particularly longer than three years post-adoption. Research focusing on the nutritional status of adult adoptees will identify whether there is an increased risk of obesity and non-communicable disease, which may become apparent. This would support earlier intervention for health care providers or adoption agencies to provide targeted education and preventative health services for CAI and potentially reduce their risk of non-communicable diseases.

The lack of research is probably due to the practical issues of conducting long cohort studies, and challenges of collecting quality data without biases such as recall bias. Lost to follow up is also a common issue within international adoption cohort studies. One study in our review reported that post-adoption anthropometric data was missing for 21% of their participants [33]. Inconsistent or inadequate anthropometry resulted in limited comparison of pre-adoption and post-adoption status. Several studies also failed to capture the information collected as part of the initial medical exam for the adoptees but allowed for subsequent follow-up medical records to be used instead; for example, in one study, the "on arrival" anthropometric data was measured from 1 week to 17 months after arrival. As a result, some children may have experienced catch-up growth prior to their initial screening, which reduces the comparability of anthropometric data. Additionally, there are many factors which may contribute to delayed growth in childhood such as small for gestational age, preterm birth, care practices, poor maternal health, poor feeding practices, low birth weight, infectious diseases, disability status and psychological deprivation [74–77]. Often there is minimal information available to researchers about children's early life. Hence, there are many biases inherent to the studies that we found, summarized by the NICE quality assessment in Table 1. We also acknowledge that we may have missed some papers due to single screening of titles and abstracts by our lead author rather than double screening by two or more authors. Our review also only included research published in English from January 1995 to July 2020, excluding other potentially relevant studies that were published in other languages or that were conducted outside of the identified timeframe. Given the limitations and biases inherent to almost all studies we did find, we feel it very unlikely that other papers would have changed our overall conclusions—what is needed to move the science forward in this field is not more of the same but better designed, higher-quality new research.

A key finding from our review was the limited amount of long-term studies measuring the nutritional status of CAI post-adoption. This radical change of environment and the impact to children's nutritional status have very important implications and additional research should also explore the impact in other migrant groups of children. Prospectively following CAI and measuring their nutritional status (anthropometric and micronutrient status) from baseline up to years after adoption will help to inform more of the impacts of environmental shifts. Important variables to focus this research on will include the impact of sex, institutionalized care, age of adoption, disability, country of origin, country of adoption and maternal health on catch-up growth. Addressing the numerous research gaps will support caregivers, health care providers and families to better understand the needs of CAI to support optimal growth and development.

5. Conclusions

The number of international adoptions has dramatically reduced over the last decade, and there is an increasing number of in-country adoptions, which is encouraging. However, in-country adoption is not possible for every child and, therefore, international adoption continues to be necessary to ensure every child has the opportunity to grow up in a safe, loving family. Based on the research of the nutritional status of CAI on arrival to their adoptive country, it is evident that CAI have a high risk of being malnourished on arrival to their adoptive country, especially those coming from institutionalized care, those with disabilities and those adopted at an older age. Encouragingly, we found evidence to suggest that the radical change of environment can result in substantial catch up in weight, height and head circumference. While the first 1000 days are important, our results found that CAI can experience catch-up growth even when adopted in their later years of childhood. Every child has the right to thrive nutritionally and adoption gives valuable lessons in the fight against malnutrition.

Supplementary Materials: The following are available online at https://www.mdpi.com/2072-6643/13/1/245/s1, List S1: Preferred Reporting items for Systematic Reviews and Meta-analysis (PRISMA) checklist; List S2: Literature search strategy used for electronic databases; Table S1: Studies excluded and reasons; Table S2: NICE quality assessment.

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Abbreviations

BMI	Body mass index
BMIZ	Body mass index Z-score
CAI	Children adopted internationally
CDC	Centers of Disease Control
HAZ	Height-for-age Z-score
HCAZ	Head circumference-for-age Z-score
LBW	Low birth weight
MDI	Mental scale index
OFCZ	Occipitofrontal circumference Z-score
PDI	Psychomotor development index
VDD	Vitamin D deficiency
WAZ	Weight-for-age Z-score
WHO	World Health Organization
WHZ	Weight-for-height Z-score

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Supplementary Material

The Nutritional Status of Individuals Adopted Internationally as Children: A Systematic Review

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List S1. Preferred Reporting items for Systematic Reviews and Meta-analysis (PRISMA) checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5

Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	4
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	5
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	5
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	5
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	5
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	6
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	5
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	12
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	12
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	5
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	12

DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	25
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	29
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	30
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	30

List S2. Literature search strategy used for electronic databases.

Databases: Medline, CINAHL PLUS, Global Health Database, EMBASE
Search strategy: Initial screening based on title and abstract, full text assessment to see if it matches inclusion/exclusion criteria and a data extraction table to summarise information on chosen articles. PRISMA guidelines.
Search terms:
1 AND 2 OR 3 will be used during the search process
1) International Adoption: adopt* AND (migration OR migrate* OR inter-country)
2) Nutrition: nutrition* OR malnutrition
3) Anthropometry: (“length-for-age” OR LFA OR LAZ OR linear growth OR stunt* OR wasting OR wasted OR oedematous OR edematous OR kwashiorkor OR protein-energy OR (SAM OR MAM OR GAM) OR “weight-for-length” OR WFL OR WLZ OR muac OR mid upper arm circumference OR underweight OR thinness OR “weight-for-age” OR WFA OR WAZ OR An?emi* OR H?emoglobin Level* OR BMI OR Body mass index OR overweight)
Inclusion criteria: Studies after 1995, English, contained research related to international adoption, children, nutrition, anthropometric data or micronutrient status, data based on those who were adopted internationally as children (under 18), peer reviewed and contains anthropometric data using standardized tools such as WHO growth standards.
Exclusion criteria: National adoption, insufficient anthropometric measurements, incorrect study population, no full text.
Medline:
Database: Ovid MEDLINE(R) <1946 to June Week 1 2020>
Search Strategy:

----

1 Adoption/ (4783)
2 Child, Adopted/ (78)
3 adopt*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (203773)
4 1 or 2 or 3 (203773) [TOTAL FOR ADOPTION]
5 exp Human Migration/ (26222)
6 exp "emigrants and immigrants"/ or "transients and migrants"/ (23421)
7 (migrant* or migration or immigrant* or transient* or international*).mp. (880486)
8 5 or 6 or 7 (888801) [TOTAL FOR international]
9 4 and 8 (14989) [TOTAL FOR INTERNATIONAL ADOPTION]
10 exp "nutritional and metabolic diseases"/ (1270864)
11 (nutrition* or malnutrition*).mp. (359644)
12 10 or 11 (1530028) [TOTAL FOR NUTRITION OR MALNUTRITION]
13 ("length-for-age" or LFA or LAZ or linear growth or stunt* or wasting or wasted or oedematous or edematous or kwashiorkor or protein-energy or SAM or MAM or GAM or "weight-for-length" or WFL or WLZ or muac or mid upper arm circumference or underweight or thinness or "weight-for-age" or WFA or WAZ or An?emi* or H?emoglobin Level* or BMI or Body mass index or overweight).mp. (535982)
14 exp Growth Disorders/ (32778)
15 body mass index/ (125696)
16 exp body weight changes/ or exp overweight/ or thinness/ (264293)

17 exp Anemia/ (160467)
18 13 or 14 or 15 or 16 or 17 (746420) [TOTAL FOR GROWTH DISORDERS ETC]
19 9 and 12 (901) [TOTAL FOR INT-ADOPTION AND (NUTRITION OR MALNUTRITION)]
20 9 and 18 (475) [TOTAL FOR INT-ADOPTION AND GROWTH DISORDERS]
21 9 and 12 and 18 (257) [TOTAL FOR INT-ADOPTION AND (NUTRITION OR MALNUTRITION) AND GROWTH DISORDERS]

19 or 20 will be used for the search.

Embase, Global Health and CINAHL PLUS:

1 Adoption/
2 limit 1 to yr="1995 -Current"
3 Child, Adopted/
4 limit 3 to yr="1995 -Current"
5 Adopt*.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]
6 limit 5 to yr="1995 -Current"
7 2 or 4 or 6
8 exp Human Migration/
9 limit 8 to yr="1995 -Current"
10 exp "Emigrants and Immigrants"/
11 limit 10 to yr="1995 -Current"
12 (migrant* or migration or immigrant* or transient* or international*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]
13 limit 12 to yr="1995 -Current"
14 9 or 11 or 13
15 7 and 14
16 exp "nutritional and metabolic diseases"/
17 limit 16 to yr="1995 -Current"
18 (nutrition* or malnutrition*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]
19 limit 18 to yr="1995 -Current"
20 7 or 19
21 "length-for-age" or LFA or LAZ or linear growth or stunt* or wasting or wasted or oedematous or edematous or kwashiorkor or protein-energy or SAM or MAM or GAM or "weight-for-length" or WFL or WLZ or muac or mid upper arm circumference or underweight or thinness or "weight-for-age" or WFA or WAZ or An?emi* or H?emoglobin Level* or BMI or Body mass index or overweight).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]
22 limit 21 to yr="1995 -Current"
23 exp Growth Disorders/
24 limit 23 to yr="1995 -Current"

25 exp Body Mass Index/
26 limit 25 to yr="1995 -Current"
27 body weight changes/ or exp overweight/ or thinness/
28 limit 27 to yr="1995 -Current"
29 exp body weight changes/ or exp overweight/ or exp thinness/
30 limit 29 to yr="1995 -Current"
31 exp Anemia/
32 limit 31 to yr="1995 -Current"
33 22 or 24 or 26 or 28 or 30 or 32
34 15 and 20
35 15 and 33
36 15 and 20 and 33
37 34 or 35

Table S1. Studies excluded and reasons

	Author, Year	Reason for exclusion
1	Balding C, 2015	Non-standard or insufficient Anthropometric measurements or micronutrient data
2	Baron S, 2000	Not appropriate population
3	Bureau J, 1999	Not appropriate population
4	De Martino M, 2019	Non-standard or insufficient Anthropometric measurements or micronutrient data
5	Diamond G, 2003	Not appropriate population
6	Jenista, 2001	Non-standard or insufficient Anthropometric measurements or micronutrient data
7	McGuinness T, 2006	Non-standard or insufficient Anthropometric measurements or micronutrient data
8	Miller B, 2009	Non-standard or insufficient Anthropometric measurements or micronutrient data
9	Mitchell M, 1997	Non-standard or insufficient Anthropometric measurements or micronutrient data
10	Albers, 2005	Non-standard or insufficient Anthropometric measurements or micronutrient data
11	Cataldo, 2006	Non-standard or insufficient Anthropometric measurements or micronutrient data
12	Cohen, 2008	Non-standard or insufficient Anthropometric measurements or micronutrient data
13	Olivan Gonzalvo G, 2018	Not appropriate population
14	Seminara S, 2011	Not appropriate population
15	Seneckyl Y, 2003	Non-standard or insufficient Anthropometric measurements or micronutrient data
16	Ijzendoorn M, 2007	Not appropriate study type
17	Mason P, 2002	Not appropriate study type
18	Mason P, 2005	Not appropriate study type
19	Mason P, 2005	Not appropriate study type

20	Barratt M, 2013	Not appropriate study type
21	Altemeier, 2000	Not appropriate study type
22	Schulte E, 2005	Not appropriate study type
23	Aita, 2011	Not appropriate study type
24	Cataldo F, 2012	Other language
25	Brown M. S, 1999	Could not find full text
26	Coulot, 2003	Other language
27	Johnson, 2000	Other language
28	Laubjerg M, 2006	Other language
29	Le Masme A, 1999	Other language
30	Miller, 1999	Not appropriate study type
31	Montano, 2013	Could not find full text
32	Nicholson, 2002	No anthropometric data
33	Paricio Talayero, 1998	Not appropriate population
34	Sonego, 2002	Other language
35	Tomlinson-Hansen S, 2015	No anthropometric data
36	Virdis R, 2019	Not appropriate study type
37	Virdis R, 2013	Could not find full text
38	Zaffaroni M, 2018	Could not find full text

Table S2. NICE risk of bias assessment

	Rating System
Best	++
	+
Worse	–
	NR (not reported)
	NA (not applicable)

	Population			Method of allocation to intervention (or comparison)										Outcomes						Analyses						Sum-mary	
Paper	1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	3.1	3.2	3.3	3.4	3.5	3.6	4.1	4.2	4.3	4.4	4.5	4.6	5.1	5.2
Albers, 1997	+	+	+	+	++	+	-	+	NA	+	-	++	++	++	+	++	++	++	+	+	NA	NA	NR	-	NR	+	+
Bortone, 2019	++	++	++	++	NA	NA	-	+	NA	++	+	NA	NA	++	++	++	++	++	+	NA	-	NA	NA	-	-	+	-
Buonsenso, 2019	++	++	++	+	++	++	-	-	++	++	++	NA	NA	++	++	+	++	-	-	+	NR	NR	++	++	++	+	+
Cataldo, 2007	++	++	-	-	++	++	-	+	NA	++	NA	NA	NA	++	+	++	++	NA	-	-	NA	-	+	-	-	-	-
Chiappini, 2016	++	++	+	++	+	NA	-	-	+	NA	++	NA	NA	++	++	++	++	NA	-	+	NA	NA	+	NA	-	+	-
Fuglestad, 2008	+	-	-	-	+	-	-	-	NA	++	++	NA	NA	++	-	+	++	NA	-	-	NA	-	-	++	-	-	-
Fuglestad, 2016	++	+	-	+	++	-	+	+	NA	+	++	NA	NA	++	-	+	++	+	-	-	NA	-	+	++	++	+	+

Gustafson, 2013	++	++	++	++	NA	NA	-	+	NA	++	+	NA	NA	++	++	++	++	++	+	NA	NA	-	-	-	-	+	-
Johnasson, 2002	++	++	-	+	+	+	+	+	+	++	+	NA	NA	++	+	+	+	+	+	+	NA	+	++	+	++	+	+
Johnson, 2011	++	++	-	-	++	++	+	+	+	+	+	NA	NA	++	-	+	++	-	-	-	-	+	+	-	-	+	-
Le Mare, 2006	++	-	-	++	++	-	-	+	+	+	++	NA	NA	-	-	-	++	+	++	+	NR	-	+	++	-	+	-
Ortiz, 2015	-	++	-	-	-	+	-	++	++	+	++	NA	NA	++	+	+	++	+	-	-	NA	+	-	++	+	-	+
Miller, 2015	-	++	-	-	++	+	-	+	+	+	NA	NA	NA	++	++	-	++	NA	-	-	NA	-	+	-	++	-	+
Miller, 2005	++	++	++	+	-	+	-	+	++	+	+	NA	NA	++	++	+	++	-	-	-	NA	-	+	++	++	+	+
Miller, 2008	+	-	-	+	+	++	-	-	++	++	NA	NA	NA	++	++	-	++	-	-	-	-	-	+	++	++	-	+
Miller, 2000	++	++	+	-	-	++	-	-	+	-	++	NA	NA	++	+	++	++	NA	-	-	NA	+	+	++	++	-	+
Palacios, 2011	++	++	-	-	+	+	-	+	+	+	NR	NA	NA	++	+	-	++	-	-	+	NR	-	+	++	+	+	+
Park, 2011	++	+	-	-	-	++	-	-	++	+	-	NA	NA	++	-	++	++	-	-	-	-	-	+	++	-	-	-
Pomerleau, 2005	++	++	-	+	++	++	-	+	++	+	-	NA	NA	++	+	++	++	++	-	-	NR	-	+	-	+	-	-
Reeves, 2000	++	-	-	-	++	++	+	+	++	+	++	NA	NA	++	+	+	++	++	+	-	NA	+	+	+	-	-	+

Salerno, 2018	++	++	+	+	+	++	+	+	++	++	NA	NA	NA	++	+	+	++	NA	-	++	NA	+	-	++	++	+	+
Ulijaszek, 2013	++	++	-	+	++	+	+	++	++	+	++	NA	NA	+	+	-	+	-	++	-	NA	NR	+	-	+	+	-
Tirella, 2011	++	++	-	-	++	+	+	++	++	+	NA	NA	NA	++	+	++	++	NA	-	-	NA	-	+	-	++	-	-
Van Kesteren, 2017	++	++	-	+	+	+	+	+	++	+	++	NA	NA	++	++	++	++	+	-	+	NA	-	++	++	-	+	+

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MSc Research Ethics Committee

Mr Richard Ivey
MSc Student
Nutrition for Global Health
LSHTM

26 June 2020

Dear Mr Richard Ivey

Study Title: Nutritional Status of individuals who were adopted internationally as children: A Systematic Review

LSHTM MSc Ethics ref: 22115

Thank you for submitting your application for the above MSc research project.

As your projectis a systematic/literature review only, it was assessed by the Research Governance & Integrity Office as not requiring ethical approval from the MSc ethics committee. It is the student's responsibility to ensure that all other required approvals are in place before starting the research project.

Any subsequent changes to the application must be submitted to the Committee via an Amendment form on the ethics online applications website: http://leo.lshtm.ac.uk .

Best of luck with your project.

Yours sincerely,

Rebecca Carter

Research Governance Coordinator

MScEthics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

Improving health worldwide

B.1.4 Dissemination: Blogs, Visual Abstracts, Conferences and Presentations

I. Blog: The Nutritional Status of Individuals Adopted Internationally as Children: A Systematic Review

A review of the nutritional status of individuals adopted internationally as children, highlighting the needs of vulnerable children in changing environments.

https://www.holtinternational.org/blog/2021/03/infographic-the-nutritional-status-of-internationally-adopted-children/?fbclid=IwAR2pIBmClgc79E0-NiEA2hgqD0aGTPu1PYHYB9YxXtArjRudJLXvrhOMc3s

II. Visual Abstract

HOLT INTERNATIONAL®
Nutrition Program

The Nutritional Status of Individuals Adopted Internationally as Children: A Systematic Review

BACKGROUND

International Adoption began in 1955 and continues to be a method to find homes for children who have been orphaned or abandoned. Globally there are more than 140 million children who are orphans, many of whom need to be placed with families.

METHODS

Using our search strategy, we looked for peer-reviewed research published from January 1995 to June 2020 in four databases. Studies which included information on anthropometric data or micronutrient status of children adopted internationally were eligible for inclusion.

RESULTS

From 4,939 papers screened, we reviewed 62 full text and found 24 papers which the inclusion criteria. One study reported data from multiple countries and the remaining studies were reported from the following countries:

All research included were observational studies, of which nine (37%) were cross-sectional studies and 13 (54%) were cohort studies.

PREVALENCE OF HEALTH IMPACTING ISSUES (AT ADOPTION)

ANTHROPOMETRIC INDICATORS

Underweight	Stunting	Wasting	Low Head Circumference
49%	12% – 39%	0% – 18.4%	5% – 17%

MICRONUTRIENT DEFICIENCIES

- Abnormal nutritional biochemical marker: 68%
- Anemia: 9.6% - 54.4%
- Vitamin D: 9% - 85.1%
- Zinc: 29%
- Low retinol-binding protein: 33%
- Iron deficiency: 15% - 25%

CONCLUSIONS

- There is a limited amount of long-term studies measuring the post-adoption nutritional status of children adopted internationally post-adoption.
- Children adopted internationally were commonly malnourished on arrival, presenting with multiple forms of undernutrition and micronutrient deficiencies, especially for those with disabilities and those adopted at an older age.
- Substantial catch-up growth is possible for children, even when adopted in their later years of childhood.
- Every child has the right to thrive nutritionally and adoption gives valuable lessons in the fight against malnutrition.

more info: holtinternational.org | mdpi.com/2072-6643/13/1/24

C. Research on the Use of MUAC for Children with Disabilities (Paper 6)

C.1.1 Scope of this Paper

This research is titled "Mid-upper arm circumference (MUAC) measurement usage among children with disabilities: A systematic review".

This paper presents the findings of a systematic review of literature on the use of MUAC measurement amongst children with disabilities.

C.1.2 Citation

Hayes, J., et al. (2022). "Mid-upper arm circumference (MUAC) measurement usage among children with disabilities: A systematic review." Maternal and Child Nutrition (Pending Peer Review).

C.1.3 Ethics

Ethical approval was not determined to be needed by LSHTM. This study did not involve patients or the public in its development. This paper followed PRISMA guidelines [103] throughout the study and a PROSPERO registration was completed prior to the start of the study
CRD42021258027 https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42021258027).

RESEARCH PAPER COVER SHEET

Please note that a cover sheet must be completed <u>for each</u> research paper included within a thesis.

<u>SECTION A – Student Details</u>

Student ID Number	lsh1804647	**Title**	Ms
First Name(s)	Emily		
Surname/Family Name	DeLacey		
Thesis Title	The Nutritional and Feeding Status of Children Living within Institution-based Care and an Evaluation of Process of the Child Nutrition Program.		
Primary Supervisor	Marko Kerac		

If the Research Paper has previously been published please complete Section B, if not please move to Section C.

<u>SECTION B – Paper already published</u>

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	Choose an item.	Was the work subject to academic peer review?	Choose an item.

*If yes, please attach evidence of retention. If no, or if the work is being included in its published format, please attach evidence of permission from the copyright holder (publisher or other author) to include this work.

<u>SECTION C – Prepared for publication, but not yet published</u>

Where is the work intended to be published?	Nutrients
Please list the paper's authors in the intended authorship order:	Julia Hayes, Michael Quiring, Marko Kerac, Tracey Smythe, Cally Tann, Nora Groce, Zerihun Gultie, Lydia Nyesigomwe, Emily DeLacey

Stage of publication	**Submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	Emily DeLacey, Julia Hayes, Michael Quiring and Marko Kerac designed the study. Julia Hayes and Emily DeLacey completed title/ abstract review and Julia Hayes, Michael Quiring and Emily DeLacey completed full text review. Julia Hayes, Emily DeLacey Marko Kerac, Tracey Smythe, Michael Quiring, Cally J Tann, Nora Groce, Zerihun Gultie, and Lydia Nyesigomwe contributed to specific areas of the methods, data analysis and quality control. Julia Hayes and Emily DeLacey led the data analysis and writing of the first draft of the manuscript. Julia Hayes, Emily DeLacey, Marko Kerac, Tracey Smythe, Michael Quiring, Cally J Tann, Nora Groce, Zerihun Gultie, and Lydia Nyesigomwe contributed to the writing of the manuscript and agree with the manuscript's results and conclusions. All the authors have read and approved of the submitted manuscript.

SECTION E

Student Signature	Emily DeLacey
Date	June 6 2022

Supervisor Signature	Marko Kerac
Date	June 21, 2022

Maternal & Child Nutrition
Open Access

Mid-Upper Arm Circumference (MUAC) Measurement Usage Among Children With Disabilities: A Systematic Review

Journal:	*Maternal & Child Nutrition*
Manuscript ID	Draft
Wiley - Manuscript type:	Original Article
Keywords:	Child Nutrition, Nutritional Status, Nutritional Epidemiology, Undernutrition, Assessment of Nutritional Status, International Child Health Nutrition
Additional Keywords:	Disability, mid-upper arm circumference, Anthropometry

Mid-Upper Arm Circumference (MUAC) Measurement Usage Among Children With Disabilities: A Systematic Review

Abstract: Anthropometric measurements, including mid-upper arm circumference (MUAC), are important for monitoring and evaluating children's nutritional status. Evidence is limited on optimal nutritional assessment for children with disabilities, who are at high risk for malnutrition. This study describes MUAC use among children with disabilities. Four databases (Embase, Global Health, Medline and CINHAL) were searched from 1990-2021 using a predefined search strategy. Of the 304 titles screened, 31 papers were included. Data included children 6 months -18 years old with disabilities. Studies from 23 countries indicate that MUAC is being currently used as part of nutritional assessment but MUAC measurement methods, references, methods and cut-offs were inconsistent. Sixteen (52%) reported MUAC as a mean ± standard deviation (SD), 11 (35%) reported ranges or percentiles, 6 (19%) reported z-scores and 3 (10%) used other methods. Fourteen (45%) studies included both MUAC and weight-for-height (WFH) but non-standard reporting made it difficult to compare the prevalence of MUAC-based vs WFH-based malnutrition. Whilst its speed, simplicity, and ease of use affords MUAC great potential for assessing children with disabilities, more work is needed to understand how it performs at identifying high-risk children in comparison to other measures. Inclusivity of children with disabilities in data collection and health services is essential, but current research and recommendations leave this unaddressed.

Keywords: Disability; child nutrition, nutritional status, undernutrition, assessment of nutritional status, mid-upper arm circumference, anthropometry

Key Messages

- Children with disabilities should not be malnourished but without inclusive, standardized methods to track and monitor their growth, millions could have severe but avoidable consequences to their health and development.
- MUAC is being used to assess nutritional status of children with disabilities, but data is limited and poor where available with lack of standardization of methods, cut-offs, and references.
- Early identification of malnutrition and inclusion into malnutrition treatment programs is crucial to improve the nutritional status of all children. Future research should critically examine the use of MUAC as part of nutrition assessment for children with disabilities.

1. Introduction

The 1989 International Convention on the Rights of the Child recognizes the rights of the child as human rights with consideration for their vulnerability and needs (UN General Assembly, 1959). The global community is in consensus that all children have the right to have their fundamental needs met. Children have the right to good nutrition, care and support, that will ensure their full development(UN General Assembly, 1959, 2015; UNICEF, 2021; United Nations Children's Fund, 2021). Countries and the global community therefore are accountable to uphold these children's rights(UN General Assembly, 1959, 2015; UNICEF, 2021; United Nations Children's Fund, 2021). When considering the needs of all children, it is important to recognize those whose rights are marginalized, including many of the nearly 240 million children worldwide living with disabilities (United Nations Children's Fund, 2021). Disability refers to the interaction between physical, mental, or intellectual impairments and a child's environment, which can limit activities and restrict participation (World Health Organization, 2011).

Children with disabilities are at increased risk of malnutrition due to many reasons directly and indirectly related to underlying impairments or their environments. These include health and medical conditions that require additional care and represent feeding challenges, and economic, social and cultural issues in the surrounding environment, including access to less food or less nutritious food than their non-disabled siblings and peers (DeLacey et al., 2022, 2021, 2020; Groce et al., 2014). Despite this, they are often neglected in malnutrition guidelines and it remains unclear which measures of nutritional status are appropriate (Engl et al., 2022; Hardy, Kuter, Campbell, & Canoy, 2018). For a population with greater needs and at higher risk of nutritional challenges, understanding and supporting their unique growth pattern and development needs is imperative.

1.1 Malnutrition

Malnutrition is "Any condition in which deficiency, excess or imbalance of energy, protein or other nutrients…adversely affects body function and/or clinical outcome" (Meier & Stratton, 2008). Types of undernutrition include stunting (low height-for-age), wasting (low weight-for-height), underweight (low weight-for-age) and micronutrient deficiencies, such as iron or vitamin A deficiency. Millions of children worldwide are affected: in 2020, 149 million children were stunted and 45 million were wasted ("UNICEF-WHO-World Bank: Joint Child Malnutrition Estimates - 2021 Edition Interactive Dashboard - UNICEF DATA," n.d.).

1.2 Anthropometry

Anthropometry is a common, reliable and easy way of assessing nutritional status of individuals since it is a key factor underlying growth (World Health Organization Expert Committee, 1995). Common measures include weight, height or length and circumferences (arm, head) (C. D. Fryar, Carroll, Gu, Afful, & Ogden, 2021). These are routinely taken at medical check-ups and plotted on growth charts to illustrate growth patterns and inform clinicians of a child's health and nutritional status (C. D. Fryar et al., 2021). Consecutive anthropometric measurements can help identify abnormal growth patterns, which could be a sign of underlying medical, nutritional or psycho-social problems (Child Health and Disability Prevention Program, 2016). Percentiles and z-scores are two methods often used to report anthropometric measures: both compare a child's individual measures with those from a healthy reference population. Percentiles rank children in size order and z-scores represent standard deviations from the reference population median whereby one z-score is one standard deviation above or below the population median.

The World Health Organization (WHO) offers child growth standards and references for children up to 19 years old, with z-scores and percentiles, for various measurements of growth including length/height-for-age, weight-for-age, weight-for-length/height, body mass index (BMI)-for-age, head circumference-for-age, and arm circumference-for-age. (World Health Organization, 2007, 2022).

1.3 Mid-upper arm circumference

Mid-upper arm circumference (MUAC) is an anthropometric measure that originated in the 1950s (Glasman, 2018). Due to simplicity, speed and ease of assessment it is widely used, especially in humanitarian settings for assessing wasting-type malnutrition in children aged six months to five years (World Health Organization, 2022). Unlike weight or length/height measurements, MUAC does not have to be adjusted for age or sex (though MUAC z-score and percentile tables do exist). For children 6 months to 5 years of age, the WHO's recommended cut-off is 11.5 cm for severe wasting (also known as severe acute malnutrition) and between 11.5 cm to 12.5 cm for moderate wasting (moderate acute malnutrition) (World Health Organization, 2013). To help with assessment, tapes are often color coded so that even those with poor numeracy can easily use and interpret them in community settings: red color below 11.5 cm indicates severe malnutrition, yellow color from 11.5 cm to 12.5 cm indicates moderate malnutrition, green color above 12.5 cm indicates normal range (Bliss et al., 2018; "MUAC,Child 11.5 Red,PAC-50,English," n.d.). Although cutoffs are not currently defined for all children older than five years some reference values are available and research on its application among older children continues with the potential to inform on children's nutritional status at all ages (Shinsugi, Gunasekara, & Takimoto, 2020; World Health Organization, 2009a). Using MUAC to assess nutritional status in children with underlying disability has also not been previously assessed. This is an important gap since both disability and malnutrition are major global public health problems: but, like all anthropometric measures, MUAC is an imperfect measure of nutritional status with both advantages and disadvantages (Briend et al., 2016; Grellety, Krause, Shams Eldin, Porten, & Isanaka, 2015; Kerac et al., 2020).

1.4 Aim and Objectives

The aim of our review is to describe the use of MUAC measurement among children with disabilities. Our objectives were to:

1. Describe the use of MUAC measurement in assessment of nutritional status of children with disabilities.
2. Examine MUAC measurements in relation to other anthropometric measurements or the use of MUAC between groups of children (e.g., comparison of those with disabilities to those without disabilities).
3. Explore the usability of current MUAC cut-off values or MUAC z-scores for children with disabilities.

2. Materials and Methods

2.1 Search Strategy

Following PRISMA guidelines, we analyzed existing published peer-reviewed literature on the use of MUAC among children with disabilities (Page et al., 2021) (S1). A PROSPERO registration was completed prior to the start of the study [PROSPERO number removed for blind review]. PICO framework was used to develop the research question (Table 1) (Aslam & Emmanuel, 2010). Ethical approval for this systematic review was determined not to be required by [school removed for blind review].

Table 1. PICO criteria for search strategy.

PICO Criteria	
Population	Children between the ages of 6 months and 18 years with one or more disabilities
Intervention	Use of MUAC measurement
Comparator	Anthropometric measurements
Outcomes	Assessment of nutrition status

2.2 Inclusion/exclusion criteria

Inclusion criteria included studies published in English between January 1990 and October 2021 which contained research on children with disabilities and MUAC measurements (Table A1). Studies needed to include at least one measurement of mid-upper arm circumference. Other anthropometric indicators were included for comparison (e.g., length/height-for-age, weight-for-age, weight-for-length/height, and BMI-for-age) where available. Full text cross-sectional studies, case control studies, cohort studies and randomized controlled trials conducted in all geographic locations were eligible for inclusion. Studies conducted in intensive care settings were excluded. Additionally, in some studies MUAC values were used to calculate other arm measurements including upper arm muscle area (UAMA) and upper arm fat area (UAFA). Studies that included only values for these calculations but no values for MUAC were excluded. Studies that included MUAC values presented in addition to UAMA and UAFA values were included.

2.3 Study selection

-, -, - and - determined the appropriate search strategy. See Table A2 for the search strategy developed with guidance from a search strategy from Banks et. al (Banks, Kuper, & Polack, 2017). - and - applied the finalized search strategy from Sept. 8, 2021 through Sept. 29, 2021. Two electronic databases were searched through OVID, Embase and Global Health, and two electronic databases were searched through EBSCO Host, PubMed/Medline and CINHAL Plus. - and - independently completed initial title and abstract screenings of articles identified from the search strategy. Papers identified by - and - as eligible for possible inclusion and full text review were then reviewed by -, - and - against the pre-determined inclusion/exclusion criteria. Any discords in inclusion of full text studies were discussed among -, - and - with - deciding any discords.

2.4 Data extraction and analysis

Studies included were imported into EndNote X9 v12 and Mendeley Desktop v1.19.8 for review, synthesis and coding (The EndNote Team, 2013; The Mendeley Team, 2008). We undertook data extraction using a standardized form that included study design, location, population, age range, sex representation, disability type and setting (Table 2a and Table2b). Additionally, data were extracted on methods for MUAC measurement with any variations in terminology, measurement references or measurement techniques noted. Z-scores and percentiles for MUAC and other forms of anthropometry were included where available.

Specific disability types were extracted for subgroup analysis if there was a sufficient data (e.g., use of MUAC among children with cerebral palsy). Heterogeneity in the type of disabilities represented and use of mid-upper arm circumference measurements prevented our ability to conduct a meta-analysis, so a narrative synthesis was used.

2.5 Critical appraisal

The JBI Critical Appraisal Tool for appraisal of cross-sectional studies, cohort studies, case-control studies and randomized control trials was used to assess the papers (Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Qureshi R, Mattis P, Lisy K, 2020). Critical appraisal of each study using the appropriate tool for study type can be found in Table A3.1- Table A3.4.

3. Results

3.1 Study selection

The database search generated 304 studies. After 121 duplicates were removed, 183 records were screened by title/abstract, of which 57 were identified for full text review (Figure 1). Following a full-text review and critical appraisal, 31 studies were determined to meet the inclusion criteria and 23 studies were excluded (Figure 1, Table A3 and Table A5).

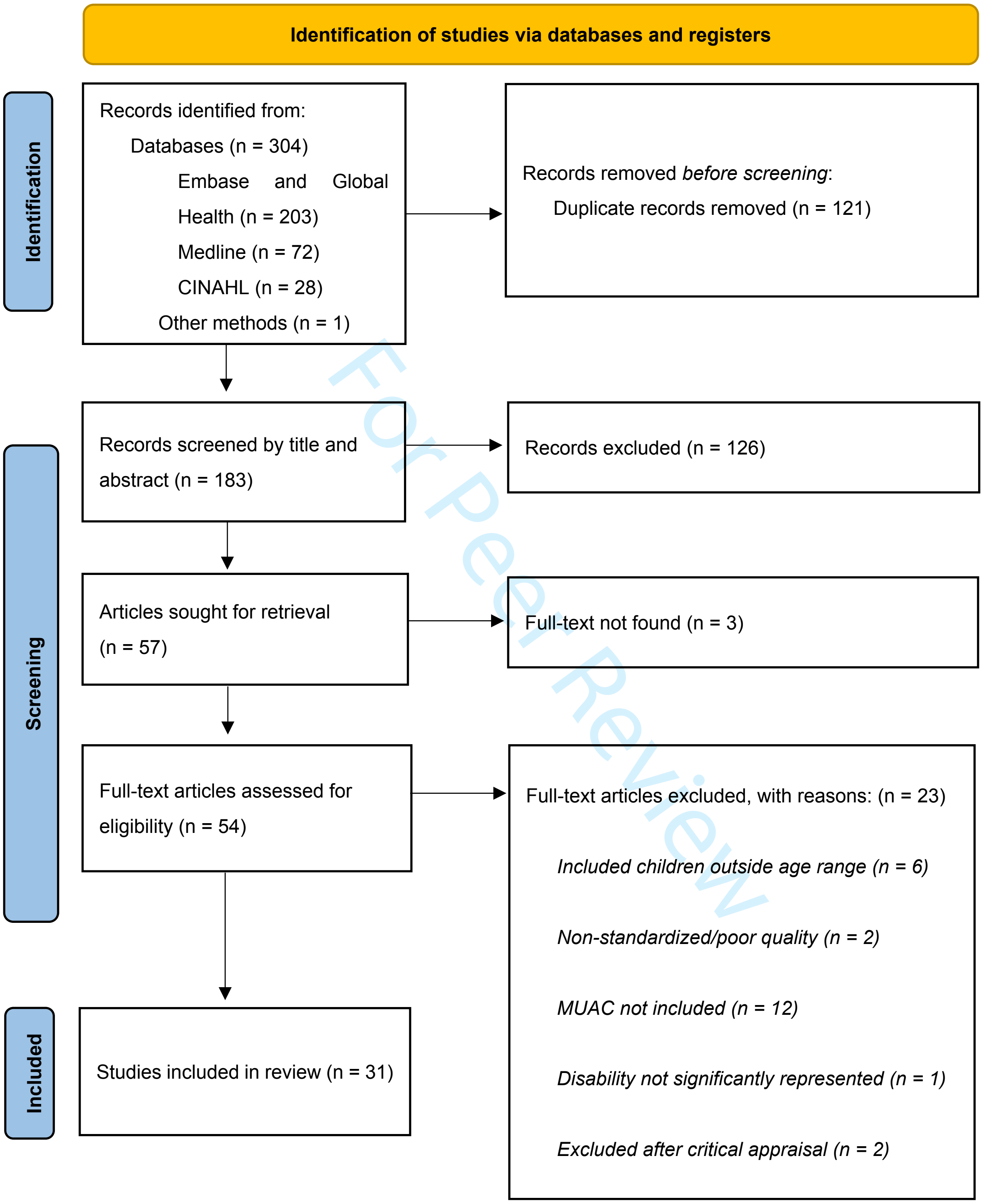

Figure 1. PRISMA flow diagram.

3.2 Study characteristics

Most of the studies included in the review were observational studies (29/31, 94%), representing 25 different countries. India, Egypt and the United States were each represented in 3/31 (10%) of the studies. Commonest regions included the Americas, Africa, South-East Asia and Europe (Table 2a, Table A4). Of the included studies, over half (17/31, 55%) were published in the past five years (2017 through 2022) (Table 2b).

The median age of children in the research was 8 years old. Commonest forms of disability reported were cerebral palsy, intellectual impairment, and autism spectrum disorder (Table 2a). Nine studies (29%) included more than one type of disability. Gender was included in 27 studies (87%). The average percentage of females among 27 studies was 47%.

Table 2a. Characteristics of studies included in the full text analysis. 219

Characteristic	N (%)
Study design	N=31 studies
Cross-sectional	17 (55%)
Case control	5 (16%)
Cohort	8 (26%)
Randomized Control Trial	1 (3%)
Decade of publication	
1990 – 1999	2 (6%)
2000 – 2010	12 (39%)
2011 – 2019	10 (32%)
2020 – 2022	7 (23%)
WHO region/country	
African Region	5 (15%)
Region of the Americas	7 (23%)
South-East Asia Region	5 (15%)
European Region	6 (19%)
Eastern Mediterranean Region	5 (16%)
Western Pacific Region	2 (10%)
Multi-Region	1 (3%)
Disability types appearing in multiple studies	
Cerebral palsy	13 (39%)
Intellectual impairment	6 (19%)
Visual impairment	3 (10%)
Autism spectrum disorder	3 (10%)
Sickle cell disease	2 (6%)
Down syndrome	2 (6%)
Epilepsy	2 (6%)
Hearing impairment	2 (6%)

Table 2b. Description of studies included in the review of use of mid-upper arm circumference (MUAC) among children with disabilities.

Author/Year	**Study Design**	**Country**	**Sample Size**	**Age Range**	**% Female**	**Disability Type(s)**	**Setting**
Dannhauser et al., 2007 (Dannhauser, Walsh, & Nel, 2007)	Cross-sectional	South Africa	N = 145	8-15 years	Not available	Multiple (Mental disability, physical disability and/or learning disability)	School
Kakooza-Mwesige et al., 2015 (Kakooza-Mwesige, Tumwine, Eliasson, Namusoke, & Forssberg, 2015)	Cohort	Uganda	N = 135	2-12 years	47%	Cerebral palsy	Clinic and hospital
Kuper et al., 2015 (Kuper et al., 2015)	Case Control	Kenya	n = 311 n† = 496	6 months - 10 years	38%	Multiple (Physical impairment, epilepsy, visual impairment, hearing impairment and intellectual impairment)	County
Lelijveld et al., 2016 (Lelijveld et al., 2016)	Cohort	Malawi	n = 352 n† = 401	7.4-12.8 years	Not available	Noncommunicable diseases	City
Tompsett et al.,1999 (Tompsett, Yousafzai, & Filteau, 1999)	Cross-sectional	Nigeria	n = 112 n† = 199	< 10 years	44%	Multiple (Poliomyelitis, neurological, orthopedic, learning difficulties and/or sensory impairments)	Multiple regions
Barnhill et al., 2017 (Barnhill et al., 2017)	Case Control	USA Region of the Americas	n = 86 n† = 57	2-13 years	12%	Autism spectrum disorder	Unspecified

Bartlett et al., 2010 (Bartlett, Hanna, Avery, Stevenson, & Galuppi, 2010)	Cohort	Canada	N = 135	11.6-17.9 years	44%	Cerebral palsy	City
Caminiti et al., 2018 (Caminiti, Saure, Weglinski, de Castro, & Campmany, 2018)	Case Control	Argentina	N = 131	0.7-18.6 years	50%	Myelomeningocele	Hospital
Kuperminc et al., 2010 (Kuperminc et al., 2010)	Cohort	USA	N = 58	8-18 years	43%	Cerebral palsy	Unspecified
Saldanha et al., 2018 (Saldanha Tschinkel, Conon, Nascimento, Bjorklund, & Chirumbolo Geir; ORCID: http://orcid.org/0000-0003-2632-3935 AO - Chirumbolo, Salvatore; ORCID: http://orcid.org/0000-0003-1789-8307, 2018)	Cross-sectional	Brazil	N = 23	1-12 years	57%	Autism spectrum disorder	City
Silva et al., 2017 (Silva et al., 2017)	Cross-sectional	Brazil	N = 68	2-11 years	31%	Cerebral palsy	Hospital
Zemel et al., 2002 (Zemel, Kawchak, Fung, Ohene-Frempong, & Stallings, 2002)	Randomized control trial	USA	N = 42	4-10 years	48%	Sickle cell disease	Hospital
Freeman et al., 2002 (Freeman, Yousafzai, Filteau, & Pai, 2002)	Case Control	India	n = 41 n† = 40	2-7 years	Not available	Multiple neurological disabilities (Mainly cerebral palsy)	Urban community
Hussain et al., 1996 (Hussain, Lindtjorn, & Kvale, 1996)	Cross-sectional	Bangladesh	n = 105 n† = 105	2-15 years	Not available	Night Blindness	Rural community
Jahan et al., 2021 (Jahan et al., 2021)	Cross-sectional	Nepal	N = 182	5.3-15.3 years	74%	Cerebral palsy	Rural community

Pai et al., 2001 (Pai et al., 2001)	Case Control	India	N = 129	2-10 years	52%	Multiple (Motor impairments, neurological impairments, speech impairments, learning impairments and/or epilepsy)	School
Rose-Clarke et al., 2019 (Rose-Clarke et al., 2019)	Cross-sectional	India	N† = 3,324 n = 14	10-<19 years	100%	Undefined	Rural community
Leonard et al., 2020 (Leonard, Dain, Pelc, Dan, & De Laet, 2020)	Retrospective Cohort	Belgium	N = 260	18 months-18 years	43%	Cerebral palsy	Hospital
Sahin and Nogay, 2021 (Sahin & Nogay, 2021)	Cross-sectional	Turkey	N = 122	4-18 years	44%	Intellectual disabilities	Rehab centers
Samara et al., 2010 (Samara, Johnson, Lamberts, Marlow, & Wolke, 2010)	Cohort	UK/Ireland	N = 223	6 years	44%	Multiple (Eating problems, behavioral disabilities, and extremely preterm)	Unspecified
Soylu et al., 2008 (Soylu et al., 2008)	Prospective Interventional Cohort	Turkey	n = 45	1.9-9.1 years	36%	Spastic quadriplegia	Hospital
Tekin et al., 2018 (Tekin et al., 2018)	Cross-sectional	Turkey	N = 1,057	1.8-12.6 years	43%	Multiple (Epilepsy, cerebral palsy, neuro-muscular disorders, neuro-metabolic disorder, neuro-immune disorders)	Clinic
Troughton and Hill, 2001 (Troughton & Hill, 2001)	Cross-sectional	Ireland	N = 93	2.6-18.7 years	38%	Cerebral palsy	School

Al-Saqladi et al., 2010 (Al-Saqladi, Bin-Gadeen, & Brabin, 2010)	Cross-sectional	Yemen	N = 102	6 months-15 years	45%	Sickle cell disease	Hospital
Hamza et al., 2015 (Hamza, Abdelaziz, & Elakkad, 2015)	Cross-sectional	Egypt	N = 84	6 months-15.5 years	55%	Osteogenesis Imperfecta (OI)	Clinic and hospital
Kotby et al., 2020 (Kotby, Mohamed, Al-Fahham, Elabd, & Tawfik, 2020)	Cross-sectional	Egypt	N = 80	7 months-4.75 years	40%	Down syndrome	Hospital
Saleem et al., 2021 (Saleem, Zakar, Mushtaq, Bukhari, & Fischer, 2021)	Cross-sectional	Pakistan	N = 200	6 months-4.9 years	50%	Multiple (Delayed social development, fine motor development, gross motor development and global development)	Clinic and rural health center
Tomoum et al., 2010 (Tomoum, Badawy, Hassan, & Alian, 2010)	Cross-sectional	Egypt	n = 40 n† = 40	2-8 years	48%	Cerebral palsy	Hospital
Ahmad et al., 2020 (Ahmad, Rahman, Hasan, Yaacob, & Ali, 2020)	Cross-sectional	Malaysia	N = 93	5-17 years	45%	Cerebral palsy	Community-based rehabilitation centers
Zainah et al., 2001 (Zainah, Ong, Sofiah, Poh, & Hussain, 2001)	Cross-sectional	Malaysia	n = 101 n† = 101	2-12 years	41%	Cerebral palsy	Clinic, hospital, and community-based rehabilitation centers

DeLacey et al., 2021 (DeLacey et al., 2021)	Retrospective Cohort	China, India, Mongolia, the Philippines, Ethiopia, Vietnam	N† = 2,926 n = 739	0-18 years 0–6 months: 746 6–12 months: 245 12–24 months: 282 24–59 months: 427 (14.6%) 5–18 years: 1226 (41.9%)	49%	Multiple (Autism spectrum disorder, cerebral palsy, cleft lip/cleft palate, cognitive impairment, Down syndrome, hearing loss/deafness, heart disease/defect, HIV/AIDS, hydrocephaly, microcephaly, vision impairment and blindness, speech/language delays, others)	IBC

n = children with disabilities, n† = children without disabilities, N = total population of only children with disabilities, N† = total population mixed of children with and without disabilities, IBC = Institution-based care

3.3 Anthropometric indicators

Different anthropometric measurements were reported inconsistently in these studies including weight-for-length/height, height-for-age, weight-for-age, BMI/BMI-for-age, weight, height, head circumference, waist circumference, triceps skinfold thickness and subscapular skinfold thickness (Table 3).

3.4 Use of MUAC

Terminology of MUAC varied in the 31 included studies (Table 3). Additional information on MUAC terminology, methods for MUAC measurement, measurement references (e.g., WHO, CDC) and data reported for MUAC and other anthropometric indicators (e.g., weight-for-age, height-for-age, weight-for-length/height, and BMI) are included in Table A4. While most studies referred to MUAC using mid-upper arm circumference or a variation of all those words, 11 used other variation of the term that did not include mid, upper, arm and circumference. Few studies (12/31, 39%) specified the location on the upper arm to be measured, the use of the left arm, and/or a 90-degree angle of the arm. Even fewer (7/31, 23%) noted measurements obtained to the nearest 0.1 centimeter and only one study mentioned the use of specialized MUAC tape. Of the studies that included methods for MUAC measurement were limited, often nonstandard, descriptions of the methods. Presentation of MUAC measurements varied greatly. Sixteen (52%) studies presented MUAC values as means with standard deviations, 11 (33%) presented MUAC values as the number or percentage of children within a specific percentile and six (18%) used z-scores to present MUAC values obtained for specific groups. Three studies (9%) presented MUAC results in other ways and two studies (6%) did not include MUAC values but did mention MUAC in their methods sections.

When grouped by disability type, a trend toward using means with standard deviations was observed for studies which included children with different types of disabilities. Of the nine studies including children with multiple disabilities, six reported MUAC as means with standard deviation. Also, of the 11 studies looking at children with cerebral palsy, three studies dated 2001 and 2010, noted the use of findings by Frisancho based on NCHS data from the United States Health and Nutritional Examination Survey of 1971 to 1974 for the assessment of anthropometric measurements (A. R. Frisancho, 1981; Andres Frisancho, 2016).

3.5 Reference values for MUAC

MUAC reference values which were used are shown in Table 3. Publication years ranged from 1996 to 2021. References have evolved through this period and therefore variation in references used for anthropometric measurements is notable. In studies dated 1996 through 2010, the US National Center for Health Statistics (NCHS) data were used most, in six of 14 studies published during this time. In the studies dated 2015 through 2021, WHO growth standards became common, referred to in 15 out of 17 studies published in this time.

Table 3. Mid-upper arm circumference (MUAC) measurement, presentation and growth references used for other anthropometry, cutoffs and methods of measurement.

Author, Year	**References used for presentation of anthropometry**	**Cutoffs if specified**	**Method of MUAC Measurement**					
			Midpoint of arm	**Left arm**	**90-degree angle of arm**	**MUAC tape**	**Nearest 0.1 CM**	**Additional information on method**
Hussain et al., 1996 (Hussain et al., 1996)	MUAC: US NHANES (Jeliffe & Jeliffe, 1989) WFH: National Center for Health Statistics reference data (P. Hamill, Drizd, Johnson, Reed, & Roche, 1977)	MUAC Normal: >/= 85% Moderate 80-84% Severe: <80% WFH Severely wasted: </= -3 standard deviations Moderately wasted: -2- -3 standard deviations		X				Upper arm measured to the nearest mm, Oil-cloth tailor's tape
Tompsett et al.,1999 (Tompsett et al., 1999)	National Center for Health Statistics reference data for WHZ and other anthropometry. Unadjusted simple MUAC presented.			X			X	

Zainah et al., 2001 (Zainah et al., 2001)	MUAC: Frisancho, 1981 (A. R. Frisancho, 1981) WFH: Hamill et al., 1979 (P. V. V. Hamill et al., 1979)			X				Upper arm Non-stretch measuring tape
Troughton and Hill, 2001 (Troughton & Hill, 2001)	Frisancho, 1981 (A. R. Frisancho, 1981)	MUAC Undernutrition: <5th centile						Harpenden plastic tape Average of at least 2 measurements
Pai et al., 2001 (Pai et al., 2001)	MUAC: Trowbridge, 1979 (Trowbridge, 1979) WFH: National Center for Health Statistics reference data	WFH Z-score Moderate-severely wasted: <-2 standard deviations MUAC Moderate and severe malnutrition: <13.5 cm					X	
Freeman et al., 2002 (Freeman et al., 2002)	National Center for Health Statistics reference data for WHZ and other anthropometry.							Unspecified

	Unadjusted simple MUAC presented.							
Zemel et al., 2002 (Zemel et al., 2002)	National Center for Health Statistics reference data						X	Non-stretchable tape Average of 3 measurements
Dannhauser et al., 2007 (Dannhauser et al., 2007)	National Center for Health Statistics reference data							Right side Average of 3 measurements
Soylu et al., 2008 (Soylu et al., 2008)	National Center for Health Statistics reference data for WFH Unadjusted MUAC presented		X	X				Arm hanging down Non-stretching tape
Tomoum et al., 2010 (Tomoum et al., 2010)	Krick, 1996 (Krick, Murphy-Miller, Zeger, & Wright, 1996)							Non-stretchable stainless-steel tape Average of 3 measurements
Al-Saqladi et al., 2010 (Al-Saqladi et al., 2010)	WHO Growth Standards for WFH and MUAC for Age [6mos- 5	WFH z-scores Moderate wasting: </= -2 standard deviations	X	X			X	Arm hanging loosely Non-extensible fiberglass tape

	years] (World Health Organization, 2022) WHO Reference Data for weight for height of older children (World Health Organization, 2007)	Severe wasting: </= -3 standard deviations						
Bartlett et al., 2010 (Bartlett et al., 2010)	Unspecified			X				Left side of body Measured in cm
Kupperminc et al., 2010 (Kupperminc et al., 2010)	Frisancho, 1990 (AR Frisancho, 1990)							Average of 2 measurements
Samara et al., 2010 (Samara et al., 2010)	Unspecified							Average of 2 measurements LASSO-O tape
Kakooza-Mwesige et al., 2015 (Kakooza-Mwesige et al., 2015)	WHO Growth Standards						X	Tape measurer Average of 2 measurements

Kuper et al., 2015 (Kuper et al., 2015)	WHO Growth Standards [MUAC for Age and other anthropometry]	MUAC Low MUAC: </= -2 standard deviations WFH Wasted: </= -2 standard deviations					X	Child tapes Average of 3 measurements
Hamza et al., 2015 (Hamza et al., 2015)	Frisancho, 1990 (AR Frisancho, 1990)	WFH Underweight: <–2 standard deviations	X	X	X		X	Average of 3 measurements Conventional non-stretchable tape
Lelijveld et al., 2016 (Lelijveld et al., 2016)	WHO Growth Reference Data							Measured in mm
Silva et al., 2017 (Silva et al., 2017)	WHO Growth Standards							Inextensible tape Three measurements obtained, closest two were averaged and reported
Barnhill et al., 2017 (Barnhill et al., 2017)	Unspecified							Unspecified
Caminiti et al., 2018 (Caminiti et al., 2018)	≤60 months: WHO Growth Standards		X					Non-extensible tape measure Measured in cm

	>60 months: National Committee for Growth and Development Argentine Society of Pediatrics, 2013 (Comité Nacional de Crecimiento y Desarrollo, 2013)								
Saldanha et al., 2018 (Saldanha Tschinkel et al., 2018)	WHO Growth Standards		X		X				Anthropometric tape fixed on marked point
Tekin et al., 2018 (Tekin et al., 2018)	National Center for Health Statistics reference data	WFH Normal: >90% Mild malnutrition: 80-90% Moderate malnutrition: 70-0% Severe malnutrition: <70%	X	X					Arm flexed slightly at elbow Plastic measuring tape

Rose-Clarke et al., 2019 (Rose-Clarke et al., 2019)	WHO Growth Reference Data For MUAC reference, see cutoffs.	For adolescent thinness: < 160 mm among girls aged 10–14 years based on nutrition guidelines for HIV-infected children						Standard adult tape (UNICEF) Average of two measurements
Ahmad et al., 2020 (Ahmad et al., 2020)	World Health Organization. Guidelines for an Integrated Approach to Nutritional care of HIV-infected Children (6 months-14 years), Geneva: World Health Organization; 2009 (World Health Organization, 2009b)		X					Measured in cm Wrapped around without compression of soft tissue
Leonard et al., 2020 (Leonard et al., 2020)	MUAC: Fryar, 2012 (C. Fryar, Gu, & Ogden, 2012) WFH: Life Expectancy, 2011	WFH Acute malnutrition: <90% Moderate malnutrition: 80-89%						Unspecified

	("Growth Charts for Children with Cerebral Palsy," 2011)	Severe malnutrition: <80%						
Kotby et al., 2020 (Kotby et al., 2020)	WHO Growth Standards	WFH Z-scores Overweight: >2 standard deviations Normal: -2 – 2 standard deviations Wasted: <-2 standard deviations		X				Upright with arm down in a fully relaxed position Tape measure perpendicular to the long axis of the arm No pinching or gaping of the tape
Saleem et al., 2021 (Saleem et al., 2021)	WHO Growth Standards	MUAC Severe malnutrition: <115 mm WFH Z-scores Severe wasting: <-3 standard deviations						Unspecified
Jahan et al., 2021 (Adrizain et al., 2018)	WHO Growth Reference Data	MUAC and WFH Z-scores Overnutrition: >+2 standard deviations				X		Measured in cm

		Normal: −2 - +2 standard deviations Moderately wasted: -2 to -3 standard deviations Severely wasted: </= -3 standard deviations						
Sahin and Nogay, 2021 (Sahin & Nogay, 2021)	WHO Growth Reference Data							Appropriate methods (WHO Technical Report Series, 1995)
DeLacey, 2021 (DeLacey et al., 2021)	WHO Growth Reference Data							

WHO = World Health Organization, WFH: Weight-for-Height, WHZ= Weight-for-Height z score, WAZ = Weight-for-Age z score, HAZ = Height-for-Age z score

3.6 MUAC vs. Weight-for-height/length

Of the studies included, 14 (45%) studies included measurements for both MUAC and weight-for-height (Table 3 and Table A4). Of these studies, four (29%) reported MUAC and weight-for-height as means with standard deviations, four (29%) reported each as the number and/or percentage of children with measurements within a specified range or percentile, three (21%) studies reported both as mean z-scores. Among the 11 studies that reported both MUAC and weight-for-height with the same method (mean ± standard deviation, number and/or percentage of children with measurements w/in a specified range or percentile, or z-scores), four reported anthropometric data in multiple ways. Four studies did not report MUAC and weight-for-height in comparable ways. Comparison of MUAC measurements with weight-for-height measurements among these studies are included in Table 4. Of the studies that included measurements for both MUAC and weight-for-height only seven reported both with the same methods. Despite this variation, narrative results indicate that MUAC was advantageous for disabilities that cause obtaining height a challenge.

Table 4: Comparison of mid-upper arm circumference and weight-for-height anthropometry. 288

Author, Year	Age Range (Whole study, MUAC, WFH)	MUAC-based nutritional status	Weight-for-height (WFH) -based nutritional status
Studies representing MUAC and WFH results as the number or percentage of children within specified category.			
Hussain et al., 1996 (Hussain et al., 1996)	Whole study: 2-15 years	**Percent of children within percentile range** Normal (>/=85%): 11% (8/71) Moderate malnutrition (80-84%): 28% (20/71) Severe malnutrition (<80%): 61% (43/71)	**Percent of children with WFH values within specified standard deviations** Normal (>-2): 73% (52/71) Moderately wasted:(-2SD - -3SD) 25% (18/71) Severely wasted (<-3SD): 2% (1/71)
Studies representing MUAC and WFH results as mean with standard deviations (SD) only.			
Soylu et al., 2008 (Soylu et al., 2008)	Whole study: 1.9-9.1 years	**Mean MUAC in cm ± SD** 45 children with disabilities: 14.4 cm ± 2.1 31 children with disabilities: Before Therapy: 14.5 cm ± 2.2 After Therapy: 15.2 cm ± 2.2	**Mean WFH percentile ± SD** 45 children with disabilities: 89.5% ± 8.3 31 children with disabilities: Before Therapy: 84.1% ± 13.9 After Therapy: 88.7% ± 13.4
Tekin et al., 2018 (Tekin et al., 2018)	Whole study: Mean age: 7.2±5.4 years	**Mean MUAC in cm ± SD** Children with disabilities and malnourished: Baseline: 15.8 cm ± 2.7 6 months: 16.4 cm ± 2.9 Children with disabilities, non-malnourished: 18.9 cm ± 3.4	**Mean WFH percentile ± SD** Children with disabilities and malnourished: Baseline: 79.2% ± 9.23 6 months: 81.4% ± 8.17 Children with disabilities, non-malnourished: 106.4% ± 16.71
Studies representing MUAC and WFH results as z-scores with standard deviations (SD) only.			
		Mean MUAC-for-age z-score ± SD	**Mean WFH z-score (WHZ) ± SD**

Al-Saqladi et al., 2010 (Al-Saqladi et al., 2010)	WFH: 6 months- 5 years MUAC: 6 months – 5 years	All: -2.23 ± 1.02 Male: -2.11 ± 1.01 Female: -2.29 ± 1.03 By age: 6-11 months: -2.58 ± 1.42 12-23 months: -1.67 ± 0.79 24-35 months: -2.12 ± 1.07 36-47 months: -2.39 ± 0.54 48-60 months: -2.34 ± 1.01	All: -1.38 ± 1.29 Male: -1.31 ± 1.24 Female: -1.42 ± 1.33 By age: 6-11 months: -1.58 ± 1.48 12-23 months: -0.53 ± 1.47 24-35 months: -1.17 ± 1.59 36-47 months: -1.68 ± 0.85 48-60 months: -1.73 ± 0.85
Kakooza-Mwesige et al., 2015 (Kakooza-Mwesige et al., 2015)	MUAC and WHZ: 2 – 5 years	**Mean MUAC-for-age z-score ± SD** Children with disabilities: -0.38 ± 1.17	**Mean weight-for-height z-score ± SD** Children with disabilities: -0.84 ± 1.41
DeLacey et al, 2021 (DeLacey et al., 2021)	Whole study: 0 -18 years MUAC: 6 months - 5 years WHZ: 0-5 years	All children: **Mean MUAC-for-age z-score:** -0.33 ± 1.20 Children with disabilities: **mean z-score ± SD** 6-12 months: -0.35 (1.58) 12-24 months: -0.70 (1.74) 24-59 months: -0.73 (1.18) Children without disabilities: **mean z-score (SD)** 6-12 months: -0.20 ± 1.19 12-24 months: -0.16 ± 1.21 24-59 months: -0.37 ± 1.14	All children: **Mean weight-for-height z-score:** −0.4 ± 1.49 Children with disabilities: **mean z-score ± SD** 0-6 months: -0.66 ± 1.61 6-12 months: -1.35 ± 1.72 12-24 months: -1.32 ± 1.33 24-59 months: -1.26 ± 1.58 Children without disabilities: **mean z-score (SD)** 0-6 months: -0.20 ± 1.51 6-12 months: -0.48 ± 1.34 12-24 months: -0.03 ± 1.24 24-59 months: -0.25 ± 1.19
Studies representing MUAC and WFH using different or multiple methods.			
Tompsett et al., 1999 (Tompsett et al., 1999)	Whole study: younger than 10 years	**Mean MUAC in cm ± SD** Children with disabilities: 16.0 cm ± 1.6 Sibling control: 15.8 cm ± 1.6 Neighbor control: 15.6 cm ± 1.3	**Mean WFH z-score (WHZ) ± SD** Children with disabilities: -0.0 ± 1.9 Sibling control: 0.5 ± 2.4 Neighbor control: 0.0 ± 1.9

Pai et al., 2001 (Pai et al., 2001)	Whole study: 2-10 years	**Mean MUAC in cm ± SD** Children with disabilities: 12.8 cm ± 1.6 Siblings: 13.2 cm ± 1.4 Neighbor Control: 13.0 cm ± 1.3	**Mean WFH z-score (WHZ) ± SD** Disabled: –1.20 ± 1.26 Siblings: 1.46 ± 1.30 Neighbor Control: 1.05 ± 0.84
Freeman et al., 2002 (Freeman et al., 2002)	Whole study: 2-7 years	**Mean MUAC in cm ± SD** Children with disabilities: Male: 14.72 cm ± 1.27, Female: 15.24 cm ± 1.50 Controls: Male: 15.17 ± 1.38, Female: 14.95 ± 1.17	**Mean WHZ ± SD** Children with disabilities: Male: -1.23 ± 0.75, Female: -0.98 ± 0.91 Controls: Male: -2.69 ± 0.84, Female: -1.22 ± 0.81
Dannhauser et al., 2007 (Dannhauser et al., 2007)	Whole study: 8-15 years	**Mean MUAC in cm ± SD** Location 1: 19.2 cm ± 6.2 Location 2: 17.2 cm ± 4.9 Location 3: 17.0 cm ± 4.4 **Number (percentage) of children in percentile category** - results listed in order of location 1, location 2, location 3 (<5): 2 (15.4%), 2 (3.2%), 0 (0%) (5-<15): 2 (15.4%), 26 (41.2%), 38 (56.7%) (15 - <85): 7 (53.8%), 32 (50.8%), 26 (38.8%) (85 - <95): 1 (7.7%), 1 (1.6%), 1 (1.5%) (≥95): 1 (7.7%), 2 (3.2%), 2 (3.0%)	**Number (percentage) of children within z-score deviation category** - results listed in order of location 1, location 2, location 3 (< –3): 0 (0%), 0 (0%), 3 (4.5%) (–3 - < –2): 0 (0%), 1 (1.6%), 1 (1.5%) (–2 - < –1): 1 (7.7%), 2 (3.1%), 6 (9.0%) (–1 - < 1): 1 (7.7%), 12 (18.8%), 13 (19.4%) (> 1 - < 2): 0 (0%), 2 (3.1%), 3 (4.5%) (≥ 2): 11 (84.6%), 47 (73.4%), 41 (61.1%)
Kuper et al., 2015 (Kuper et al., 2015)	Whole study: 6 months - 12 years	**Number (percentage) of children in percentile category** Low MUAC for age (z-score ≤-2): Children with disabilities: 39/155 (25%) Sibling control: 17/113 (15%) Neighborhood control: 17/165 (10%)	**Number (percentage) of children in z-score deviation category** Low WFH (z-score ≤-2): Children with disabilities: 39/120 (33%) Sibling control: 26/112 (23%) Neighborhood control: 31/153 (20%) **Mean WHZ ± SD** Children with disabilities: -1.5 ± 1.4

Kotby et al., 2020 (Kotby et al., 2020)	Whole study: 7 months - 4.75 years	**Mean MUAC in cm ± SD** Overall: 13.65 cm ± 2.46 Children with disabilities: 13.79 cm ± 2.79 Controls: 15.41 cm ± 2.29	**Number (percentage) of children in z-score deviation category** Wasted (<-2): 9/80 (11.3%) Normal (-2 – 2): 55/80 (68.8%) Overweight (>2): 16/80 (20%)
Saleem et al., 2021 (Saleem et al., 2021)	Whole study: 6 months - 59 months	**Mean MUAC in cm ± SD** Children with disabilities: 10 cm ± 0.98 Controls: 14 cm ± 1.19	**Mean WHZ ± SD** Children with disabilities: -4.07 ± 1.25 Control: 0.40 ± 1.27
Jahan et al., 2021 (Jahan et al., 2021)	Whole study: Mean age: 10.3±5.0 years	**Mean MUAC-for-age z-score ± SD** Children with disabilities: -0.9 ±1.4 **Number (percentage) of children within z-score deviation category** Overnutrition: (z score: >+2 SD): 0/28 (0%) Normal: (z score: −2 SD - +2 SD): 21/28 (75%) Moderate undernutrition: (z score: > −3 to <−2.0): 3/28 (10.7%) Severe undernutrition: (z score: ≤−3.0): 4/28 (14.3%)	**Mean WHZ ± SD** Children with disabilities: −0.5 ± 1.6 **Number (percentage) of children within** Overnutrition: (z score: >+2 SD): 1/26 (3.8%) Normal: (z score: −2 SD - +2 SD): 21/26 (80.8%) Moderate undernutrition: (z score: >−3 SD - <−2.0 SD): 2/26 (7.7%) Severe undernutrition: (z score: ≤−3.0 SD): 2/26 (7.7%)

SD = Standard deviation, WFH = Weight-for-height, WHZ = Weight-for-height z score, cm = Centimeters

4. Discussion

We found that MUAC is being used in the assessment of nutritional status of a wide range of disability types in several countries within various settings. However, methods for obtaining MUAC measurements and reporting methods varied markedly. This made it difficult to compare if the prevalence and severity of undernutrition was identified as greater or less than when using MUAC-based assessment vs weight-for-length/height z-score-based assessment. Standardized references for cut-offs available at the time of publication were mostly used; however not all studies referenced the guidelines used for MUAC specifically.

4.1 Use of anthropometric measurements for children with disabilities

Older guidelines suggest that anthropometric results from children with disabilities should be disregarded (Tompsett et al., 1999). However, near the turn of the 21st century, researchers recognized the importance of resolving the measurement gaps between populations so that all children, regardless of ability, could achieve their right to good nutrition (Child Health and Disability Prevention Program, 2016; Tompsett et al., 1999). Despite this recognition by Tompsett et al. (1999) more than 20 years ago, there remains a gap in the research and recommendations for the use of anthropometric measurements among children with disabilities (Child Health and Disability Prevention Program, 2016; Tompsett et al., 1999; United Nations Children's Fund., 2021).

Although there is clear WHO guidance on how to take anthropometry measurements for children, there is not currently separate guidance for measurements for children with disabilities (World Health Organization, 2008, 2022). This is also true for other nutritional assessment tools including ESPGHAN, NCHS and the CDC (Centers for Disease Control and Prevention, 2000; "Published Guidelines - ESPGHAN," n.d.; World Health Organization, 2022). A common finding among studies included in this review is the limitations associated with anthropometric measurements that require physical manipulation for children with disabilities. Disabilities with physical impairments, such as cerebral palsy, were the most common disabilities included in the studies (20/31, 65%). Length/Height-based measures are therefore challenging and will either result in missing values or incorrect values – likely under-estimating height since a child cannot stand or lie straight and thus leading to a falsely high weight-for-height, missing true cases of malnutrition and misidentifying children eligible and needing to enter feeding programs. Our findings suggest that MUAC could be the more appropriate assessment for children with a wide variety of disabilities, especially when measurements are taken as part of a multimodal nutrition assessment and routinely tracked. Through this routine tracking, it becomes possible to gain insights into a child's overall nutritional status and growth patterns (Shinsugi et al., 2020; World Health Organization, 2007, 2009b, 2022). If a child falls below pre-specific MUAC thresholds it is also possible to refer him/her for treatment: <11.5cm is an independent admission criterion for most therapeutic feeding programs; 11.5cm to <12.5 cm is an independent criterion for most supplementary feeding programs (Bhutta et al., 2017).

Nearly one-third of the studies included in this review included children with cerebral palsy. Cerebral palsy is the most common motor disability in childhood with an overall prevalence of approximately 2 per 1,000 live births (Stavsky et al., 2017). Due to physical characteristics such as body contractures and spinal deformities found in varying degrees of severity among children with cerebral palsy, there has been debate around which anthropometric measurements are most appropriate for use in this population. Zainah et al. 2001 notes, "Alterations in body composition and proportion in children with CP, partly because of differential muscle tone, disuse atrophy and skeletal growth (depending on which extremities are affected), has many ramifications" (Zainah et al., 2001). Stature or height/length is one measurement that can be significantly hindered by the physical attributes of children with cerebral palsy. Troughton and Hill (2001) were unable to obtain height measurements in 20% of the study population due to contractures (Troughton & Hill, 2001). The inability to collect an accurate height measurement for these children limits the application of other anthropometric indices including weight-for-height or BMI-for-age. Some research supports the use of other equations or alternative height measurements, such as upper arm length (UAL) or lower leg length

(LLL), but these also present with limitations for use of other standardized references such as BMI-for-age and weight-for-height and their associated growth charts (Zainah et al., 2001). Cerebral palsy is not the only disability type to experience physical impairments or differences in body composition. Fat and lean masses of children with Down syndrome can differ from children without Down syndrome (González-Agüero, Ara, Moreno, Vicente-Rodríguez, & Casajús, 2011). Identifying anthropometric measurements that are appropriate for children of varying physicality and ability is imperative to the process of tracking, monitoring and improving their nutritional status.

4.2 Anthropometry and use of MUAC to assess nutritional status

Anthropometry is key to assessing nutritional status and evaluating children's growth and health (World Health Organization, 2007, 2022). It is not, however, a direct measure of nutrition and there is no one single 'gold standard' anthropometric measure. All have benefits and limitations and what matters is how well the various measures can predict clinically relevant health and developmental risks. There is much recent interest in MUAC for identifying children at high risk of mortality and morbidity in resource-poor and humanitarian settings (Myatt, Khara, & Collins, 2006). A big advantage over other measures is simplicity, speed and ease of use since it does not need to be age or sex-adjusted as do weight and height measures. This makes it suitable for use in most settings including large-scale community services and programs. There is even evidence that suggests use of MUAC by families to assess their own children (Blackwell et al., 2015; Bliss et al., 2018).

4.3 Malnutrition and children with disabilities

Children with disabilities are at a greater risk of malnutrition and other health-related consequences (Black, Alderman, et al., 2013; Black, Victora, et al., 2013; DeLacey et al., 2022, 2021, 2020; Groce et al., 2014). Compared to children without disabilities, children with disabilities are 25% more likely to be wasted and 34% more likely to be stunted (United Nations Children's Fund, 2021).Childhood is a critical period of growth and development. Children who experience undernutrition may experience lifelong consequences including poor overall health, affected neurobehavioral and cognitive growth and limited educational or economic attainment later in life (Gakidou et al., 2017). Undernutrition can affect not only quality of life but overall life span. In 2016, stunting, wasting and undernutrition were estimated to cause more than 1 million deaths and 3.8% of the disability-adjusted life years (DALYs) lost globally (Gakidou et al., 2017).. Unfortunately, the non-standard and diverse reporting methods in the studies limits our ability to report on the prevalence of malnutrition among children with disabilities as assessed by different methods.

4.4 Use of MUAC for children with disabilities

Overall, we found MUAC is being used among children with disabilities. However, of the studies that included MUAC, there was limited information on the methods used to interpret the results and limited description of how they were used for referral to local nutrition services or for monitoring nutritional status. A major challenge was wide variance in reporting. Among the unknowns which affect data quality were which arm is used, type and thickness of tape, angle of the arm and the point on the arm at which the measurement was obtained. These were either inconsistent among studies or not mentioned in the methods at all.

The type of tape used for the measurement of MUAC has evolved throughout time. In 1997 the WHO first published a standard reference for MUAC, which was updated in 2007 and then again in 2009 (Glasman, 2018). A widely used threshold for moderate malnutrition for children 6 months - 5 years old is under 12.5 cm and under 11.5 cm for severe malnutrition. As part of the new 2006 child WHO growth standards, MUAC-for-age references were also developed (World Health Organization & UNICEF, 2009). Recently some MUAC reference values for older children were published. However, globally agreed upon cutoffs are still unavailable for this demographic and there are no specific guidelines for children with disabilities (Mramba et al., 2017). This is a major gap since optimal cutoffs for referral to nutrition support services are unknown and these children may be:

- Smaller than the general population – children with disabilities are more likely to be stunted, wasted or underweight.
- Have variations in muscle mass and fat deposits related to some genetic disorders or disabilities.
- Larger than the general population – some children with disabilities may mobilize using their arms and thus have a larger-than normal MUAC.

Many of our studies utilized MUAC for children of all ages and abilities and did not adjust for different subgroups of children. Given that MUAC is already widely used as an independent nutrition treatment program admission and discharge criterion and that children with disabilities are commonly measured using this method, as evident in the studies we found, our review suggests MUAC could be a valuable addition to nutritional assessment for children with disabilities. It could be especially useful for those who face challenges in having their length/height measured or have difficulty with being weighed.

4.5 Future use of MUAC

Future research on the use of MUAC should include children with all types of disabilities. As a potentially more disability-inclusive measure, it might allow more children to be reached and included in treatment programs for malnutrition (United Nations Children's Fund, 2021). In combination with other anthropometric measures including weight-for-length/height, length/height-for-age, weight-for-age and BMI, it could help build a greater foundation of population-specific data to inform future programming, practices and policies. A key question is whether mortality/morbidity and development risks are the same for children with disabilities with a low MUAC as for children without disabilities with low MUAC. Do thresholds need to be adjusted to take the disability into account – and if so, which thresholds for which types of disabilities? WHO guidelines are highly regarded and used to develop malnutrition protocols worldwide but the lack of disability-specific recommendations leaves children with disabilities underserved.

4.6 Equality in assessment and treatment of malnutrition for all children

Every child deserves to live in a society where their basic human rights are not merely recognized but upheld and honored. Being born with or acquiring a disability or functional impairment should not exclude this population of children from good health. If appropriate methods for screening malnutrition are not identified, it could result in exclusion from services to treat malnutrition (United Nations Children's Fund, 2021).

Assessment of nutritional status with standardized anthropometry is woefully neglected for many vulnerable groups of children, and the need for this data is nowhere more apparent than for children with disabilities. The 31 papers included in this review indicated that most children with disabilities were able to be measured using MUAC as part of assessments to determine their nutritional status, although fewer studies compared MUAC to other anthropometry or analyzed the findings within the broader context of changes in nutritional status or long-term health outcomes. There was also limited comparison of findings among children with disabilities to counterparts without disabilities and only limited reference to the appropriateness of the tool for children older than 5 years.

4.7 Strengths and limitations

This study utilized a comprehensive search strategy with inclusive terms for disability. Of the papers identified, the use of non-standardized language, measurements or methods was common. Despite the lack of internationally agreed upon standards, many of the studies used MUAC for children of all ages and ability types. Additionally, our search strategy included studies from 1990-2021 during which research and findings on the use of MUAC have markedly changed and developed. This paper was also limited to peer-reviewed research published in English. Although we found some research, this review did not find enough studies to be able to compare the ability of MUAC to identify malnutrition in comparison to other anthropometric indicators or compare the difference in MUAC's ability to identify malnutrition in children with disabilities compared to those without. This could be related in part to the limited inclusion of children with disabilities in research (DeLacey et al., 2020; United Nations Children's Fund, 2021). Many of the studies focus on other outcomes and anthropometric indicators, although often the description of their use was limited. There is a potential risk of bias of measurement error for the anthropometric indicators. Additionally, this research was not able to examine differences in use of MUAC for children of different ages or disability types.

Disabilities are measured in various ways in different countries. Future research in this area should aim to utilize standardized measurement methods such as the Washington Group Questionnaire to identify those with disabilities (Grellety et al., 2015). Causes of malnutrition may be underdiagnosed for children with disabilities, possibly related to perceptions of disability in different contexts or perceptions of individual children with disabilities who may weigh less or have a reduced height related to their clinical sequalae. There are also many different types of disabilities, but this research was limited by the types of disabilities included in the studies which may have been selected for their high risk of malnutrition or for other factors such as severity of disability. Additionally, these studies come from a variety of different settings. Most importantly, no study asked the key question of which anthropometric measure best identifies children at high risk of mortality/morbidity/poor development: this information is critical to being able to understand the true benefits of different measures (Mwangome, Fegan, Fulford, Prentice, & Berkley, 2012). Neither did any study directly explore the reliability of the different measures as would be ideal to know (Mwangome & Berkley, 2014).

To our knowledge, this is the first systematic review of literature looking at the use of MUAC for children with disabilities. Findings from this study should be used with caution, especially for children older than 5 years, for whom there are no internationally agreed upon MUAC ranges for nutritional assessment. Additionally, the needs of children with different types of impairments should be considered; although routine tracking of anthropometric indicators over time should identify children whose growth patterns are flat or declining, interventions to address their growth will vary. Given the biological links between malnutrition, development and disability, evaluation of the most useful tools to track and monitor children's nutritional status should be prioritized.

5. Conclusions

There are 240 million children worldwide living with a disability who are at risk for malnutrition but are routinely excluded from health services, nutrition programs, research and even basic demographic and census data — all of which could improve their lives. Without tools to measure and count these children, they will continue to be underserved or excluded entirely. MUAC is currently being used among children with disabilities and could be a useful tool as part of anthropometric assessment but there is a limited amount of interpretable or clear data on its use. Without validated measures to identify malnutrition and monitor the growth of these children, millions could have severe but avoidable consequences to their health and development. Future research should examine the use of MUAC as an important measurement of nutritional status for those children with disabilities, as part of a multimodal nutrition assessment, especially when other anthropometric measurements may not be appropriate based on clinical sequelae.

Appendix Materials:

Supplementary Materials:

References

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Appendix

Table A1. Inclusion/exclusion criteria for search strategy.

Inclusion Criteria	Exclusion Criteria
English	Non-English language
6 months through 18 years old Children with disabilities	Infants younger than 6 months Adults older than 18 years old No children with disabilities
All geographic locations	Intensive care units
Use of mid-upper arm circumference measurement	No use of mid-upper arm circumference measurement
Measures nutritional status or health outcome	No measures of nutritional status
Since 1990	Before 1990

Table A2. Full Search Strategy for Systematic Review Developed with Guidance from Banks et. al. [27]. 743

1	((arm OR midarm OR mid-arm) AND circumference) OR MUAC
2	MH (Malnutrition OR Protein-Energy Malnutrition OR Nutritional Status OR Nutrition) OR malnutrition OR nutrition* status OR undernutrition OR nutrition* deficiency OR nutrition
3	MH (Nutrition Assessment) OR (nutrition* AND (assessment OR screen* OR evaluation OR measurement))
4	2 OR 3
5	MH (Child OR Preschool OR Adolescents OR Infants) OR child* OR preschool* OR adolescen* OR infan* OR baby OR babies OR young people* OR young person* OR youth OR teen*
6	MH (Disabled persons OR Disabled children) OR disabilit* OR disabled OR handicap*
7	Physical impair* or physically impair* OR physical deficien* OR physically deficien* OR physical disab* OR physically disab* OR physical handicap* OR physically handicap* OR physically challeng*
8	MH (Cerebral palsy OR Arthritis spinal dysraphism OR muscular dystrophies OR Musculoskeletal Abnormalities OR Chronic Brain Injury OR Poliomyelitis OR Paraplegia OR Hemiplegia) OR Cerebral pals* OR Spina bifida OR Muscular dystroph* OR Arthriti* OR Osteogenesis imperfecta OR Musculoskeletal abnormalit* OR Musculo-skeletal abnormalit* OR Muscular abnormalit* OR Skeletal abnormalit* OR limb abnormalit* OR Amputation* OR Amputee OR Clubfoot OR Polio* OR Paraplegi* OR Paralys* OR Paralyz* OR Hemiplegi*
9	MH (Hearing loss) OR (Hearing loss* OR hearing impair* OR hearing deficien* OR hearing disable* OR hearing disabili* OR hearing handicap* OR acoustic loss* OR acoustic impair* OR acoustic deficien* OR acoustic disable* OR acoustic disabili* OR acoustic handicap* OR Deaf* or hearing loss)
10	MH (Blindness) OR (vision loss* OR vision impair* OR vision deficien* OR vision disable* OR vision disabili* OR vision handicap* OR visual loss* OR visual impair* OR visually impair* OR visual deficien* OR visually deficien* OR visual disable* OR visually disable* OR visual disabili* OR visually disabili* OR visual handicap* OR visually handicap* OR low vision OR reduced vision NOT double blind* NOT blinding NOT triple blind*)
11	MH (schizophrenia and disorders with psychotic features) OR (Mental disorder* OR Schizophreni* OR Psychosis OR psychoses OR Psychotic Disorder* OR Schizoaffective Disorder* OR Schizophreniform Disorder*)
12	(intellectual illness* OR intellectual impair* OR intellectual deficien* OR intellectual disable* OR intellectual disabili* OR intellectual handicap* OR intellectual retard* OR mental ill OR mentally ill OR mental illness* OR mental impair* OR mentally impair* OR mental deficien* OR mentally deficien* OR mental disable* OR mentally disable* OR mental disabili* OR mental handicap* OR mentally handicap* OR developmental impair* OR developmentally impair* OR developmental deficien* OR developmentally deficien* OR developmental disable* OR developmentally disable* OR developmental disabili* OR developmentally disabili* OR developmental handicap* OR developmentally handicap* OR developmental retard* OR developmentally retard* OR psychological ill OR psychologically ill OR psychological illness* OR psychological impair* OR psychologically impair* OR psychological deficien* OR psychologically deficien* OR psychological disable* OR psychologically disable* OR psychological disabili* OR psychological handicap* OR psychologically handicap*)
13	MH (Learning disorders OR communication disorders) OR (learning disorder* OR communication disorder* OR language disorder* OR speech disorder* OR speech disorder*)
14	MH (Pervasive Child Development Disorders) OR (autistic OR autism OR asperger* or dyslexi* OR Down's Syndrome OR Down Syndrome OR Mongolism or Trisomy 21)

15	6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14
16	1 AND 4 AND 5 AND 15

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Table A3. Quality appraisals for cross sectional, cohort, case-control and randomized control trial studies using the JBI Critical Appraisal Tool [30].

Table A3.1 Cross sectional studies

Author	**Year**	**1. Were the criteria for inclusion in the sample clearly defined?**	**2. Were the study subjects and the setting described in detail?**	**3. Was the exposure measured in a valid and reliable way?**	**4. Were objective, standard criteria used for measurement of the condition?**	**5. Were confounding factors identified?**	**6. Were strategies to deal with confounding factors stated?**	**7. Were the outcomes measured in a valid and reliable way?**	**8. Was appropriate statistical analysis is used?**	**Overall appraisal (include, exclude or seek further information)**
A. Hussain	1996	Y	Y	Y	Y	N	N/A	Y	Y	Include
J. Tompsett	1999	Y	Y	Y	Y	N	N/A	Y	Y	Include
S. Zainah	2001	Y	Y	Y	Y	N	N/A	Y	Y	Include
K. Troughton	2001	Y	Y	Y	Y	N/A	N/A	Y	Y	Include
A. Dannhauser	2007	Y	Y	Y	Y	N/A	N/A	Y	Y	Include
HY. Tomoum	2010	Y	Y	Y	Y	N	N/A	Y	Y	Include
A. Al-Saqladi	2010	Y	Y	Y	Y	N/A	N/A	Y	Y	Include
R. Hamza	2015	Y	Y	Y	Y	N/A	N/A	Y	Y	Include
B. Silva	2017	Y	Y	Y	Y	N/A	N/A	Y	Y	Include
P. Saldanha	2018	Y	Y	Y	Y	N	N	Y	Y	Include
H. Tekin	2018	Y	Y	Y	Y	Y	Y	Y	Y	Include
K. Rose-Clarke	2019	Y	Y	Y	Y	N	N	Y	Y	Include
R. Ahmad	2020	Y	Y	Y	Y	Y	Y	Y	Y	Include
A. Kotby	2020	Y	Y	Y	Y	N	N	Y	Y	Include
J. Saleem	2021	Y	Y	Y	Unclear	Y	N	Y	Y	Include
M. Zenitani	2021	Y	Y	Unclear	Unclear	N	N	Y	Y	Exclude
I. Jahan	2021	Y	Y	Y	Y	Y	Y	Y	Y	Include
H. Sahin	2021	Y	Y	Y	Y	Y	N	Y	Y	Include
D. Arony	2018									Exclude
M. Leonard	2020	Y	Y	Y	Y	Y	N	Y	Y	Include
DeLacey	2021	Y	Y	Y	Y	Y	Y	Y	Y	Include

Table A3.2 Cohort Studies

Author	Year	1.Were the two groups similar and recruited from the same population?	2.Were the exposures measured similarly to assign people to both exposed and unexposed groups?	3.Was the exposure measured in a valid and reliable way?	4.Were confounding factors identified?	5.Were strategies to deal with confounding factors stated?	6.Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	7.Were the outcomes measured in a valid and reliable way?	8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	9.Was follow up complete, and if not, were the reasons for loss to follow up described and explored?	10.Were strategies to address incomplete follow up utilized?	11.Was appropriate statistical analysis used?	Overall appraisal (include, exclude or seek further information)
DJ. Bartlett	2010	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include
M. Kupermanc	2010	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include
M. Samara	2010	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include
J. Tumwine	2015	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include
N. Lelijveld	2016	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include

Table A3.3 Case control studies

Author	**Year**	**1.Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?**	**2.Were cases and controls matched appropriately?**	**3.Were the same criteria used for identification of cases and controls?**	**4.Was exposure measured in a standard, valid and reliable way?**	**5.Was exposure measured in the same way for cases and controls?**	**6.Were confounding factors identified?**	**7.Were strategies to deal with confounding factors stated?**	**8.Were outcomes assessed in a standard, valid and reliable way for cases and controls?**	**9.Was the exposure period of interest long enough to be meaningful?**	**10.Was appropriate statistical analysis used?**	**Overall appraisal (include, exclude or seek further information)**
M. Pai	2001	Y	Y	Y	Y	Y	N	N/A	Y	Y	Y	Include
A. Freeman	2002	Unclear	Unclear	Y	Y	Y	N	N/A	Y	Y	Y	Include
H. Kuper	2015	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include
K. Barnhill	2017	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include
C. Caminiti	2018	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Include

Table A3.4 RCT

Author	Year	1.Was true randomization used for assignment of participants to treatment groups?	2.Was allocation to treatment groups concealed?	3.Were treatment groups similar at the baseline?	4.Were participants blind to treatment assignment?	5.Were those delivering treatment blind to treatment assignment?	6.Were outcomes assessors blind to treatment assignment?	7.Were treatment groups treated identically other than the intervention of interest?	8.Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	9.Were participants analyzed in the groups to which they were randomized?	10.Were outcomes measured in the same way for treatment groups?	11.Were outcomes measured in a reliable way?	12.Was appropriate statistical analysis used?	13.Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?	Overall appraisal (include, exclude or seek further information)
B. Zemel	2002	Y	Unclear	Y	Unclear	Unclear	Unclear	Y	Y	Y	Y	Y	Y	Y	Include
O. Soylu	2008	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Include

Table A4. Full Table 2- MUAC terminology, methods, references and comparison to other anthropometric indicators.

Author, Year	**MUAC Terminology**	**How MUAC was Measured**	**Reference for Measurements**	**MUAC Results**	**BMI**	**Height-for-age**	**Weight-for-age**	**Weight-for-height**	**Other Anthropometry**
African Region									
Dannhauser et al., 2007	mid upper-arm circumference (MUAC)	Right side Average of 3 measurements	National Centre for Health Statistics	MEAN (SD) Martie du Plessis (13) - 19.2 SD 6.2 Pholoho (64) - 17.2 SD 4.9 Tswellang (67) - 17.0 SD 4.4 Percentage of children in percentile category MDP, Pho, Tsw (<5): 15.4, 3.2, 0 (5-<15): 15.4, 41.2, 56.7 (15 - <85): 53.8, 50.8, 38.8 (85 - <95): 7.7, 1.6, 1.5		Reported as percentage of group within z-score deviation category (< –3) MDP 1 (7.7) Pho 6 (9.3) Tsw 21 (31.3) (–3 - < –2) MDP 1 (7.7) Pho 18 (28.1) Tsw 11 (16.4) (–2 - < –1) MDP 5 (38.5) Pho 16 (25.0) Tsw 16 (23.9) (–1 - < 1) MDP 4 (30.8) Pho 22 (34.4) Tsw 18 (26.9) (> 1 - < 2) MDP 2 (15.4) Pho 1 (1.6)	Reported as percentage of group within z-score deviation category MDP, Pho, Tsw (< –3): 7.7, 0, 10.5 (–3 - < –2): 30.7, 18.7, 19.4 (–2 - < –1): 7.7, 35.9, 29.9 (–1 - < 1): 23.1, 43.8, 38.8 (1 - < 2): 23.1, 0, 0 (>/= 2): 7.7, 1.6, 1.5	Reported as percentage of group within z-score deviation category MDP, Pho, Tsw (< –3): 0, 0, 4.5 (–3 - < –2): 0, 1.6, 1.5 (–2 - < –1): 7.7, 3.1, 9.0 (–1 - < 1): 7.7, 18.8, 19.4 (> 1 - < 2): 0, 3.1, 4.5 (>/= 2): 84.6, 73.4, 61.1	Triceps skinfold (mm) Martie du Plessis (13) - 15.6 SD 14.4 Pholoho (63) - 11.2 SD 5.1 Tswellang (67) - 9.3 SD 4.0 Percentage of children in percentile category (<5): 15.4, 0, 0 (5 - <15): 0, 14.3, 23.9 (15 - <85): 69.2, 80.9, 70.1 (85 - <95): 0, 3.2, 4.5 (>/= 95): 15.4, 1.6, 1.5

				(>/= 95): 7.7, 3.2, 3.0		Tsw1 (1.5) (>/=2) MDP 0 (0) Pho 1 (1.6) Tsw 0 (0)			Others: Upper-arm muscle area, upper-arm fat area
Kakooza-Mwesige et al., 2015	mid-upper arm circumference	Tape measurer Measured to the nearest 0.1 cm Average of 2 measurements	WHO growth standards	Z-SCORE Mean (SD) n=94 -0.38 (1.17)	Z-SCORE Mean (SD) n=131 -0.92 (1.56)	Z-SCORE Mean (SD) n=128 -1.57 (1.57)	Z-SCORE Mean (SD) n=127 -1.57 (1.48)	Z-SCORE Mean (SD) n=94 -0.84 (1.41)	Head circumference Z-SCORE Mean (SD) n=94 -1.08 (2.00)
Kuper et al., 2015	mid Upper Arm Circumference	Child tapes Measured to the nearest 0.1 cm Average of 3 measurements	WHO Child Growth Standards	MUAC (reported as the number of children (percentage) in range) Low MUAC for age: (z-score -2 or less) Children with disabilities: 39 (25%) Sibling Control: 17 (15%) Neighborhood Control: 17	Reported as the number of children (percentage) in the range Low BMI for age (z-score -2 or less) Children with disabilities: 84 (37%) Sibling Control: 47 (26%) Neighborhood Control: 68 (24%)	Reported as the number of children (percentage) in the range Low height for age (z-score -2 or less) Children with disabilities: 77 (34%) Sibling Control: 42 (23%) Neighborhood Control: 58 (21%) MEAN (SD)	Reported as the number of children (percentage) in the range Low cutoff (z-score -2 or less) Children with disabilities: 158 (54%) Sibling Control: 63 (34%) Neighborhood Control: 86 (30%) MEAN (SD)	Reported as the number of children (percentage) in the range Low cutoff (z-score -2 or less) Children with disabilities: 39 (33%) Sibling Control: 26 (23%) Neighborhood Control: 31 (20%) MEAN (SD)	

				(10%) MUAC for height MEAN (SD) n=155 -1.4 (1.3)	MEAN (SD) n=227 -1.6 (1.3)	n=225 -1.4 (1.8)	n=294 -2.1 (1.6)	n=120 -1.5 (1.4)	
Lelijveld et al., 2016	mid-upper arm circumference	Measured in mm	Guidelines by Lohman and colleagues and WHO	MEAN (SD) Cases: 172 (20) Sibling controls: 183 (29.8) P value: 0.002 Community controls: 178 (22) P value: 0.001	MEAN (SD) Cases: -0.8 (0.9) Sibling controls: -0.8 (0.9) P value: 0.39 Community Control:-0.7 (0.9) P value: 0.31	MEAN (SD) Cases: -1.8 (1.2) Sibling controls: 1.5 (1.2) P value: 0.04 Community Control: -1.3 (1.1) P value: 0.001	MEAN (SD) Cases: -1.6 (0.9) Sibling controls: -1.4 (1.0) P value: 0.16 Community Control: -1.2 (0.9) P value: 0.06		Standing height: MEAN (SD) Cases: 124.9 (9.0) Controls:130.3 (16.8) P value: 0.004 Community Control: 127.4 (9.9) P value: 0.001 Head circumference: MEAN (SD) Cases: 51.1 (2.1) Sibling Controls: 52.1 P value:0.31 Community Control: 52.1 (1.9) P value:

									0.12 Others: leg length, sitting height, calf circumference, R/height, Xc/height, phase angle, waist circumference, hip circumference, waist to hip ratio
Tompsett et al.,1999	mid-upper arm circumference (MUAC)	Left arm Sitting position Measured to the nearest 0.1 cm	Standard methods (United Nations, 1986)	MEAN +/- S.D. Disabled: 16.0 +/- 1.6 Siblings: 15.8 +/- 1.6 Neighbors: 15.6 +/- 1.3		Reported as Z-score for group Disabled: -2.5+/-1.8 (66/112) Siblings: -1.8+/-1.8 (39/87) Neighbors: -1.3 +/- 1.6 (37/112)	Reported as Z-score for group Disabled: -1.6 +/-1.1 (42/112) Siblings: -1.1 +/1 1.3 (14/87) Neighbors: -1.0 +/- 1.1 (13/112)	Reported as Z-score for group Disabled: -0.0 +/- 1.9 (7/112) Siblings: 0.5 +/- 2.4 (2/87) Neighbors: 0.0 +/- 1.9 (1/112)	
Region of the Americas									
Barnhill et al., 2017	mid-arm circumference (MAC)	Standard steel precision calipers	CDC charts and the percentile rankings	No values. With regard to MAC measurements for children with and without ASD, no participants met the criteria	BMI MEAN (SD) Cases: 16.15 (2.04) Controls: 16.32 (1.88) BMI Z-Score Cases 0.16	MEAN (SD) Height (cm) Cases: 112.13 (12.31) Controls:117.52 (13.65)	MEAN (SD) Weight (kg) Cases: 20.55 (5.35) Controls:22.91 (5.94)		MAMC - Cases: <5th percentile: 26 (30.6%) 5-10th: 15 (17.64%) 10-25th: 7 (8.2%) 25-50th: 19

				for any category of undernutrition or risk of undernutrition.	(1.17) Controls: 0.25 (1.07)				(22.35%) 50-75th: 12 (14.11%) 75th-90th: 2 (2.35%) >90th: 4 (4.71%) Controls: <5th percentile: 26 (30.6%) 5-10th: 15 (17.64%) 10-25th: 7 (8.2%) 25-50th: 19 (22.35%) 50-75th: 12 (14.11%) 75th-90th: 2 (2.35%) >90th: The results indicate no significant association between ASD status and MAMC percentile range as measured by

									Fisher's exact test (P = 0.268).
Bartlett et al., 2010	mid-arm circumference	Left side Sitting down Measured in cm Obtained by 2 raters to determine acceptable variation	Standard methods	Correlations between potential determinant and drop in GMFM-66 scores Mean mid-arm circumference: n=135 Correlation coefficient (-0.02 -0.16, 0.12) p-value 0.81 Change in mid-arm circumference: n=103 Correlation coefficient -0.23 (-0.38, -					Correlations between potential determinants and drop in GMFM-66 scores Mean triceps skinfold: n=134 Correlation coefficient -0.07 (-0.21, 0.08) p-value 0.44 Change in triceps skinfold: n=101 Correlation coefficient-0.19 (-0.35, -0.03) p-value 0.06

				0.07) p-value 0.02					
Caminiti et al., 2018	arm circumference	Non-extensible tape measure Mid-point between the olecranon process and the acromion Measured in cm	WHO's standards up to 60 months old Argentine references as of 61 months old	MEAN +/- SD (cm) 20.5 ± 5.7	MEAN (SD) BMI (kg/height^2) 19 ± 4.8 BMI Z-score 0.88 (-5.3/4.4)	MEAN (SD) Height (cm) 116 ± 29.3 Height Z-score -1.63 (-7.5/3.9)	MEAN (SD) Weight (kg) 22 (6.3/79) Weight Z-score -0.2 (-4.4/4)		Waist (CM): 65.2 ± 12 Tricipital skinfold (mm): 10.5 ± 3.9 Others: Bicipital skinfold (mm), Subscapular skinfold (mm), Suprailiac skinfold (mm)
Kupermin c et al., 2010	mid-upper arm circumference	Average of two measurements	Standardized measures	Z-SCORES (SD) Cases: -0.8 (1.3) References: 0.5 (1.3) Represented as R2 values to quantify	Z-SCORES (SD) Cases:-0.7 (2.0) References: 0.5 (1.1) Represented as R2 values to quantify				Z-SCORES (SD) Cases: -0.1 (1.1) References: 0.5 (1.2)

				amount of variation observed in DXA percentage body fat explained by each anthropometric measure. (CP R2 =0.30; NHANES R2 =0.43)	amount of variation observed in DXA percentage body fat explained by each anthropometric measure. CP R2 =0.30; NHANES R2 =0.43				
Saldanha et al., 2018	arm circumference	Flexed the elbow at 90 degrees with the palm facing up Calculated distance between anatomical landmarks and the central point is marked with a demographic pencil Anthropometric tape fixed on marked point	WHO growth curves 2007	MEAN +/- SD (cm) 22.09 ± 6.33	MEAN +/- SD BMI (kg/m2) 18.43 ± 5.87	MEAN +/- SD Height (m) 1.27 ± 0.27	MEAN +/- SD Weight (Kg) 33.72 ± 26-21		Triceps skinfold - MEAN +/- SD (mm) 16.44 ± 12.00

Silva et al., 2017	arm circumference	Inextensible tape Three measurements obtained, closest two were averaged and reported	WHO: weight, estimated height, BMI Frisancho: brachial circumference, tricep skinfold, and arm circumference	Reported as number of children (percentage) in range Under 91% percentile: n=25 (36.8)	Reported as number of children (percentage) in range Less than or equal to -2.0 z-score: n=29, 42.6%	Reported as number of children (percentage) in range Less than or equal to -2.0 z-score: n=26 , 38.2%	Reported as number of children (percentage) in range Less than or equal to -2.0 z-score: n=17, 27.0%		Triceps skinfold thickness Arm muscle circumference
Zemel et al., 2002	arm circumference (AC)	Non-stretchable tape Measured to the nearest 0.1 cm Mean value of 3 measurements	Unspecified	MEAN +/- S.D. MUAC (cm) Baseline - Control: 17.0 ± 2.4 Zinc: 16.5 ± 1.2 12 months Control: 17.6 ± 3.1 Zinc: 17.5 ± 1.4 Z SCORES Baseline - Control: 1.12 ± 1.19 Zinc: 1.19 ± 0.70 12 months -	MEAN +/- S.D. Baseline - Control: 14.9 ± 2.2 Zinc: 14.8 ± 0.8 12 months Control: 15.0 ± 2.3 Zinc: 15.0 ± 1.1	Reported as z-score for group at baseline and 12 months Baseline Control: 0.28 ± 1.04 Zinc: 0.42 ± 1.02 12 months Control: 0.23 ± 1.14 Zinc: 0.35 ± 1.03	Reported as z-score for group at baseline and 12 months Baseline: Control: 0.74 ± 1.22 Zinc: 0.71 ± 0.86 12 months Control: 0.77 ± 1.21 Zinc: 0.68 ± 1.00		BMI-for-age (z-score) Baseline: Control : 0.91 ± 1.31 Zinc: 0.57 ± 0.62 12 months Control: 1.03 ± 4.5 Zinc: 0.65 ± 0.76 Triceps skinfold thickness (mm) Baseline: Control: 6.9 ± 3.1

				Control: 1.18 ± 1.16 Zinc: 0.93 ± 0.77					Zinc: 7.8 ± 3.1 12 months Control: 6.6 ± 5.0 Zinc: 7.2 ± 2.4 Others: Weight, arm muscle area, arm fat area, triceps skinfold thickness z-score, UAMA z-score, UAFA z-score
South-East Asia Region									
Freeman et al., 2002	mid-upper-arm circumference (MUAC)	Unspecified	UN Guidelines (United Nations, 1986)	MEAN +/- S.D. MUAC (cm) Disabled: Male - 14.72 (1.27), Female - 15.24 (1.50) Non-Disabled: Male - 15.17 (1.38), Female - 14.95 (1.17)	MEAN +/- S.D BMI (kg/m2)d Disabled: Male: 14.36 (1.16), Female: 14.43 (1.47) Non-disabled: Male: 15.09 (1.56),	Reported as z-score for disabled male and female vs non-disable male and female Disabled: Male: -2.64 (1.80), Female: -1.73 (1.80) Non-disabled: Male: -2.69 (1.84),	Reported as z-score for disabled male and female vs non-disable male and female Disabled: Male: -2.43 (1.11), Female: -1.80 (1.33) Non-disabled: Male: -2.16 (1.09), Female: -1.92 (1.05)	Reported as z-score for disabled male and female vs non-disable male and female Disabled: Male: -1.23 (0.75), Female: -0.98 (0.91) Non-disabled: Male: -2.69 (0.84), Female: -1.22 (0.81)	Subscapular skinfold (cm) Disabled: Male: 6.70 (1.96), Female: 8.14 (1.91) Non-disabled: Male: 6.84 (1.62), Female: 7.54 (1.49) Triceps skinfold (cm)

					Female: 14.02 (1.18)	Female: -1.53 (1.77)			Disabled: Male: 7.84 (2.25), Female: 10.04 (1.91) Non-disabled: Male: 9.93 (1.83), Female: 10.03 (1.41)
Hussain et al., 1996	mid-upper arm circumference (MUAC)	Left upper arm Measured to the nearest cm Oil-cloth tailor's tape	National Center for Health Statistics US NHANES 1	PERCENTILE Normal: >85% Cases: 8, Controls 24 OR 1.0 Moderate: 80-84% Cases: 20, Controls: 22 OR 2.7 (0.9-8.4) Severe: <80% Cases: 43, Controls: 24 OR 5.4 (1.9-15.5)		Reported as number of children in range For those with a confirmed dx: Normal: > -2 H/A Cases 31, Controls 37 OR Moderately stunted: -2 to -2.99 H/A Cases 16 Controls 17, OR 1.1 (0.4-2.8) Severely stunted: </= -3 H/A Cases 24, Controls 16 OR 1.8 (0. 7-4.3)	Reported as number of children in range Normal: > -2 W/A Cases 23, Controls 37 OR 1.0 Moderately wasted: -2 to -2.99 W/A Cases 28, Controls 20, OR 1.6 (0.7-3.9) Severely wasted: </= -3 W/A Cases 20, Controls 13, OR 2.5 (1.0-6.5)	Reported as number of children in range Normal: > -2 W/H Cases 52, Controls 54, OR 1.0 Moderately wasted: -2 to -2.99 W.H Cases 18, Controls 16, OR 1.2 (0.5-2.7) Severely wasted: </= -3 W/H Cases 1, Controls 0, OR -	

Jahan et al., 2021	mid-upper-arm-circumference	Measured in cm MUAC tapes	WHO protocol	MEAN (SD): −0.9 (1.4) Reported as number (percentage) within range Overnutrition: (z score: >+2 SD): 0 Normal: (z score: −2 SD to +2 SD): 21 (75) Moderate undernutrition: (z score: >−3 SD to <−2.0 SD): 3 (10.7) Severe undernutrition: (z score: ≤−3.0 SD): 4 (14.3)	MEAN (SD): −0.5 (4.1) Reported as number (percentage) within range Overnutrition: (z score: >+2 SD): 13 (7.9) Normal: (z score: −2 SD to +2 SD): 103 (62.8) Moderate undernutrition: (z score: >−3 SD to <−2.0 SD): 19 (11.6) Severe undernutrition: (z score: ≤−3.0 SD): 29 (17.7)	MEAN (SD): −2.9 (2.6) Reported as number (percentage) within range Overnutrition: (z score: >+2 SD): 6 (3.5) Normal: (z score: −2 SD to +2 SD): 55 (32.4) Moderate undernutrition: (z score: >−3 SD to <−2.0 SD): 30 (17.6) Severe undernutrition: (z score: ≤−3.0 SD): 79 (46.5)	MEAN (SD): −2.2 (1.9) Reported as number (percentage) within range Overnutrition: (z score: >+2 SD): 4 (4.6) Normal: (z score: −2 SD to +2 SD): 38 (43.7) Moderate undernutrition: (z score: >−3 SD to <−2.0 SD): 11 (12.6) Severe undernutrition: (z score: ≤−3.0 SD): 34 (39.1)	MEAN (SD): −0.5 (1.6) Reported as number (percentage) within range Overnutrition: (z score: >+2 SD): 1 (3.8) Normal: (z score: −2 SD to +2 SD): 21 (80.8) Moderate undernutrition: (z score: >−3 SD to <−2.0 SD): 2 (7.7) Severe undernutrition: (z score: ≤−3.0 SD): 2 (7.7)	

Pai et al., 2001	mid-upper arm circumference (MUAC)	Measured to the nearest 0.1 cm	National Center for Health Statistics reference data	MEAN +/- S.D. MUAC (cm) Disabled: 12.8(1.6) Siblings: 13.2(1.4) Neighbor Control: 13.0(1.3)		Reported as z-score for group Disabled: 3.47(1.87)a – Siblings: 2.50(1.66)b – Neighbor Control: 2.78(1.74)b	WAZ (Z score) – Disabled: 2.78(1.25) Sibling: 2.53(1.10) – Neighbor Control: 2.37(0.95)	WHZ (Z score) Disabled–1.20(1.26) Siblings: 1.46(1.30) Neighbor Control: 1.05(0.84)	
Rose-Clarke et al., 2019 Does not present data for disability only, all inclusive.	mid upper arm circumference (MUAC)	Standard adult tape (UNICEF) Average of 2 measurements	WHO Reference 2007	Reported as number of children (percentage) in range 10-14 years MUAC <160 mm 64 (3.6) MUAC (SD) 10-19 years Mean 21.4 (2.8)	Reported as number of children (percentage) in range 15-19 years BMI <18.5 609 (40.8) BMI <-2 SD 10-19 years 350 (10.7)	Reported as number of children (percentage) in range 15-19 years: 1488 (44.8)			Overweight BMI >1 SD Reported as number of children (percentage) in range 50 (1.5)
European Region									

Leonard et al., 2020	mid-upper arm circumference (MUAC)	Unspecified	CDC charts for MUAC WHO charts for weight, height and BMI	In total, 35 of 82 patients whose MUAC was measured had a MUAC of < p10.					Specific anthropometrics not provided, only number of malnourished as determined by measurements. In all, 55 children had acute malnutrition (28 moderate, 25 severe, two unclassified), 47 children had chronic malnutrition (29 moderate, 18 severe) (Fig. 1); 13 were malnourished both acutely and chronically (mixed malnutrition). A total of 22 children were obese; one of these also had chronic

									malnutrition. A normal nutritional status was found for 140 children. A nutritional diagnosis could not be attributed to 10 children: 7 with no anthropometric data recorded; 2 with a very low height.
Sahin and Nogay, 2021	mid-upper arm circumference (MUAC)	Appropriate methods (WHO Technical Report Series 1995)	WHO – Child Growth Standards 2019, WHO Growth Reference Data 2007	Reported as number (percentage) within range Severe thinness: 19 (21.3%) Thinness: 18 (14.8%) Normal: 63 (51.6%) Overweight: 9 (7.4%) Obesity: 6 (4.9%)	Reported as number (percentage) within range Severe thinness: 3 (2.5%) Thinness: 9 (7.4%) Normal: 71 (58.2%) Overweight: 15 (12.3%) Obesity: 24 (19.8%)	Reported as number (percentage) within range Stunted: 24 (19.7%) Short: 32 (26.2%) Normal: 57 (46.7%) Tall: 4 (3.3%) Very Tall: 5 (4.1%)	Reported as number (percentage) within range Severe thinness: 12 (9.8%) Thinness: 21 (17.2%) Normal: 30 (24.6%) Overweight: 29 (23.8%) Obesity: 30 (24.6%)		

Samara et al., 2010	mid-arm circumference	Average of 2 measurements LASSO-O tape	Not stated	MEAN DIFFERENCE Cases: 1.2 cm 95% CI 0.7-1.7cm; p<0.001	MEAN DIFFERENCE Cases: 1.2; 95% CI 0.8–1.7; p<0.001	Height: (mean difference 3.1cm; 95% CI 1.6–4.6cm; p<0.001	Weight: (mean difference 2.6kg; 95% CI 1.6–3.7kg; p<0.001		Head circumference: mean difference 1.4cm 95% CI 1.03–1.8cm; p<0.001
Soylu et al., 2008	midarm circumference	Left arm hanging down Non-stretching tape Midway between the olecranon and the acromion	Criteria of Waterlow	MEAN +/- S.D. Midarm circumference (cm) 14.4 +/- 2.1 Midarm circumference (cm) Before Therapy 14.5 +/-2.2 After Therapy 15.2 +/-2.2	Reported as mean +/- SD Before: 13.6 +/- 2.1 After: 14.4 +/- 2.0	Reported as percentage +/- SD Before 89.4 +/- 8.8 After: 89.9 +/- 13.4	Reported as percentage +/- SD Before: 64.9 +/- 15.1 After: 66.2 +/- 19.2 Weight z-score Mean +/- SD: 2.1 +/- 0.9 Before therapy: 2.1 +/- 0.9 After therapy: 1.8 +/- 0.9	Reported as percentage +/- SD Before: 84.1 +/- 13.9 After: 88.7 +/- 13.4	Head circumference (cm) Mean +/- SD: 46.2 +/- 3.0 Before therapy: 46.3 +/- 3.1 After therapy: 46.0 +/- 3.4 Triceps skinfold thickness (mm) Mean +/- SD 9.6 +/- 3.4 Before therapy: 9.8 +/- 3.5 After therapy: 10.4 +/- 4.1 Others: weight,

									height, height s-score,
Tekin et al., 2018	mid-upper arm circumference (MUAC)	Left upper arm flexed slightly at elbow Half distance between the acromion and the olecranon Plastic measuring tape	WHO growth standards	MEAN (SD) MUAC (cm) Cases: Baseline: 15.8 (2.7) 6 months: 16.4 (2.9) Controls: 18.9 (3.4)		MEAN (SD) and Percentage Cases: Baseline: -1.0 (1.77) 6 months: - Controls: 0.07 (1.23)	MEAN (SD) Malnourished: Baseline: -2.38 (2.53) 6 months: -1.04 (0.35) Non-malnourished: 0.16 (1.76)	MEAN (SD) Cases: Baseline: 79.16 (9.23) 6 months: 81.42 (8.17) Controls: 106.4 (16.71)	Triceps Skinfold Thickness: MEAN (SD) Cases: Baseline: 7.6 (3.1) 6 months: 7.7 (2.9) Controls: 10.4 (3.2)

Troughton and Hill, 2001	mid-arm circumference	Harpenden plastic tape Average of at least 2 measurements	United States Health and Nutritional Survey 1 of 1971 to 1974	PERCENTILE Mid-arm circumference <5th centile in 27 participants (30%). Overall 46% of participants (41 of 90) fulfilled the criteria for undernutrition.			Weight: 24 (27%) were <2nd centile		Subscapular skinfold: 5 (6%) were <3rd centile Triceps skinfold: 17 (19%) were < 3rd centile
Eastern Mediterranean Region									
Al-Saqladi et al., 2010	mid-upper arm circumference (MUAC)	Measured to the nearest 0.1 cm Mid-point between the acromion and olecranon process Left arm hanging loosely Non-extensible fiberglass tape	WHO reference values (WHO Multicentre Growth Reference Study Group, 2006–2007)	Z-SCORES (SD) All: -2.23 (1.02) Male: -2.11 (1.01) Female: -2.29 (1.03) Ages 6-11 months: -2.58 (1.42) 12-23 months: -1.67 (0.79) 24-35 months: -2.12 (1.07) 36-47 months: -	Z-SCORES (SD) All: -1.21 (1.42) Male: -1.08 (1.53) Female: -1.29 (1.39) Ages 6-11 months: -2.04 (1.62) 12-23 months: -0.04 (1.68) 24-35 months: -0.83 (1.67) 36-47 months:	Z-SCORES (SD) All: -2.16 (1.23) Male: -2.79 (1.24) Female: -1.84 (1.12) Ages 6-11 months: 0.96 (1.13) 12-23 months: -2.60 (1.56) 24-35 months: -2.50 (1.33) 36-47 months: -2.21 (1.21) 48-60 months: -2.08 (0.90)	Z-SCORES (SD) All: -2.17 (1.03) Male: -2.40 (0.96) Female: -2.05 (1.07) Ages 6-11 months: -1.83 (1.17) 12-23 months: -1.66 (1.03) 24-35 months: -2.16 (1.27) 36-47 months: -2.44 (0.67) 48-60 months: -2.41 (0.88)	Z-SCORES (SD) All: -1.38 (1.29) Male: -1.31 (1.24) Female: -1.42 (1.33) Ages 6-11 months: -1.58 (1.48) 12-23 months: -0.53 (1.47) 24-35 months: -1.17 (1.59) 36-47 months: -1.68 (0.85) 48-60 months: -1.73 (0.85)	

				2.39 (0.54) 48-60 months: -2.34 (1.01)	-1.46 (0.99) 48-60 months: -1.61 (0.79)				
Hamza et al., 2015	mid upper arm circumference	Average of 3 measurements Measured to the nearest 0.1 cm Left arm at 90 degrees across the body Conventional non-stretchable tape Midpoint between inferior border of the acromion and the tip of the olecranon	Norms of Frisancho	MUAC Percentile MEAN +/- SD 56±7.53 (3–97)	BMI SDS MEAN +/- SD –0.98±0.23 (2.28 to –3.7)	Height SDS MEAN +/- SD –3.52±0.55 (–1.01 to –6.22)	Weight SDS MEAN +/- SD –0.53±0.25 (2.29 to –3.50)		Head circumference 1.10±0.52 (–0.49 to 2.77) Triceps skinfold thickness (TSFT) percentile 65±1.25 (3–98) Subscapular skinfold thickness (SSFT) percentile 68±2.11 (3–98) Others: RAS, SH

Kotby et al., 2020	left mid-upper arm circumflex	Left arm Upright with arm down in fully relaxed position Tape measure perpendicular to the long axis of the arm No punching or gaping of the tape	WHO global database	MEAN (SD) 13.65±2.46cm Range: 9-22cm Cases: 13.79±2.79 Range: 9-22 Controls: 15.41±2.29 Range: 10.5-20		Reported as number (percentage) within range <-2: 36 (45.0%) -2 to 2 31 (38.8%) >2: 13 (16.3%)	Reported as number (percentage) within <-2: 19 (23.8%) -2 to 2: 61 (76.3%)	Reported as number (percentage) within range <-2: 9 (11.3%) -2 to 2: 55 (68.8%) >2: 16 (20.0%)	
Saleem et al., 2021	mid-upper arm circumference (MUAC)	Unspecified	WHO Child Growth Standards	MEAN (SD) Cases: 9.97cm ±0.98cm Controls: 14.00cm ±1.19cm		Cases: Mean 66.82kg±9.58cm Mean HAZ: -3.94±1.41 Controls: Mean: 80.60kg±12.85cm Mean HAZ: -1.04±5.13	Cases: Mean: 5.39±1.69kg Mean WAZ: -4.64±1.07 Controls: Mean: 11.21±2.71kg -0.58±2.79	Cases: Mean: 66.82±9.58cm Mean WHZ: -4.07±1.25 Controls: Mean: 80.60±12.85cm Mean WHZ: 0.40±1.27	

Tomoum et al., 2010	mid-upper arm circumference (MAC)	Non-stretchable stainless-steel tape Mean value of 3 measurements	Anthropometry Procedures Manual, National Center for Health Statistics, Centers for Disease Control and Prevention	No significant difference in MAC between patient and control groups.					Weight: Males (cases): 14.3% < 10th percentile, 38.1% <50th percentile Females (cases): 15.8% < 10th percentile, 47.4% below 50th percentile Cases (% of median[IQ Range]: 80.75[19.13] Controls (% of median[IQ Range]: 92.7[13.35] Height: Male (cases): 4.8% < 10th percentile, 47.7% below 50th percentile Female (cases): 5.3% < 10th percentile, 78.9% below

									50th percentile Cases (% of median[IQ Range]: 91.15[9.35] Controls (% of median[IQ Range]: 98.05[9.38] Head Circumference: Cases: 45.94±3.2 cm Controls: 50.03±1.17 cm Waist Circumference: Cases (mean±SD): 46.72±5.09 cm Controls (mean±SD): 48.53±3.44 cm Tricep Skinfold Thickness Cases (mean±SD):

									8.31±2.60 cm Controls (mean±SD): 9.23±1.93 cm
Western Pacific Region									
Ahmad et al., 2020	mid-upper-arm circumference (MUAC)	Measured in cm Midpoint of the long axis of the upper arm Wrapped around without compression of soft tissue	WHO	MEAN (SD) 18.7cm (5.37cm) Reported as number of children (percentage) in range Normal: 52 (55.9%) Moderate Acute Malnutrition: 20 (21.5%)	MEAN (SD) -2.5 (3.14) Reported as number of children (percentage) in range Overweight: 5 (5.8%) At risk of overweight: 12 (14.0%) Normal: 22 (25.6%)	MEAN (SD) −4.6 (1.92) Reported as number of children (percentage) in range Normal: 2 (2.3%) Stunted: 14 (16.3%) Severe Stunted: 70 (81.4%)			

				Severe Acute Malnutrition: 21 (22.6%)	Thinness: 7 (8.1%) Severe Thinness: 40 (46.5%)				
Zainah et al., 2001	mid-arm circumference	Left upper arm Non-stretch measuring tape	Standardized methods	PERCENTILE and MEAN (SD) <5 percentile - CP - 52 Controls - 22 P-value <0.001 Mean (SD), difference between means 2.5 (– 3.50 to – 1.43) CP - 18.8 (3.67) Controls - 17.61 (3.09) P Value 0.001					Upper-arm length (cm) <5th percentile - CP: 54 (53.5) Controls: 28 (27.7) P-value <0.001 Mean (SD) CP: 18.8 (3.67) Controls: 20.0 (3.61) P-value (<0.001) Difference between means: – 1.1 (– 1.65 to – 0.59); Tricep skinfold thickness (mm) <5th percentile - CP: 40 (39.6) Controls: 7 (6.9)

									P-value <0.001 Mean (SD) CP: 7.1 (3.57) Controls: 9.5 (3.66) P-value (<0.001) Weight (kg) <5th percentile - CP: 79 (78.2) Controls: 15 (14.8) P-value <0.001 Mean (SD) CP: 15.1 (6.14) Controls: 21.1 (9.13) P-value (<0.001)
Multi-Region									

DeLacey et al., 2021	Mid-upper arm circumference-for-age Mid-upper arm circumference-for-age z-score (ACAZ)	For children 6 months - 5 years	WHO – Child Growth Standards 2019	All children: Mid upper arm circumference-for-age z-score (ACAZ) (6 months to 5 years), n=426 -0.33±1.20 Children with disabilities: 6-12 months (n=9): -0.35 ± 1.58, 12-24 months (n=11): -0.70 ± 1.74 24-59 months (n=34): -0.73 ± 1.18 Children without disabilities: 6-12 months (n=60): -0.20 ± 1.19 12-24 months (n=88): -0.16 ± 1.21	All children: BMI z-score (0–18 years) (n=2733) −0.62±1.45 Children with disabilities: 0-6 months (n=210): -1.79 ± 1.51 6-12 months (n=46): -1.63 ± 1.74 12-24 months (n=55): -1.04 ± 1.34 24-59 months (n=129): -0.92 ± 1.62 5-18 years (n=235): -0.56 ± 1.69 Children without disabilities: 0-6 months (n=643): -0.84 ± 1.39 6-12 months	All children: Height-for-age z-score (0–18 years) (n=1686) −1.74±1.67 Children with disabilities: 0-6 months (n=192): -2.68 ± 1.73 6-12 months (n=45): -2.34 ± 1.85 12-24 months (n=54): -2.18 ± 1.31 24-59 months (n=132): -2.43 ± 1. 62 5-18 years (n=231): -1.98 ± 1.47 Children without disabilities: 0-6 months (n=713): -1.54 ± 1.73 6-12 months (n=105): -1.04 ±	All children: Weight-for-age z-score (0–10 years) (n=2308) −1.48±1.54 Children with disabilities: 0-6 months (n=192): -2.68 ± 1.73 6-12 months (n=45): -2.34 ± 1.85 12-24 months (n=54): -2.18 ± 1.31 24-59 months (n=132): -2.43 ± 1. 62 5-18 years (n=231): -1.98 ± 1.47 Children without disabilities: 0-6 months (n=727): -1.48 ± 1.46 6-12 months (n=108): -1.04 ± 1.27 12-24 months (n=142): -0.69 ± 1.26 24-59 months (n=307): -1.09 ± 1.17 5-18 years (n=469): -0.99 ± 1.36	All children: Weight-for-height z-score (0–5 years) (n=1678) −0.42±1.49 Children with disabilities: 0-6 months (n=189): -0.66 ± 1.61 6-12 months (n=46): -1.35 ± 1.72 12-24 months (n=55): -1.32 ± 1.33 24-59 months (n=130): -1.26 ± 1.58 Children without disabilities: 0-6 months (n=707): -0.20 ± 1.51 6-12 months (n=105): -0.48 ± 1.34 12-24 months (n=142): -0.03 ± 1.24 24-59 months (n=303): -0.25 ± 1.19	All children: Head circumference-for-age z-score (0–5 years) (n=1095) −1.26±1.37 Children with disabilities 0-6 months (n=102): -2.36 ± 1.22 6-12 months (n=18): -2.09 ± 1.24 12-24 months (n=13): -0.82 ± 1.22 24-59 months (n=44): -1.18 ± 1.43 Children without disabilities: 0-6 months (n=483): -1.41 ± 1.41 6-12 months (n=77): -0.75 ± 1.33

				24-59 months (n=223): -0.37 ± 1.14	(n=102): -0.56 ± 1.38 12-24 months (n=137): 0.21 ± 1.25 24-59 months (n=287): -0.05 ± 1.22 5-18 years (n=888): -0.41 ± 1.23	1.62 12-24 months (n=142): -1.38 ± 1.46 24-59 months (n=303): -1.60 ± 1.29 5-18 years (n=895): -1.23 ± 1.24			12-24 months (n=111): -0.65 ± 1.12 24-59 months (n=247): -0.92 ± 1.23

Table A5. Excluded studies based on exclusion criteria.

#	Author, Year	Reason for Exclusion
1	Melunovic, 2017	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
2	Huysentruyt, 2018	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
3	Hasegawa, 2020	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
4	Gagil, 2001	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
5	Mortensen, 1990	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
6	Thommessen, 1991	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
7	Henderson, 1992	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
8	Strano, 1995	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
9	Samson-Fang, 2000	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
10	Lofthouse, 2002	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
11	Tuzun, 2013	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
12	Ponte, 2013	MUAC measurement not directly used as an anthropometric measurement for nutritional evaluation
13	Nogay, 2013	Non standardized
14	Pancheva, 2019	Non standardized
15	Craig, 2006	Includes subjects outside age range
16	Sanchez-Lastres, 2003	Includes subjects outside age range
17	Schmitz, 2018	Includes subjects outside age range
18	Zambrano, 2014	Includes subjects outside age range
19	Teixeira, 2014	Includes subjects outside age range
20	Caselli, 2017	Includes subjects outside age range
21	Saleem, 2021	Disability not significantly represented
22	Arony, 2018	Excluded during critical appraisal
23	Zenitani, 2021	Excluded during critical appraisal

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	2-3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	5
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	5
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	5-6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	5
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	5
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	5
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	5
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	5
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	5
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	5
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	5
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	5
Certainty	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	n/a

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
assessment			
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	6-28
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	74
Study characteristics	17	Cite each included study and present its characteristics.	10-14
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	46-48
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	10-28
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	8-15
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	10-28
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	15
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	n/a
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	n/a
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	n/a
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	29-32
	23b	Discuss any limitations of the evidence included in the review.	29-32
	23c	Discuss any limitations of the review processes used.	29-32
	23d	Discuss implications of the results for practice, policy, and future research.	29-32
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	3
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Cover page
Competing interests	26	Declare any competing interests of review authors.	Cover page
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	5

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

LSHTM Ethics Online | Work Area | Contacts | Help | Ms Emily DeLacey (lsh1804647@lshtm.ac.uk)

Project

The use of Mid-Upper Arm Circumference (MUAC) measurements to assess nutritional status of children with disabilities: A systematic review. 25468

Project Tree

The use of Mid-Upper Arm Circumference (MUAC) measurements to assess nutritional status of children with disabilities: A systematic review.

LSHTM Ethics Application & CARE Form

Action Required on Form	Status	Review Reference	Date Modified
No	MSc Ethics Approval Not Reqd	25468 /RR/23165	19/04/2021 12:42

Navigation | Documents | Signatures | Collaborators | Submissions | Correspondence | History

Submissions

Review Reference	Date	Status	Committee	Pdf
25468 /RR/23165	20/04/2021	MSc Ethics Approval Not Reqd	MSc	View as PDF

C.1.4 Dissemination: Blogs, Visual Abstracts, Conferences and Presentations

I. Global Health Practitioner Conference- CORE Group, Poster Presentation: The use of mid-upper arm circumference (MUAC) among children with disabilities: A systematic review; October 3rd-5th, 2022, Washington, D.C., USA (presented by Julia Hayes on behalf of co-authors)

II. Visual Abstract

Mid-Upper Arm Circumference (MUAC) Measurement Usage Among Children With Disabilities: A Systematic Review

Julia Hayes, Michael Quiring, Marko Kerac, Tracey Smythe, Cally Tann, Nora Groce, Zerihun Gultie, Lydia Nyesigomwe, Emily DeLacey

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Abstract

Background: Anthropometric measurements, including mid-upper arm circumference (MUAC), are important for monitoring and evaluating children's nutritional status. Evidence is limited on optimal nutritional assessment for children with disabilities, who are at risk for malnutrition. This study describes MUAC use among children with disabilities.

Method: Four databases (Embase, Global Health, Medline and CINHAL) were searched from 1990-2021 using a predefined search strategy. Of the 304 titles screened, 31 papers were included. Data included children 6 months - 18 years old with disabilities.

Results: Studies from 23 countries found inconsistent MUAC measurement methods, references, methods and cut-offs. Sixteen (52%) reported MUAC as a mean ± standard deviation (SD), 11 (35%) reported ranges or percentiles, 6 (19%) reported z-scores and 3 (10%) used other methods. Fourteen (45%) studies included both MUAC and weight-for-height (WFH) but non-standard reporting made it difficult to compare the prevalence of MUAC-based vs WFH-based malnutrition.

Conclusion: Whilst its speed, simplicity, and ease of use affords MUAC great potential for assessing children with disabilities, more work is needed to understand how it performs at identifying high-risk children in comparison to other measures. Inclusivity of children with disabilities in data collection and health services is essential, but current research and recommendations leave this un-addressed.

Background

Children with disabilities are at increased risk of malnutrition due to many reasons directly and indirectly related to underlying impairments or their environments. Despite this, they are often neglected in malnutrition guidelines, and it remains unclear which measures of nutritional status are appropriate [1,2].

Unlike weight or length/height measurements, MUAC does not have to be adjusted for age or sex (though MUAC z-score and percentile tables do exist). Using MUAC to assess nutritional status in children with underlying disability has also not been previously assessed. This is an important gap since both disability and malnutrition are major global public health problems: but, like all anthropometric measures, MUAC is an imperfect measure of nutritional status with both advantages and disadvantages [3-5].

Method

Following PRISMA guidelines, we analyzed existing published peer-reviewed literature on the use of MUAC among children with disabilities [6]. Two electronic databases were searched through OVID, Embase and Global Health, and two electronic databases were searched through EBSCO Host, PubMed/Medline and CINHAL Plus. After initial title and abstract screenings of articles identified from the search strategy, a full-text review determined 31 studies met the inclusion criteria.

We undertook data extraction using a standardized form that included study design, location, population, age range, sex representation, disability type and setting. Additionally, data was extracted on methods for MUAC measurement with any variations in terminology, measurement references or measurement techniques noted. Z-scores and percentiles for MUAC and other forms of anthropometry were included where available. Specific disability types were extracted for subgroup analysis if there was a sufficient data (e.g., use of MUAC among children with cerebral palsy). The JBI Critical Appraisal Tool for appraisal of cross-sectional studies, cohort studies, case-control studies and randomized control trials was used to assess the papers [7].

Disability Type	Prevalence
Cerebral palsy	13 (39%)
Intellectual impairment	6 (19%)
Visual impairment	3 (10%)
Autism spectrum disorder	3 (10%)
Sickle cell disease	2 (6%)
Down syndrome	2 (6%)
Epilepsy	2 (6%)
Hearing impairment	2 (6%)

Table 1. Representation of disability type

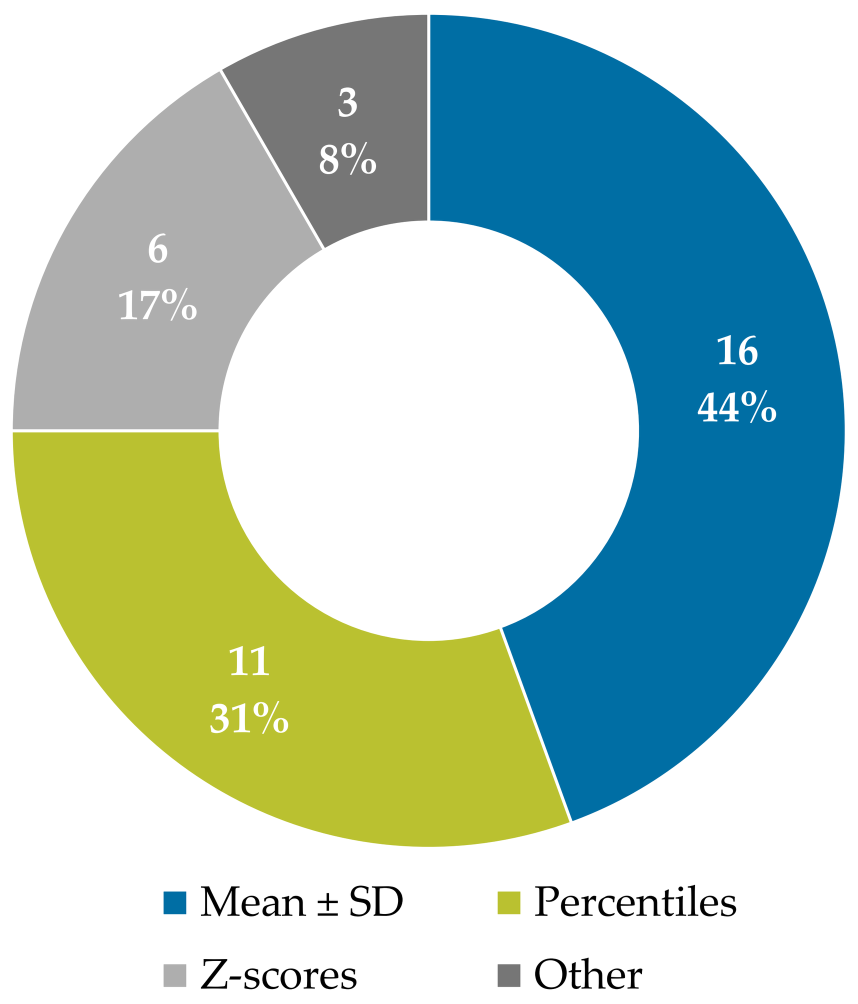

Figure 1. Methods used for reporting MUAC results

Results

A total of 31 studies were included for final analysis. Of the included studies, over half (17/31, 55%) were published in the past five years (2017 through 2022). Most were observational studies (29/31, 94%), representing 25 different countries. India, Egypt and the United States were each represented in 3/31 (10%) of the studies. The median age of children was 8 years old. Commonest forms of disability reported were cerebral palsy, intellectual impairment, visual impairment and autism spectrum disorder (Table 1). Nine studies (29%) included more than one type of disability. Terminology of MUAC and methods for obtaining MUAC measurements varied.

Reporting of MUAC also varied among studies (Figure 1). Of the studies that included measurements for both MUAC and weight-for-height only seven reported both with the same method. Despite this variation, narrative results indicate that MUAC was advantageous for disabilities that cause obtaining height a challenge. Publication years ranged from 1996 to 2021. References have evolved through this period and therefore variation in references used for anthropometric measurements is notable (Figure 2).

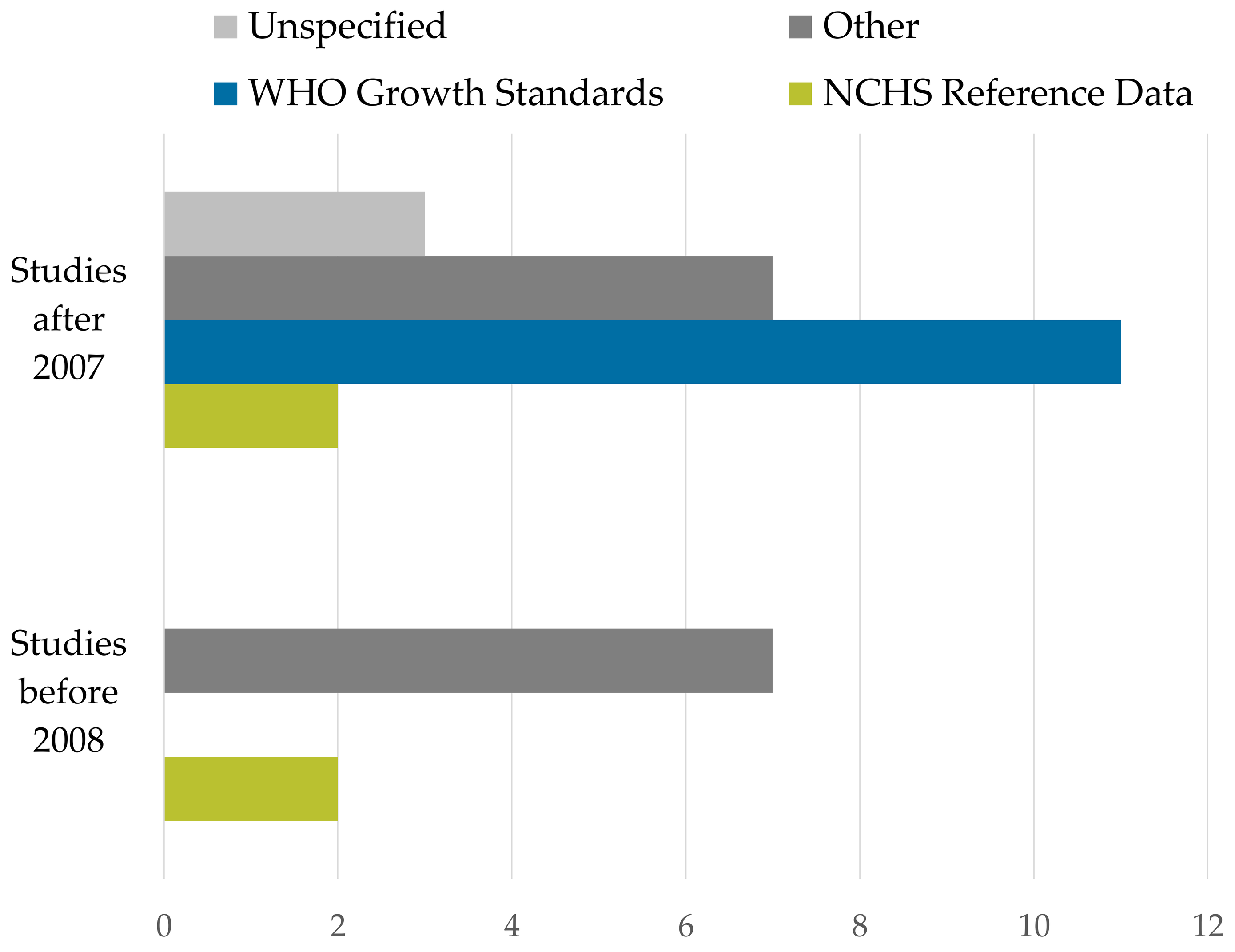

Figure 2. Reference data used for MUAC

Conclusion

A key finding from our review was the limited amount of interpretable data on MUAC use for children with disabilities and lack of standardization on MUAC use. Without validated measures to identify malnutrition and monitor the growth of these children, millions could have severe but avoidable consequences to their health and development. Without tools to measure and count these children, they will continue to be underserved or excluded entirely. Further research should examine the use of MUAC as an important measurement of nutritional status for those children with disabilities, as part of a multimodal nutrition assessment, especially when other anthropometric measurements may not be appropriate based on clinical sequelae.

References

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Mid-upper arm circumference (MUAC) measurement usage among children with disabilities: a systematic review

BACKGROUND

Anthropometric measurements, such as mid-upper arm circumference (MUAC), are important for monitoring and evaluating the nutritional status of children. However, there is limited evidence on methods to assess the nutritional status of children with disabilities, who are at risk for malnutrition. This study describes the use of MUAC among children with disabilities.

METHODS

Four databases (Embase, Global Health, Medline and CINHAL) were searched for studies from 1990-2021 using a predefined search strategy. Of the 304 titles screened, 31 papers were included. Data included children 6 months-18 years with disabilities.

FINDINGS

Sixteen (52%) reported MUAC as a mean±SD, eleven (35%) reported ranges or percentiles, six (19%) reported z-scores and three (10%) used other methods.

In the studies, from 25 different countries, cerebral palsy (39%) and intellectual impairments (19%) were the most commonly included disabilities.

MUAC was found to be a useful tool in assessing the nutritional status of children with disabilities.

Of the studies that included methods for MUAC measurement there were limited, often nonstandard, descriptions of the methods.

Narrative results indicate MUAC may be advantageous over other anthropometric measurements (i.e. weight-for-height) for children with disabilities that make obtaining height a challenge.

CONCLUSIONS

- Children with disabilities should not be malnourished but without inclusive, standardized methods to track and monitor their growth, millions could have severe but avoidable consequences to their health and development.
- There is currently a limited amount of interpretable data on MUAC and children with disabilities as well as a lack of standardization on MUAC use for this population.
- Early identification of malnutrition is crucial in improving the nutritional status of all children.
- Future research should critically examine the use of MUAC as part of nutritional assessments for children with disabilities.

More Information: https://www.holtinternational.org/nutrition-health/

D. Supplementary Materials for Paper 1: Nutritional Systematic Review

D.1.1 Ethics

Ethical approval was not determined to be needed by LSHTM. This study did not involve patients or the public in its development. This study is available through open access publication to the public and all stakeholders. This paper followed PRISMA guidelines throughout the study and was registered on PROSPERO prior to the start of the study. (PROSPERO 2019 CRD42019117103 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42019117103)

D.1.2 PICO Statement

Annex Table D. PICOS statement for systematic review on nutritional status of children living within institution-based care.

PICOS Statement	
Population	Children ages birth to 18 years of age, including children with disabilities.
Exposure	Institution-based care.
Comparator	Any study type including observational studies.
Outcomes	Description of nutritional status, including micronutrient lab measures (vitamins, minerals, or proxy measures such as anemia), anthropometric measurements (WHZ, WAZ, HAZ, BMIZ, ACAZ, HCAZ), and dietary intake or diversity. Other nutrition related information was included, such as birth status (birth weight, gestational age), food security, clinical signs/symptoms, or infections.
Setting	Any geographical region.

D.1.3 Systematic Review Bias

This systematic review and other systematic reviews are subject to a number of different potential biases. Bias can occur in systematic reviews at each stage of the process including in the design, selection, synthesis and summary of systematic reviews.

I. Design Bias

Systematic Reviews can have bias in their design including in design of their search strategy and development of inclusion and exclusion criteria. When search strategies are limited to certain time periods or geographical regions or only peer-reviewed publications, it can produced a biased study design. We did not limit this study to geographical regions but did have inclusion criteria of peer-reviewed publications published between January 1990 and January 2019. Due to changes in children's rights and protections, this criteria was determined appropriate for this study but may not have collected all available evidence which could potentially introduce study selection bias. Additionally, researchers may have preconceived ideas about their research area which may result in bias in the types of questions and searches designed. By using a clear research question, PICOS statement, and by addressing why inclusion and exclusion criteria were chosen, in addition to pre-registration of research protocols, researchers can reduce bias in their studies.[105]

II. Study Selection Bias

Systematic reviews have the potential to have study selection bias, which can occur when search strategies are not comprehensive. In this study, Ovid (a research platform) was used to search four electronic databases for data available from January 1990 to January 2019. There is potentially more research that was not selected because of the inclusion criteria dates and the use of one research platform and only four electronic databases. Additionally, there is the potential for bias in locating studies; some research may not be published online, or research can be lost if the journal goes out of business or is not captured by search engines or research platforms. This study was not able to find the full text of 7 papers, despite searching other platforms and databases. Furthermore, this specific systematic review only included peer reviewed research in English and excluded grey literature or research in other languages which could have potentially provided additional information. Future research methods could expand the search strategies to potentially identify other valuable information and include two or more reviewers during the screening process.

III. Publication Bias

Often systematic reviews are limited to the available research which could exclude potentially valuable information from LMIC's, individual experiences, programs, or research groups with limited funding for research and publication costs. Bias within publications could occur when there is selective reporting of findings or outcomes. Research is also more likely to be published in English, which limits valuable findings in other languages. Additionally, some researchers may exclude research that does not fit the narrative of their paper. We reduced the risk of this bias by following our search strategy and including all research which met our inclusion and exclusion criteria. Within our paper we also mention that the research available may have been biased from the samples of children included. Future research could examine data from unpublished studies or grey literature in addition to peer-reviewed published research in other languages.

IV. Synthesis Bias

Authors of systematic reviews may have bias in their synthesis of the research identified by their search strategies. By following their search strategies and inclusion and exclusion criteria, they can help to reduce bias in their synthesis. Personal bias of researchers can also factor into how the data is synthesized. We presented our findings in light of biases mentioned in the limitations section of this study and acknowledge that there is the potential for healthy survivor bias and sampling bias in the research we identified. We registered the protocol for this systematic review on PROSPERO, which helped to counteract biases associated with synthesizing studies.[105]

D.1.4 Dissemination: Blogs, Visual Abstracts, Conferences and Presentations

I. Blog: https://www.holtinternational.org/the-nutritional-status-of-children-living-within-institutionalized-care-a-systematic-review/

II. Research For Nutrition Conference- Action Against Hunger (ACF), Poster Presentation: A systematic review of the nutritional status of children living within institutionalized care; Nov. 20-21, 2019; Nanterre, France (presented by Dr. Marko Kerac on behalf of co-authors)

III. London School of Hygiene and Tropical Medicine Poster Day, Poster Presentation: A systematic review of the nutritional status of children living in institutionalized care; Mar. 7-17, 2020; Online (Presented by Emily DeLacey on behalf of co-authors)

IV. American Society of Nutrition Conference, Poster Presentation: Nutritional status of children living within institutionalized care: A systematic review; May 30-Jun. 2, 2020; Online (Presented by Emily DeLacey on behalf of co-authors)

Emily DeLacey, Cally Tann, Nora Groce, Maria Kett, Michael Quiring, Ethan Bergman, Caryl Garcia, Marko Kerac, A Systematic Review of the Nutritional Status of Children Living in Institution Care, *Current Developments in Nutrition*, Volume 4, Issue Supplement_2, June 2020, Page 822, https://doi.org/10.1093/cdn/nzaa053_027

V. Visual Abstract

A systematic review of the nutritional status of children living within institutionalized care

Presenter: Dr. Marko Kerac BSc MBBS DTM&H MPH PhD RNutr

Emily DeLacey[1, 2, 3], Cally Tann[3, 4, 5, 6], Nora Groce[7], Maria Kett[7], Michael Quiring[2], Ethan Bergman[8], Caryl Garcia[2], Marko Kerac[1, 3]

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Context and Objectives

There are an estimated 2.7 million children living within institutionalized care worldwide. This review aimed to evaluate currently available data on the nutrition status of children living within institutionalized care.

Methods

We searched four databases (Pubmed/Medline, CINHAL Plus, Embase and Global Health Database) for relevant articles published from January 1990 to February 2019. Studies that included information on anthropometry or micronutrient status of children living within institutionalized care were eligible for inclusion. The review is registered on PROSPERO: CRD42019117103.

Results

We screened 3,602 titles screened and reviewed 98 full texts. We found 25 eligible papers. Two (8%) studies reported data from multiple countries, nine (36%) were from Asia, four (16%) from Africa, three (12%) from Eastern Europe, four (16%) from the European Union and one (4%) from each of the remaining regions (Middle East, South America and the Caribbean). Twenty-two (88%) of the studies were cross sectional. Ten (40%) of the studies focused on children >5 years, seven (28%) on children <5 years, seven (28%) covered a wide age range and one did not include ages.

Low birth weight ranged from 25 to 39%. Only five (20%) included information on children with disabilities reporting prevalence from 8 to 70%. Prevalence of undernutrition varied between ages, sites and countries: stunting ranged from 9 to 72%; wasting from 0 to 27%; underweight from 7 to 79%; low BMI from 5 to 27%. Overweight/obesity ranged from 10 to 32% and small head circumference from 17 to 41%. The prevalence of HIV was between 2 to 23% and anemia from 3 to 90%. Skin conditions or infections ranged between 10 to 31% and parasites between 6 and 76%. Half the studies with dietary information found inadequate intake or diet diversity. Institution-based children were more malnourished than community peers, although community children were also often below growth standards. Younger children were more malnourished than older children. High risk of bias was found in the studies.

Conclusions

Addressing the nutrition needs of this underrepresented vulnerable population of children is important in the fight against undernutrition worldwide. Prevention and treatment of poor nutrition in this population can have far reaching impacts but there is a very limited amount of research on the nutrition status of this population.

Our review found children living within institutionalized care were commonly malnourished; affected by undernutrition, overweight and micronutrient deficiencies. Few of the studies described disabilities, despite disabilities being common in this population and having a big potential impact on nutritional status. Together, these findings suggest a need for greater focus prevention and treatment of malnutrition in this population, especially focusing on younger children and children with disabilities.

More information about children's nutrition status is needed to support the more than two million of children living within institutionalized care to fully address their rights and need for healthy development.

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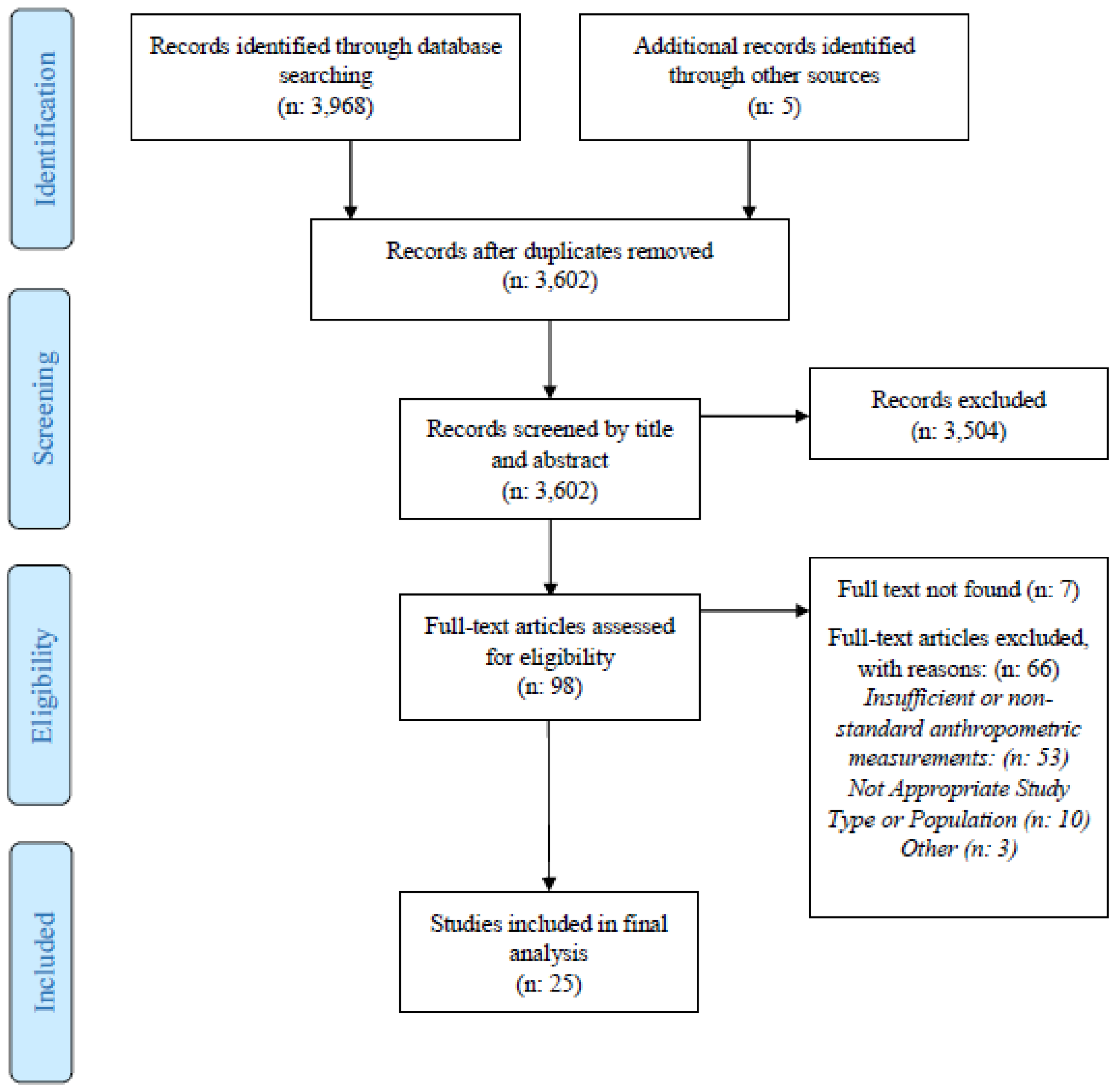
Figure 1. Search Results (adapted from PRISMA 2009 Flow Diagram)



Funding

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Competing Interests

None

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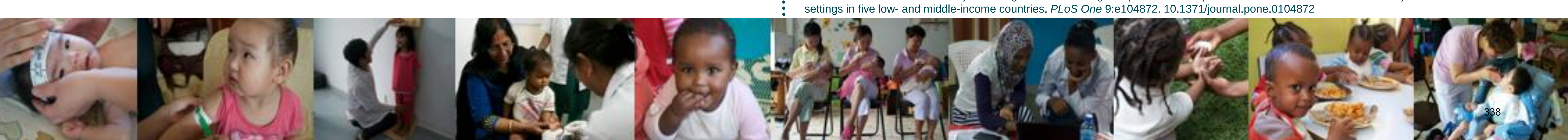

Nutritional status of children living within institutionalized care: a systematic review

Emily DeLacey[1, 2, 3], Cally Tann[3, 4, 5, 6], Nora Groce[7], Maria Kett[7], Michael Quiring[2], Ethan Bergman[8], Caryl Garcia[2], Marko Kerac[1, 3]

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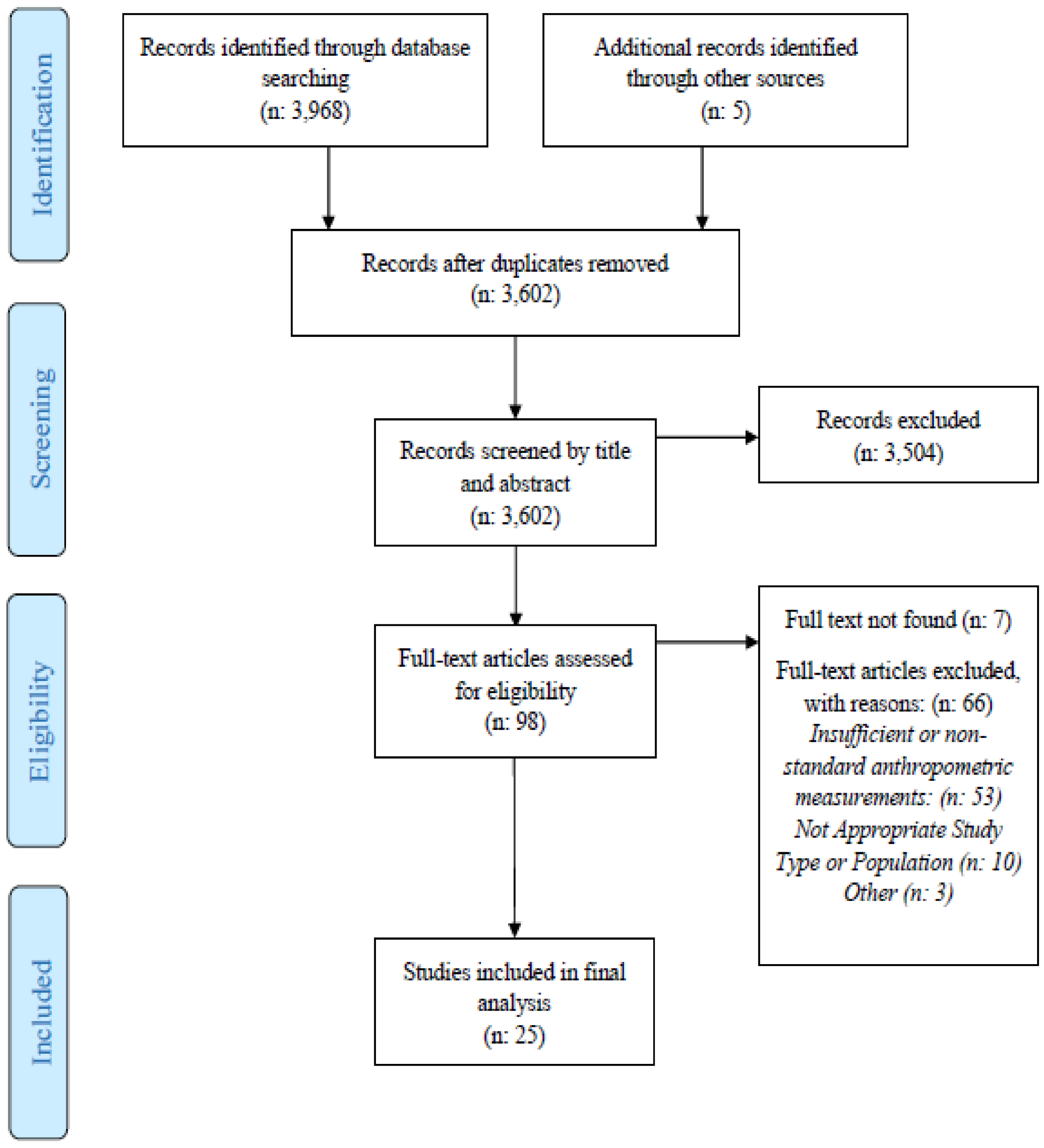

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A systematic review of the nutritional status of children living in institutionalized care

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

Emily DeLacey[1, 2, 3], Cally Tann[3, 4, 5, 6], Nora Groce[7], Maria Kett[7], Michael Quiring[2], Ethan Bergman[8], Caryl Garcia[2], Marko Kerac[1, 3]

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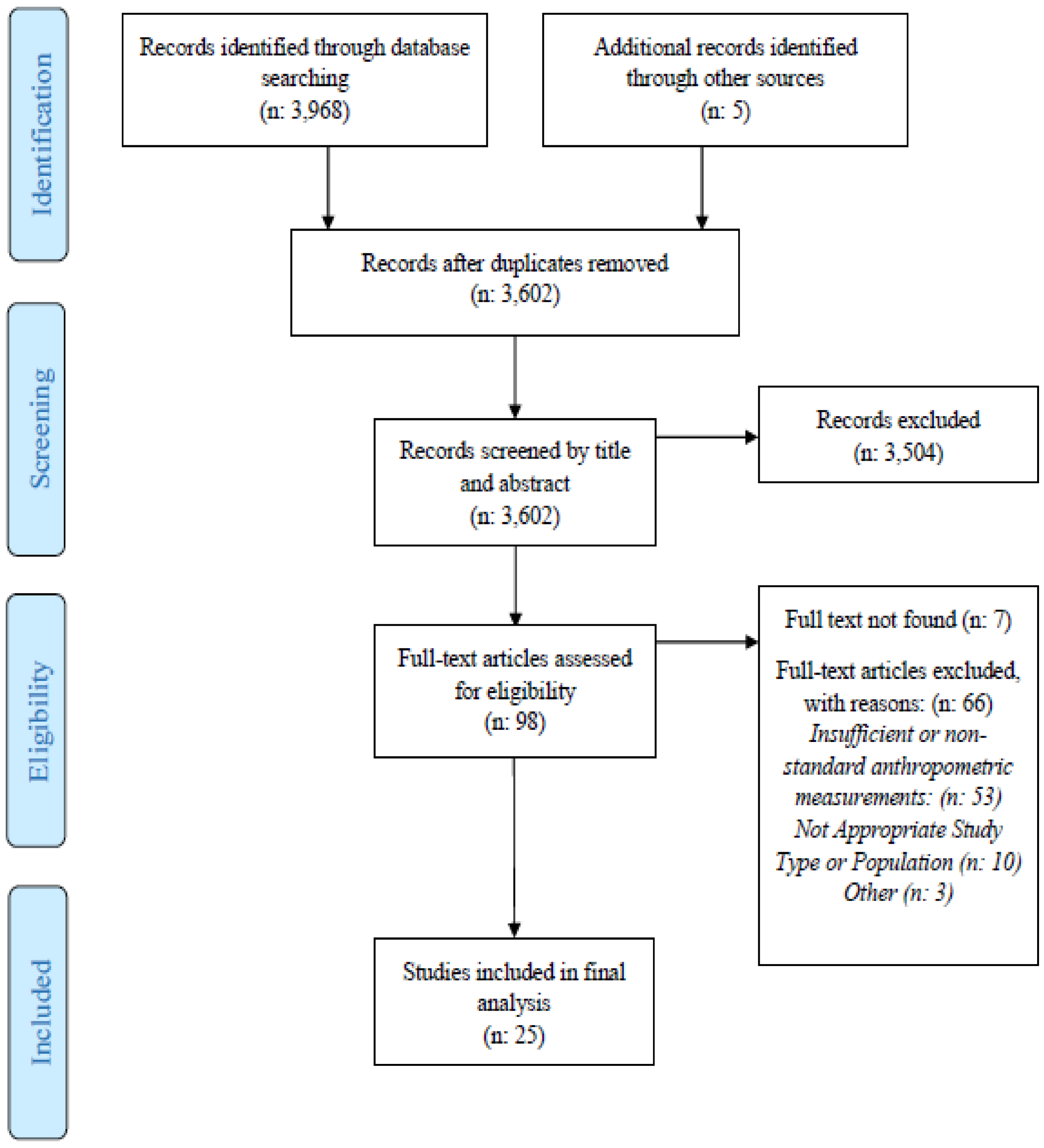

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None

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A Systematic Review of the Nutritional Status of Children Living in Institutionalized Care

Emily DeLacey[1], Cally Tann[2], Nora Groce[3], Maria Kett[3], Michael Quiring[4], Ethan Bergman[5], Caryl Garcia[4], and Marko Kerac[6]

[1]Holt International; London School of Hygiene and Tropical Medicine; [2]Department of Infectious Disease Epidemiology, Faculty of Epidemiology & Population Health, London School of Hygiene & Tropical Medicine; Neonatal Medicine, University College London Hospitals NHS Trust; [3]UCL International Disability Research Centre, Department of Epidemiology and Health Care, University College London; [4]Holt International; [5]Department of Health Sciences, College of Education and Professional Studies, Central Washington University; and [6]London School of Hygiene and Tropical Medicine

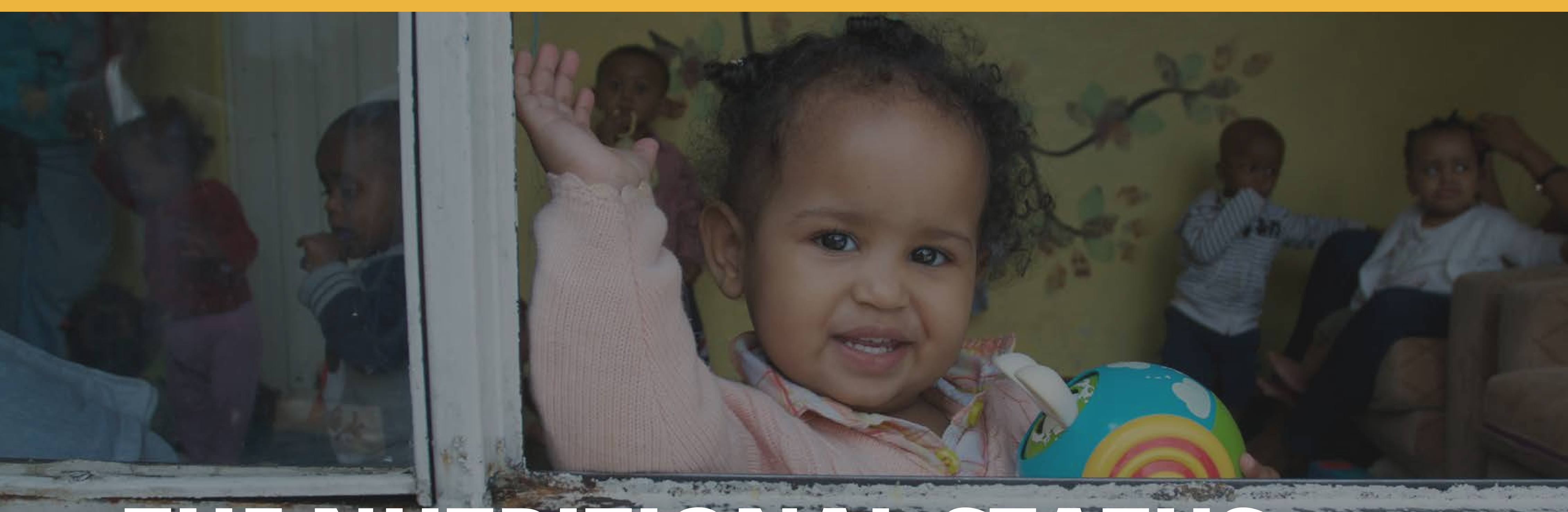
Objectives: An estimated 2.7 million children live within institutionalized care worldwide. This systematic review aimed to evaluate available data on the nutritional status of children living within institutionalized care.

Methods: Four databases were searched for articles published between January 1990 to January 2019. Studies were eligible for inclusion if they contained information on anthropometry or micronutrient status of children living within institutionalized care. The review is registered on PROSPERO: CRD42019117103.

Results: We screened 3602 titles and reviewed 98 full texts, from which 25 papers were determined eligible. The majority of studies were cross sectional (88%). Low birth weight ranged from 25 to 39%. Five (20%) studies included information on children with disabilities reporting prevalence from 8 to 75%. Prevalence of undernutrition varied between ages, sites and countries: stunting ranged from 9 to 72%; wasting from 0 to 27%; underweight from 7 to 79%; low BMI from 5 to 27%. Overweight/obesity ranged between 10 to 32% and small head circumference from 17 to 41%. The prevalence of HIV was between 2 to 23% and anemia from 3 to 90%. Skin conditions or infections ranged between 10 to 31% and parasites from 6 to 76%. Institution-based children were more malnourished than community peers and younger children were more malnourished than older children. A high risk of bias was found in the studies.

Conclusions: Addressing the nutrition needs of this underrepresented vulnerable population of children is important in the fight against malnutrition worldwide. Prevention and treatment of poor nutrition in this population can have far reaching impacts but there is limited research on their nutritional status. Children in institutions were commonly malnourished; affected by undernutrition, overnutrition and micronutrient deficiencies. Few studies described disabilities, despite disabilities being common in this population and having a big potential impact on nutritional status. Together, these findings suggest a need for greater focus on prevention and treatment of malnutrition in this population, especially for younger children and children with disabilities. More information is needed to support the millions of children living within institutionalized care to address their rights and needs for healthy development.

Funding Sources: No funding.



THE NUTRITIONAL STATUS OF CHILDREN LIVING WITHIN INSTITUTIONALIZED CARE: A SYSTEMATIC REVIEW

BACKGROUND

An estimated
2.7 MILLION CHILDREN
live in institutionalized care worldwide. This review evaluated currently available data on the nutritional status of children living within institutionalized care.

METHODS

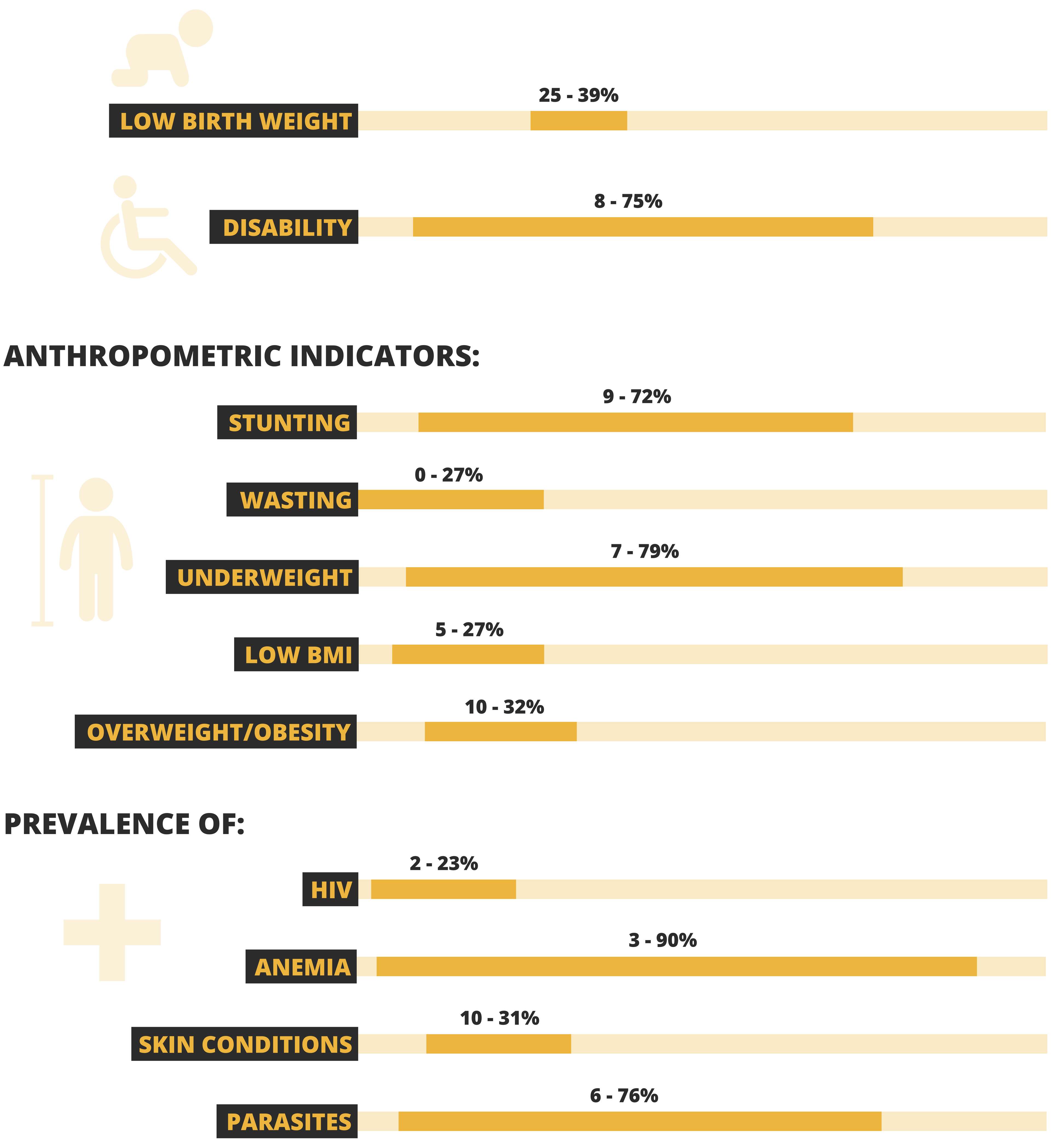
Using our search strategy, we looked for peer-reviewed research published between January 1990 and January 2019 in four databases: Pubmed/Medline, CINHAL Plus, Embase and Global Health Database. Studies that included information on the anthropometry or micronutrient status of children living within institutionalized care were eligible for inclusion.

RESULTS

From the 3,602 titles screened, we reviewed 98 full texts and found that **25 papers were eligible**. Two studies reported data from multiple regions. The other studies reported data from the following regions:

Twenty-two (88%) studies were cross sectional. Half of the studies with dietary information found inadequate intake or diet diversity.

PREVALENCE OF HEALTH IMPACTING ISSUES



CONCLUSIONS

There is a **limited amount of quality evidence-based data** available on the nutritional status of children in institutions, especially for those with disabilities.

Children living within institutionalized care were **commonly malnourished**.

There needs to be a **greater focus on improving the nutritional status** of children living in institutional care, especially for younger children and children with disabilities.

More information about children's nutritional status is needed to support the millions of children living within institutionalized care to fully address their right and need for healthy development.

PeerJ
The nutritional status of children living within institutionalized care: a systematic review
PeerJ 4:e8484 DOI: 10.7717/peerj.8484
http://peerj.com/articles/8484/

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E. Supplementary Materials for Paper 2: Nutritional Retrospective Analysis

E.1.1 Ethics

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the London School of Hygiene and Tropical Medicine's Ethics Committee (ref: 17808). This study did not involve patients or the public in its development. This study is available through open access publication to the public and all stakeholders. Holt International has gave consent for the publication.

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LONDON SCHOOL of HYGIENE & TROPICAL MEDICINE

Observational / Interventions Research Ethics Committee

Ms Emily DeLacey

LSHTM

4 February 2020

Dear Emily,

Study Title: The nutritional status of children living within institutionalized care in 6 countries: A cross-sectional study

LSHTM ethics ref: 17808

Thank you for your application for the above research, which has now been considered by the Observational Committee.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Protocol / Proposal	4a NSS_Form_Final_8_7_2019	07/08/2019	1
Investigator CV	Garcia_Caryl_resume 2017 (003)	07/08/2019	1
Investigator CV	QuiringMichaelResumeHolt2019	07/08/2019	1
Investigator CV	Emily DeLacey Resume 8.13	13/08/2019	1
Investigator CV	CV Cally Tann_Apr2019	13/09/2019	1
Investigator CV	SCHOOL CV TEMPLATE_Kerac_2018_v2.0_Sent	13/09/2019	1
Protocol / Proposal	Data Use Agreement Signed Emily DeLacey Holt International	23/09/2019	1
Consent form	Data Use Agreement Signed Emily DeLacey Holt International	23/09/2019	1
Consent form	LSHTM-Staff-Data Management Plan 10.3.2019	04/10/2019	1
Other	citiCompletionReport7020411 Emily DeLacey Certificate	05/11/2019	1
Other	citiCompletionReport7020411 Researcher Emily DeLacey Module Report	05/11/2019	V1
Other	ResearchInvestigators M Quiring	05/11/2019	V1
Protocol / Proposal	App 1_LSHTM Protocol Template - Nutritional Status Cross Sectional Study Emily DeLacey 11.27.2019	27/11/2019	V1

After ethical review

The Chief Investigator (CI) or delegate is responsible for informing the ethics committee of any subsequent changes to the application. These must be submitted to the Committee for review using an Amendment form. Amendments must not be initiated before receipt of written favourable opinion from the committee.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reactions (SUSARs) which occur during the project by submitting a Serious Adverse Event form.

An annual report should be submitted to the committee using an Annual Report form on the anniversary of the approval of the study during the lifetime of the study.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at: http://leo.lshtm.ac.uk

Additional information is available at: www.lshtm.ac.uk/ethics

Yours sincerely,

Professor Jimmy Whitworth
Chair

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Research Ethics Committee

Ms Emily DeLacey
28 October 2020

Dear Ms Emily DeLacey,

Study Title: The nutritional status of children living within institutionalized care in 6 countries: A cross-sectional study

LSHTM Ethics ref: 17808 - 1

Thank you for submitting your amendment for the above research project.

Your amendment has been assessed by the Research Governance & Integrity Office and has been approved as a non-substantial change. The amendment does not require further ethical approval from the observational ethics committee.

List of documents reviewed:

Document Type	File Name	Date	Version
Other	Leo Ethics Care Form Update 8.14.2020 for Extension Emily DeLacey	14/08/2020	1

Any subsequent changes to the application must be submitted to the Committee via an Amendment form on the ethics online applications website: http://leo.lshtm.ac.uk .

Best of luck with your project.

Yours sincerely,

Rebecca Carter

Research Governance Coordinator

Ethics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

Improving health worldwide

E.1.2 Missing Data Analysis

Missing data is important to examine because it has the potential to impact research results. The missing data analysis of data from this study indicates that the majority of missing data were due to anthropometric indicators not being appropriate for the age of children based on the World Health Organization growth charts (Annex table E.1 and E.2).[71,72] The other large group of missing data were related to delayed introduction of mid-upper arm circumference and head circumference into the program (Annex table E.1., E.2, 5.4 and E.5). In addition to delayed introduction, initial use of mid-upper arm circumference was only for children 6 months-5 years, although MUAC measurements are now used for children of all ages from 6 months- 18 years (Annex table E.1- E.5). This analysis of missing data uses the cleaning criteria used in this paper to further examine missing MUAC data using the age range of 6 months-5 years. After removing missing data from age-inappropriate observations, the amount of missing data substantially decreased. For example WAZ missing data went from 16.6% missing to 1.3% for all children after removing observations from children older than 10 years of age. Similarly for children with disabilities, missing WAZ data reduced from 19.3% to 3.2%, and for those without disabilities, 15.7% to 0.3%.

Some data in this study were excluded due to implausible z-score values (Annex table E.3). Children with disabilities have a higher prevalence of missing data compared to children without disabilities (Annex table E.1 and E.5). This could be potentially related to some disabilities limiting the ability to measure certain anthropometric indicators. More missing data for children with disabilities may cause the results to over represent healthier children or children with less severe disabilities or potentially under report malnourished children with disabilities. Missing data does not appear to vary substantially by age group (Annex table E.5). Missing data from initial pilot sites prior to November 2016 has patterns of missing similar to data from the onset of use of the electronic health record system starting in November 2016 (Annex Table E.2). This could be related to strong quarterly data audit processes which started in 2016. Analysis of missing data in this study was helpful in better understanding the dataset. Fortunately, the patterns of missing observed in the data does not affect the overall major conclusions or key messages of the already published paper. Malnutrition is prevalent among children living within IBC, notably different forms of undernutrition (stunting, underweight, wasting).

Annex Table E.1 Total missing anthropometric data and missing data using appropriate age cutoffs based on World Health Organization anthropometric indicators, for all children, children with disabilities and children without disabilities.[71,72]

All Children		
	Total Missing (%)	Missing by age cut off (%)
WAZ (0-10 years)	3364/19864 (16.9)	224/16661 (1.3)
HAZ (0-18 years)	917/19864 (4.6)	917/19864 (4.6)
WHZ (0-5 years)	4771/19864 (24)	261/12783 (2)
BMIZ (0-18 years)	1622/19864 (8.2)	1622/19864 (8.2)
ACAZ (6 months- 5 years)	13859/19864 (69.8)	4613/9979 (46.2)
HCAZ (0- 5 years)	10714/19864 (53.9)	3675/12783 (28.8)
Children with Disabilities		
	Total Missing (%)	Missing by age cut off (%)
WAZ (0-10 years)	1353/7013 (19.3)	188/5819 (3.2)
HAZ (0-18 years)	686/7013 (9.8)	686/7011 (9.8)
WHZ (0-5 years)	1664/7013 (23.7)	146/4384 (3.3)
BMIZ (0-18 years)	716/7013 (10.2)	716/7011 (10.2)
ACAZ (6 months- 5 years)	5566/7013 (79.4)	2408/3753 (64.2)
HCAZ (0- 5 years)	4802/7013 (68.5)	2189/4384 (49.9)
Children without Disabilities		
	Total Missing (%)	Missing by age cut off (%)
WAZ (0-10 years)	2011/12851 (15.7)	36/10842 (0.3)
HAZ (0-18 years)	231/12851 (1.8)	231/12851 (1.8)
WHZ (0-5 years)	3107/12851 (24.2)	115/8399 (1.4)
BMIZ (0-18 years)	906/12851 (7.1)	906/12851 (7.1)
ACAZ (6 months- 5 years)	8293/12851 (64.5)	2205/6226 (35.4)
HCAZ (0- 5 years)	5912/12851 (46)	1486/8399 (17.7)

Table E.1 highlights that the primary source of missing data was because the anthropometric measurement was not appropriate for that age of child or were missing due to the delayed introduction of MUAC and head circumference measurements into the program. After examining only missing data from children's records for whom the anthropometric measurements were appropriate for, there is a substantial decrease in the amount missing data. However, children with disabilities have more missing data than those without disabilities which could be related to some measurements not being possible for some children. This could potentially over represent children with less severe disabilities and under report higher risk children.

Annex Table E.2 All missing data and missing data using age cut offs based on World Health Organization anthropometric indicators for data from pilot sites prior to November 2016 and missing data in the electronic health record system after November 2016.[71,72]

	All missing data prior to November 2016 (%)	Missing by age cut off (%) (%)	All missing data after November 2016 (%)	Missing by age cut off (%) (%)
WAZ (0-10 years)	592/4644 (18.2)	71/4112 (0.2)	2772/15220 (18.2)	153/12549 (1.2)
HAZ (0-18 years)	247/4644 (5.3)	-	670/15220 (4.4)	-
WHZ (0-5 years)	782/4644 (16.8)	62/3318 (1.9)	3989/15220 (26.2)	199/9465 (2.1)
BMIZ (0-18 years)	180/4644 (3.9)	-	1442/15220 (9.5)	-
ACAZ (6 months- 5 years)	4633/4644 (99.8)	2506/2517 (99.7)	9226/15,220 (60.6)	2107/7462 (28.2)
HCAZ (0- 5 years)	4309/4644 (92.8)	2984/3318 (89.9)	6405/15220 (42.1)	691/9465 (7.3)

One area of missing data I considered was from initial pilot sites. This pilot data was entered into a Microsoft Access database which had a higher potential for entry errors. This data set was then uploaded into the electronic health record system once it was developed. At the start, this pilot data set was noted by my team to have a lot of missing data. However, due to strong quarterly data audit processes, missing data was filled in and we see patterns of missing data are now similar for pilot data and data entered after November 2016 into the electronic health record system. The electronic health record system has data entry limits and requirements which ensures overall data quality. Table E.2 shows all missing data from the pilot sites and missing data after pilot programs with missing data for age appropriate anthropometric observations.

Annex Table E.3 Implausible z-scores outside of World Health Organization data cleaning cut offs.[71,72]

Implausible Z-Score Values		
	Under (%)	Over (%)
WAZ	209/16726 (1.3)	17/16726 (0.1)
HAZ	555/19522 (2.8)	20/19522 (0.1)
WHZ	105/15343 (0.7)	145/15343 (1)
BMIZ	203/18662 (1.1)	217/18662 (1.2)
ACAZ	58/6086 (1)	23/6086 (0.4)
HCAZ	609/9827 (6.2)	68/9827 (0.7)

Data was also excluded in this study if there were implausible z-scores for the anthropometric measures. Using the World Health Organization's data cleaning cut offs, in table E.3 a small amount of data is summarized by anthropometric indicator. This small amount of amount of excluded data is unlikely to have changed the overall conclusions in this study.

Annex Table E.4 Missing anthropometric data by screening period from baseline to 2 years out of total observations at each timepoint using age cut offs based on World Health Organization anthropometric indicators.[71,72]

	Baseline screening (%)	6 months screening (%)	1 year screening (%)	1.5 years screening (%)	2 years screening (%)
WAZ (0-10 years)	None	None	None	None	None
HAZ (0-18 years)	21/2930 (0.7)	8/1996 (0.4)	16/1614 (1)	21/1062 (2)	34/811 (4.2)
WHZ (0-5 years)	62/1757 (3.5)	2/ 1352 (0.2)	4/768 (0.5)	3/488 (0.6)	5/308 (1.6)
BMIZ (0-18 years)	132/2930 (4.5)	120/1996 (6)	74/1614 (4.6)	52/1062 (4.9)	46/811 (5.7)
ACAZ (6 months- 5 years)	367/ 801 (45.8)	476/1011 (47.1)	334/768 (43.5)	209/489 (42.7)	135/308 (43.8)
HCAZ (0- 5 years)	555/1757 (31.6)	378/1352 (28)	183/768 (23.8)	117/488 (24)	27/308 (8.8)

In table E.4, missing data was examined at different observation timepoints, from baseline to two years. Patterns of missing at these different timepoints are similar for the various anthropometric measures.

Annex Table E.5 Missing anthropometric data by age category using age cut offs based on World Health Organization anthropometric indicators for all children, children with disabilities and children without disabilities out of total observations in each age group.

All Children (Total Observations: 19864)					
	0-6 months	6-12 months	12-24 months	24-60 months	>60 months
WAZ (0-10 years)	61/3243 (1.9)	28/2433 (1.2)	27/3560 (0.8)	38/3616 (1.1)	70/3807 (1.8)
HAZ (0-18 years)	110/3243 (3.4)	32/2433 (1.3)	19/3560 (0.5)	79/3616 (2.2)	677/7012 (9.7)
WHZ (0-5 years)	111/3243 (3.4)	32/2433 (1.3)	21/3560 (0.6)	97/3547 (2.7)	N/A
BMIZ (0-18 years)	404/3243 (12.5)	217/2433 (8.9)	198/3560 (5.6)	221/3616 (6.1)	582/7012 (8.3)
ACAZ (6 months-5 years)	N/A	1154.2433 (47.4)	1642/3560 (46.1)	1598/3547 (45.1)	N/A
HCAZ (0-5 years)	1054/3243 (32.5)	638/2433 (26.2)	861/3560 (24.2)	1122/3547 (31.6)	N/A
Children with Disabilities (Total Observations: 7013)					
	0-6 months	6-12 months	12-24 months	24-60 months	>60 months
WAZ (0-10 years)	43/759 (5.7)	24/819 (2.9)	22/1289 (1.7)	35/1546 (2.3)	64/1405 (4.6)
HAZ (0-18 years)	63/759 (8.3)	15/819 (1.8)	14/1289 (1.1)	51/1546 (3.3)	543/2600 (20.9)
WHZ (0-5 years)	57/759 (7.5)	16/819 (2)	12/1289 (0.9)	61/1517 (4)	N/A
BMIZ (0-18 years)	49/759 (6.6)	56/819 (6.8)	57/1289 (4.4)	99/1546 (6.4)	455/2600 (17.5)
ACAZ (6 months-5 years)	N/A	517/819 (63.1)	833/1289 (64.6)	966/1517 (63.7)	N/A
HCAZ (0-5 years)	387/759 (51)	354/819 (43.2)	578/1289 (44.8)	870/1517 (57.4)	N/A
Children without Disabilities (Total Observations: 12851)					
	0-6 months	6-12 months	12-24 months	24-60 months	>60 months
WAZ (0-10 years)	18/ 2484 (0.7)	4/1614 (0.2)	5/2271 (0.2)	3/2070 (0.1)	6/2402 (0.2)
HAZ (0-18 years)	47/2484 (1.9)	17/1614 (1.1)	5/2271 (0.2)	28/2070 (1.4)	134/4412 (3)
WHZ (0-5 years)	54/2484 (2.2)	16/ 1614 (1)	9/2271 (0.4)	36/2030 (1.8)	N/A
BMIZ (0-18 years)	355/2484 (14.3)	161/1614 (10)	141/2271 (6.2)	122/2070 (5.9)	127/4412 (2.9)
ACAZ (6 months-5 years)	N/A	637/1614 (39.5)	809/2271 (35.6)	632/2030 (31.1)	N/A
HCAZ (0-5 years)	667/2484 (26.8)	284/1614 (17.6)	283/2271 (12.5)	252/2030 (12.4)	N/A

Table E.5 examined missing data from observations of different age groups of children. Additionally, this table presents data by all children, children with disabilities and those without. Broad patterns of missing data are similar for different age groups. Children with disabilities have a higher prevalence of missing data compared to those without disabilities, which may be related to some children's disabilities limiting them from measurement.

E.1.3 Dissemination: Blogs, Visual Abstracts, Conferences and Presentations

I. Blogs: https://www.holtinternational.org/preview-holts-newest-nutritional-research-publication/?fbclid=IwAR18fuqUVAdE_kK_Kj_oND0MAAGUixQuIm7kz896wh4O70eM-JMHa8SOoe0
https://www.holtinternational.org/how-feeding-nutrition-affects-children-living-in-care/

II. London School of Hygiene and Tropical Medicine Poster Day, Poster Presentation: The nutritional status of children living in institutionalized care with control charts and funnel plots for program monitoring; Apr. 21- May 15, 2021; Online (Presented by Emily DeLacey on behalf of Co-authors)

III. 8th International Conference on Nutrition and Growth, Poster Presentation: The nutritional status of children living in institutionalized care with control charts and funnel plots for program monitoring; Aug. 26-28, 2021; Online (Presented by Emily DeLacey on behalf of co-authors)

E. DeLacey, E. H., E. Allen, M. Quiring, C. Tann, N. Groce, J. Vilus, E. Bergman, M. Demasu-Ay, H. Dam, M. Kerac (2021). The Nutritional Status of Children Living Within Institutionalized Care with Control Charts and Funnel Plots for Program Monitoring. 8th International Conference on Nutrition and Growth. https://nutrition-growth.kenes.com/wp-content/uploads/sites/131/2021/08/E-posters-Abstracts-1.pdf

V. Visual Abstract

The nutritional status of children living in institutionalized care with control charts and funnel plots for program monitoring.

Emily DeLacey[1, 2, 3], Evan Hilberg[2], Elizabeth Allen[4], Michael Quiring[2], Cally Tann[3, 5, 6, 7], Nora Groce[8], James Vilus[2], Ethan Bergman[9], Merzel Demasu-ay[10], Hang T. Dam[2], Marko Kerac[1, 3]

[1] Department of Population Health, Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, University of London; London, United Kingdom
[2] Holt International, Eugene; Oregon, United States of America
[3] Centre for Maternal, Adolescent, Reproductive, & Child Health (MARCH), London School of Hygiene & Tropical Medicine, University of London; London, United Kingdom
[4] Department of Medical Statistics, Faculty of Epidemiology & Population Health, London School of Hygiene & Tropical Medicine, University of London; London, United Kingdom
[5] Department of Infectious Disease Epidemiology, Faculty of Epidemiology & Population Health, London School of Hygiene & Tropical Medicine, University of London; London, United Kingdom
[6] MRC/UVRI & LSHTM Uganda Research Unit, London School of Hygiene & Tropical Medicine, University of London; Entebbe, Uganda
[7] Neonatal Medicine, University College London Hospitals NHS Trust; London, United Kingdom
[8] UCL International Disability Research Centre, Department of Epidemiology and Public Health, University College London; London, United Kingdom
[9] Department of Health Sciences, College of Education and Professional Studies, Central Washington University; Ellensburg, Washington, United States of America
[10] Kaisahang Buhay Foundation, Inc.; Quezon City, the Philippines

Background and Aims

Upward of 9.42 million children live within institutionalized care worldwide.

This retrospective analysis aimed to describe the nutrition-related epidemiology of children living within institutionalized care and explore the use of control charts and funnel plots for program monitoring.

Method

Records from 2,926 children, 0-18 years old in 6 countries were analyzed.

Data collected included information on age, sex, anthropometry, disability status and hemoglobin. Shewhart control charts and funnel plots were used to explore inter-site and over-time variations in nutritional status.

Results

Baseline screening found:

- Disabilities: 739 (25·3%)
- Low birth weight: 514 (57.5%)
- Prematurity: 294 (42·2%)
- Anemia: 717 (28.8%)
- Wasting: 212 (12·6%)
- Stunting: 1048 (37·3%)
- Underweight: 788 (34·1%)
- Overweight or obese:135 (12%)
- Small head circumference: 339 (31%)

- Children with disabilities had higher prevalence of malnutrition compared to counterparts without disabilities. All children had higher malnutrition when compared to global prevalence.
- There was inter-site variation.
- Funnel plots show sites with malnutrition prevalence outside expected limits for this specific population taking into consideration natural variation. Control charts highlight changes in site mean z-scores over time in relation to population control limits.

Conclusion

- Malnutrition is prevalent among children living in institutional-based care, including stunting, underweight, anemia and wasting.
- Underlying risk factors are more common than global prevalence: low birth weight, prematurity and disability.
- When exploring inter-site variations in malnutrition prevalence, disability should be accounted for by using disability-specific control charts.
- Control charts and funnel plots present useful data to site staff and managers as sites outside of control limits, taking natural variation into account.

Funding

Emily DeLacey, Michael Quiring, James Vilus, Hang Dam and Evan Hilberg work for Holt International. Holt international holds the primary data.

Competing Interests

None

References

1. United Nations General Assembly, *Guidelines for the Alternative Care of Children, UN document A/RES/64/142.* 2009: Geneva: United Nations.
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16. Lelijveld, N., et al., *Long-term outcomes for children with disability and severe acute malnutrition in Malawi.* BMJ Glob Health, 2020. **5**(10).
17. Washington Group on Disability Statistics. *Washington Group on Disability Statistics*. 2001 [cited 2020 November 21, 2020].

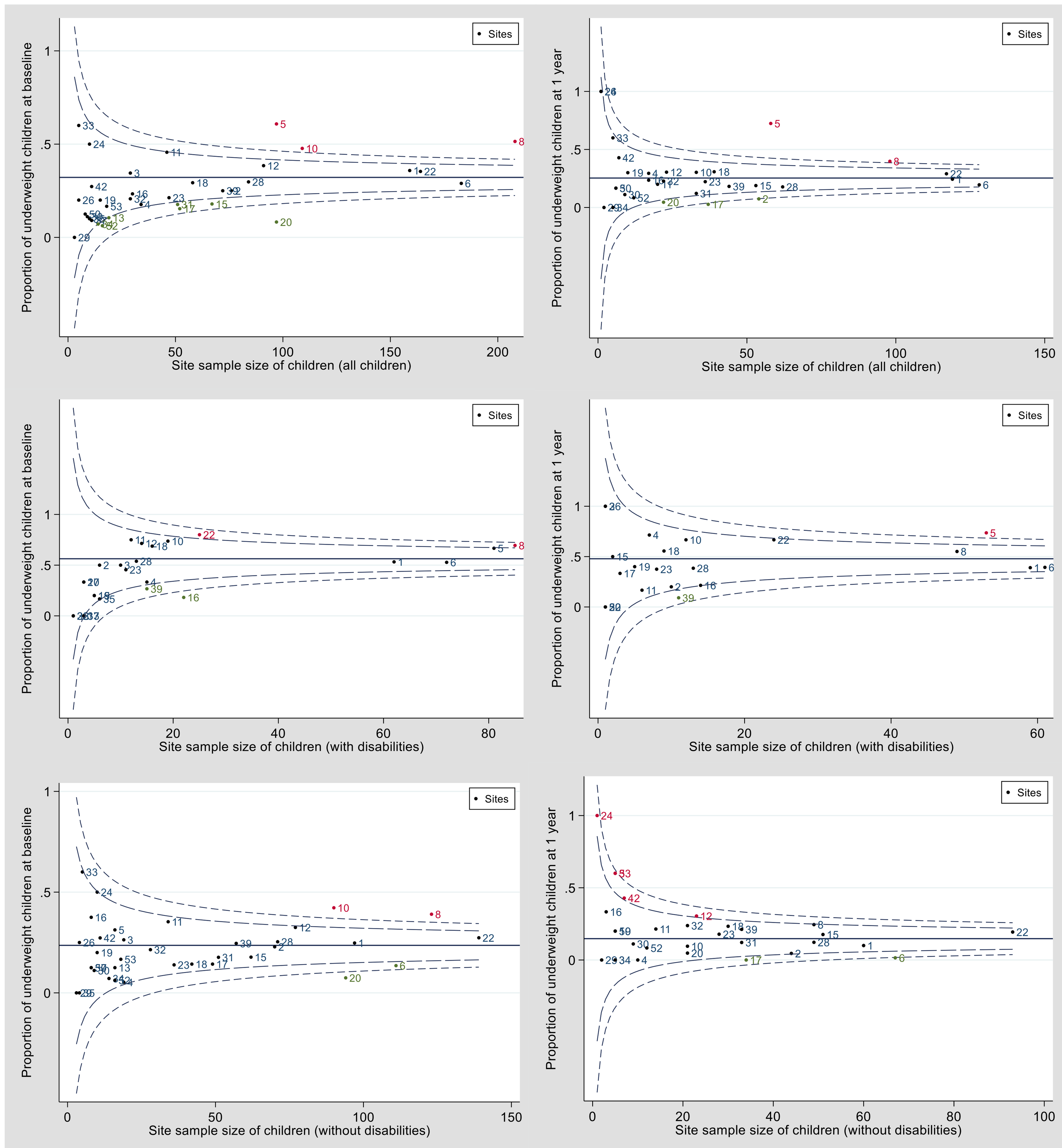

Figure 1: Funnel plots of proportion of underweight children (WAZ), 0-10 years at baseline (left side panels) and 1 year (right panels) for all children (top row), children with a disability (middle row) and those without disability (bottom row).

Site: 1 **Site: 6**

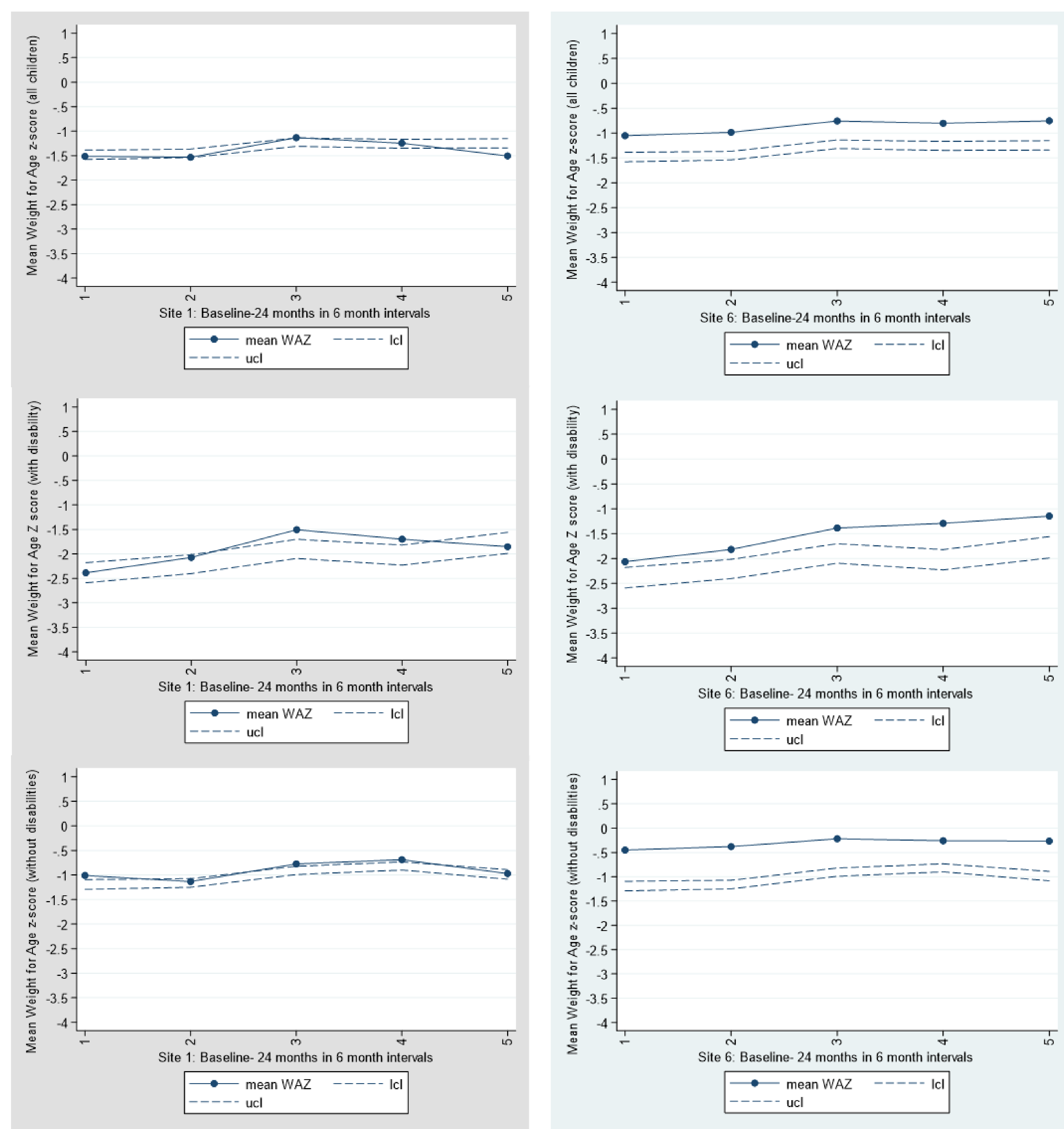

Figure 2: Individual site control charts showing mean WAZ for children 0-10 over time. Left panels (site 1) illustrate 'average' performance (site 1) and right panels (site 6) show 'above-average' performance. The top row shows all children; the middle row shows those with disability; and the bottom row shows those without disability.

The nutritional status of children living in institutionalized care with control charts and funnel plots for program monitoring.

Emily DeLacey[1, 2, 3], Evan Hilberg[2], Elizabeth Allen[1], Michael Quiring[2], Cally Tann[1, 4, 6], Nora Groce[8], James Vilus[2], Ethan Bergman[9], Merzel Demasu-ay[10], Hang T. Dam[2], Marko Kerac[1, 3]

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

[1]London School of Hygiene & Tropical Medicine, London, United Kingdom [2] Holt International, Eugene; Oregon, United States of America [3] Centre for Maternal, Adolescent, Reproductive, & Child Health (MARCH), LSHTM, London, United Kingdom [4] MRC/UVRI & LSHTM Uganda Research Unit, LSHTM, Entebbe, Uganda [8] UCL International Disability Research Centre, University College London; London, United Kingdom [9] Central Washington University; Ellensburg, Washington, United States of America [10] Kaisahang Buhay Foundation, Inc.; Quezon City, the Philippines

Background and Aims

Upward of 9.42 million children live within institutionalized care worldwide. This retrospective analysis aimed to describe the nutrition-related epidemiology of children living within institutionalized care and explore the use of control charts and funnel plots for program monitoring.

Method

Demographic and anthropometric data from 2,926 children, 0-18 years old in 6 countries were analyzed. Shewhart control charts and funnel plots were used to explore inter-site and over-time variations in nutritional status.

Results

At baseline screening: Disabilities: 739 (25·3%), low birth weight: 514 (57.5%), prematurity: 294 (42·2%), anemia: 717 (28.8%), wasting: 212 (12·6%), stunting: 1048 (37·3%), underweight: 788 (34·1%), overweight or obese:135 (12%), small head circumference: 339 (31%)

- Children with disabilities had higher prevalence of malnutrition compared to counterparts without disabilities. All children had higher malnutrition when compared to global prevalence.
- Funnel plots show sites with malnutrition prevalence outside expected limits for this specific population taking into consideration natural variation.
- There was inter-site variation.

Conclusion

- Malnutrition is prevalent among children living in institutional-based care, including stunting, underweight, anemia and wasting.
- Underlying risk factors are more common than global prevalence: low birth weight, prematurity and disability.

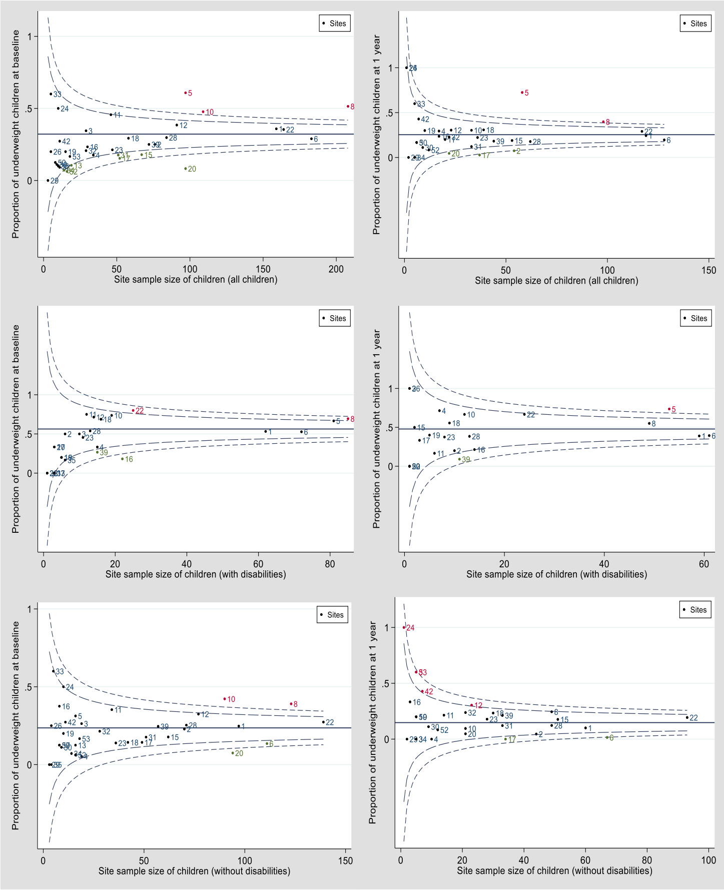

Figure 1: Funnel plots of proportion of underweight children (WAZ), 0-10 years at baseline (left side panels) and 1 year (right panels) for all children (top row), children with a disability (middle row) and those without disability (bottom row).

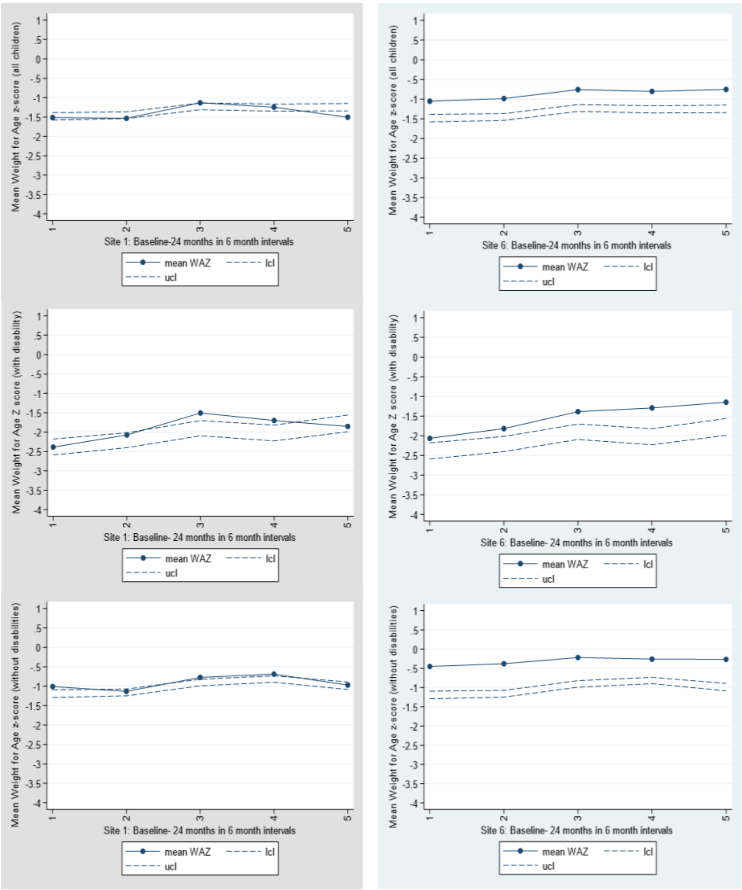

Figure 2: Individual site control charts showing mean WAZ for children 0-10 over time. Left panels (site 1) illustrate 'average' performance (site 1) and right panels (site 6) show 'above-average' performance. The top row shows all children; the middle row shows those with disability; and the bottom row shows those without disability.

Conclusion cont.

- When exploring inter-site variations in malnutrition prevalence, disability should be accounted for by using disability-specific control charts.
- Control charts and funnel plots present useful data to site staff and managers as sites outside of control limits, taking natural variation into account.

Funding

Emily DeLacey, Michael Quiring, James Vilus, Hang Dam and Evan Hilberg work for Holt International.

Competing Interests

None

References

1. United Nations General Assembly, *Guidelines for the Alternative Care of Children, UN document A/RES/64/142.* 2009: Geneva: United Nations.
2. Black, R.E., et al., *Maternal and child undernutrition and overweight in low-income and middle-income countries.* The Lancet, 2013. **382**(9890): p. 427-451.
3. Washington Group on Disability Statistics. *Washington Group on Disability Statistics*. 2001 [cited 2020 November 21, 2020].
4. DeLacey, E., et al., *The nutritional status of children living within institutionalized care: a systematic review.* PeerJ, 2020. **8**: p. e8484.
5. Johnson, D.E. and M.R. Gunnar, *IV. Growth Failure in Institutionalized Children.* Monographs for the Society for Research in Child Development, , 2011. **76**(4): p. 92-126.
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8. The St. Petersburg- USA Orphanage Research Team, *Characteristics of children, caregivers, and orphanages for young children* 23. Groce, N., et al., *Malnutrition and disability: unexplored opportunities for collaboration.* Paediatr Int Child Health, 2014. **34**(4): p. 308-14.

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The Nutritional Status Of Children Living Within Institution-based Care: A Retrospective Analysis With Funnel Plots And Control Charts For Program Monitoring.

BACKGROUND

Upward of 9.42 million children live in institution-based care (IBC) worldwide. This analysis provides key information on the nutrition-related epidemiology of children living within IBC.

METHODS

We conducted a retrospective analysis of records from 2,926 children, 0-18 years old, in Holt International's Child Nutrition Program. Collection occured from 35 sites in six countries. Data collected from an online nutrition screening database included information on age, sex, anthropometry, disability status and hemoglobin. We used Shewhart control charts and funnel plots to explore inter-site and over-time variations in nutritional status.

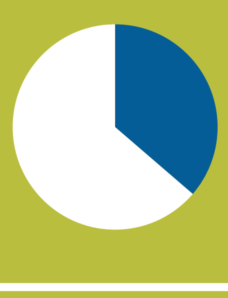
PREVALENCE OF MALNUTRITION INDICATORS

At initial screening,

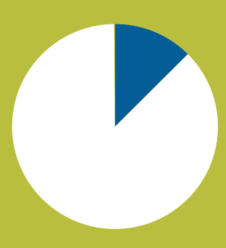
Anemic
717/2,494 (28.8%)

Underweight
788/2,308 (34.1%)

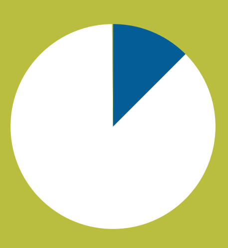
Stunted
1048/2,812 (37.3%)



Wasted
212/1,678 (12.6%)



Overweight or obese
135/1,123 (12%)



Small head circumference
339/1,095 (31%)

Many had underlying conditions:

Low birth weight
514/895 (57.4%)

Prematurity
294/697 (42.2%)

Disabilities
739/2,926 (25.3%)

Children with disabilities had a higher prevalence of malnutrition compared with counterparts without disabilities.

Funnel plots highlight sites with malnutrition prevalence outside expected limits for this specific population taking into consideration natural variation. Control charts show changes in site mean z-scores over time in relation to population control limits.

CONCLUSIONS

Malnutrition is prevalent among children living in IBC, notably different forms of undernutrition (stunting, underweight, wasting). Underlying risk factors for malnutrition are also common: prematurity, low birth weight and disability.

Control charts and funnel plots are valuable tools to track and monitor children's growth and site performance.

The nutritional needs of the millions of children residing in IBC need to be prioritized. These children have a basic human right to grow and fully develop regardless of where they received care early in their lives.

https://bmjopen.bmj.com/content/11/12/e050371
More info: holtinternational.org/nutrition

F. Supplementary Materials for Paper 3: Feeding Retrospective Analysis

F.1.1 Ethics

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the London School of Hygiene and Tropical Medicine's Ethics Committee (ref: 22822). This study did not involve patients or the public in its development. This study is available through open access publication to the public and all stakeholders. Holt International has gave consent for the publication.

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Observational / Interventions Research Ethics Committee

Ms Emily DeLacey
LSHTM

2 March 2021

Dear Ms Emily DeLacey

Study Title: The feeding practices of children living within institutionalized care: A retrospective analysis of surveillance data

LSHTM Ethics Ref: 22822

Thank you for responding to the Observational Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Investigator CV	CV Cally Tann_Apr2019	29/10/2020	1
Investigator CV	SCHOOL CV TEMPLATE_Kerac_2019_09_19	29/10/2020	1
Other	citiCompletionReport7020411 Emily DeLacey Certificate	29/10/2020	1
Local Approval	DATA USE AGREEMENT FOR LIMITED DATA SETS Signed	30/10/2020	1
Consent form	DATA USE AGREEMENT FOR LIMITED DATA SETS Signed	30/10/2020	1
Investigator CV	Emily DeLacey Resume 8.13	13/11/2020	1
Protocol / Proposal	App 1_LSHTM Protocol Template - Feeding Analysis 11.24.2020 Draft ED V2	25/11/2020	2
Protocol / Proposal	LSHTM-Staff-Data Management Plan 11.24.2020 Cohort Study Emily DeLacey V2	25/11/2020	2
Covering Letter	Ethics Response Feeding Analysis Emily DeLacey V1 FINAL	15/02/2021	1
Protocol / Proposal	Holt International Research Consent TB Feeding Analysis FINAL	15/02/2021	1
Consent form	Holt International Research Consent TB Feeding Analysis FINAL	15/02/2021	1

After ethical review

The Chief Investigator (CI) or delegate is responsible for informing the ethics committee of any subsequent changes to the application. These must be submitted to the Committee for review using an Amendment form. Amendments must not be initiated before receipt of written favourable opinion from the committee.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reactions (SUSARs) which occur during the project by submitting a Serious Adverse Event form.

An annual report should be submitted to the committee using an Annual Report form on the anniversary of the approval of the study during the lifetime of the study.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at: http://leo.lshtm.ac.uk

Additional information is available at: www.lshtm.ac.uk/ethics

Yours sincerely,

Professor Jimmy Whitworth
Chair

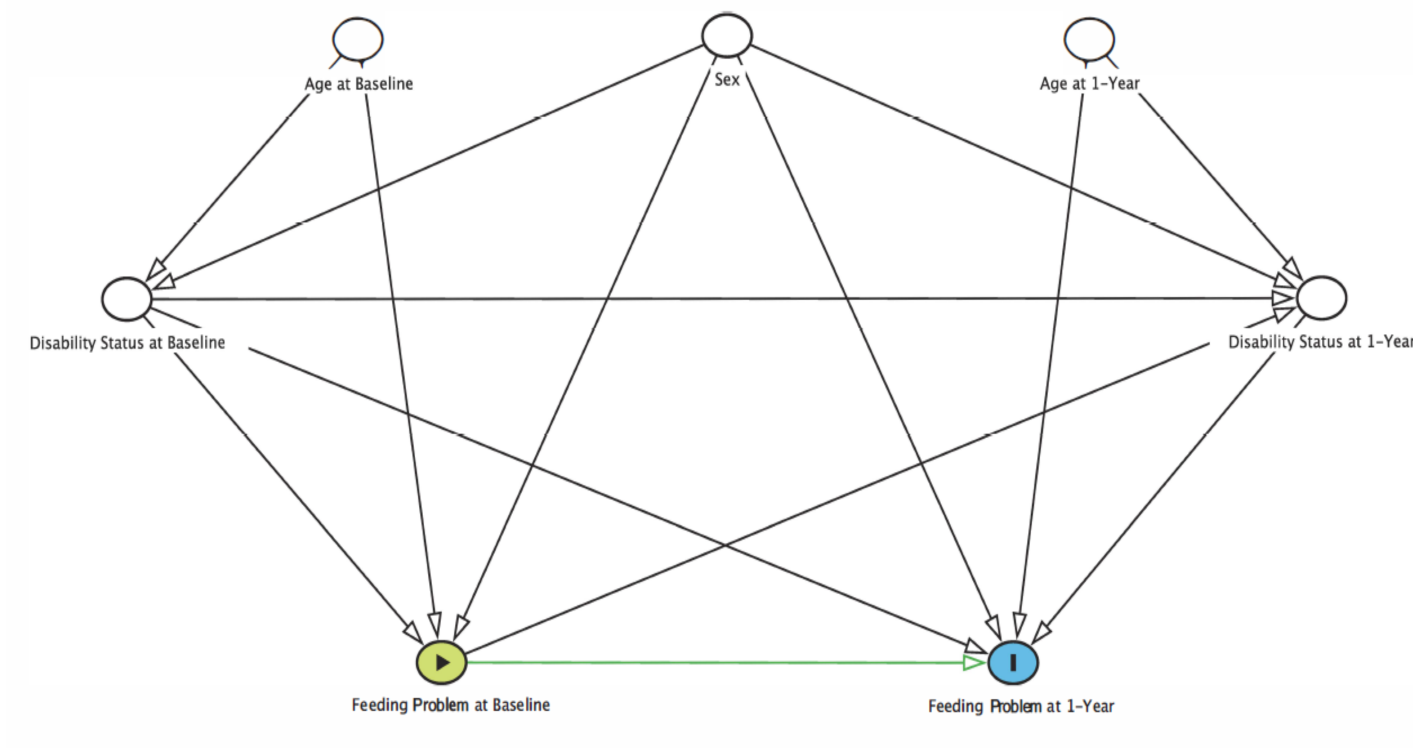
ethics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

F.1.2 Confounding and Directed Acyclic Graphs

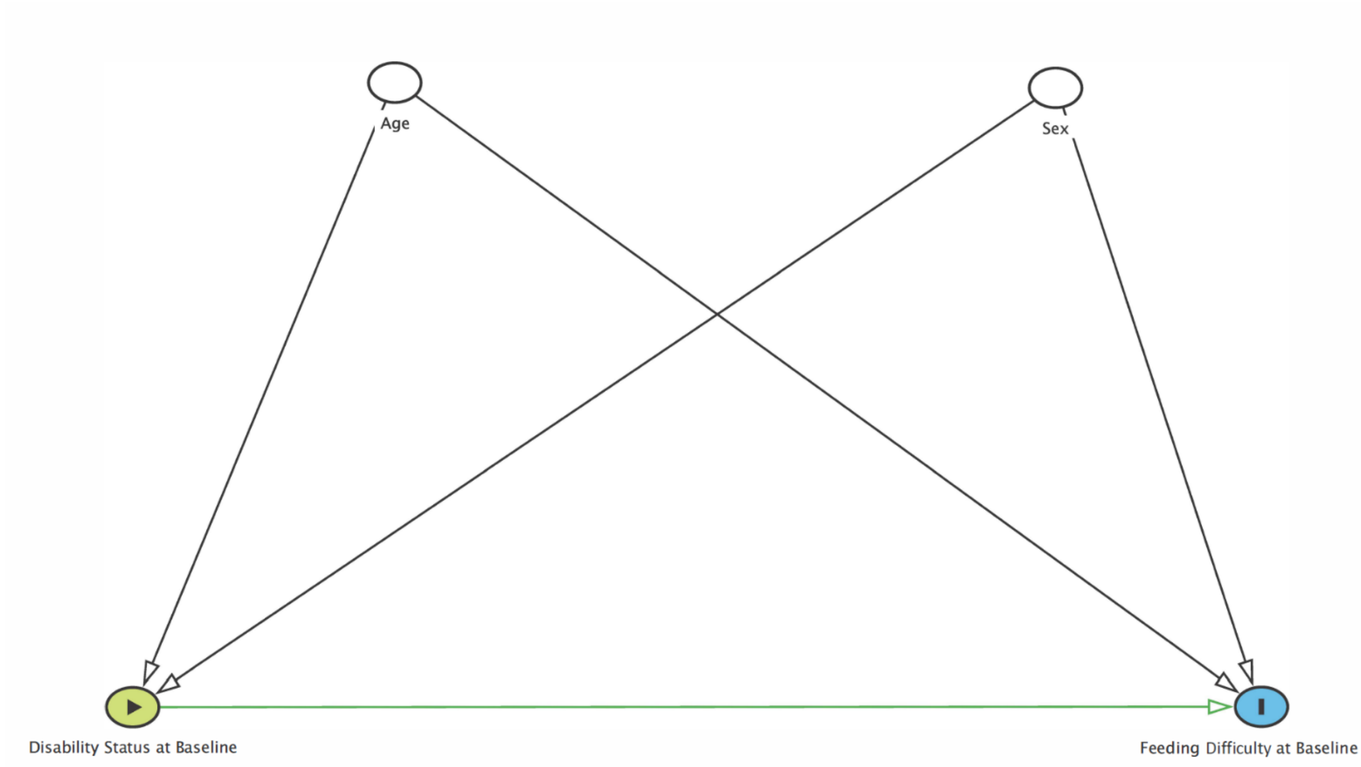
Confounders are variables that are independently associated with both the exposure and outcome variables and are not on the causal pathway. Confounders can potentially cause the outcome or results seen in a study. I used directed acyclic graphs (DAG) to look at the relationship between my exposure and outcome variables and potential confounders including age, sex and disability status. I used DAGitty[107], an open access software, for drawing and analyzing my variables in directed acyclic graphs. Age, sex and disability status were determined to be potential confounders after considering potential biological or social reasons why these variables may impact the association, as well as including these variables in the models to see if the stratum-specific measures of effect varied. Initially, I looked at other variables such as prematurity and low birth weight but removed them from the models after no variation from the crude measure was observed. Reducing the number of variables included in the model also potentially helped to reduce "noise" from adjusting for too many variables.

Annex Figure F.1 was a DAG created for a model we had initially considered for this paper. This DAG looked at feeding difficulties at baseline and feeding difficulties at 1-year taking into account potential confounders of disability status, age and sex at each time point. Instead of using a model with these variables, we used cross-tabulation to look at feeding difficulties at baseline and feeding difficulties at 1-year by disability status.

Annex Figure F.2 was a DAG created to inform the generalized linear model with a log link used in this paper. This DAG looks at the association between disability status at baseline and feeding difficulties at baseline, taking into account potential confounders of age and sex. We fitted the generalized linear model to assess the association of feeding difficulties and disability status at children's baseline screening after adjusting for our preidentified potential confounders of age and sex. Robust standard errors were used to allow for clustering by site. We found an adjusted risk ratio of 5.08 (95% CI: 2.65-9.7, $p \leq 0.001$), which indicated an increased risk of having a feeding difficulty among children with disabilities at their baseline screening.



Annex Figure F.1 Directed Acyclic graph of feeding problems at baseline and feeding problems at 1-year considering potential confounders of age, sex and disability status using DAGitty.[107]



Annex Figure F.2 Directed acyclic graph looking at the relationship between disability status at baseline and having a feeding difficulty at baseline, considering potential confounders of age and sex using DAGitty.[107]

F.1.3 Dissemination: Blogs, Visual Abstracts, Conferences and Presentations

I. National Council for Adoption, Speaker, Presentation: The nutrition and feeding of children in institution-based care; Jun. 15-17, 2022, Indianapolis, USA (Presented by Emily DeLacey on behalf of co-authors)

II. Blog: https://www.holtinternational.org/how-feeding-nutrition-affects-children-living-in-care/

III. Visual Abstract

Feeding practices of children within institution-based care: A retrospective analysis of surveillance data

BACKGROUND

Up to 9.42 million children live within institution-based care (IBC) worldwide. Poor feeding practices can predispose or exacerbate malnutrition, illness and disability. This paper describes the feeding practices and difficulties of children living within IBC.

METHODS

This is a retrospective analysis of records from 3,335 children, 0-18 years old, participating in Holt International's Child Nutrition Program from 36 sites in six countries. Data analyzed included demographic information on age, sex, feeding practices, disabilities and feeding difficulties. Descriptive statistics were produced. Logistic regression explored associations between feeding difficulties and disability and 2x2 tables examined feeding difficulties over time. An additional data set of feeding observations with qualitative and quantitative data was analyzed.

RESULTS: At baseline,

- **Median age of children was 16 months** (IQR: 0.66 months- 68 months)
- **Children with disabilities** 757/3,335 (22.7%)
- **Low birth weight** 550/984 (55.9%)
- **Premature** 311/784 (39.7%)
- **Low BMI** 447/3,113 (14.4%)
- **Feeding difficulties** 378/3,335 (11.3%)
- **The odds of having a feeding difficulty was 6.62 ((CI: 4.9-9.0), p= <0.001) times greater for children with disabilities than those without.**
- **Many children saw their feeding difficulties resolve after one year in Holt's Child Nutrition Program, 54/163 (33.1%) for children with disabilities and 57/106 (53.8%) for those without disabilities.**
- **Suboptimal hygiene, dietary and feeding practices were common.**

CONCLUSIONS

1) Feeding is a critically important and currently largely overlooked component of improving the health and well-being of millions of children currently living in IBC.

2) Feeding difficulties are common amongst children living in IBC, especially for those children with disabilities. However, some children see their feeding difficulties resolve over time in Holt's Child Nutrition Program.

3) Suboptimal feeding, dietary and nutritional practices are common in IBC.

4) Children's feeding needs should be prioritized to ensure overall health and development and help ease the transition into eventual family-based care as we move towards deinstitutionalizing children and strengthening families.

http://doi.org/10.1111/mcn.13352

More info: holtinternational.org/nutrition

G. Supplementary Materials for Paper 4: Evaluation of Process

G.1.1 Ethics

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the London School of Hygiene and Tropical Medicine's Ethics Committee (ref: 22865); the National Center of Public Health of Mongolia approved the research methodology/ protocol and ethical approval was obtained from the Medical Ethics Control Committee of the Mongolian Ministry of Health (ref: 230); the St. Cabrini Medical Center-Asian Eye Institute Ethics Review Committee (SCMC-AEI) Ethics Review Committee in the Philippines (ref: 2021-002). Written informed consent was obtained from all subjects/patients. Additionally, verbal consent was also witnessed and formally recorded on video.

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Observational / Interventions Research Ethics Committee

Ms Emily DeLacey
LSHTM

2 March 2021

Dear Ms Emily DeLacey

Study Title: Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process

LSHTM Ethics Ref: 22865

Thank you for responding to the Observational Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

Notes:

1. It would be helpful for future partnerships with Holt International to be assured that participants are aware that their personal and clinical details may be shared with external research groups.

2. Please consider adding contact details for somebody in the Philippines or Mongolia to the consent form. it might be daunting for participants to need to email somebody in the UK if they have any questions.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document Type	File Name	Date	Version
Investigator CV	Smythe_CV_ publications_Aug20	13/11/2020	1
Investigator CV	CV Cally Tann_Apr2019	13/11/2020	1
Investigator CV	SCHOOL CV TEMPLATE_Kerac_2019_09_19	13/11/2020	1
Other	citiCompletionReport7020411 Emily DeLacey Certificate	13/11/2020	1
Investigator CV	Emily DeLacey Resume 8.13	13/11/2020	1
Protocol / Proposal	Key Informant Interview Questions 11.25.2020 ED Draft	25/11/2020	1
Protocol / Proposal	2.KAP_EN_11.27.2017	25/11/2020	1
Protocol / Proposal	LSHTM-Staff-Data Management Plan 11.24.2020 Evaluation Emily DeLacey V2	25/11/2020	2
Information Sheet	Consent Form Evaluation of Process Emily DeLacey V2	14/02/2021	2
Information Sheet	Participant Information Sheet Holt International Emily DeLacey V2	14/02/2021	2
Protocol / Proposal	Consent Form Evaluation of Process Emily DeLacey V2	14/02/2021	2
Protocol / Proposal	App 1_LSHTM Protocol - Evaluation of Process Study Emily DeLacey V3	14/02/2021	3

Protocol / Proposal	Participant Information Sheet Holt International Emily DeLacey V2	14/02/2021	2
Information Sheet	Holt International Research Consent for Process Evaluation TB	15/02/2021	1
Covering Letter	Ethics Response Evaluation Process Emily DeLacey V1	15/02/2021	1

After ethical review

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Yours sincerely,

Professor Jimmy Whitworth
Chair

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LONDON SCHOOL of HYGIENE & TROPICAL MEDICINE

Observational / Interventions Research Ethics Committee

Ms Emily DeLacey
LSHTM

2 February 2022

Dear Ms Emily DeLacey,

Project Title: Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process

Project ID: 22865

Thank you for your annual report application for the continuation of your research dated 31/01/2022 21:08 , which has now been considered by the Chair on behalf of the Ethics Committee.

Confirmation of ethical opinion

This application is approved by the committee for a further year from the date of this letter.

Conditions of the favourable opinion

Approval is dependent on local ethical approval having been received, where relevant.

After ethical review

Any changes to the application must be submitted to the committee via an Amendment form.

The CI or delegate is also required to notify the ethics committee of any protocol violations and/or Suspected Unexpected Serious Adverse Reaction (SUSARs) which occur during the project by submitting a SUSAR and Protocol Violation form.

An annual report should be submitted to the committee using an Annual Report form on the anniversary of the approval of the study during the lifetime of the study.

At the end of the study, the CI or delegate must notify the committee using an End of Study form.

All aforementioned forms are available on the ethics online applications website and can only be submitted to the committee via the website at http://leo.lshtm.ac.uk.

Additional information is available at: www.lshtm.ac.uk/ethics.

Yours sincerely,

Professor Jimmy Whitworth
Chair

ethics@lshtm.ac.uk
http://www.lshtm.ac.uk/ethics/

Improving health worldwide

ЭРҮҮЛ МЭНДИЙН ЯАМ
АНАГААХ УХААНЫ ЁС ЗҮЙН ХЯНАЛТЫН ХОРООНЫ
ТОГТООЛ

2021 оны 04 дугаар сарын 21-ны өдөр

№230

210648 Улаанбаатар хот 6
Сүхбаатар дүүрэг,
Олимпийн гудамж-2,
Засгийн газрын VIII байр,
Эрүүл мэндийн яам
Утас: 261845, Факс:323541

Анагаах ухааны ёс зүйн хяналтын хорооны 2021 оны 04 дүгээр сарын 21-ны өдрийн 07 дүгээр хурлын протоколыг үндэслэн ТОГТООХ нь:

1. “Хүүхдийн хоол тэжээлийн хөтөлбөрийн хэрэгжилтээс суралцах нь” явцыг холимог аргаар үнэлэх нь” сэдэвт судалгааны ажлыг судлаач АУ-ны доктор Б.Батжаргал, АУ-ны доктор, профессор Марко Керакын удирдлаган дор 2021-2022 онд багтаан хийж гүйцэтгэхийг зөвшөөрсүгэй.
2. Судалгааны явцад тодорхой шалтгааны улмаас арга аргачлалд өөрчлөгдөх, гадаад орон руу сорьц тээвэрлэх, Хельсинкгийн тунхаглалд туссан ёс зүйн асуудал хөндөгдсөн тохиолдолд анагаах ухааны ёс зүйн хяналтын хороонд мэдэгдэж, дахин хэлэлцүүлэхийг судалгааны удирдагч болон багийнханд үүрэг болгосугай.
3. Судалгааны явцын тайланг эрдмийн зөвлөлөөр хэлэлцүүлэн анагаах ухааны ёс зүйн хяналтын хороонд ирүүлэхийг төслийн удирдагчид үүрэг болгосугай.
4. Судалгааны төгсгөлийн тайланг эрдмийн зөвлөлөөр хэлэлцүүлэн судалгаа дууссан хугацаанаас хойш 2 сарын дотор багтаан анагаах ухааны ёс зүйн хяналтын хороонд ирүүлэхийг төслийн удирдагчид үүрэг болгосугай.

[redacted]

1118270972 9087443

RESOLUTION OF MEDICAL ETHICS CONTROL COMMITTEE OF MINISTRY OF HEALTH

Date: Apr 21, 2021 No.: 230 Address:

RESOLUTING based on the minutes of the 7th meeting of the Medical Ethics Review Committee held on April 21, 2021:

1. Conducting research work with topic “Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process” under the guidance of J.Batjargal, Ph.D, and Professor Marko Kerac within 2021-2022 has been hereby allowed.

2. The supervisors and members of the research team have been hereby required to be responsible to inform to the Medical Ethics Review Committee for further discussion and reconsideration in case of making any changes in methodology, transporting samples abroad, raising any ethical issues stated in the Helsinki Declaration.

3. The project leader has been hereby required to submit the research process report for discussion of Scientific Council of National Center for Public Health and then for review of the Medical Ethics Review Committee.

4. The project leader has been hereby required to submit the research final report for discussion of Scientific Council of National Center for Public Health and then for review of the Medical Ethics Review Committee within 2 months from the research finalized date.

CHAIRMAN **(*Stamped & Signed)*** D. TSERENDAGVA

PROTOCOL DECISION FORM

24 February 2021

RE: ERC No.: 2021-002; Title: Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation Process

Emily DeLacey, MS, RDN, LDN
Principal Investigator

Dear Ms. DeLacey

Peace and all good!

The SCMC-AEI ERC had a full board review on the above-mentioned protocol and has approved the same.

For your guidance, the necessary *Certificate of Approval* is attached in this communication with the necessary details of the said approval.

This SCMC-AEI ERC is organized and operates in accordance with the requirements set by the Philippine Health Research Ethics Board (PHREB); and in compliance with the WHO Standards and Operational Guidance for Ethics Review of Health-related Research with Human Participants (2011), the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (2016), and the National Ethical Guidelines for Health and Health-related Research (2017).

Yours sincerely,

Emerson M. Cruz, M.D.
Chairperson
St. Cabrini Medical Center – Asian Eye Institute Ethics Review Committee

CERTIFICATION OF APPROVAL

This certifies that the *St. Cabrini Medical Center – Asian Eye Institute Ethics Review Committee* (SCMC-AEI ERC) which is constituted and established, and functions in accordance with the requirements set by the Philippine Health Research Ethics Board (PHREB); and in compliance with the WHO Standards and Operational Guidance for Ethics Review of Health-related Research with Human Participants (2011), the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (2016), and the National Ethical Guidelines for Health and Health-related Research (2017), has approved the following study protocol and related documents:

Type of Submission: Re-submision	
SCMC-AEI ERC Protocol Reference No.: 2021-002	
Title: Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation Process	
Principal Investigator: Emily DeLacey, MS, RDN, LDN	
Address:	
Contract Research Organization: **Emily DeLacey, Holt International**	**Sponsor:**
Co-Investigator/s:	
Type of Review: Expedited Review	
Approval Date: 24 February 2021	**Expiry of Ethical Clearance:** 24 February 2022 Study protocols are reclassified as Inactive after expiry of ethical clearance.
Due Date of Application for Renewal of Ethical Clearance (30 days before expiry)**:** 24 January 2022 Submit application using the Continuing Review Application/Progress Report Form (SCMC-AEI ERC FORM II-N).	**Frequency of Continuing Review:** Yearly
Approved site/s: Mongolia and Philippines	
Date of ERC Meeting: N/A	
Quorum: N/A	
Conflict of interest: None	
Members in Attendance: N/A	

Documents Approved by SCMC-AEI ERC:

1. *Study Protocol Evaluation of Process Study Emily DeLacey V2*
2. *Appendix 4 Participant Information Sheet with Filipino Translation V2*
3. *Appendix 5 Consent Form with Filipino Translation V2*
4. *Key Informant Interview11.15.2020*

Documents as reference:

5. *1 Page Study Summary 12.23.2020 Holt International*
6. *Systematic Literature Review*
7. *Response to SCME AEI Ethics Letter*
8. *Appendix 2 Data Management Plan 12.23.2020 Evaluation Emily DeLacey V1*
9. *Appendix 3 DATA USE AGREEMENT Evaluation of Process 11.13.202 Signed*
10. *Complex Interventions Guidance 29-9-08 (4)*
11. *Letter of Endorsement Holt International 12.23.2020*
12. *LSHTM Ethics Application and CARE Form V1 Submitted*
13. *Study Protocol Evaluation of Process Study Emily DeLacey 12.23.2020 V1*
14. *trendstatement_TREND_Checklist*
15. *citiCompletionReport7020411 Researcher Emily DeLacey Certificate*
16. *Curriculum Vitae_Demasu-ay as Co-Author*
17. *CV__Dr Marko Kerac_2020*
18. *Emily DeLacey Resume 11.16 Signed*
19. *Kerac_GCP_training_2019 Signed*
20. *Quiring_M_Resume*
21. *RCR Certificate M Quiring signed*
22. *ResearchInvestigators M Quiring signed*

Responsibilities of Principal Investigator while Study is in Progress:

1. Register research study in the Philippine Health Research Registry upon approval (http://registry.healthresearch.ph)
2. Progress report using the attached *Continuing Review Application/Progress Report Form* (SCMC-AEI ERC FORM II-N), as indicated above, which includes the following: (NOTE: In view of active ethical clearance, this report is mandatory even if the study has not started or is still awaiting release of funds.)
   - ✓ Date covered by the report
   - ✓ Protocol summary and status report on the progress of the research
   - ✓ Philippine Health Research Registry ID
   - ✓ Number of participants accrued
   - ✓ Withdrawal or termination of participants
   - ✓ Complaints on the research since the last SCMC-AEI ERC review
   - ✓ Summary of relevant recent research literature, interim findings and amendments since the last SCMC-AEI ERC review
   - ✓ Any relevant multi-center research reports
   - ✓ Any relevant information especially about risks associated with the research
   - ✓ A copy of the informed consent document
3. Any amendment/s in the protocol, especially those that may adversely affect the safety of the participants during the conduct of the trial including changes in personnel, and revisions in the informed consent, must be submitted or reported using *Protocol Amendment Submission Form* (SCMC-AEI ERC FORM II-F).
4. Report of non-compliance (deviation/violation), whether minor or major, at the soonest possible time up to six (6) months after the event, using *Study Protocol Deviation Report Form* (SCMC-AEI ERC FORM II-O).
5. Reports of adverse events including from other study sites (national, international) using the *Serious Adverse Event/s (SAE) / Suspected Unexpected Serious Adverse Reaction/s (SUSAR) Report Form* (SCMC-AEI ERC FORM II-N), with timelines for submission guided by the GL 02 Version 2.0: Guideline on Reporting Serious Adverse Events; or list of reportable negative events.
6. Notice of early termination of the study and reasons for such, or notice of time of completion of the study using *Final Report Form* (SCMC-AEI ERC FORM II-M)
7. Any event which may have ethical significance, and/or any information which is needed by the SCMC-AEI ERC to do ongoing review.

SCMC-AEI ERC Chairperson	Signature:		Date: (dd/mm/yyyy)
	Printed Name:	Emerson M. Cruz, MD	24 Feb 2021

PROTOCOL DECISION FORM

9 February 2022

RE: ERC # 2021-002; Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process

Ms. Emily DeLacey
Principal Investigator

Dear Ms. DeLacey,

Peace and all good!

The SCMC-AEI ERC had a Full Board review on the above-mentioned protocol and has approved the same.

For your guidance, the necessary *Certificate of Approval* is attached in this communication with the necessary details of the said approval.

This SCMC-AEI ERC is organized and operates in accordance with the requirements set by the Philippine Health Research Ethics Board (PHREB); and in compliance with the WHO Standards and Operational Guidance for Ethics Review of Health-related Research with Human Participants (2011), the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (2016), and the National Ethical Guidelines for Health and Health-related Research (2017).

Yours sincerely,

Emerson M. Cruz, M.D.
Chairperson
St. Cabrini Medical Center – Asian Eye Institute Ethics Review Committee

CERTIFICATION OF APPROVAL

This certifies that the *St. Cabrini Medical Center – Asian Eye Institute Ethics Review Committee* (SCMC-AEI ERC) which is constituted and established, and functions in accordance with the requirements set by the Philippine Health Research Ethics Board (PHREB); and in compliance with the WHO Standards and Operational Guidance for Ethics Review of Health-related Research with Human Participants (2011), the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (2016), and the National Ethical Guidelines for Health and Health-related Research (2017), has approved the following study protocol and related documents:

Type of Submission: Progress Report	
SCMC-AEI ERC Protocol Reference No.: 2021-002	
Protocol Number and Title: Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process	
Principal Investigator: Ms. Emily DeLacey	
Address: Metro Manila, Philippines	
Contract Research Organization: N/A	**Sponsor:** Holt International
Co-Investigator/s: N/A	
Type of Review: Full Board Review	
Approval Date: 09 February 2022	**Expiry of Ethical Clearance:** 15 March 2023 Study protocols are reclassified as Inactive after expiry of ethical clearance.
Due Date of Application for Renewal of Ethical Clearance (30 days before expiry)**:** 15 February 2023 Submit application using the Continuing Review Application/Progress Report Form (QR-ERC-002-12).	**Frequency of Continuing Review:** Yearly
Approved site/s: Asian Eye Institute	
Date of ERC Meeting: 09 Feb 2022	
Quorum: (6) out of (8) members were present	
Conflict of interest: None	
Members in Attendance: 1. **Dr. Pacifico Eric Calderon** 2. **Dr. Antonio Ligsay** 3. **Ms. Noemi Luz P. Mojares** 4. **Atty. Joe Vincent Aguila** 5. **Mr. Amir Austria** 6. **Dr. Gina Eubanas**	

Documents Approved by SCMC-AEI ERC: *1. 2021-002_Progress Report dated 19Jan2022_AOR21Jan2022*
Responsibilities of Principal Investigator while Study is in Progress: 1. Register research study in the Philippine Health Research Registry upon approval (http://registry.healthresearch.ph) 2. Progress report using the attached *Continuing Review Application/Progress Report Form* (QR-ERC-002-12), as indicated above, which includes the following: (NOTE: In view of active ethical clearance, this report is mandatory even if the study has not started or is still awaiting release of funds.) ✓ Date covered by the report ✓ Protocol summary and status report on the progress of the research ✓ Philippine Health Research Registry ID ✓ Number of participants accrued ✓ Withdrawal or termination of participants ✓ Complaints on the research since the last SCMC-AEI ERC review ✓ Summary of relevant recent research literature, interim findings and amendments since the last SCMC-AEI ERC review ✓ Any relevant multi-center research reports ✓ Any relevant information especially about risks associated with the research ✓ A copy of the informed consent document 3. Any amendment/s in the protocol, especially those that may adversely affect the safety of the participants during the conduct of the trial including changes in personnel, and revisions in the informed consent, must be submitted or reported using *Protocol Amendment Submission Form* (QR-ERC-002-06). 4. Report of non-compliance (deviation/violation), whether minor or major, at the soonest possible time up to six (6) months after the event, using *Protocol Deviation Report Form* (QR-ERC-002-15). 5. Reports of adverse events including from other study sites (national, international) using the *Serious Adverse Event/s (SAE) / Suspected Unexpected Serious Adverse Reaction/s (SUSAR) Report Form* (QR-ERC-002-14), with timelines for submission guided by the GL 02 Version 2.0: Guideline on Reporting Serious Adverse Events; or list of reportable negative events. 6. Notice of early termination of the study and reasons for such, or notice of time of completion of the study using *Final Report Form* (QR-ERC-002-13) 7. Any event which may have ethical significance, and/or any information which is needed by the SCMC-AEI ERC to do ongoing review.

SCMC-AEI ERC Chairperson	Signature:		Date: (dd/mmm/yyyy)
	Printed Name:	Emerson M. Cruz, MD	9 Feb 2022

G.1.2 Participant Information and Consent

Participant Information Sheet

Participant Informed Consent

Participant Information Sheet

Project Title: Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process

Please take the time to read this information sheet carefully. Feel free to ask questions if you need any additional information!

What is the purpose of the study?

This study is undertaken as part of work at Holt International and research with the London School of Hygiene and Tropical Medicine. The results of this interview will be analyzed together and included in a research project headed up by Emily DeLacey, the Director of Holt International's Nutrition Program. The results will be used by Holt International in participation with the London School of Hygiene and Tropical Medicine for an Evaluation of Process which will help a broader audience to understand the implementation of the Child Nutrition Program.

After completion of this research, we are planning to submit this study for publication in a peer-reviewed journal. The study aims to identify and describe key factors underlying successful program implementation through a mixed methods evaluation of process of Holt International's Child Nutrition Program in two countries. As part of this study, we will interview people who are participating in the Child Nutrition program to describe factors underlying the successful implementation of the program. The outcome of this study will help to inform future program growth, scaling measures and the wider global audiences on implementation processes.

Voluntary Participation and Withdrawal from the Study

Your participation is purely voluntary. If you decide to participate, we will ask you to sign a consent form. You may refuse to participate or withdraw from the study at any time without stating a reason.

What does agreeing to participate mean for me?

If you agree to participate and be interviewed for this study, an online audio call lasting a maximum of 90 minutes will be conducted. <u>If a call is not feasible due to poor connectivity or preference, the interview can be conducted via email, phone call or in-person.</u> All statements made by participants are to be given strictly in a personal capacity, not representing any organisations or countries.

Risks and Discomforts

No risks or discomfort are expected to be encountered by you.

Compensation

There will be no remuneration for participants of this study.

Confidentiality and Data Storage

The interview audio will be recorded on a password protected device. If you wish, you will be able to review the transcripts for accuracy. Audio transcripts or, if applicable, compilations of email interviews or phone interviews will be anonymised and securely stored on a computer in encrypted and password protected files. You will not be identified in any publication or presentation resulting from this study. All records will be kept indefinitely by Holt International. Data will be stored securely on Holt's International's server can and future research on this data will need approval from Holt International.

Who has reviewed this study?
This study was approved by the London School of Tropical Medicine and Hygiene Ethics Committee and a local ethics committee.

Further information and contact details
Thank you for taking time to read this information sheet. If you would like to take part in the study, please read and sign the consent form.
Should you like any further information, please reach out to us using the following contact details:

Principal Investigator: Emily DeLacey, Director of Nutrition Program, Holt International
EmilyD@Holtinternational.org

Supervisor: Dr. Marko Kerac
marko.kerac@lshtm.ac.uk

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

Participant Consent Form

Project Title: Learning from the Implementation of Holt International's Child Nutrition Program: A Mixed Methods Evaluation of Process

<u>Consent (please initial each box and sign below to consent)</u>

I have read and understood this Informed Consent Form. I have received sufficient information on this study and the details on participation in the study. My questions and/or concerns have been answered adequately. ☐

I consent to the interview audio to be recorded. ☐

I agree to the secure storage of anonymized interview transcripts on Holt International's secure servers, indefinitely. ☐

I voluntarily agree to participate in this study. I understand I can withdraw my consent at any time. ☐

Participant Name: ______________________ Participant Signature: ________________________ Date:____________________

Contact Information

Interviewer: Emily DeLacey, Director of Nutrition Program, Holt International
EmilyD@Holtinternational.org

Supervisor: Dr. Marko Kerac, marko.kerac@lshtm.ac.uk

G.1.3 Dissemination: Blogs, Visual Abstracts, Conferences and Presentations

I. Blogs: https://www.holtinternational.org/learning-from-the-implementation-of-the-child-nutrition-program/
https://www.holtinternational.org/infographic-results-of-the-child-nutrition-program-in-mongolia-and-the-philippines/?fbclid=IwAR36-9lsIKYzXZkLfvalf8uPTCDGnSeIdNSMDdKbrcdqS51LAEnwlhNrF68

II. Speaker Presentation: Global Nutrition, Disability and why PhDs Matter; May 25th, 2022, Central Washington University, USA

III. Visual Abstract

HOLT INTERNATIONAL
Nutrition & Health

Learning from the Implementation of the Child Nutrition Program: A Mixed Methods Evaluation of Process

OBJECTIVE

Holt International's Child Nutrition Program (CNP) is a nutrition and feeding intervention. This study describes the implementation of CNP in Mongolia and the Philippines.

METHODS

A mixed-methods evaluation of process of CNP implementation in Mongolia and the Philippines.

Utilizing routine program audit data analysis included:

- Qualitative and quantitative data
- Key informant interviews (KIIs)
- Knowledge, Attitude and Practice Surveys (KAPS)
- Pre-/post-tests
- Framework analysis using the WHO's Monitoring the Building Blocks of Health Systems guided the framework for analysis.

RESULTS

Mean Difference from Pre-Training to Post-Training Nutrition Tests

Mongolia: 12.1% (95% CI: 0.08-0.17 (p=<0.0001))
Philippines: 11.6% (95% CI: 0.08-0.16 (p=<0.001))

Mean Difference from Pre-training to Post-training Feeding Tests

Mongolia: 17.8% (95% CI: -0.24- -0.12 (p=<0.0001))
Philippines: 11.8% (95% CI: -0.17- -0.07 (p=<0.0001))

KAPS showed changes in desired practices from pre-training to post-training.

Thematic analysis of KIIs highlighted essential components for program implementation and effectiveness including strong leadership, adequate staffing, buy-in, incentives, quality relationships, appropriate technology, secure funding, reliable supply chains, frequent training, strong monitoring and evaluation systems.

CONCLUSIONS

This evaluation of program implementation highlights successful strategies and challenges in implementing CNP to improve the health of children.

- Nutrition and feeding interventions are important for children's growth and development.
- Strong partnerships and relationships with local government, secure funding, buy-in at all levels, adequate staffing, frequent training and support systems are essential to sustained implementation.
- Lessons learned from the implementation of CNP can inform growth of the program, scaling strategies and provide insights for similar interventions.

More Information: https://www.holtinternational.org/nutrition-health/