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Evaluation of primary healthcare worker training to screen children under 5 years of age with a low-cost alternative to the direct ophthalmoscope, the 'Arclight', as part of the Integrated Management of Newborn and Childhood Illness (IMNCI) programme in Tanzania

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ABSTRACT

Objective To evaluate the integration of childhood eye screening with the Arclight direct ophthalmoscope into an already existing WHO/UNICEF Integrated Management of Newborn and Childhood Illness (IMNCI) programme in Tanzania.

Design Prospective interventional study.

Setting Primary healthcare facilities in a semirural district, central Tanzania.

Participants Two IMNCI (Integrated Management of Newborn and Childhood Illness) facilitators received training enhanced with four newly developed videos on using the Arclight. These facilitators then trained 378 primary healthcare workers (PHCWs) who were already familiar with the IMNCI 'Eye Module'. The training covered how to perform red reflex testing with the Arclight device, interpret the results and appropriately refer children who failed the screening.

Intervention 'Arclight' direct ophthalmoscope and training of primary healthcare workers.

Main outcome measures Number of children screened and diagnosed with eye conditions.

Results Over 4 months, 2 trained IMNCI facilitators trained 378 PHCWs on how to use the Arclight direct ophthalmoscope to screen children's eyes. Over a 6-month period, 36 000 children were screened in primary care settings with 136 seen at district level facilities and 105 referred to regional and tertiary facilities. The most common diagnoses of children referred were allergic conjunctivitis (37.4%), bacterial conjunctivitis (31.2%) and cataract (7.1%). There were six cases of ophthalmia neonatorum (3.9%) and two cases of retinoblastoma (1.3%). The incidence rate per 10 000 children of cataract was 3.05, ophthalmia neonatorum 1.67 and retinoblastoma 0.55.

Conclusion Primary healthcare workers in Tanzania can be trained to screen for eye disease in babies and children using the Arclight direct ophthalmoscope as part of an ongoing child health programme leading to the detection of treatable and

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The WHO Postnatal Care Guidelines recommend screening of all newborns for eye disease; however, this rarely occurs in low and middle-income countries (LMICs). The WHO/UNICEF Integrated Management of Newborn and Childhood Illness (IMNCI) child health programme in Tanzania now includes eye care but a practical means to deliver eye screening of newborns was not included. This was due to the lack of suitable screening devices and trained personnel. This study is consequently important to establish evidence on how to scale eye screening of all children in LMICs.

WHAT THIS STUDY ADDS

⇒ Primary healthcare workers can be trained to use the low-cost alternative to the direct ophthalmoscope, the 'Arclight', to screen for eye disease in newborns and children under 5 years old within an ongoing child health programme. This training and subsequent screening can lead to children with serious conditions such as cataract and retinoblastoma being diagnosed. This model of training and delivery is practical, potentially sustainable and scalable.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study provides a model to implement the WHO recommendations to screen all children after birth for eye disease. The training of primary healthcare workers was integrated into an ongoing WHO/UNICEF programme in Tanzania, the Integrated Management of Newborn and Childhood Illness (IMNCI) and could be used to scale eye screening for children under 5 years old in over 100 countries where the IMNCI programme is active.

serious eye diseases. Training all PHCWs would allow every child under 5 years old to be screened for eye disease, detecting serious eye conditions such as cataract and retinoblastoma earlier preventing avoidable childhood blindness and mortality.

INTRODUCTION

Globally, 70.2 million children are estimated to have sight loss, 1.4 million of whom are blind.[1] The vast majority of children with sight loss live in Africa, Asia and South America. Early identification and management of childhood eye conditions is essential as delays can affect visual development leading to permanent visual impairment.[2–4]

In Tanzania, the prevalence of blindness in children under 5 years is estimated to be 5 per 10 000 children although likely to be higher in poorer rural communities.[5] This is in line with the regional prevalence of blindness in sub-Saharan Africa calculated to be 7.1 per 10 000 children. This includes refractive error not typically included in under five prevalence estimates.[1]

Most blindness in children is caused by congenital disorders or from eye disease acquired before the age of 5 years.[6] Any condition which deprives a child of vision can lead to developmental delay affecting motor, cognitive, social and emotional development, which can also impact their subsequent educational attainment.[7]

The major causes of blindness in children are congenital and developmental cataract, corneal scarring (from measles infection, vitamin A deficiency and conjunctivitis of the newborn) and genetic retinal dystrophies and structural abnormalities such as coloboma. Approximately 40%–50% of the causes of blindness in children are preventable or treatable and can be detected by eye screening.[5] Screening can also identify the rare but devastating eye cancer retinoblastoma.

A systematic review highlights that in high-income settings, newborn eye screening in maternity wards is effective in increasing newborns' congenital cataract referrals and the number of babies operated on by 6 weeks of age.[8] The effect was similar in well-baby clinics (before 6 weeks of age) but the certainty of the evidence was lower. These studies were undertaken in a high-income setting with primary outcomes based on that context where best practice guidelines aim to operate on newborns with congenital cataracts by 6 weeks of age. In high-income settings, children are screened for eye disease at birth and 6–8 weeks of age with additional opportunistic community eye examinations offered, if caregivers have concerns. Routine newborn eye screening is rarely performed in low and middle-income countries due to shortages of both trained personnel and necessary equipment. Although the WHO postnatal care guidelines now recommend newborn eye screening in all settings,[9] a recent review of all published national guidelines globally for newborn eye screening identified recommendations in only eight guidelines across five countries (USA, Canada, UK, New Zealand and India), with India being the only low-resource setting among them.[8]

To address lack of eye screening for children under 5 years of age in low-resource settings, a study based in Tanzania developed an eye care module training package for primary healthcare workers (PHCWs). This was integrated into the ongoing WHO/UNICEF Integrated Management of Newborn and Childhood Illness (IMNCI) programme in Tanzania.[10] The IMNCI strategy was designed to promote integrated services to reduce mortality and morbidity among young children from the main treatable and preventable diseases in countries with high under five mortality rates.[11] Over 100 countries have now adopted IMNCI to varying degrees and although it includes ear conditions, up until now, eye conditions have not been included. The IMNCI model has however been shown to be effective and has become national policy in Tanzania leading to more than 3000 trained PHCWs in the country.[10] The eye module developed in Tanzania included 'red reflex testing' of children's eyes as a screening tool for eye disease, such as cataract and retinoblastoma. However, red reflex screening, as part of eye screening, had never been implemented due to a lack of an affordable and effective ophthalmoscope.

To address the lack of a suitable ophthalmoscope for this setting, the Arclight has been developed. It is a low-cost, solar-powered alternative and has previously been shown to be an effective tool to deliver 'red reflex testing' in workshops, clinic and the community.[12–15] The device is particularly suited for low-resource settings for several key reasons. It requires no consumables like batteries or bulbs, is highly portable and robust, and is simple to use. Importantly, its low cost (approximately $15) makes it realistic to equip even community healthcare workers.

This study consequently aimed to develop a training programme to teach PHCWs to use the Arclight for eye screening within the existing IMNCI programme. The goal was to evaluate if it is possible to create a practical, scalable model for implementing routine eye screening for children from birth to 5 years of age in low and middle-income countries (LMICs).

METHODS

Study design and setting

The London School of Hygiene and Tropical Medicine (LSHTM) previously in partnership with Muhimbili University of Health and Allied Sciences (MUHAS) and the Ministry of Health created a training curriculum on eye conditions and red reflex testing for PHCWs (the Eye Module) for inclusion into the IMNCI programme in Tanzania. This was endorsed by the Ministry of Health in Tanzania and is now in routine use. This current study was conducted by Kilimanjaro Christian Medical Centre (KCMC) in partnership with LSHTM, University of St Andrews and MUHAS to include training PHCWs on red reflex testing who were already trained in the Eye Module as part of their routine IMNCI training.[10]

Four training videos were developed on how to use the Arclight for eye screening in children. A fifth video

illustrated how to conduct a training workshop. These were designed to be complementary to the current IMNCI eye training module. The IMNCI facilitators were trained on how to use the Arclight and training materials at a 2-day meeting by the authors. The IMNCI facilitators began training PHCWs as part of 'Supportive Supervision' which is a routine structure in Tanzania designed to ensure quality of care from PHCWs.[16] The facilitators would conduct a 2-hour training session with PHCWs where they would demonstrate the use of the Arclight, show the videos and then give a 'hands on' training where the PHCWs would practice using the Arclight on each other. The training sessions focused on familiarising PHCWs with the Arclight, how to effectively screen children's eyes including positioning the child during screening as well as looking for signs of external eye disease and low vision. The PHCWs were trained to use the Arclight in undilated pupils and in darkened rooms. PHCWs were also taught how to counsel carers, and, with the use of referral slips, explain how to access referral sites for children who fail screening. The trainers were asked to emphasise the importance of screening newborns within 8 weeks of birth, and an equal number of girls and boys. PHCWs were then encouraged to start systematic screening as soon as the training had been undertaken.

Selection of sites and participants

District level facilities also have PHCWs which are trained in IMNCI but these are mainly clinical and medical officers. They are able to treat some conditions once trained. Otherwise, regional and tertiary centres (can be national, subnational) are the referral centres where trained PHCWs would refer children for specialist treatment. 39 primary and secondary healthcare sites in Tanga and Kilimanjaro regions were selected by the Ministry of Health for this study. The sites were chosen based on:

1. Having received training with IMNCI and eye care module in the last 24 months.
2. 'Supportive Supervision' being planned as part of routine primary and IMNCI follow-up.
3. Availability of IMNCI facilitators to conduct training.

All PHCWS who were already trained in IMNCI at the sites received the training as part of their 'Supportive Supervision.' The PHCWs can range from nurses to clinical officers and medical officers (therefore with some basic medical training). In this context, 'Supported supervision' is conducted by an IMNCI trainer or supervisor to follow-up on training to check that the training is being implemented effectively by PHCWs and to give any guidance and support as needed.

The screening was all done at primary health facilities by the PHCWs trained, only for those children already attending for other reasons, that is, there was no mechanism put in place to get more children to attend or ensure they attend. The training was part of IMNCI training which included three types of examinations: (1) newborn eye screening (part of newborn module), (2) well child screening (part of well child module) and (3) children where mothers/caregivers reported eye problems (this may or may not be part of their reason for attendance). The well child screening is opportunistic or done with growth monitoring visits but not done routinely as part of routine immunisation visits (as these are very busy clinics); although, this was encouraged.

Data collection

A data collection system was put in place which recorded gender and work location of trained IMNCI facilitators and PHCWs. Data were collected from each of the health centres on children screened by trained PHCWs for 6 months including outcome of screening (pass/fail, treatment, referral). Caregivers whose children failed the screening were counselled on why they were being referred and where to go (regional hospital with an eye care professional) with the use of referral slips. Data from primary healthcare facilities were collected monthly from the IMNCI leads for each district who would collect the eye screening forms. Data were collected from the regional referral hospitals on children who were referred from the trained PHCWs on their outcomes and treatment from hospital clinic registers. Any children who were referred and not seen at the hospital were contacted by phone by the research eye clinic nurse and counselled and supported as needed to improve referral uptake.

Data analysis

All the data collected on the screening and referrals were double-entered and managed in Excel (Microsoft). The analysis was performed in STATA (Version 17 StataCorp LLC, College Station, Texas, USA), which was used for statistical analysis.

Patient and public involvement

While patients and community members were not directly involved in the design, conduct or reporting of this research, the study was developed in close collaboration with the Tanzanian Ministry of Health and built on the existing IMNCI programme.

RESULTS

A total of 378 PHCWs were trained (164 PHCWs from Tanga and 214 from Kilimanjaro region). Training was conducted between December 2022 and February 2023. 70% of the trained PHCWs were female reflecting that there are more nurses than clinicians (clinical officer and medical officers) at the primary care level and the majority of nurses are female.[10]

During the 6 months (March to August 2022), 36 000 children were screened. 105 children were referred to regional and tertiary facilities with 29 successfully attending but 76 failing to attend. Of those who attended, 15 were treated at the tertiary level hospital and 14 at the regional hospital (table 1). 11 had cataracts, 2 retinoblastoma, 1 squint and 1 child with glaucoma.

Table 1 Diagnoses made at regional and tertiary level facilities over 6 months

Diagnoses	# of cases	Incidence rate per 10 000 children
Tertiary hospital		
Cataract	11	3.05
Retinoblastoma	2	0.55
Glaucoma	1	0.28
Squint	1	0.28
Regional hospital		
Orbital cellulitis	1	0.28
Chalazion	1	0.55
Cornea ulcer	1	0.28
Eye injury/trauma	2	0.55
Corneal foreign body	2	0.55
Nasal lacrimal duct obstruction	1	0.28
Ophthalmia neonatorum	6	1.67
Total	29	

136 children were seen and treated at district hospitals with the most common diagnosis being allergic or bacterial conjunctivitis (table 2). These children had been seen by trained PHCWs who also can work at district level facilities, most of whom are clinical officers or medical officers therefore more able to make diagnosis and treat.

Table 2 Diagnoses made at district level facilities over 6 months

Diagnoses	# of cases	Incidence rate per 10 000 children
Allergic conjunctivitis	62	17.22
Bacterial conjunctivitis	58	16.11
Eye injury	3	0.28
Orbital cellulitis	1	0.28
Chalazion	2	0.55
Cornea ulcer	1	0.28
Corneal foreign body	2	0.55
Nasal lacrimal duct obstruction	1	0.28
Ophthalmia neonatorum	6	1.67
Swollen lid	1	0.28
Total	136	

DISCUSSION

Maternal and PHCWs are the first point of contact for mothers and children in the critical early months of life. Integrating eye health into child health programmes is new and raises key questions about how best to train, equip and implement screening effectively.[4]

This study describes a means to successfully train PHCWs to use the Arclight, a low-cost direct ophthalmoscope, to perform red reflex testing as part of the WHO/UNICEF IMNCI curriculum. Training workshops used simulation eyes, tailored instructional videos and 'Supportive Supervision' to reinforce learning. The results demonstrate the feasibility of this approach: 378 PHCWs across 39 healthcare sites screened 36 000 children over 6 months without disrupting routine care. This large-scale, low-cost implementation led to the early detection of serious yet treatable conditions, with 115 children referred and 29 receiving specialised treatment for cataract, retinoblastoma and other sight-threatening conditions.

However, despite 105 children being referred for specialist care, only 29 (28%) reached higher-level facilities and received treatment. This highlights a critical barrier in the referral system, where nearly two-thirds of children failed to access specialist assessment. As this was anticipated, a research eye clinic nurse was assigned to call patients referred. However, there were serious gaps in phone numbers obtained and those who answered the calls. This is also not a sustainable intervention but was done to support collecting data on diagnosis of those referred for this study. Despite this, the numbers attending remained low. Our study did not address this issue of poor attendance of referrals but it will be addressed in a future planned study.

Despite the poor attendance rates, the observed incidence rates for cataract (3.05 per 10 000), retinoblastoma (0.55 per 10 000) and ophthalmia neonatorum (1.67 per 10 000) align with published estimates, demonstrating that PHCWs effectively identified cases within the community.[17 18] Crucially, the use of a simple, low-cost device alongside structured, practical training ensured that eye screening was seamlessly incorporated into routine care without burdening PHCWs. This study consequently provides new evidence that integrating eye health into existing child health frameworks is feasible and potentially scalable in low-resource settings. However, further strategies will be needed to strengthen referral pathways and improve access to specialist treatment.

A study in Tanzania previously assessed the feasibility of using the Arclight for screening children under 5 years of age in primary healthcare settings by trained nurses.[13] Most nurses reported they could differentiate a normal from an abnormal red reflex easily, and that the examination took less than 2–3 min to perform. However, there were challenges as they felt that eye screening was an additional burden to their daily activities made worse by already being overstretched, frequent staff shortages, the large numbers of children needing screening and the many other tasks they were obliged to deliver. This is a

challenge in the context of delivery of eye care to children at primary care level as it is an additional task for PHCWs.

One of the advantages of integrating eye care into IMNCI is that PHCWs find it more practical to integrate it into their daily activities and deliver the screening. This has previously been shown in another study from Tanzania.[10] Integrating an easy to use and simplified ophthalmoscope with focused training into an already established and familiar child health programme is likely to have made the additional task more acceptable as part of routine care.

The successful integration of eye care into the IMNCI programme is particularly significant because eye health has traditionally been perceived as too specialised to fall within the role of PHCWs. However, this study demonstrates that when training is embedded within an existing child health framework and supported with the right tools, PHCWs can effectively take on eye screening as part of their routine responsibilities.

A key factor in this success was the use of the Arclight, a frugal yet sophisticated direct ophthalmoscope designed for ease of use in resource-poor settings. Unlike conventional ophthalmoscopes, which require extensive training and maintenance, the Arclight's simple design and intuitive functionality enabled PHCWs to quickly learn and confidently perform red reflex testing. The structured training, delivered through high-quality instructional videos, simulation eyes and practical hands-on workshops, further facilitated the adoption of these skills. The addition of 'Supportive Supervision' reinforced learning, ensuring that PHCWs retained and applied their knowledge effectively in their daily practice.

Importantly, PHCWs in Tanzania already frequently encounter childhood eye disease as it is among the top five most frequently reported issues at the primary care level. Because of this, they are highly motivated to receive additional training on eye screening. The provision of a simple yet effective device further enhanced this motivation, fostering a sense of professional empowerment. Many PHCWs expressed enthusiasm for learning about eye health, recognising that they were now equipped with a tool that not only improved their diagnostic capabilities but also strengthened their position as key frontline healthcare providers.

This increased sense of ownership and responsibility is critical for the long-term sustainability of childhood eye screening in primary care. By combining an easy-to-use device with a well-structured training approach, this study highlights a practical and scalable solution for integrating eye screening into existing child health programmes. The success of this model underscores its potential for widespread adoption in other resource-limited settings, ultimately contributing to earlier detection and treatment of childhood eye diseases and preventing avoidable blindness.

In this study, we trained the PHCWs during 'Supportive Supervision' which is a routine part of IMNCI and primary healthcare system strengthening. 'Supported supervision' is used to describe a range of activities where there is direct observation by a more senior health professional or supervisor to ensure that the correct activities are being performed effectively by PHCWs and to give guidance and support to help them become more effective in their work.[19] It has been shown that the addition of supervision is also more effective than training alone in improving healthcare workers' practices.[20 21] In this case, we included training in the Arclight which lasted around 1–2 hours with both a presentation with videos on how to examine and a practical session where the PHCWs would practice on each other. This relatively short training was possible due to their previous training in child eye health and shows how efficiently training in Arclight can occur in this setting. This shortened training is an important factor in both its sustainability and scalability. IMNCI training has been adapted to a distance learning approach from its traditional 11-day face to face training which has become too costly to continue for many countries.

This work, integrating Arclight training within the IMNCI strategy in Tanzania, was however not just about refining the IMNCI curriculum but was also 'proof-of-concept' for broader implementation within child health programmes globally. By embedding eye screening within a well-established child health programme, this approach demonstrates a scalable model that could be adapted across the more than 100 countries where IMNCI is active.

The key strengths are its feasibility, sustainability and potential for expansion: (a) primary healthcare workers can be trained to conduct routine eye screening effectively, (b) integrating eye care within an existing child health framework ensures acceptability and ease of implementation, and (c) training can be delivered through non-specialist trainers using cost-effective methods. This systematic approach not only validates the inclusion of eye health within IMNCI but also provides a template for replication in other newborn and child health programmes, supporting WHO recommendations for universal newborn eye screening in low-resource settings.[22]

CONCLUSION

Our findings are consistent with the published data on incidence of congenital cataract and retinoblastoma from screening in primary care settings in sub-Saharan Africa. We were able to train PHCWs who already had been trained in child eye health as part of their IMNCI training with a shortened training in using the Arclight device through 'Supported Supervision'. On the basis of this work, in the future, it is planned to incorporate Arclight training into the main IMNCI training in Tanzania as part of the eye health, newborn and well child modules. This approach can be used in other child health programmes and child eye screening could be

included in the WHO African regional office primary eye care training manual, which includes an algorithm for managing eye conditions in children.[18] The WHO Postnatal Care guidelines recommend newborn eye screening, and our approach could also be adapted for postnatal care programmes. This study demonstrates that integrating eye screening into routine child health systems is a practical and scalable solution for the early detection of childhood eye conditions, helping to prevent avoidable blindness. However, the poor attendance rates at referral centres highlight a critical barrier to ensuring timely treatment. To maximise the impact of screening, further efforts are needed to improve referral uptake. Strategies such as enhanced caregiver counselling, community-based follow-up and referral tracking systems could help bridge this gap. Strengthening health system coordination, reducing logistical barriers, and providing transport or telemedicine-based consultations may also improve access to specialist care. Addressing these challenges will be essential for ensuring that early detection translates into timely treatment and better visual outcomes for children in resource-limited settings

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