










Primary healthcare readiness for nutritionally at-risk infants aged under 6 months: a facility-based survey in Senegal

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Background: Malnutrition in infants aged <6 mo (u6m) is poorly identified and managed in many countries, increasing the risk of poor growth and development. Addressing this gap, 2023 WHO malnutrition guidelines recommend assessment, classification and treatment at primary care level. This study aimed to assess primary healthcare facility readiness for nutritional care in infants u6m.

Methods: We adapted the Harmonized Health Facility Assessment (HHFA), adding items for Management of small and nutritionally At-risk Infants u6m and their Mothers (MAMI) at five care contact points. Our HHFA-MAMI tool captured 342 items using healthcare provider interviews, observations and registers data to calculate mean scores per area and median patient visits.

Results: We surveyed 15 facilities in Senegal. General readiness scored 69.5%, MAMI availability and readiness 37.7%. Infrastructure (72.0%) and health workforce (60.7%) were available, while equipment (32.5%) and training (22.3%) scored low. Infants were frequently assessed (53.6%), not often classified (15.2%) as at risk, nor adequately treated (38.2%). Comparing contact points, delivery and sick child clinic scored highest in readiness, immunization in utilization.

Conclusions: Primary care readiness gaps exist in classifying and treating at-risk infants u6m, equipment and training. We found opportunities at each of the five contact points to implement WHO-recommended care.

Keywords: breastfeeding, health facility administration, infant nutritional disorders, primary healthcare.

Introduction

Infants aged <6 mo (u6m) are often left behind in global efforts to reduce child malnutrition.¹ Nutritional risk begins in utero and continues during the neonatal period and thereafter.² More than one-quarter of babies worldwide are born low birth weight (LBW),³ and in a review of 54 low- and middle-income countries, between birth and 6 mo of age, an estimated 20.1% of infants were underweight, 21.3% were wasted and 17.6% were stunted.⁴ These infants have a higher direct mortality risk and will continue to be at risk of consecutive malnutrition.^{5,6} Longer-term conse-

quences include impaired development and an increased risk of cardiometabolic non-communicable diseases in adult life.^{7,8}

In Senegal, the prevalence of LBW (estimated at 15%) and acute malnutrition u6m (estimated at 6.4%) have been stagnant over the past years.⁹ Current management and referral to secondary or tertiary level as per current guidelines does not reach all those who need care.¹⁰ Outpatient care for uncomplicated cases would be more accessible, as revealed in qualitative research among mothers and healthcare providers.¹¹ Nutritional (preventative) care for infants u6m is currently offered in primary healthcare (PHC) facilities in Senegal at five contact points

along the continuum of care: delivery with basic newborn care, postnatal care, immunization, sick child clinics and community healthcare.¹² These services are generally well utilized with 94% of births taking place in a health facility; most (74%) mothers attend at least one postnatal visit; and there is full infant vaccination coverage of 41%.⁹ Integrated Management of Childhood Illnesses (IMCI) is offered at many primary health facilities.¹²

To address the care gap, in 2023 the WHO proposed a transformative shift in approach for infants u6m, from predominantly hospital-based care to outpatient PHC. The updated 'Guidelines on the prevention and management of wasting and nutritional oedema (acute malnutrition) in infants and children under 5 years' define 'infants less than six months of age at risk of poor growth and development' as infants born small or preterm as well as infants u6m with poor anthropometry as a single or sequential measures.¹³ The emphasis of the guidelines is on early detection at community level and feeding and health assessment at PHC level. Treatment includes intensive feeding support, including breastfeeding and/or supplementary feeding for lactational failure, and management of infants' physical conditions and maternal mental health support.

This novel treatment approach has previously been developed and pilot tested by the MAMI (Management of small and nutritionally At-risk Infants u6m and their Mothers) Global Network of researchers, programmers and policymakers.¹⁴ The MAMI Care Pathway is a care package consistent with the new WHO guidelines, following the IMCI clinical approach of 'assess, classify and treat' for the infant and mother dyad. The MAMI Care Pathway has been used to frame this study.

As countries begin to implement the new WHO guidelines, health facility assessment is an important step to determine readiness to provide care as recommended. Service readiness assessment looks at the structure (the facility characteristics such as building, equipment and human resources) and the process (what is done to the patient, such as services provided and organization of care) that determine health outcomes.¹⁵ Service readiness assessment tools such as Service Availability and Readiness Assessment (SARA) have supported readiness measurement of facilities at primary and hospital care level, for a variety of health services.¹⁶ In implementation research, readiness assessment has been used to evaluate specific service areas such as emergency newborn care or elderly care.^{17,18} Nutritional service readiness research had focused on preventative care for a wider age range (<5 y), such as maternal and child health services in Nigeria,¹⁹ and a nutrition readiness survey at primary care level in 11 countries.²⁰

Service readiness for nutritionally at-risk infants u6m has not yet been conducted and we hypothesize that measuring MAMI service-specific readiness at PHC level reveals opportunities and gaps relevant for the implementation of the updated WHO guidelines.

For this study, we used a novel comprehensive tool, launched by the WHO in 2022: the Harmonized Health Facility Assessment (HHFA).²¹ The HHFA includes a few nutrition-related items such as anthropometric equipment and essential newborn care, but nutritional care for infants u6m at PHC is currently not captured. The objectives of our study are:

1. To measure general service readiness in PHC facilities in Senegal

2. To measure service-specific MAMI availability and readiness in PHC facilities in Senegal
3. To assess gaps and opportunities to implement WHO-recommended nutritional care for infants u6m at PHC contact points.

Methods

We conducted a descriptive, cross-sectional survey in 15 PHC facilities in three districts in Senegal, and we used the STROBE guidelines in reporting.²²

Setting and facilities

Senegal has 77 health districts and 809 primary health facilities, each covering on average 11 500 inhabitants.²³ The health district provides administrative and financial management of PHC facilities. In Senegal, PHC facilities are staffed by at least one certified state nurse, a midwife and a few nurse assistants. Each facility is assigned a catchment area and provides all basic primary care for its target population, including infants u6m at five contact points: delivery care, postnatal care, immunization, sick child clinic (IMCI) and community healthcare.

Survey tool development

We adapted the original HHFA version 2, which consists of five dimensions: general service availability, general service readiness, service-specific availability and readiness, management and finance, as well as quality of care.²¹ First, we selected items concerning PHC in Senegal, using the national healthcare policy plan and expert review including coauthors who practice clinically in Senegal (TDvI, AB and DS).²³ Then, we created a service-specific MAMI availability and readiness dimension using the MAMI Care Pathway (which aligns with the new WHO guidelines) (Figure 1), as well as a similar expert review for contextualization.¹⁴ Adaptations are described in Table 1, and used an iterative process, including translation into French, pilot testing at a non-participating health facility and expert review. The final HHFA-MAMI tool consisted of 137 items across the four general dimensions and a service-specific 'MAMI availability & readiness' dimension with 41 items, repeated for five care contact points (205 items in total) (Figure 2, Supplementary Table S1 for a complete list of items).

Health facility sampling

We purposively selected three health districts, two rural (Dahra, Kaffrine) and one urban (Pikine) (Figure 1). We randomly selected 15 PHC facilities, five from each district using random number allocation from the complete list of health facilities (18 facilities in Dahra, 24 in Kaffrine and 12 in Pikine). The sample size was set a priori, in view of the formative character of the study, providing sufficient variability within the health systems context for piloting the tool, that could later be repeated in a larger, more representative sample. This sampling frame has been described in earlier service readiness studies with sample sizes of 12 and 18 health facilities.^{24,25}

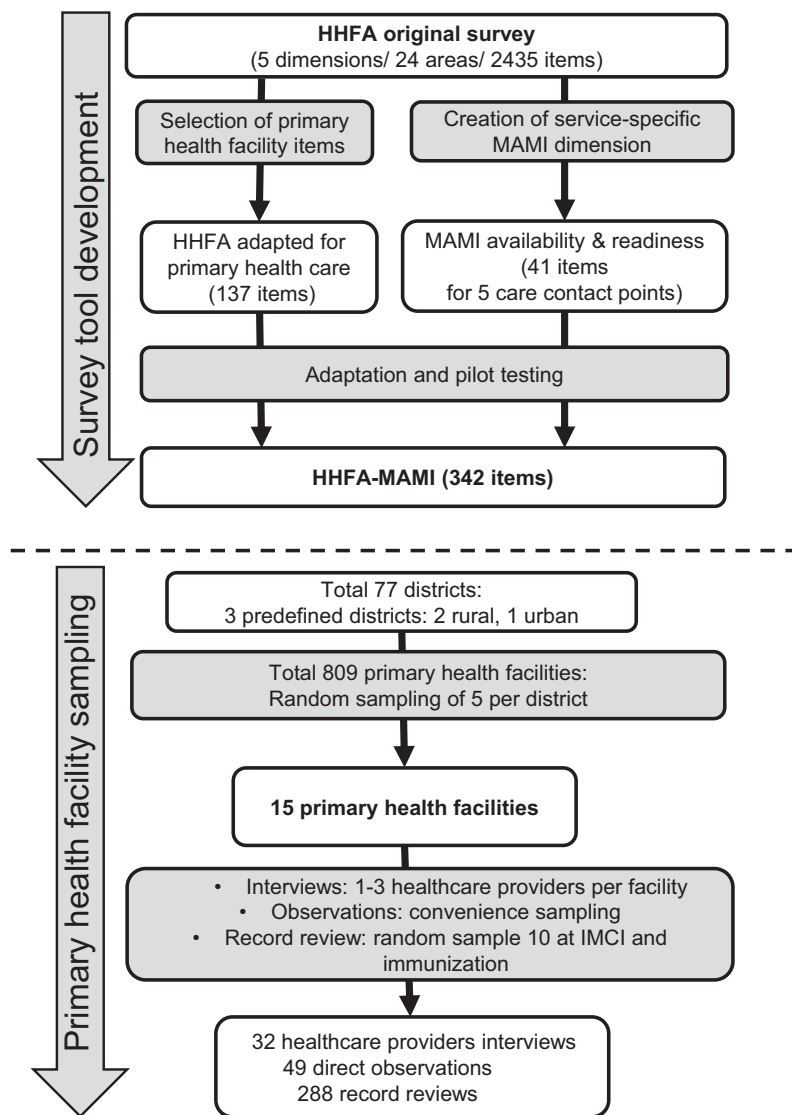


Figure 1. Flow diagram of HHFA-MAMI tool development and health facility survey sampling. HHFA-MAMI: Harmonized Health Facility Assessment-Management of small and nutritionally At-risk Infants u6m and their Mothers.

Data collection

Researchers affiliated to the University in Senegal (TDvI, DS, AB) explained the study to the chief medical officer, who then contacted the selected health facilities. Two researchers (TDvI—a Dutch clinician in Senegal and a Senegalese state nurse) conducted the HHFA-MAMI survey over 2 d at each health facility. Healthcare providers were recruited from 9 June to 17 September 2023. The first day, a face-to-face general questionnaire was administered to those healthcare providers most knowledgeable for each of the five contact points, most often the head nurse and the midwife. The second day was used for observations of building, equipment and consultations and data collection from registers. Mother/infant dyads were recruited at convenience to observe consultations with healthcare providers (all infants u6m consulted at any of the contact points during the second survey day).

Data management and analysis

HHFA-MAMI data were collected using a customized digital ODK form on a password-protected tablet.²⁶ The tablet synchronized with an encrypted central database, manually checked by the data collection team—from both Senegal (TDvI, ID, AB) and London School of Hygiene & Tropical Medicine (LSHTM) (MK, LD)—on a regular basis, exported to Excel and saved on the LSHTM-secured cloud storage.²⁷ Service utilization was calculated using the median and IQR, for each of the five contact points for the year 2022. For each health facility, we calculated the readiness scores as a percentage of items marked positively for the total list of items per subarea. The mean scores of an area were calculated, with equal weighting of the subareas, the mean score per dimension with equal weighting of the areas, then the mean score for all 15 health facilities. For the MAMI availability and readiness dimension, we calculated the score of the five contact points separately.

Table 1. Adaptations to the HHFA tool (version 2) in creating the HHFA-MAMI survey tool

HHFA level	Adaptation to HHFA	Justification
Dimensions	Keeping the 5 original dimensions of HHFA creating 'MAMI availability & readiness' dimension under the 'service-specific dimension'	Respecting the HHFA structure HHFA dimension 3 gives room for service-specific assessment
Areas	Joining areas 'safety systems' and 'quality systems' under dimension 'Management and finance' Replacing areas 'record review HIV and malaria' for 'Record review immunization and IMCI' under dimension 'Quality of care'	Each contained few PHC items More relevant for MAMI
Subareas	Selecting subareas relevant for PHC level Adding the subarea 'direct observations of care' to the 'Quality of care' dimension Adding 'assess, classify and treat' as subheading under MAMI availability	e.g. not selecting 'beds and units' and 'medical specialist density' This subarea does not exist in HHFA version 2, but complements the record review as per SARA tool To assess aspects of MAMI care following the MAMI Care Pathway
Items	Selecting items relevant for PHC level Removing items that are not relevant for PHC in Senegal Reformulating items to reflect terminology used in Senegal Reducing some question options such as recording equipment as present only when functional Reorganizing the order of items	Not selecting inpatient service and specialist items e.g. 'existence of a quality committee', which is not implemented in PHC in Senegal e.g. changing 'governing board' to 'health committee' To simplify the analysis For efficiency of the survey, e.g. all questions for the midwife grouped

HHFA: Harmonized Health Facility Assessment; MAMI: Management of small and nutritionally At-risk Infants u6m and their Mothers; PHC: primary healthcare; SARA: Service Availability and Readiness Assessment.

Ethics

Ethical approval was obtained from the National Ethics Committee in Senegal (Ref: SEN 19/78) and LSHTM (Ref: 28311). Written informed consent was obtained from all healthcare providers prior to conducting the surveys. Written informed consent was obtained from the mothers, or a trusted witness (family member/neighbor), before observing a consultation. Although patient identifiable data were accessible to the researchers who extracted data, all register data were collected without identifiers.

Results

The HHFA-MAMI was used to survey 32 healthcare providers, conduct 49 patient observations and 288 record reviews in 15 PHC facilities.

The median catchment area population for the included PHC facilities was 14 557 (IQR 9079–26 098), with a median of 320 (IQR 213–415) infants u6m (Table 2). Service utilization was high in immunization with 719 (IQR 389–1541) and postnatal care with 578 (IQR 315–1319) patient visits in 2022, compared with 4202 (IQR 2990–9190) curative visits for all ages. Community healthcare was not provided in

the urban district, and registers were not accessible in another two facilities, leaving eight PHC facilities to calculate service utilization.

General service readiness in PHC facilities (objective 1)

General service readiness scored highest among the five dimensions (69.5%), with the areas infection prevention (75.8%) and diagnostics capacity (80.7%) scoring particularly high.

General service availability had a mean score of 50.6%, with infrastructure 50.0% and health workforce 21.1%. These subareas are based on WHO facility density indicator (met by four facilities) and the nurse/midwife density indicator (met by one facility).²⁸ Management and finance scored 50.2%, with governance (84.4%) and facility finances (60.0%) scoring higher than staff support systems (45.6%), quality and safety systems (32.0%) and health information systems (29.2%). Clinical quality of care scored 56.9% on record review and 37.3% on direct observations of care (Table 3).

Service-specific MAMI availability and readiness at five contact points (objectives 2 and 3)

Overall, the MAMI availability and readiness dimension scored 37.7%: 47.9% on availability and 27.4% on readiness.

HHFA-MAMI tool					
Dimensions and areas: PHC	no items	method	Areas and sub-areas: MAMI	no items	method
1. General service availability			3.1 MAMI service availability		
1.1 Health infrastructure	1	registers	Infrastructure MAMI	1x5	interview
	8	observation			
1.2 Health workforce	1	registers	Health workforce MAMI	2x5	interview
	3	interview			
1.3 Services available	1	interview	Assess MAMI	9x5	interview
	5	interview	Classify MAMI	5x5	interview
			Treat MAMI	8x5	interview
2. General service readiness			3.2 MAMI service readiness		
2.1 Amenities	12	interview			
2.2 Basic equipment	12	observation	Equipment and medicine MAMI	8x5	interview, observation
2.3 Infection prevention	11	observation			
2.4 Diagnostic capacity	9	interview	Guidelines and training MAMI	8x5	interview, observation
2.5 Essential medicines and commodities	11	interview			
	6	observation			
4. Management & finance					
4.1 Facility governance and management	6	interview			
4.2 Facility finances and accounting	6	interview			
4.3 Staff support systems	6	interview			
4.4 Quality and safety systems	5	interview			
4.5 Health information systems	8	interview			
5. Quality of care					
5.1 Record review	6	registers			
	6	registers			
5.2 Direct observation of care	9	observation			
	5	observation			

Figure 2. HHFA-MAMI tool dimensions, areas, number of items and methods for data collection. HHFA-MAMI: Harmonized Health Facility Assessment-Management of small and nutritionally At-risk Infants u6m and their Mothers.

Table 2. Characteristics of the target population and service utilization (n=15 PHC facilities)

Target population for selected primary health facilities (n=15)	(median, IQR)
Target whole population	14 557 (9079–26 098)
Expected births	596 (373–963)
Target population u6m	320 (213–415)
Service utilization (number of visits in 2022)	
Curative care visits all ages (n=15)	4202 (2990–9190)
Delivery (n=15)	295 (151–410)
Postnatal care (n=15)	578 (315–1319)
Immunization (n=15)	719 (389–1541)
Sick child clinic (n=15)	216 (133–419)
Community health (n=8)	248 (102–482)

PHC: primary healthcare.

Infrastructure (72.0%) and health workforce (60.7%) scored higher than assess (53.6%), classify (15.2%) and treat (38.2%) MAMI. Equipment scored 32.5%, and guidelines and training 22.3% (Table 3). Comparing the contact points, delivery (50%)

and sick child clinic (47%) scored highest. Scores per subarea for each of the five contact points are shown in Figure 3. The complete list of MAMI availability and readiness items is visualized in a heatmap in Figure 4.

Table 3. HHFA-MAMI results: PHC dimensions and MAMI availability and readiness dimension scores

Dimensions and areas	HHFA-MAMI results Subareas (number of items)	Mean % (n=15)		
		subarea	area	dimension
1. General service availability				50.6
1.1 Health infrastructure	Primary health facility density ^a (1) Building structure and security conditions (8)	26.7 73.4	50.0	
1.2 Health workforce	Health workforce density ^b (1) Staffing plan (3)	13.3 28.9	21.1	
1.3 Services available	Outpatient service availability 24 h/day (1) Availability of infant services (5)	66.7 94.7	80.7	
2. General service readiness				69.5
2.1 Amenities	Basic amenities main service area (12)	67.8	67.8	
2.2 Basic equipment	Basic equipment outpatient area functional (12)	62.8	62.8	
2.3 Infection prevention	Standard precautions for infection prevention (11)	75.8	75.8	
2.4 Diagnostic capacity	Basic diagnostic capacity (9)	80.7	80.7	
2.5 Essential medicines and commodities	Essential medicines (11) Pharmaceutical commodity storage (6)	46.1 74.4	60.3	
3. MAMI availability and readiness				37.7
3.1 MAMI service availability	Infrastructure MAMI (1×5) Health workforce MAMI (2×5) Assess MAMI (9×5) Classify MAMI (5×5) Treat MAMI (8×5)	72.0 60.7 53.6 15.2 38.2	47.9	
3.2 MAMI service readiness (n=15)	Equipment and medicine MAMI (8×5) Guidelines and training MAMI (8×5)	32.5 22.3	27.4	
4. Management and finance				50.2
4.1 Facility governance/ management (6)			84.4	
4.2 Facility finances and accounting (6)			60.0	
4.3 Staff support systems (6)			45.6	
4.4 Quality and safety systems (5)			32.0	
4.5 Health information systems (8)			29.2	
5. Quality of care				47.1
5.1 Record review	Record review immunization (6) Record review sick child clinic (6)	44.1 69.7	56.9	
5.2 Direct observation of care	Service delivery observations (9) General observations (5)	38.3 36.3	37.3	

HHFA: Harmonized Health Facility Assessment; MAMI: Management of small and nutritionally At-risk Infants u6m and their Mothers; PHC: primary healthcare.

^acompared with standard 1/10 000 people.

^bcompared with standard 2.5 primary care workers/1000 people.²⁸

Infrastructure

Care for infants u6m was available mostly 7 d a week at the contact points delivery, postnatal care and sick child clinics, while immunization was often provided weekly. Community health activities were provided monthly and were not offered in the urban district.

Health workforce

Midwives or state nurses, who could potentially care for at-risk infants, provided delivery care, postnatal care and sick child care in

our study facilities. Lower trained healthcare providers provided immunization service and community healthcare. Numbers of healthcare providers were lowest in sick child clinics (27% at least three providers), while community health had the most service providers (13 on average).

'Assess'

Healthcare providers reported that weight was taken at all contact points, while at delivery, a detailed anthropometric assessment was done, including weight and length (100% of facilities) and mid-upper-arm-circumference (MUAC) (93%). Midwives

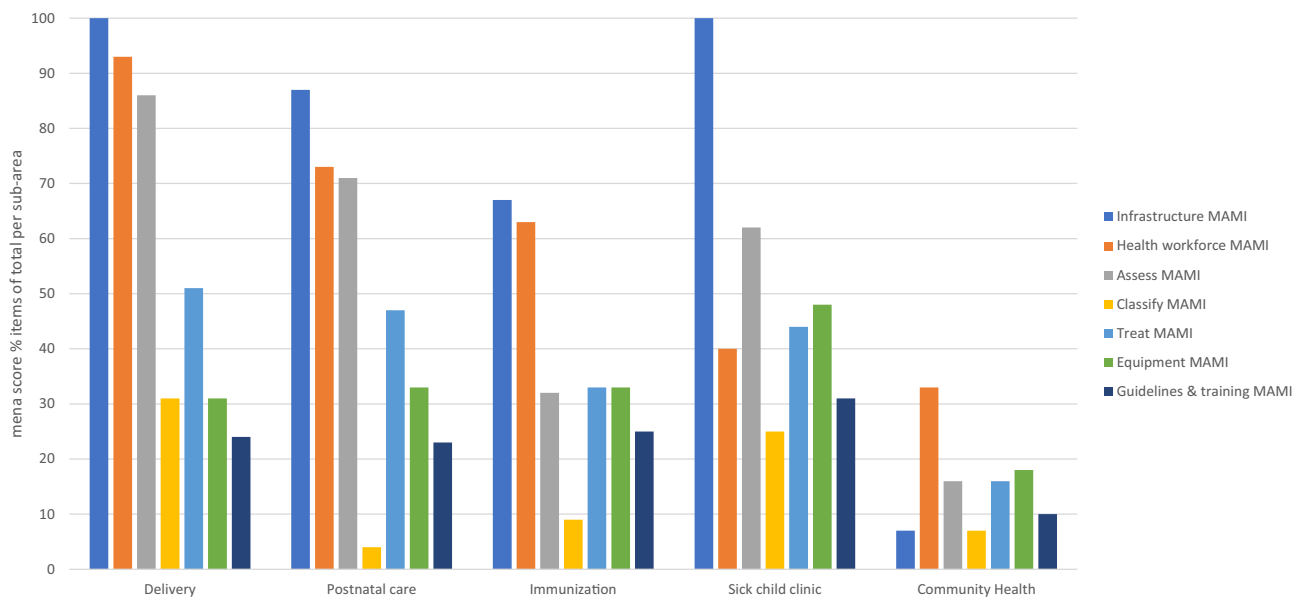


Figure 3. MAMI service availability and readiness subareas mean scores for five care contact points for infants $u6m$ (n=15 PHC facilities). MAMI: Management of small and nutritionally At-risk Infants $u6m$ and their Mothers; PHC: primary healthcare.

routinely observed breastfeeding after birth (100%), some routinely asked for feeding difficulties (60%). Most midwives also reported conducting assessment of maternal nutritional status (93%) and maternal mental health (87%), although the survey did not collect information on this. Infant physical examination was reported to be done by midwives (73% at delivery, 67% at postnatal care) and at sick child clinics (80%).

'Classify'

Classification of adverse birth outcomes or at-risk infants $u6m$ scored low overall (15%). Midwives reported detecting LBW (100%) and sometimes prematurity (47%). Nurses classified infants as wasted/non-wasted (80%) at sick child clinics, using weight for length, rarely MUAC (7%). At immunization programs, weight was sometimes plotted for age (27%) or for length (20%). At postnatal care and community health, classification was rarely done.

'Treat'

Referral of at-risk infants was reported in 84% of all five contact points at the 15 facilities, either to a different facility contact point (e.g. sick child clinic) or externally. Breastfeeding counseling was reported at delivery and postnatal care (100%), immunization programs (80%) and sick child clinics (80%). At more than two-thirds (67%) of the delivery and postnatal care contact points, and at more than one-half (53%) of the sick child clinics, providers reported regular prescription of infant formula. Explanation of growth charts to the mother occurred at 27% of immunization programs and 20% of sick child clinics. Medical treatment for infants was provided at birth (93%), postnatal care (87%) and sick child clinics (100%). Community follow-up was mostly absent.

Equipment

In 93% of the facilities, an adult scale was seen at the general outpatient area, but rarely (7%) at the contact points for infants $u6m$. All facilities had at least one functioning infant scale, most (13) facilities an analog scale, five a digital, five a SECA-876 mother/baby scale and at 12 a Salter scale. Healthcare providers at most (12) facilities stated that their equipment is usually calibrated. A standardized length board was observed in all 15 health facilities, in sick child clinics (100%) and immunization programs (53%). A standardized colored MUAC tape was seen in 100% of sick child clinics and 53% of immunization programs. At delivery and postnatal care, a non-recommended simple measuring tape was seen, used for taking both length and MUAC. Growth charts for weight and length were observed in 5% of the total contact points, although these were present in parent-held immunization booklets that could not be verified in this study. Laminated weight for height Z-score tables was observed, at consultation desks at sick child clinics (20%). In community healthcare we saw a customized 'look-up table' to determine expected monthly weight gain (independent of the infants' age).²⁹ Infant formula milk was not observed to be stocked at any of the facilities.

Guidelines and training

In more than one-half (53%) of the sick child clinics, IMCI-related guidelines were observed, often displayed on walls. Breastfeeding visual aids existed in the immunization booklets, and midwives reported using them for breastfeeding counseling after birth (93%) and during postnatal care (93%). Staff training at contact points over the previous 3 y was most frequent on immunization (40%), malnutrition (36%) and IMCI (12%). Guidelines or referral criteria for infants with LBW or malnutrition $u6m$ were not seen.

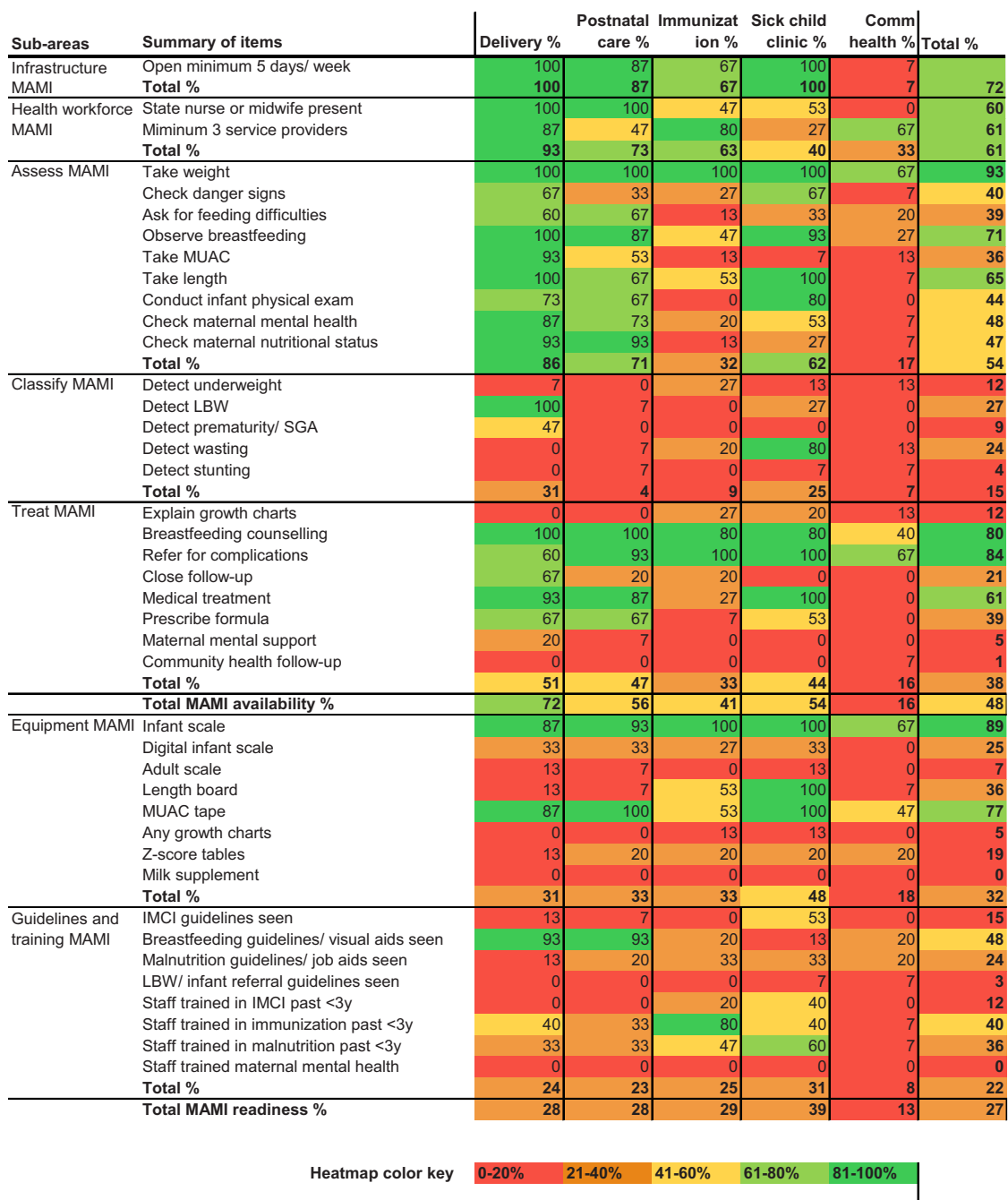


Figure 4. MAMI availability and readiness items mean scores for five care contact points for infants u6m (n=15 PHC facilities). MAMI: Management of small and nutritionally At-risk Infants u6m and their Mothers; PHC: primary healthcare.

Discussion

The HHFA-MAMI survey in 15 primary health facilities in Senegal found high (69.5%) general primary care service readiness and some (37.7%) availability and readiness to care for infants u6m at risk of poor growth and development. Infrastructure for MAMI

(72.0%) and health workforce (60.7%) were available, while equipment (32.5%) and training (22.3%) were low and varied between care contact points for infants u6m. Among the three steps, infants were frequently assessed (53.6%) including for anthropometry, but not often classified (15.2%) as at risk, which is essential for adequate treatment (38.2%) as outpatients and

referral for complications. We found opportunities at each of the five contact points to implement WHO nutritional recommendations for at-risk infants u6m.

Interpretation

The HHFA has been created to evaluate existing health services; however, we found our HHFA-MAMI informative at the preimplementation phase of the WHO guidelines. When gaps shown in this study are addressed, low scores could improve while implementing the WHO recommendations. Repeated readiness analysis has been used in more general maternal and child services in Senegal.³⁰ Similarly, for small and sick newborns, the NEST360 Alliance has developed a readiness assessment tool, used for repeated analysis of hospital care.¹⁷

Our HHFA-MAMI general service readiness of 69.5% was higher than other studies that assessed PHC readiness, for example, 60.5% in Bangladesh and 61.5% in Mongolia.^{31,32} Our HHFA general service availability showed neither facility density nor health worker density meeting WHO standards, which are important indicators of primary care coverage.³³ Management and finance is rarely included in readiness studies; when assessed, this dimension scored poorest.²⁵ Our low scores for health information systems (29.2%) and quality systems (32.0%) will require attention, implementing new services. The 'quality of care' dimension is essential in the HHFA, because readiness measured by only structural inputs has shown to poorly correlate with quality of care.³⁴

Although our data did not allow calculating service coverage, the service utilization provided insight into opportunities for MAMI care at highly utilized contact points such as immunization. Combining service utilization with readiness has earlier been described as a useful way to assess effective coverage.³⁵

Addressing MAMI readiness gaps at PHC contact points in Senegal

After facility births in Senegal, midwives routinely measure birth weight, length and MUAC, and LBW is frequently detected. These measurements align with the novel WHO recommendations and could be used to identify at-risk infants at birth. However, MUAC in infants u6m needs more evidence to validate cut-off values and improve MAMI readiness.³⁶

At postnatal care, breastfeeding support was routinely provided in our study facilities, and extending this practice beyond the neonatal age would be crucial to improve MAMI readiness.³⁷ A standardized breastfeeding assessment tool could help identify those at risk, needing closer support.³⁸ Infant formula prescription was frequently reported in our study and new WHO guidelines could support supplementary feeding counseling.

Immunization services are well utilized in Senegal, providing opportunities to detect and care for at-risk infants u6m. Integration of nutrition and immunization services is an important domain of further study.³⁹ Weight is routinely taken at immunization, and new research showed weight for age to detect most children at risk of mortality.⁴⁰ However, there is a need for improved usage of growth charts or simplified tools such as lookup tables to close this readiness gap.⁴¹

Sick child clinics in Senegal apply IMCI, although concerns have been expressed regarding fidelity to guidelines.³⁰ The MAMI Care Pathway uses the IMCI structure 'assess, classify, treat', which could be beneficial, aligning WHO guidelines to existing IMCI care and making PHC more ready for MAMI. Maternal mental health support is an important element in the new WHO guidelines, which complements IMCI and could contribute to improving nutritional outcomes.⁴²

Community healthcare provides opportunities in detecting at-risk infants, with large numbers of healthcare providers at this contact point in our study. To benefit from these human resources, there is a need for supervision and clinical mentoring to strengthen MAMI readiness.⁴³

Strengths and limitations

Our study describes the first adaptation of the HHFA for assessment of u6m infant nutrition. We used this tool because it is more comprehensive than older tools, but being novel, this makes our study less comparable with similar studies. The number of nutritional items captured in our tool is limited, not covering all the risk factors underlying infant malnutrition, although feasible in a 2-d data collection.⁴⁴ Another limitation is that cut-off points for readiness scores have not yet been defined. Readiness cut-offs should be linked to outcomes, and these data are currently not available in the literature. Therefore, our scores are currently valid, but future validation studies are needed.

Generalizability

A recent stakeholder consultation in 42 countries revealed a perceived need for improved management of at-risk infants u6m.⁴⁵ Senegal was mentioned as an exemplar country in an earlier study on stunting reduction, because of its effective implementation of nutrition policy and multisectoral approach.⁴⁶ The HHFA-MAMI survey tool we developed and future WHO guidelines implementation lessons learned from Senegal might therefore set an example to countries in the region and beyond.

Conclusion

Primary care facilities in Senegal have the potential to provide WHO-recommended care for nutritionally at-risk infants u6m, with high general primary care readiness and high service utilization, especially in immunization. Our HHFA-MAMI survey identified gaps in classifying and treating at-risk infants, equipment and training, while the existing infrastructure and health workforce provide opportunities to facilitate implementation.

Supplementary data

Supplementary data are available at [International Health](https://doi.org/10.1093/infdis/jnab020) online.

Authors contributions: TDvI, LTD and AB conceived the study; TDvI, AB, MK and CSGE designed the study protocol; TDvI, AB, AM and CSGE worked on the data collection tool; TDvI, DS, AD and MD worked on data collection; TDvI, AB, MD, ID and REP worked on analysis and interpretation of these data. TDvI drafted the manuscript; LTD, MK, REP, ID and MD

critically revised the manuscript for intellectual content. All the authors read and approved the final manuscript.

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References

- 1 Victora CG, Christian P, Vdaletti LP, et al. Revisiting maternal and child undernutrition in low-income and middle-income countries: Variable progress towards an unfinished agenda. *Lancet*. 2021;397(10282):1388–99.
- 2 *The Biology of the First 1000 Days*. Abingdon, UK: CRC Press: Taylor & Francis Group; 2018.
- 3 Lawn JE, Ohuma EO, Bradley E, et al. Small babies, big risks: Global estimates of prevalence and mortality for vulnerable newborns to accelerate change and improve counting. *Lancet*. 2023;401(10389):1707–19.
- 4 Kerac M, James PT, McGrath M, et al. Infant malnutrition in low- and middle-income countries: Assessment and prevalence of small and nutritionally at-risk infants aged under 6 months in 54 Demographic & Health Survey datasets. medRxiv. 2021.
- 5 Mertens A, Benjamin-Chung J, Colford JM Jr, et al. Child wasting and concurrent stunting in low- and middle-income countries. *Nature*. 2023;621(7979):558–67.
- 6 Grijalva-Eternod CS, Beaumont E, Rana R, et al. Malnutrition in infants aged under 6 months attending community health Centres: A cross sectional survey. *Nutrients*. 2021;13(8):2489.
- 7 Kirolos A, Goyheneix M, Kalmus Elias M, et al. Neurodevelopmental, cognitive, behavioural and mental health impairments following childhood malnutrition: A systematic review. *BMJ Glob Health*. 2022;7(7):e0093990.
- 8 Grey K, Gonzales GB, Abera M, et al. Severe malnutrition or famine exposure in childhood and cardiometabolic non-communicable disease later in life: A systematic review. *BMJ Glob Health*. 2021;6(3):e003161.
- 9 ANSD. Enquête Démographique et Sanitaire Du Sénégal 2023. Dakar, Senegal: Republique du Sénégal; 2024.
- 10 Kerac M, Mwangome M, McGrath M, et al. Management of acute malnutrition in infants aged under 6 months (MAMI): Current issues and future directions in policy and research. *Food Nutr Bull*. 2015; 36(1):S30–4.
- 11 van Immerzeel TD, Camara MD, Deme Ly I, et al. Inpatient and outpatient treatment for acute malnutrition in infants under 6 months; a qualitative study from Senegal. *BMC Health Serv Res*. 2019;19(1):69.
- 12 ANSD. Sénégal: Enquête Continue sur la Prestation Des Services De Soins De Santé (ECPSS) 2019. Rapport Des Indicateurs Clés. Dakar, Senegal: The DHS Program ICF; 2020.
- 13 WHO. Guidelines on the prevention and management of wasting and nutritional oedema (acute malnutrition) in infants and children under 5 years. 2023. Available at <https://www.who.int/publications/i/item/9789240082830> [accessed 12 December, 2023].
- 14 Kelsey Grey EB, Kerac M, McGrath M. The MAMI Care Pathway Package: A resource to support the management of small and nutritionally at-risk infants under six months of age and their mothers (MAMI). *South Sudan Medical Journal*. 2021;14:94–7.
- 15 Moxon SG, Guenther T, Gabrysch S, et al. Service readiness for inpatient care of small and sick newborns: What do we need and what can we measure now? *J Glob Health*. 2018;8(1):010702.
- 16 WHO. Service availability and readiness assessment (SARA): An annual monitoring system for service delivery: Reference manual 2013. Available at <https://www.who.int/data/data-collection-tools/service-availability-and-readiness-assessment-sara> [accessed 23 November, 2023].
- 17 Penzias RE, Bohne C, Ngwala SK, et al. Health facility assessment of small and sick newborn care in low- and middle-income countries: Systematic tool development and operationalisation with NEST360 and UNICEF. *BMC Pediatr*. 2024;23(Suppl 2):655.
- 18 Ssensamba JT, Mukuru M, Nakafeero M, et al. Health systems readiness to provide geriatric friendly care services in Uganda: A cross-sectional study. *BMC Geriatr*. 2019;19(1):256.
- 19 Oluwole EO, Adeniran A, Chieme CF, et al. Maternal and child health service readiness among primary health care facilities in Ekiti, Nigeria. *Afr J Prim Health Care Fam Med*. 2022;14(1):e1–7.
- 20 Ramadan M, Muthee TB, Okara L, et al. Existing gaps and missed opportunities in delivering quality nutrition services in primary health-care: A descriptive analysis of patient experience and provider competence in 11 low-income and middle-income countries. *BMJ Open*. 2023;13(2):e064819.
- 21 WHO. Harmonized health facility assessment. 2022. Available at <https://www.who.int/data/data-collection-tools/harmonized-health-facility-assessment> [accessed 13 December, 2022].
- 22 EQUATOR. Enhancing the QUALITY and transparency of health research. 2023. Available at <https://www.equator-network.org/reporting-guidelines/> [accessed 10 October 2023].
- 23 MSAS. Plan National de Développement Sanitaire et Social Du Sénégal 2019- 2028. Dakar, Senegal: Republique du Sénégal; 2019.
- 24 Chaulagain DR, Malqvist M, Wrammert J, et al. Service readiness and availability of perinatal care in public hospitals—a multi-centric baseline study in Nepal. *BMC Pregnancy Childbirth*. 2022;22(1):842.
- 25 Ssensamba JT, Mukuru M, Nakafeero M, et al. Health systems readiness to provide geriatric friendly care services in Uganda: A cross-sectional study. *BMC geriatrics*. 2019;19(1):1–13.
- 26 Hartung C. Open Data Kit: Tools to Build Information Services for Developing Regions. In: ICTD, San Diego, US: ODK Inc; 2010.

- 27 Microsoft Corporation. Microsoft Excel. 2402 ed. Washington, US; 2018.
- 28 WHO. Global Health Observatory data repository. By category, health workforce, 2018. Available at <https://apps.who.int/gho/data/?theme=main> [accessed 17 October, 2023].
- 29 CNDN. Table poids attendu. 2019. Available at <https://cndn.sn/bon-a-savoir/enfant/> [accessed 17 October, 2023].
- 30 Leslie HH, Hategeka C, Ndour PI, et al. Stability of healthcare quality measures for maternal and child services: Analysis of the continuous service provision assessment of health facilities in Senegal, 2012–2018. *Trop Med Int Health*. 2022;27(1):68–80.
- 31 Shawon MSR, Adhikary G, Ali MW, et al. General service and child immunization-specific readiness assessment of healthcare facilities in two selected divisions in Bangladesh. *BMC Health Serv Res*. 2018;18(1):39.
- 32 Jigjidsuren A, Byambaa T, Altangerel E, et al. Free and universal access to primary healthcare in Mongolia: The service availability and readiness assessment. *BMC Health Serv Res*. 2019;19(1):129.
- 33 Ahmat A, Asamani JA, Abdou Illou MM, et al. Estimating the threshold of health workforce densities towards universal health coverage in Africa. *BMJ Glob Health*. 2022;7(Suppl 1):e008310.
- 34 Leslie HH, Sun Z, Kruk ME. Association between infrastructure and observed quality of care in 4 healthcare services: A cross-sectional study of 4,300 facilities in 8 countries. *PLoS Med*. 2017;14(12):e1002464.
- 35 Wang W, Mallick L, Allen C, et al. Effective coverage of facility delivery in Bangladesh, Haiti, Malawi, Nepal, Senegal, and Tanzania. *PLoS One*. 2019;14(6):e0217853.
- 36 Hoehn C, Lelijveld N, Mwangome M, et al. Anthropometric criteria for identifying infants under 6 months of age at risk of morbidity and mortality: A systematic review. *Clin Med Insights: Pediatrics*. 2021;15:11795565211049904.
- 37 Rana R, McGrath M, Gupta P, et al. Feeding interventions for infants with growth failure in the first six months of life: A systematic review. *Nutrients*. 2020;12(7):2044.
- 38 Brugaletta C, Le Roch K, Saxton J, et al. Breastfeeding assessment tools for at-risk and malnourished infants aged under 6 months old: A systematic review. *F1000Res*. 2020;9:1310.
- 39 B. Andreuzzi MK, Andreuzzi B, Kerac M. Integrating infant and Young child feeding (IYCF) interventions into immunization programmes for children under two: A systematic review. 2019. Available at https://www.crd.york.ac.uk/prosperto/display_record.php?ID=CRD42019142028 [accessed 25 August, 2024].
- 40 Khara T, Myatt M, Sadler K, et al. Anthropometric criteria for best-identifying children at high risk of mortality: A pooled analysis of twelve cohorts. *Public Health Nutr*. 2023;26(4):803–19.
- 41 Pannapat Amy Chanyarungrojn NL, Crampin A, Nkhwazi L, et al. Tools for assessing child and adolescent stunting: Lookup tables, growth charts and a novel appropriate-technology “MEIRU” wallchart—a diagnostic accuracy study. 2023.
- 42 Tol WA, Greene MC, Lasater ME, et al. Impact of maternal mental health interventions on child-related outcomes in low- and middle-income countries: A systematic review and meta-analysis. *Epidemiol Psychiatr Sci*. 2020;29:e174.
- 43 Daka DW, Wordofa MA, Berhanu D, et al. Quality of sick child management by health extension workers: Role of a complex improvement intervention. *BMC Health Serv Res*. 2023;23(1):165.
- 44 Kerac M, Frison S, Connell N, et al. Informing the management of acute malnutrition in infants aged under 6 months (MAMI): Risk factor analysis using nationally-representative demographic & health survey secondary data. *PeerJ*. 2019;6:e5848.
- 45 van Immerzeel TD, Diagne M, Deme/Ly I, et al. Implementing a care pathway for small and nutritionally at-risk infants under six months of age: A multi-country stakeholder consultation. *Matern Child Nutr*. 2022;19(1):e13455.
- 46 Brar S, Akseer N, Sall M, et al. Drivers of stunting reduction in Senegal: A country case study. *Am J Clin Nutr*. 2020;112(Suppl 2):860S–74S.