Cost Effectiveness and Budget Impact Analysis of Delivering Vision Screening and Refractive Error Correction through Integrated School-Based Health Programmes in Ghana and Cambodia

Final Report

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Table of Contents

Acknowledgements

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List of figures

List of tables

Executive summary

The School Health Integrated Programming (SHIP) project was developed to demonstrate how schools can be an effective platform to deliver integrated health interventions, using deworming and vision screening as examples. From January 8 to December 30, 2016, the Project was successfully implemented in four focus countries: Cambodia, Ethiopia, Ghana and Senegal. This analysis aims to assess the incremental costs and cost-effectiveness of vision screening and treating uncorrected refractive error as part of an integrated school-based health program, as well as discuss budget implications for its scale up in Cambodia and Ghana. Three sets of cost estimates were calculated: i) SHIP project actual cost, ii) standard costs of implementing vision screening, and iii) budget impact analysis of implementing a national school-based vision screening program. One-way and multi-way sensitivity analyses tested the robustness and identified parameters of the model, which have the largest influence on the budget of the scale up. Data was password protected, consolidated and analysed within excel.

SHIP project actual costs analysis showed that in country implementation, expenditure amounted to $61,019 in Cambodia and $61,257 in Ghana (in USD 2016). Teacher training (38%, $23,384) and coordination activities (26%, $15,753) accounted for the largest share of expenditure in Cambodia (64%), whereas in Ghana, capacity building and partnership strengthening was the largest expenditure (29%, $17,840) followed by project coordination (24%, $14,840) (53% combined).

Standard project expenditures were calculated to allow cross-country comparisons and model parameters. Standard unit costs were similar for most activities in Cambodia and Ghana with some exceptions, such as cost of capacity and partnership strengthening ($76 per participant/day in Cambodia vs $396 in Ghana), and cost of custom-made spectacles ($6 per pair in Cambodia vs $25 in Ghana). This is explained in part by variations in salary levels, per diem rates and accommodation costs between the two countries.

Based on the budget impact estimates for implementing national school-based vision screening programs, the overall cost of the program over five academic years (2018/19-2022/23) is projected to be $7,285,244 in Cambodia and $16,706,133 in Ghana for children and teachers in public primary and lower secondary schools. The first year is the most expensive for both countries, representing over a third of the overall program budget for each country (40% in Cambodia and 44% in Ghana). The results of the multivariate sensitivity analysis showed that the projected total cost of the screening program over 5 years in

Cambodia ranges from $5,025,655 to $10,304,335. In Ghana, the estimated range is between $11,678,041 and $23,526,227.

The projected five-year national program would result in vision screening of 5,477,614 schoolchildren and 64,712 teachers, 31,703 children with refractive error (RE) receiving a pair of spectacles and 9,687 children referred to eye care services for further examination and treatment in Cambodia. In addition, 38,827 teachers would receive spectacles for presbyopia. In Ghana, the program would result in screening of 9,098,192 schoolchildren and 221,486 teachers, 70,270 children and 132,892 teachers receiving a pair of spectacles and 66,667 children referred to eye care services. In terms of cost-effectiveness of the program, the average cost per child screened is $1.33 across all provinces (ranging from $0.56 per child in Phnom Penh to $6.38 in Kep province). The cost per child with corrected refractive error is $230 on average, ranging from $97 in Phnom Penh to $1,103 in Kep province. In Ghana, the average cost per child screened is $1.84, ranging from $1.61 per child in the Upper West region to $2.20 in the Central region and in the Eastern region. The cost per child with corrected refractive error is $238 on average (ranging from $209 in the Northern region to $285 in the Eastern region).

There is a lack of evidence on the cost of school-based vision screening programs in low-and middle-income countries (LMICs). This study assesses the costs of the screening pilots in Ghana and Cambodia and estimates the budget impact for the scale up of such programmes in the two countries. Results confirm that vision screening of schoolchildren, as part of a school-based health package, is a cost-effective way to identify and provide spectacles to children with uncorrected refractive error (URE). Analysis of the current health and education sector budgets suggests that the scale up of the programs in Ghana and Cambodia is affordable if there is sufficient in country capacity to deliver such interventions at scale. Integrating vision screening with other school-based interventions identified in the essential packages of the Disease Control Priorities, 3rd Edition (DCP3) Volume 8 on Child and Adolescent Health and Development, and delivering this at scale can maximize both the economies of scale and economies of scope, reducing the unit cost of delivering these interventions.

Introduction

Visual impairment (VI) as a global health problem

Recent Global Burden of Disease (GBD) data shows that 253 million people globally are visually impaired, including 36 million who are blind and 217 million with moderate or severe visual impairment (MSVI) [1]. The burden is disproportionally affecting LMICs, with around 89% of visually impaired people living in these countries [2].

URE is the leading cause of MSVI, and the second leading cause of blindness after cataract [2]. Refractive error (RE) results in an unfocused image falling on the retina, causing blurred and/or distorted vision. However, RE can be simply diagnosed and corrected with the aid of optical devices such as spectacles, contact lenses or refractive surgical procedures [3]. The annual global economic cost of lost productivity due to RE was estimated at I$269 billion (international dollars), approximately US$202 billion [4]. A relatively small investment (compared to the cost) of US$28 billion could establish the eye care services required to provide good vision to people with URE and create significant new gains to the global economy [5].

Refractive errors in children

Data on prevalence and causes of visual impairment in children is limited. The World Health Organisation (WHO) estimates that around 19 million children are visually impaired globally; 12 million of these cases are due to RE.

The prevalence of blindness and severe visual impairment in children varies according to socioeconomic development and under-5 mortality ranging from 0.1 per 1000 children aged 0-15 years in the wealthiest countries to 1.1 per 1000 in the poorest economies [6, 7]. Studies also show that the magnitude of visual impairment in children varies by age and sex. For example, while the overall prevalence of visual impairment in boys and girls aged 5-9 years is estimated at 0.33% and 0.43%, respectively; the respective prevalence estimates in older children (10-14 years) are 0.39% and 0.50% [2].

The epidemiology of refractive error in children is complex and there are significant variations in, magnitude and type of refractive error across countries. A series of studies conducted in different ethnic and cultural settings over the past decade (Refractive Error Study in Children, RESC) confirmed URE is a public health problem for children in low- and middle-income countries (LMICs). The proportion of children with visual impairment caused by RE is 55% in

Chile, 55.1% in Nepal, 63.6% in South Africa, 70% in rural India, 83% in urban India and 93% in China [3].

The most common cause of RE in children is myopia. With this condition, children can see nearby objects clearly, but objects farther away are blurry. A recent systematic review of studies of myopia in children from 42 countries showed that the prevalence of myopia was associated with age and ethnicity. Children in East Asia have the highest prevalence at each age, ranging from 6.3% in children aged 5 years to 69% among 15 year olds. Data also suggests that the prevalence of myopia is increasing over time; and the number of myopic children globally is estimated to increase from 312 million in 2015 to 324 million by 2025 [8].

Other types of refractive errors in children include astigmatism, which can cause objects at any distance to appear blurry, and hyperopia, which causes up-close objects to appear out of focus [9]. Results from RESC showed that the prevalence of astigmatism in children ranged from 10% in rural India to 42.8% in urban China [3]. A recent systematic review on hyperopia in children showed that the prevalence depended on age and was higher in younger children. The mean prevalence of hyperopia in children aged 5-15 years ranged from 2.1% in Nepal to 19.3% in Iran and Chile [10].

Impact of visual impairment on children's education

Children with poor vision are facing multiple barriers to learning, as around 80% of all learning during the first 12 years of life occurs through visual instruction. Children with uncorrected visual impairment are at a major disadvantage in a range of educational activities, such as looking at the classroom blackboard, reading books and taking notes, and have limited opportunities to succeed in their studies [9].

Several studies investigated the impact of poor vision on school attendance and education outcomes in low-and middle-income countries. A study in Northeast Brazil found that primary school children with vision problems had a 10 percentage point higher probability of dropping out, an 18 percentage point higher probability of repeating a grade, and scored 0.2 to 0.3 standard deviations lower on academic tests compared to children with good vision [11]. A study in northwest China showed that wearing eyeglasses increased literacy and numeracy test scores by 0.26 and 0.44 standard deviations respectively, and the odds of failing a class were reduced by 35% [12]. Another study in the same setting concluded that wearing eyeglasses for one academic year increased the average test scores by 0.16 to 0.22 standard deviations, equivalent to 0.3 to 0.5 additional years of schooling, and the benefits were even greater for under-performing children. Finally, a study by Ma et al. in Western China investigated an impact of provision of free spectacles to children, and found that those who received free eyeglasses were more likely to wear them and achieved higher academic scores in mathematics compared to the control group [13].

Mainstreaming vision screening in school health and nutrition programs

School health and nutrition (SHN) programs use schools as a platform to deliver safe, simple and effective interventions essential for child development and growth. These programs provide an opportunity to both address health needs and support education goals of school age children through getting children into schools and ensuring that they can better learn whilst there [14].

Evidence from mathematical simulation models shows that annual vision screening of school children and correction of refractive error is amongst the most cost effective interventions to control visual impairment in children [15]. Although the cost-effectiveness ratio varies depending on the population size, URE prevalence, and school enrolment rates, evidence shows vision screening in schools is cost-effective is all WHO sub regions. The cost per disability-adjusted life year (DALY) averted was estimated at I$67-130 for South-East Asia, I$165-443 for Africa, I$178-258 for South America and I$ 458-734 for Europe [16].

The Disease Control Priorities (DCP) series is an ongoing project, which aims at systematically assessing the cost-effectiveness (value for money) of interventions addressing the major causes of disease burden in LIMCs. The third and latest edition (DCP3) comprises nine topical volumes published between 2015 and 2018, and delineates essential health intervention packages and their related delivery platforms to assist decision makers in allocating what are often tight and constrained budgets. DCP3 Volume 8 on Child and Adolescent Health and Development proposes two essential packages for child and adolescent health and development, one targeting school-age children (5-14 years), focusing on pre-primary and primary schools as delivery platforms; and an adolescent package (15-19 years), which focuses on mental health and behaviour using a mix of delivery platforms [17]. The school-age package includes vision screening and correction of RE among other health interventions such as deworming, insecticide-treated net promotion, key immunisations, oral health promotion, and school feeding with micronutrient fortification [18].

Rationale for the study

Whilst return on investment and cost-effectiveness are important criteria for policy makers to decide which health or education program to implement, this information does not necessarily provide an assessment of the affordability for governments, particularly in resource-poor settings. This scarcity of context-specific information often inhibits governments from making informed choices about public funding allocation or management of publicly funded services. For example, the lack of primary data on the costs of school health and nutrition (SHN) interventions is a barrier for mainstreaming these activities within education and health sector plans. Costing studies are therefore a prerequisite to assess affordability of introducing a new intervention in a specific country or context, and useful for improving the efficiency and sustainability of government-funded programs.

The purpose of this cost-effectiveness and budget implications analysis is to generate evidence for policy makers and planners, so they can better assess the feasibility and affordability of including vision screening and correction of refractive error as part of an essential package of SHN interventions. Findings from this analysis lay the foundation for the development of a generic costing tool that can be used globally, especially in resource-poor settings, to enable education planners and international partners to improve their planning and budgeting processes for school-based vision screening programs.

School Health Integrated Programming (SHIP)

Overview

In 2012, the Global Partnership for Education (GPE) supported the Ministry of Education, Youth and Sport (MoEYS) in Cambodia to conduct a disability prevalence study to identify the main health related barriers to successful participation in education in line with GPE's global priorities [19]. Cambodia was selected by GPE and the World Bank to develop and conduct a school-based vision screening pilot to support students with URE aged 11-15years. The objective was to develop a model for school-based vision screening with the intention to scale up this model in Cambodia and trial in other countries. A global advisory committee composed of staff from the World Bank, GPE, technical partners at Sightsavers, the Partnership for Child Development (PCD), and the Centre for Eye Research Australia, supported the project. The pilot successfully demonstrated that with the right training, teachers are capable of conducting basic vision screening in schools, identifying children for further diagnoses and treatment [20]. The pilot also showed that mobile refraction teams can adequately examine and dispense spectacles to the children identified through screening, using mainly ready-made spectacles to correct refractive error. In addition, teachers were screened and given spectacles if needed.

The positive outcomes of the pilot provided the foundation for the design of the SHIP program, with an additional deworming component to test an integrated, cost-effective approach to school health promotion in Cambodia and three additional countries in Africa. Sightsavers and PCD developed and implemented the SHIP program in 2016, with oversight from the World Bank and funding from GPE's Global and Regional Activities (GRA) grant mechanism. The aim of the project was to support countries to build their awareness, capacity, and the operational and technical resources to develop and implement SHN plans using vision screening and deworming as exemplars. These interventions were chosen as they are diverse but both have a significant impact of a child's educational outcome. The SHIP project was implemented between January 8th, and December 30th, 2016 in four focus countries: Cambodia, Ethiopia, Ghana, and Senegal.

The aim of the SHIP project was to create a foundation by which countries would have the awareness, capacity, and the operational and technical resources to include SHN into their Education Sector Plans (ESPs). The project supported this through facilitating the engagement and collaboration between government education and health sectors and Local Education Donor Groups (LEGs). SHIP undertook co-design and co-implementation approaches and developed technical capacity from national stakeholders through national capacity building workshops, trainings, and the development of an operational manual for integrated school health programs. In addition, technical guidance documents[1] on delivering deworming and vision screening interventions, and a Teachers' Handbook incorporating IEC (information, education, and communication) materials were developed and made openly available as an online resource for global use [21].

The screening and referral procedure supported by SHIP is described in a simplified diagram (Figure 1).

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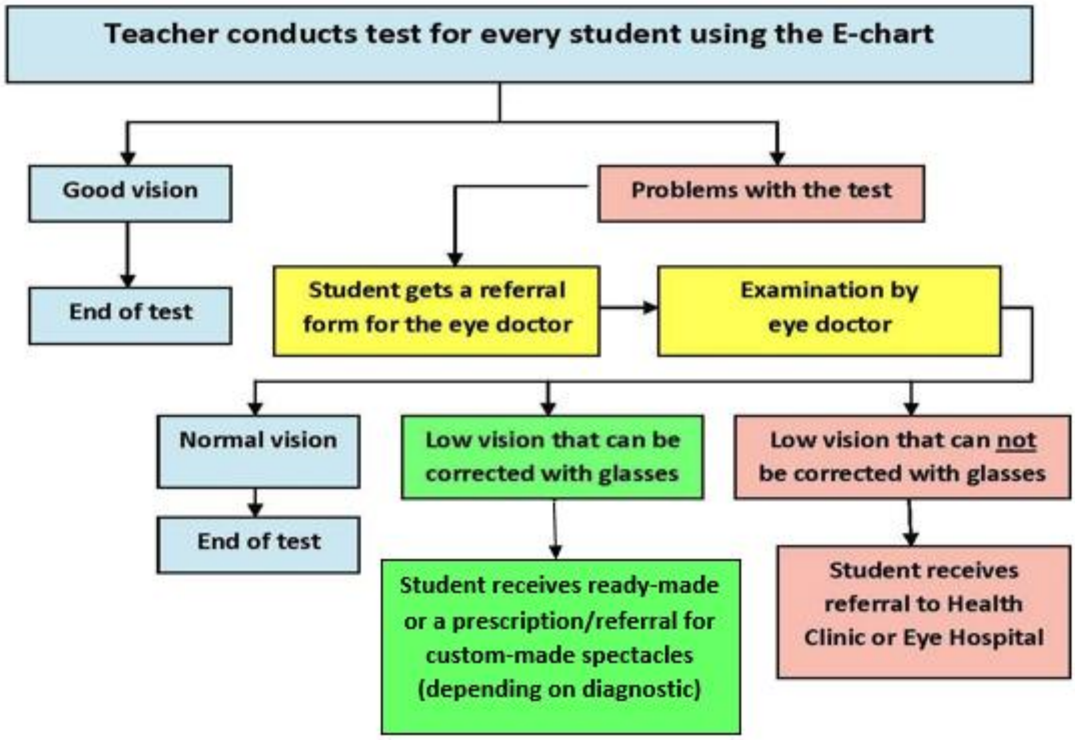
[1] Available here : http://www.schoolsandhealth.org/Shared%20Documents/School%20Health%20Integrated%20Programming(SHIP)_Inclusive%20SHN%20Teachers%20Manual.pdf

Figure 1: Screening and referral procedure for SHIP project



Children are referred to the mobile refraction team if they fail the vision screening (vision worse than 6/9). The mobile refraction team examined children who failed the screening and provided ready-made spectacles when i) anisometropia (the difference between the two eyes) was less than 0.50D, ii) astigmatism was less than or equal to 0.75D, and when iii) prescribed prism was less than or equal to 0.5D. It was recommended to limit ready-made spectacles to powers less than or equal to 3.50D, except in sites difficult to access. Otherwise, the team provided a prescription for pre-paid custom-made spectacles that were ordered and delivered to the child when available (more details available in the SHIP guidelines [22]). It was also recommended that teachers receive screening for visual impairment and that teachers with presbyopia receive ready-made spectacles to improve their near vision. This also helped promote the use of spectacles for children in the classroom.

A global team supported by country teams, consisting of Sightsavers and PCD staff and consultants, managed the project, working with Ministries of Education (MoE) as the primary partners in each of the focus countries. The work was implemented in a number of phases including scoping missions, national capacity building workshops, development of tools and manuals, teacher training, implementation of project interventions, dissemination of project documents, lessons learned and guidelines for future programming.

Study settings

Detailed country reports on the implementation of the SHIP project are available in the project's final report [23]. Due to time constraints to complete the study, two out of the four SHIP countries were included in the costing study: Cambodia and Ghana. The countries represent both continents involved in the project with the assumption that an in-depth costing analysis in each country can provide a solid foundation for the development of a generic costing tool for global use in similar settings.

Cambodia

In Cambodia, the successful results of the 2012 pilot study led to the incorporation of school-based vision screening in the GPE-funded Second Education Sector Support project (SESSP) 2014-2017, based on the priority areas outlined in the Education Sector Plan 2014-2018. In preparation for the implementation, the Ministry of Education, Youth and Sport led the formulation of National Visual Acuity Guidelines, endorsed by the Minister of Education and the Minister of Health. This implemented vision screening in schools during the 2015/16 academic year. Consequently, when the SHIP project was introduced in Cambodia in May 2016, it aligned with the existing vision screening (V-STaR) MoEYS project to ensure maximum synergy between the two initiatives. SHIP was implemented in Cambodia between May and December 2016 in two adjacent districts in the Siem Reap Province in the northwest of the country, namely Banthey Srey and Angkor Thum. The target districts had a joint population of 67,108 people (2008 General Population Census) [24].

The focus of the project was on vision screening and treatment of refractive errors and other eye conditions for students aged 6-15 years (primary school Grades 1 – 6), including out-of-school children where possible. Although the initial objective of SHIP was to integrate vision screening with deworming activities, it was not feasible to completely synchronise the two activities in Cambodia, as the country has had a well-established national deworming program since 2014, with deworming delivered twice a year in May and November. The SHIP workshops and trainings took place in July, followed by school vision screening in August before the long summer break in September and October. This prevented inclusion of deworming medication provision, as it could not align with the national deworming cycle. Deworming was still included in training to refresh the general knowledge of participants as well as ensure a clear understanding of the process of requesting and distributing the medication, which supported the deworming intervention implemented in November 2016.

Multiple departments were involved in SHIP implementation in Cambodia, including the Primary Education Department, the School Health Department, the Special Education Department and the Department of Finance. The implementation of SHIP in Cambodia followed an innovative management model where the program was directly led and implemented by MoEYS. The technical partner, Fred Hollows Foundation (FHF), provided technical expertise, training, supervision and Monitoring & Evaluation. FHF was also responsible for mobile refraction teams. This approach changed the traditional partnership arrangement between the government and NGOs, and allowed stronger MoEYS leadership and ownership, promoting an easier integration of SHN within the Education Strategic Plan.

Essilor donated ready-made (ready-to-clip) spectacles for children and teachers with visual impairment (as in all SHIP countries) and a partnership with Angkor Hospital for Children was established for hospital referrals. The SHIP approach was slightly different from other MoEYS vision screening interventions, as SHIP provided glasses and follow up referrals, while other interventions included only basic vision screening by teachers and further assessment by mobile refraction team, who provided prescriptions but not spectacles. This difference in approaches provided opportunities for comparing different models, costs and outcomes in order to identify the most effective approach for future vision screening programming. Another specificity of the SHIP project in Cambodia was that training for vision screening was used as an opportunity to also provide training on Inclusive Education. The NGO partner, Krousar Thmey, who specialises in education of visually impaired children, provided training on Inclusive Education as part of the SHIP training.

A total of 126 participants from 48 primary schools received training for vision screening, deworming and inclusive education during a two-day workshop. The teachers screened 12,440 students and identified 214 students as potentially in need of refraction. Of the students examined by the mobile refraction team, 72 students received glasses and 22 students received a referral for further examination or treatment at the Angkor Hospital for Children. One student needed surgery that could only be provided in Phnom Penh, which was facilitated by SHIP. Three students had severe visual impairment and were advised to move to Krousar Thmey's school for the blind in Siem Reap town. In addition to children, 209 adults, mainly school staff but also some community members or workshop participants, received glasses as a result of screening.

<u>Ghana</u>

SHIP was implemented in Ghana between May and November 2016, and vision screening was implemented in October in Denkyembour district in the Eastern Region, with a population of 78,841 people (2010 Population and Housing Census). More than half (57.7%) of the population lives in the urban area, and about two-fifth (39.5%) of the population of the District is below 15 years Service [25]

The country's Inclusive Education Policy calls on development partners to contribute to rigorous research and monitoring and evaluation initiatives [26]. The SHIP project was designed in line with the national objectives and policy requirements that all schools should undertake early identification, referral and intervention through periodic screening of all learners [26]. The objective of the project in Ghana was to enable government partners to generalize the use of good practices for school-based health programmes within their sector policies and practices, particularly the Education Sector Plan. The project also demonstrated the feasibility of integrating interventions in school health programmes and promoted the importance of school health in general. Along with these, the project documented best practices and identified gaps in Ghana's school health program to develop guidelines for integrating school health interventions.

The SHIP project was implemented in collaboration with PCD, the Ghana Education Service (Special Education Division and the School Health Program Unit) and the Ghana Health Service (Eye Care Unit and the Neglected Tropical Diseases Programme). The School Health Program(SHEP) was the leading implementing unit in the country and served as the interface for interactions between the partners and the government. It also mobilised the schools for the implementation. The Neglected Tropical Diseases Program(NTDP) provided training and oversight for deworming activities, while the Special Education Division (SpED) facilitated a package of screening services including vision, intellectual disability and hearing impairment. St. Dominics Hospital in Akwatia provided supervision, follow up assessment and treatment for children with visual impairments. SpED provided supervision, follow up assessments and supported special school placements for children with hearing and intellectual disabilities.

120 teachers benefited from the school-based training across all 60 government schools in Denkyembour district. 12,052 children comprising 10,317 pupils and 1,735 out of school children were dewormed. 10,099 pupils aged 4 to 15 years (KG-JHS3) were screened for visual impairments and other eye health problems. Following the screening, 2,138 were identified as potentially having eye problems and were further examined by a mobile refraction team of optometrists. Following this examination, 262 pupils were confirmed as having eye problems and were referred for treatment at the eye care unit in Saint Dominic Hospital. 78 pairs of spectacles were provided, including 55 ready-made and 23 custom-made spectacles.

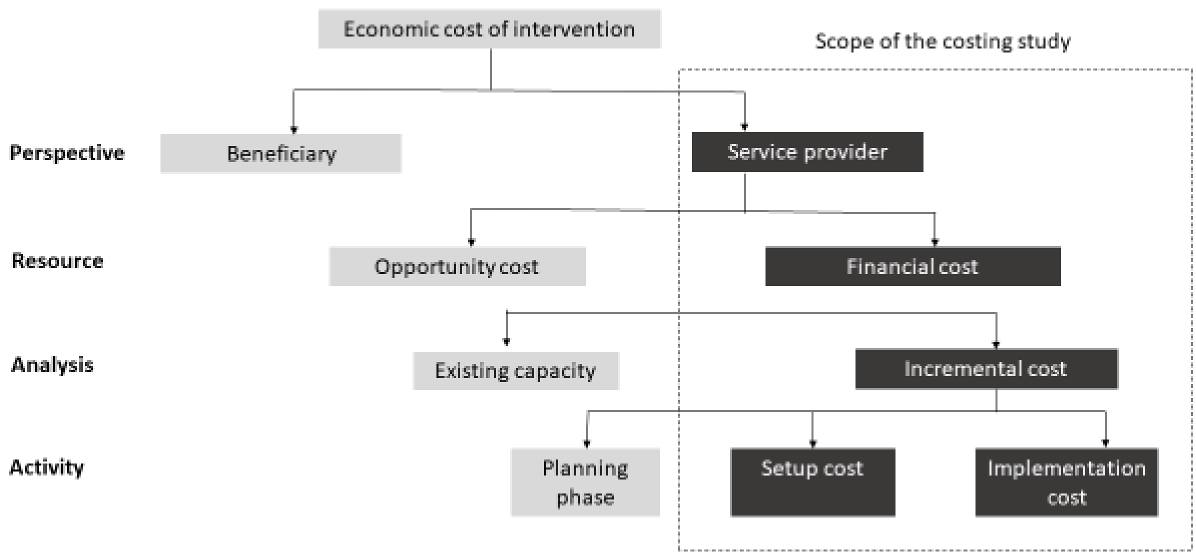
Other conditions referred for treatment were allergy, amblyopia, cataract, glaucoma, and vernal conjunctivitis. In addition to children, teachers received screening, with 97 receiving glasses. Integration of vision screening with hearing and intellectual impairment screening also led to the identification of 109 children with moderate to severe ear infections and/or hearing impairments, and 105 children with intellectual impairments and/or learning difficulties; all were referred for further assessment. 4 children with hearing impairments and 17 children with intellectual impairments were identified by SpED as requiring special education and placement in special schools.

Methods

This analysis aimed to assess the incremental costs and cost-effectiveness of vision screening and treating uncorrected refractive error as part of an integrated school-based health program, as well as discuss the budget implications for the scale up of this approach in Cambodia and Ghana.

Overview of costing approach

Figure 2: Overview of costing approach



<u>Perspective:</u>

This costing analysis was carried out from the perspective of the service provider, in this case the government (i.e. the Ministry of Education and the Ministry of Health). It did not include the costs incurred by project beneficiaries (i.e. children and their families). The way the SHIP project was designed, costs incurred by project beneficiaries were minimal, as most of the expenditures were covered by the project, including the costs of spectacles and transport allowance for children referred to an eye clinic for further examination or treatment.

Resources included in the analysis

The study did not calculate the full economic cost of vision screening for schoolchildren; but rather estimated the additional resources needed to include vision screening and correction of refractive errors to existing school-based health programs. Therefore, the data presented in this analysis captures the incremental cost, meaning that the costs of the existing resources or capacities within the countries were not accounted for. For example, the cost of screening kits needed was included in the analysis, but the cost of teachers' time performing the screening was not, as this time was already paid by the Ministry of Education irrespective of the vision screening program.

Furthermore, only expenditures related to the setup and implementation of the intervention in country were included; any expenditure incurred at the global level was excluded, such as grant management, development of generic technical materials and guidelines, and global coordination.

Data collection

Data collection was done retrospectively in January-March 2018 and included a review of secondary data (project accounts and reports) and country visits to Ghana and Cambodia to meet key project stakeholders and obtain and/or validate the routine financial data and outputs. Expenditure data was extracted from the project manager's (Sightsavers) accounting system with additional financial information obtained from the records held by the Ministry of Education and Health in Ghana and the Ministry of Education, Youth and Sport in Cambodia.

Output data gathered from the SHIP country reports included the number of children screened, examined and referred, the number of ready-made and custom-made spectacles provided, the number of schools covered and the number of teachers trained. Socio-demographic data, enrolment and flow rates (i.e. promotion, repetition, dropout rates), the number of schools and teachers in each country, and other non-financial data used in the cost projections, were collected from the national Education Management Information Systems (EMIS) or other relevant sources such as demographic, education, and health surveys.

Table 1 provides a detailed list of the sources of information used to define parameters of the scale up model.

Table 1: Cost projection model: inputs, assumption

Variable	Assumption Cambodia	Assumption Ghana	Data source
Capacity and partnership strengthening (workshop)			
Expected number of participants	23 + 25	45 + 10	Number of participants based on SHIP projects (2016) + one coordinator per region
Administrative units			
Number of provinces/regions	25	10	Ghana Districts and National Institute of Statistics, Ministry of Planning (Cambodia)
Number of districts	196	210	
Education data basis*:			
Enrolment in primary school in 2016/2017	2,022,061	3,258,996	EMIS (2017)
Enrolment in lower secondary school in 2016/2017	586,042	1,256,908	
Number of schools (primary and lower secondary) in 2016/2017 (A)	8,389	25,305	
Number of teacher per school (primary and lower secondary) in 2016/2017	7	8	
Estimated growth rate of new entrants in primary school	-1.08%	-1.33%	
Estimated growth rate of number of schools	0.88%	1.78%	
Implementation recommendation:			
Year 1: All children in primary and lower secondary	2,647,911	4,429,018	SHIP guidelines (2016) and EMIS (2017)
Year 2: New entrants in primary and lower secondary, and children given spectacles in previous year	665,758	1,027,717	
Year 3: New entrants in primary school, all children in lower secondary, and children given spectacles in previous year	998,737	1,862,585	
Year 4: As per year 2	605,604	960,376	
Year 5: As per year 5	588,070	927,536	
Training:			
Number of teacher to train per school	2	2	SHIP guidelines and financial data from SHIP projects (2016)
Trainers to train per teachers (B)	17.5	17.5	2 trainers for 35 teachers, from SHIP guidelines (2016)
Number of training of teachers session facilitated by trainers (C)	10	10	
Number of trainers to be trained (A/B)/C	98	300	
Training frequency	Every 5 years	Every 5 years	Baltussen et al. (2009) [27]
Screening at school costs:			
Screening material costs (tape, card etc.)	$3	$4	Output and financial data from SHIP projects (2016)
Useful life of screening kit	5 years	5 years	
Number of screening kit per school	1	1	
Eye examination from mobile refraction team:			
Excepted number proportion of children referred by teachers	2%	2%	Output from SHIP projects (2016)
Expected number of schools covered by Mobile refraction team per day	4	4	
Expect prevalence of Presbyopia among school teachers	60%	60%	Based on expert opinion, Holden et al., Bourne RRA, Flaxman SR, Braithwaite T, et. Al [28, 29]
Proportion of children provided with ready-made spectacles	0.4%	0.54%	Output from SHIP projects (2016)
Proportion of children provided with custom-made spectacles	0.18%	0.23%	
Transportation to health clinic:			
Proportion of children referred to health clinic	0.18%	0.73%	Output and financial data from SHIP projects (2016)

Data analysis

Data was password protected, consolidated and analysed within excel. Three sets of cost estimates were calculated: i) SHIP project actual cost, ii) standard costs of implementing vision screening, and iii) budget impact analysis of implementing a national school-based vision screening program. All SHIP project expenditure were allocated to specific activities and to project phase, as summarized in Figure 2. One-way and multi-way sensitivity analyses tested the robustness and parameters of the model, which have the largest influence on the budget of the scale up.

Figure 3: SHIP expenditure and standard costs overview

SHIP expenditures *Based on a review of cash expenditures linked to implementation of SHIP project (including expenditures covered by SHIP budget and by implementing partners)*			**Standard costs and budget impact analysis** *Based on SHIP guidelines and country-specific intervention scenarios*
Planning phase *Activities conducted for all 4 countries prior to the implementation phase*	**Implementation phase** *Review of cash expenditure linked to activities implemented as part of projects conducted in each country*		
	Setup costs *Investment required at start of vision screening program*	**Recurrent costs** *Activities to be implemented on an annual basis*	
• Project design and planning • Scoping mission • Development of technical and operational guidelines • Operational & technical support	• Capacity building activities (workshop, etc.) • Training of Trainers (ToT) • Training of teachers	• Community sensitisation • Vision screening of children and teachers • Eye examination by mobile refraction team • Spectacle dispensing (ready-to-clip or custom-made spectacles) • Referral & treatment at eye clinic (if needed) • Coordination • Monitoring & Evaluation • Supervision	• Capacity building activities (workshop, etc.) • Training activities • Community sensitization • Procurement of equipment • Assessment of children failing screening • Provision of spectacles • Referral and treatment at eye clinic • Coordination (incl. Supervision and, Monitoring & evaluation)

SHIP project actual cost

The actual costs included all direct expenditure covered by the project budget and other financial contributions made by project partners (i.e. Ministry of Education, Ministry of Health and other financial & technical partners) during the implementation of the SHIP project between January and December 2016. Only expenditures related to the setup and implementation of SHIP activities in the two studied countries were analysed; global level expenditure on management, material development, monitoring or coordination were excluded.

Although vision screening was integrated with other school-based health interventions (screening for hearing and intellectual impairments and deworming in Ghana, and teacher training on deworming and inclusive education in Cambodia), detailed records were kept on specific activities of the project, and it was hence possible to separate the expenditures related to vision screening.

Given that the focus of the intervention was on vision screening and provision of spectacles in schools, the costs of treatment for children referred to eye clinics were excluded (with the exception of custom-made spectacles and costs of transportation of families to eye facilities in Cambodia).

To identify cost drivers, expenditures were categorized by project activity, cost categories (Personnel, equipment, materials and supply; venue rental; services; and transportation) and type of expense (i.e. start-up, capital or recurrent expenditures, shared or specific costs, etc.) (Figure 2).

Estimating standard costs

Although the SHIP project established clear guidelines for the implementation of school-based vision screening program [22], the activities in each country differed slightly depending on the local context. These differences can limit cross-country comparisons and the ability of policy makers and planners to extrapolate the costs of the projects to planning and budgeting in other settings. To address this issue, we calculated standard costs of vision screening using the same standard set of activities and expenditure items for each country included in this analysis.

Standard costs were computed using a set of activities outlined in the SHIP guidelines and expenditure data from the SHIP projects. The expenditures for non-standard activities implemented in the project countries were removed; the activities that were in the guidelines but had not been implemented were added. Standard costs of activities that were not implemented were estimated using the costs of the same activity in another project country adjusted for price level using PPP (Purchasing Power Parity) ratios. Any donated items such as ready-made spectacles were valued and added to the standard costs. Activities included in the standard set were capacity building, planning and partnership strengthening, training of trainers and teachers, community sensitization, screening by teachers, assessment of children who failed screening, provision of spectacles, referral to eye clinic, supervision and coordination, and monitoring and evaluation.

Budget Impact Analysis

A Budget Impact Analysis (BIA) is an economic assessment that estimates the financial consequences and affordability of implementing a new intervention or program. To do this, cost projections estimated funding requirements for expanding vision screening and correction of refractive errors to cover all existing primary and lower secondary public schools as a component of the existing school health programs in each country. The cost projections were made for five years covering the period 2019-2023.

The enrolment rates in primary and lower secondary schools were projected using a flow model and followed UNESCO's International Institute for Educational Planning (IIEP) technical guidelines [30]. A flow model is a simulation model based on the analysis of enrolment data by grade including promotion, dropout and repetition rates. The year 2016/17 was the base school year to estimate the student enrolment, as this is the most recent academic year for which complete and reliable statistics was available in the national EMISs. The flow rates (measuring the number of students flowing from one grade to the next one) were assumed to remain constant and equal to those observed at base year. New admissions in primary and lower secondary schools were projected from the base year and past trends, i.e. new admissions were projected for the period 2019-2023 based on trends from 2010 to 2016. Both exponential growth rate and least square growth rate approaches helped estimate growth rates in new admissions [31]. A similar approach influenced assumptions on the trends in the number of new schools and teachers for each year.

Intervention scenarios for each country were established by translating the SHIP guidelines into the local context; for example, national recommendations were used for the frequency of child vision screening in different age groups. The BIA only considered standard activities as per the SHIP guidelines. With regard to treatment, the cost of spectacles and transportation cost for children referred to an eye clinic were (separately) included. It excluded the cost of treatment in eye clinics as well as the costs of referrals to rehabilitation services and specialist schools.

The budget requirements were then calculated applying standard unit costs. Where appropriate, the cost of international or NGO staff was replaced using government standard per diems and salary grid, assuming that the government (Ministry of education and/or Health) will implement the vision screening programs and local expertise is available. The projections were made in constant 2016 prices. Future inflation is difficult to predict and therefore not incorporated into the model.

Sensitivity/uncertainty analysis

Both one-way and multi-way deterministic sensitivity analysis (DSA) were conducted to account for uncertainties around the parameters used in the model. DSA is a method that can assess the sensitivity of results from a model-based analysis to variations in a specific parameter or set of parameters. One or more parameters are manually changed across a pre-specified range of values and the results are analysed to determine to what extent the change impacts the output values of the model; in this case, the analysis assessed the budget impact of implementing a national school-based vision screening program.

For one-way sensitivity analysis, the value of one parameter changed while holding all other parameters constant. The model used three different values for each parameter: one central value corresponding to the base (actual) case, and lower-and upper-bound values that were obtained by increasing or decreasing the base case value by 25%. Results of the one-way sensitivity analysis are presented in the tornado diagrams in Figure 4, where the results are shown using a horizontal bar which represents the variation in the model output for extreme values of each parameter (as compared to the base-case analysis). Typically, the horizontal bars are ordered such that with those with the greatest spread (i.e. parameters to which the model output is most sensitive) come at the top of the diagram, and those with the lowest spread come at the bottom. Tornado diagrams are useful to assess which parameter has the greatest influence on its results.

For the multi-way sensitivity analysis, the value of each parameter changed simultaneously. Given that the number of possible combinations of parameter values has the potential to get very large, a scenario approach constructed the best-case and worst-case scenarios for the budget impact. We selected key parameter values to produce the maximum decrease (best-case scenario) and the maximum increase (worst-case scenario) in the budget requirements. The results of the multi-way sensitivity analysis are summarized in the box plot charts (Figure 4) and detailed information are provided in heat tables showing each combination of results where the red colour indicated the most prohibitive scenario and the green colour shows the least prohibitive scenario (Table 6 and Table 7 in Annexes).

Currency

All expenditures are in US Dollars (USD) 2016. All expenses in Cambodia were reported in USD 2016, and expenses in Ghana were reported in Ghanaian Cedi (GHS) and converted in USD 2016 using monthly currency exchange rates from XE[2]. To facilitate comparison with other relevant studies, we converted cost per child treated to international dollar using price level ratio of PPP conversion factor (Gross Domestic Product) to market exchange rate (2000). This allowed for cross-country and cross-time comparison, as it compensates for price level differences between countries and inflation over time.

Ethical considerations

The study was exclusively based on the review of secondary data, including accounting data and project output data and reports. As the study did not collect data from human subjects, no ethics approval was required. However, we received administrative approvals and authorisations from the relevant departments at the Ministry of Education and Ministry of Health in Ghana, and at the Ministry of Education, Youth and Sport in Cambodia.

Children who needed further examination or treatment were referred to eye clinics with the costs covered by the project. All vision screening activities and eye examinations were carried out under the supervision of staff appointed by the Ministries of Education and Health in the two countries. All data management procedures ensured confidentiality; all data were anonymised and stored in password-protected files that could only be accessed by the principal investigator and the co-investigator of this study.

[2] https://www.xe.com/

Results

Actual SHIP project expenditures

Table 2 provides information on the unit costs of training and vision screening activities based on expenditures from the SHIP project. In Cambodia, the cost per teacher trained was $186 and the cost of vision screening and provision of spectacles amounted to $2.9 per child screened; $168 per child examined by the refraction mobile team and $499 per child receiving spectacles. In Ghana, the cost of training was $674 per trainer and $112 per teacher trained. When considering the cost of vision screening provision of spectacles to children with URE, the cost amounted to $3.0 per child screened, $14 per child examined and $404 per child receiving spectacles.

Table 2: Unit costs based on SHIP project expenditures for Cambodia and Ghana (in USD 2016)

	Cambodia		Ghana	
Output	**Count (N)**	**Total/Unit cost ($)**	**Count (N)**	**Total/Unit cost ($)**
Training costs		*23,384*		*13,485*
Trainers trained*	-	-	20	674
Teachers trained	126	186	120	112
Vision screening and provision of spectacles (excl. training)		*35,898*		*29,933*
School screened	48	748	60	499
Child screened	12,440	2.9	10,099	3.0
Child examined**	214	168	2138	14
Child provided with spectacles	72	499	74	404

*No trainers' training necessary in Cambodia
**Cost per children examined by mobile refraction team reflects the high number children referred by teachers in Ghana compared to Cambodia (due to a higher prevalence of eye conditions but also higher false positive rate for children referred by teachers)

Table 3shows the SHIP project (vision screening component) expenditure in Cambodia and Ghana, presented by activity and cost category. For the analysis, all project expenditures were allocated to ten groups: i) capacity building and partnership workshop; ii) sensitisation; iii) training of trainers (in Ghana only); iv) training of teachers; v) screening in school; vi) eye examination (for those who failed screening); vii) referral to eye clinic transportation (in

Cambodia only); viii) supervision; ix) coordination and x) monitoring and evaluation (in Cambodia only). The cost categories were personnel, equipment, materials and supply, venue rental, services and transportation.

The total in country implementation expenditure was $61,019 in Cambodia and $61,257 in Ghana. Although the two countries had similar overall expenditure, the breakdown by activity was different. In Cambodia, the largest share of expenditure was teacher training (38%, $23,384); followed by project coordination (26%, $15,753). In Ghana, capacity building and partnership strengthening was the largest expenditure (29%, $17,840) also followed by project coordination (24%, $14,840). Training of teachers in Ghana accounted for 13% of the total expenditure ($8,022) and for 22% if combined with the training of trainers ($13,485 in total). In Cambodia, capacity building and partnership strengthening combined with stakeholder sensitisation accounted for 8.7% of the expenditure ($5,311).

School screening itself accounted for 3.3% of the total expenditure in Cambodia and 0.4% in Ghana ($2,040 and $240 respectively). When combined with eye examinations of those referred to mobile refraction teams and transportation to eye clinic (in Cambodia), the share of the total expenditure spent on screening and treatment of refractive error was 15% in Cambodia ($9,237) and 17% in Ghana ($10,133). Supervision of screening was 8% of the total expenditure in Ghana ($4,959). In Cambodia, it was 6% ($3,652). However, in Cambodia another 6% ($3,682) was spent on monitoring and evaluation.

The overall cost of program start up expenditures (capacity building, stakeholder sensitisation and training of teachers/trainers) accounted for 47% of the total expenditure in Cambodia ($28,695) and 51% in Ghana ($31,325).

Personnel was by far the largest cost category within each activity, particularly for examination by mobile refraction team (87% in Cambodia and 81% in Ghana), project supervision (77% and 83%), coordination (99% and 76%), monitoring and evaluation in Cambodia (82%) and capacity building/partnership strengthening in Ghana (88%). Personnel was also a significant share of training expenditures, accounting for 55% of teacher training in Cambodia, 55% of training of trainers in Ghana and 28% of training of teachers in Ghana.

Venue rental costs were different in the two countries. In Cambodia, the costs were significantly higher, accounting for 61% of the capacity strengthening and stakeholder sensitisation expenditures and 40% of the teacher training expenditures. In Ghana, the rental accounted for 18% of the training of trainers, 15% of the training of teachers and only 0.7% of the capacity building/partnership strengthening expenditure.

The costs of school screening included only materials and supplies in both countries ($2,040 in Cambodia and $240 in Ghana). Within the eye examination/referral activity, the highest cost category was personnel, followed by transportation (9%) and equipment/materials (2.4%) in Cambodia. In Ghana, the order was the opposite, with 11% of the activity expenditure spent on equipment/materials and 5% on transportation.

Supervision required two categories of inputs: i) personnel (the highest expenditure in both countries, 77% in Cambodia and 83% in Ghana) and ii) transportation (23% in Cambodia and 17% in Ghana). A similar breakdown applied for Monitoring & Evaluation in Cambodia (81.5% personnel and 18% transportation). Project coordination required mainly personnel in Cambodia (99%). In Ghana, the activity required materials/supplies (19.5%) in addition to personnel costs (76%).

Table 3: Actual SHIP project expenditure for Cambodia and Ghana, by activity and input (in US$ 2016)

Activities and inputs		Cambodia		Ghana	
		USD	**%**	**USD**	**%**
Capacity and partnership strengthening (workshop)		**1,737**	**2.8%**	**17,840**	**29.1%**
	Venue rental	1,050	60.5%	126	0.7%
	Personnel	569	32.7%	15,679	87.9%
	Materials & supplies	118	6.8%	12	0.1%
Sensitisation*		**3,574**	**5.9%**		
	Venue rental	2,161	60.5%		
	Personnel	1,170	32.7%		
	Materials & supplies	243	6.8%		
	Services				
Training of trainers				**5,463**	**8.9%**
	Personnel			3,020	55.3%
	Transportation			1,455	26.6%
	Venue rental			988	18.1%
	Materials & supplies				
	Services				
Training of teachers		**23,384**	**38.3%**	**8,022**	**13.1%**
	Personnel	12,777	54.6%	2,211	27.6%
	Venue rental	9,139	39.1%	1,209	15.1%
	Materials & supplies	1,065	4.6%	26	0.3%
	Transportation	402	1.7%	4,498	56.1%
	Services			79	1.0%
Vision screening at school		**2,040**	**3.3%**	**240**	**0.4%**
	Materials and supplies	2,040	100.0%	240	100.0%
Eye examination (Failed screening)		**5,991**	**9.8%**	**9,893**	**16.2%**
	Personnel	5,222	87.2%	7,985	80.7%
	Transportation	544	9.1%	496	5.0%
	Equipment	141	2.4%	1,066	10.8%
	Materials and supplies	84	1.4%	347	3.5%
Referral at eye clinic		**1,206**	**2.0%**		
	Transportation	1,206	100.0%		
Supervision		**3,652**	**6.0%**	**4,959**	**8.1%**
	Personnel	2,796	76.6%	4,101	82.7%
	Transportation	856	23.4%	858	17.3%
Coordination		**15,753**	**25.8%**	**14,840**	**24.2%**
	Personnel	15,599	99.0%	11,296	76.1%
	Services	100	0.6%	224	1.5%
	Transportation	54	0.3%	348	2.3%
	Materials and supplies			2,887	19.5%
	Venue rental			84	0.6%
Monitoring and Evaluation		**3,682**	**6.0%**		
	Personnel	2,999	81.5%		
	Transportation	659	17.9%		
	Material and supplies	24	0.7%		
TOTAL		**61,019**	**100%**	**61,257**	**100%**

*Sensitisation refers to sensitisation of local stakeholders; no community sensitisation activities were included in the project.

Standard package expenditures

Standard project expenditures were calculated to allow cross-country comparisons. The estimates were based on the standard set of activities described in the SHIP guidance and the actual project expenditures and outputs in each country.

Table 4 presents standard unit costs estimated for Cambodia and Ghana. The unit costs were similar for most activities, with the exception of: i) costs for capacity and partnership strengthening ($76 per participant/day in Cambodia vs $396 in Ghana), ii) cost of mobile optometrist team per day ($315 in Cambodia vs $255 in Ghana), iii) cost of custom-made spectacles ($6 per pair in Cambodia vs $25 in Ghana), and iv) annual cost of coordination, supervision and M&E at the national level ($10,296 and $38,400 in Cambodia and Ghana respectively) and regional/provincial level ($13,310 per province and $28,738 per region in Cambodia and Ghana respectively) levels. The differences between the two countries can be explained to some extent by variations in salary levels, per diems rates and accommodation costs.

Table 4: Standard unit costs for Cambodia and Ghana (in US$ 2016); based on SHIP project data and technical guidelines

Item	Unit	Cambodia	Ghana
		Unit cost	**Unit cost**
Capacity and partnership strengthening			
Workshop	Per participant per day	**76**	**396**
Training			
Training of trainers	Per trainer	**438**	**459**
Training of teachers	Per teacher	**93**	**72**
Community sensitisation (a)			
	Per district	**76**	**79**
	Per region	**218**	**210**
Vision screening, eye examination and treatment/referral			
Vision screening kit (b)	Per screening kit	**3.9**	**4**
Mobile refraction team (c)	Per day	**315**	**255**
Ready-made spectacle (d)	Per spectacles	**2**	**2**
Customized spectacle	Per spectacles	**6.4**	**25**
Transportation allowance	Per child referred	**20**	**21**
Coordination, supervision and M&E (e)			
Coordination expenses per year (at national level)	Per year	**10,296**	**38,400**
Coordination expenses per year per region	Per year per region	**13,310**	**28,738**

(a) Cost include costs for radio messages, posters, and other activities for reaching out of school children and building awareness amongst school and community on eye health

(b) One kit per school, screening kit for teachers includes a vision screener for three meters (6/9 optotype), three meter rope and record forms

(c) Based on project actuals expenditure per day worked

(d) Ready-to-clip spectacles used in SHIP were donated by Essilor; spectacles can be purchased for a unit price of 2USD

(e) Personnel involved in eye health program as per SHIP guidelines: one program manager and one technical manager (at central level), and one coordinator per administrative unit (either province or region)

Budget impact analysis

Budget impact estimates for implementing national school-based vision screening programs for all primary and lower secondary school in Cambodia and Ghana is found in Table 5: Annual costs of implementing national school-based vision screening programs in Ghana and Cambodia, projection by activity (2018-2023).

The overall cost of the program over five academic years (2018/19-2022/23) is projected to be $7,285,244 in Cambodia and $16,706,133 in Ghana. The first year is the most expensive for both countries, representing over a third of the overall program budget for each country (40% in Cambodia and 44% in Ghana. This is largely due to program start up expenditures (mainly capacity building and training activities) and the fact that children in primary and lower secondary schools must be screened in year one according to the SHIP guidelines. After the first year, only new entrants received screening each year and all children in secondary school every other year. The guidelines also recommend that children who received spectacles the previous year should be `-examined by the optometrist mobile team. In Cambodia, the program start-up costs amount to $1,630,300 and screening, examination and referral costs to $851,171 in year 1. Recurrent expenditures the following years amount to $4,365,401, ranging between $1,079,199 and $1,104,041 annually. In Ghana, the start-up costs are higher and amount to $3,947,702; while screening, examination and referrals costs are estimated to be $2,890,825 in year 1. Recurrent expenditures in the subsequent years amount to $9,417,752, ranging from $2,264,880 to $2,488,328 annually.

Table 5: Annual costs of implementing national school-based vision screening programmes in Ghana and Cambodia, projection by activity (2018-2023)

	Cambodia						Ghana					
Implementation financial costs of screening of school children	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
I. Capacity and partnership strengthening (workshop)												
Number of participants (A1)	48					48	55					55
Cost per participants (A2)	76					76	396					396
Cost of capacity building, collaboration workshop (A)=(A1) x (A2)	3,625					3,625	21,804					21,804
II. Community sensitisation												
Number of region (B1)	25	25	25	25	25		10	10	10	10	10	
Cost per region (B2)	218	218	218	218	218		210	210	210	210	210	
Number of district (B3)	196	196	196	196	196		217	217	217	217	217	
Cost per district (B4)	76	76	76	76	76		79	79	79	79	79	
Total cost of community sensitization (B) = ((B1) x (B2)) + ((B3) x (B4))	20,345	20,345	20,345	20,345	20,345	101,725	19,215	19,215	19,215	19,215	19,215	96,074
III. Coordination (incl. supervision and M&E)												
Cost of coordination per year (at national level) (C1)	10,296	10,296	10,296	10,296	10,296		38,400	38,400	38,400	38,400	38,400	
Cost of coordination per year per region (C2)	13,310	13,310	13,310	13,310	13,310		28,738	28,738	28,738	28,738	28,738	
Total Cost of coordination and supervision (C)=(C1) + ((B1) x (C2))	343,047	343,047	343,047	343,047	343,047	1,715,235	325,784	325,784	325,784	325,784	325,784	1,628,919
II. Training cost												
Total number of school (primary and secondary) (D1)	8,537	8,612	8,688	8,765	8,842	43,444	26,214	26,680	27,155	27,639	28,131	135,819
Teachers to train per number of school (D2)	2						2					
Number of teachers to train (D3) = (D1) x 2	17,075						52,428					
Trainers to train per teachers, 2 trainers for 35 teachers (D4)	18						18					
Number of trainers to train, 10 training session per trainer (D5)= ((D3)/(D4))/10	98						300					
Cost per teacher to train (D7)	93						72					
Cost per trainer to train (D6)	438						459					
Training cost: Y1 (D)= (D3) x (D7) + (D5) x (D6)	1,626, ,675					1,626,675	3,925,897					3,925,897
III. Screening at schools												
Screening kit costs per school (cards, ropes etc.) (E1)	4						4					
Number of schools (E2)	8,537	75	76	76	77	8,842	26,214	467	475	483	492	28,131
Total cost for material (E)=(E1) x (E2)	32,892	289	292	295	297	34,065	104,856	1,866	1,900	1,933	1,968	112,523
IV. Treatment by mobile refraction team												
Number of schools covered by mobile refraction team per day	4						4					
Cost per day per mobile refraction team (F1)	315	315	315	315	315		255	255	255	255	255	
Total by mobile refraction team (F)=(E2) x (F1)	673,326	679,251	685,229	691,259	697,342	3,426,406	1,671,106.88	1,700,853	1,731,128	1,761,942	1,793,304	8,658,333
VI. Cost of spectacles												
Total number of school children to be screened per year (G1)	2,647,911	650,432	994,883	599,823	584,565	5,477,614	4,429,018	969,388	1,849,051	935,846	914,888	9,098,192
Proportion of children requiring ready-made spectacles (G2)	0.40%	0.40%	0.40%	0.40%	0.40%		0.54%	0.54%	0.54%	0.54%	0.54%	
Total number of children requiring ready-made spectacles (G3)= (G1) x (G2)	**10,643**	**2,614**	**3,999**	**2,411**	**2,350**	**22,016**	**24,121**	**5,279**	**10,070**	**5,097**	**4,983**	**49,550**
Ratio teacher per school (G4)	7						8					
Number of teacher to screen (G5) = (E2) x (G4)	62,483	550	555	560	564	64,712	206,394	3,674	3,739	3,806	3,874	221,486
Proportion of teacher requiring ready-made spectacles (G6)	60%						60%					
Total number of teacher requiring ready-made spectacles (G7) = (G5) x (G6)	**37,490**	**330**	**333**	**336**	**339**	**38,827**	**123,836**	**2,204**	**2,244**	**2,283**	**2,324**	**132,892**
Number of already made spectacles provided (G8)= (G3) x (G7)	48,133	2,944	4,332	2,747	2,688	60,843	147,957	7,484	12,314	7,380	7,307	182,441
Price of ready-made spectacles (G9)	2	2	2	2	2		2	2	2	2	2	
Total cost of already made spectacles; (G10)=(G8)x(G9)	**96,265**	**5,888**	**8,663**	**5,493**	**5,376**	**121,687**	**295,914**	**14,967**	**24,627**	**14,760**	**14,613**	**364,883**
Proportion of children requiring custom-made spectacles (G10)	0.18%	0.18%	0.18%	0.18%	0.18%		0.23%	0.23%	0.23%	0.23%	0.23%	
Number of custom-made spectacles provided (G11)=(G1) x (G10)	4,683	1,150	1,759	1,061	1,034	9,687	10,087	2,208	4,211	2,131	2,084	20,721
Price of custom-made spectacles (G12)	6	6	6	6	6		25	25	25	25	25	
Total cost of customized spectacles; (G13)=(G11) x (G12)	**30,012**	**7,372**	**11,276**	**6,799**	**6,626**	**62,086**	**249,917**	**54,700**	**104,337**	**52,807**	**51,625**	**513,386**
Total cost of spectacles (G)=(G10) + (G13)	**126,278**	**13,261**	**19,939**	**12,292**	**12,002**	**183,772**	**545,832**	**69,667**	**128,964**	**67,568**	**66,238**	**878,269**
VII. Referral to eye clinic												
Number of children referred to eye clinic (by teachers and optometrists) (H1)	4,683	1,150	1,759	1,061	1,034	9,687	32,453	7,103	13,549	6,857	6,704	66,667
Transportation cost per child (H2)	20	20	20	20	20		21	21	21	21	21	
Total cost transportation for referred children (H)=(H1) x (H2)	93,656	23,006	35,189	21,216	20,676	193,742	673,886	147,495	281,338	142,391	139,203	1,384,313
Total cost = (A) + (B) + (C) + (D) + (E) + (F) + (G) + (H)	2,919,843	1,079,199	1,104,041	1,088,453	1,093,709	7,285,244	7,288,381	2,264,880	2,488,328	2,318,833	2,345,711	16,706,133

*Based on unit cost estimates (see table 3)

Cost-effectiveness

Table 6 presents the budget and expected outputs of the national school-based vision screening programs in Cambodia (by province) and Ghana (by region).

Table 6: Cost and effectiveness of national school-based vision screening programmes in Ghana and Cambodia, projections by region or province (2018-2023)

Country	Administrative unit	Total cost (US$ 2016)	# of teachers trained	# of schools covered	# of children screened	# of children examined	# of children to receive glasses*	# of children referred to health clinic
Cambodia	Banteay Meanchey	373,101	944	2,403	258,833	10,643	1,498	458
	Battambang	544,563	1,474	3,749	432,211	8,644	2,502	764
	Kampong Cham	395,663	995	2,532	382,873	7,657	2,216	677
	Kampong Chhnang	289,198	678	1,725	206,387	4,128	1,195	365
	Kampong Speu	325,403	780	1,983	305,427	6,109	1,768	540
	Kampong Thom	422,903	1,109	2,822	264,560	5,291	1,531	468
	Kampot	321,375	782	1,989	220,597	4,412	1,277	390
	Kandal	390,650	969	2,465	430,574	8,611	2,492	761
	Kep	87,362	53	135	13,690	274	79	24
	Koh Kong	159,297	279	709	44,698	894	259	79
	Kratie	272,817	635	1,616	157,192	3,144	910	278
	Mondul Kiri	134,808	202	513	38,596	772	223	68
	Otdar Meanchey	224,194	486	1,238	96,923	1,938	561	171
	Pailin	106,004	112	285	28,079	562	163	50
	Phnom Penh	214,703	395	1,005	381,071	7,621	2,206	674
	Preah Sihanouk	131,354	185	471	72,408	1,448	419	128
	Preah Vihear	242,213	543	1,383	97,308	1,946	563	172
	Prey Veng	488,493	1,292	3,288	415,838	8,317	2,407	735
	Pursat	294,534	702	1,787	182,772	3,655	1,058	323
	Ratanak Kiri	212,861	444	1,129	98,329	1,967	569	174
	Siemreap	460,830	1,199	3,050	434,787	8,696	2,516	769
	Stung Treng	175,960	334	849	59,303	1,186	343	105
	Svay Rieng	278,542	643	1,636	202,915	4,058	1,174	359
	Takeo	370,474	918	2,336	350,115	7,002	2,026	619
	Tbaung Khmum	367,939	922	2,346	302,127	6,043	1,749	534
Total	All provinces (n=25)	7,285,244	17,075	43,444	5,477,614	115,018	31,703	9,687
Ghana	Ashanti	2,693,805	8,774	22,730	1,576,835	31,537	12,179	11,554
	Brong Ahafo	1,935,869	6,195	16,048	1,036,424	20,728	8,005	7,594
	Central	1,716,834	5,546	14,368	781,537	15,631	6,036	5,727
	Eastern	1,967,563	6,452	16,714	893,214	17,864	6,899	6,545
	Greater Accra	1,155,523	3,356	8,695	698,234	13,965	5,393	5,116
	Northern	1,988,925	6,236	16,156	1,233,284	24,666	9,525	9,037
	Upper East	924,795	2,565	6,645	543,930	10,879	4,201	3,986
	Upper West	831,804	2,262	5,861	464,586	9,292	3,588	3,404
	Volta	1,732,037	5,470	14,170	928,186	18,564	7,169	6,801
	Western	1,758,978	5,571	14,433	941,962	18,839	7,275	6,902
Total	All region (n=10)	16,706,133	52,428	135,819	9,098,192	181,964	70,270	66,667

*Excluding number of spectacles distributed to teachers

It is estimated that over five years in Cambodia, the national school-based vision screening program would result in 5,477,614 school children being screened, 31,703 children with RE receiving a pair of spectacles and 9,687 children referred to eye care services for further examination and treatment. The cost of implementing such program would vary by province, from $87,362 in Kep to $544,563 in Battambang province.

In terms of cost-effectiveness of the program, the average cost per child screened is $1.33 across all provinces (ranging from $0.56 per child in Phnom Penh to $6.38 in Kep province). The cost per child with corrected refractive error is 230$ on average, ranging from $97 in Phnom Penh to $1,103 in Kep province.

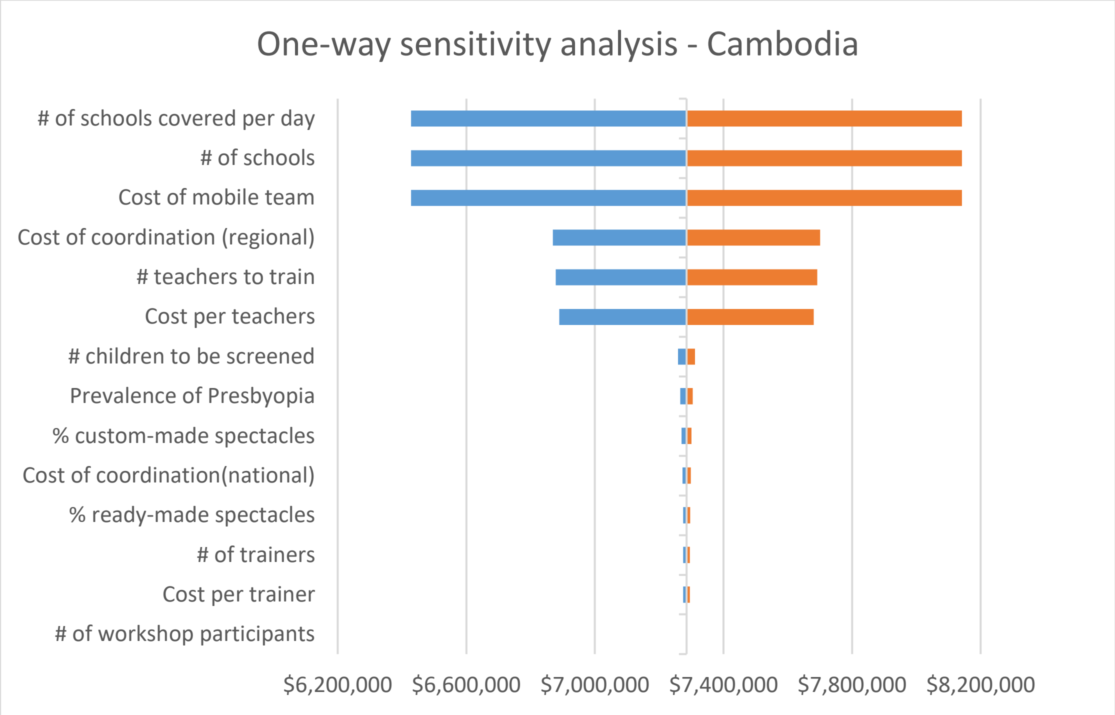
In Ghana, the estimated cost of the national program over five years varies between $831,804 in Upper West region and $2,693,805 in Ashanti region. The average cost per child screened is $1.84, ranging from $1.61 per child in the Upper West region to $2.20 in the Central region and in the Eastern region. The cost per child with corrected refractive error is $238 on average (ranging from $209 in the Northern region to $285 in the Eastern region). Over five years, the national program in Ghana would result in 9,098,192 school children being screened, 70,270 children receiving spectacles and 66,667 children referred to eye care services.

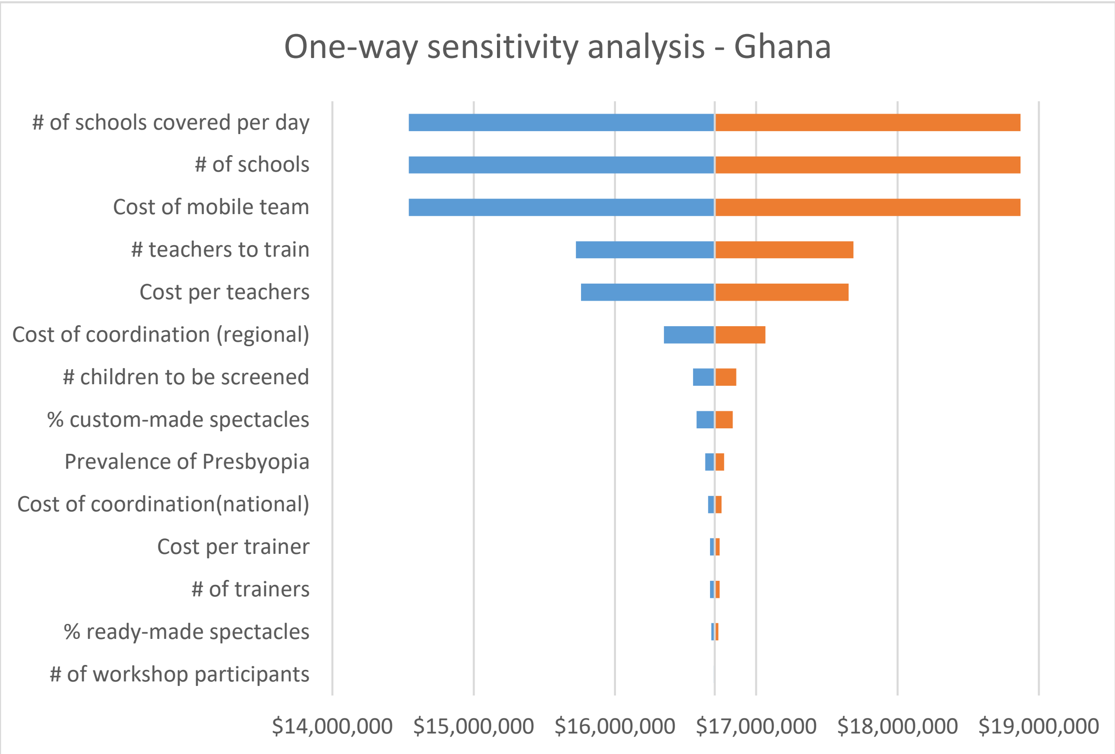
The cost-effectiveness of the vision screening program will increase as the number of schools covered by the program as well as the size of the school-aged population screened grow. This shows the economy of scale effect due to large share of fixed or start-up costs associated with establishing or scaling up school-based vision screening programs.

Sensitivity analysis

Figure 4 shows the results of the univariate sensitivity analysis. The tornado diagram shows the degree to which the model output is sensitive to changes in each parameter used in the model. Each bar represents the change in the estimated budget when each parameter was set to its lower-bound, central, and upper-bound value (with the other model parameters being held constant).

Figure 4: Univariate sensitivity analysis. Tornado diagrams for Cambodia and Ghana (in USD 2016)

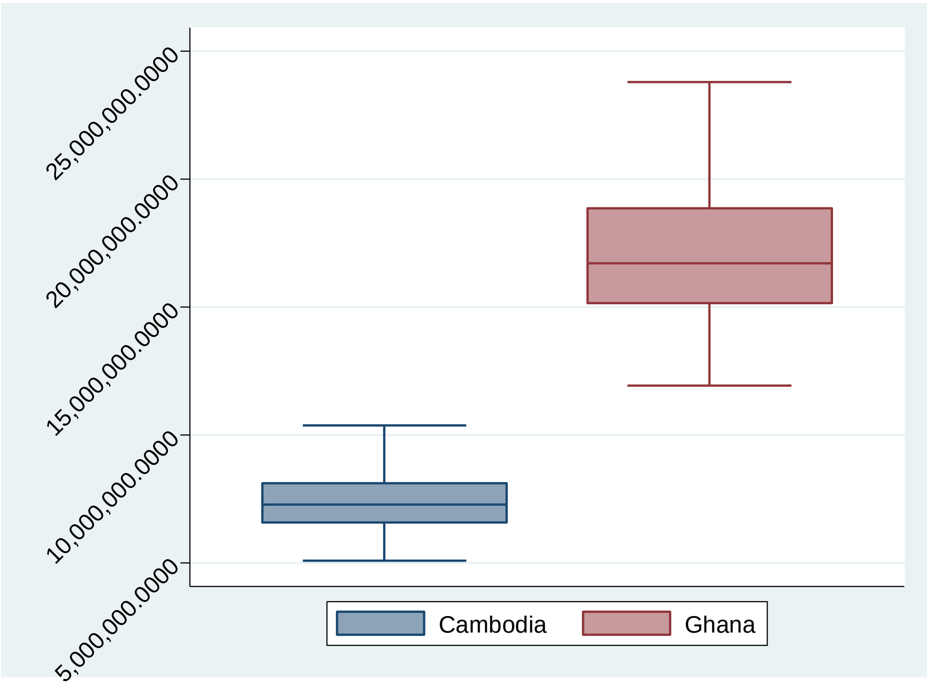




Six model parameters produced the largest impact on the five-year base case budget estimate when their value changed: i) the number of schools covered by the optometrist mobile team per day, ii) the total number of schools covered, iii) the cost of the optometrist mobile team per day, iv) the cost of coordination per region, v) the number of teachers to train; and vi) the cost per teacher trained. Among these six parameters, changes in the number of schools covered by the optometrist mobile team per day, the total number of schools covered, and the cost of the optometrist mobile team per day had an equally big impact on the program budget. This was followed by cost of coordination, the number of teachers to be trained and the cost of training per teacher. The results were similar in both countries.

Figure 5 summarizes the results of the multivariate sensitivity analysis. The projected total cost of the screening program over five years in Cambodia ranges between $5,025,655 and $10,304,335, corresponding to -30% and +43% of the base case value $7,208,141). In Ghana, the estimated range was between $11,678,041 and $23,526,227; -29% and +43% of the base case ($17,285,539). Detailed results of the multivariate sensitivity analysis for different combinations of parameter values are presented in the annex section in Table 7 (for Cambodia) and Table 8 (for Ghana).

Figure 5: Budget impact of national visions screening programs in Ghana and Cambodia (for base case, best- and worst-case scenarios), in USD 2016



Discussion

Summary and interpretation of findings

This study aimed to analyse the expenditure of the two pilot school-based vision screening programs and make projections of the budgets required to scale up this intervention nationally in Ghana and Cambodia.

Analysis of SHIP expenditures indicates that unit costs of delivering school-based vision screening were similar except for the cost per teacher trained ($186 in Cambodia and 112 in Ghana), the cost of vision screening and provision of spectacles per school ($748 in Cambodia and $499 in Ghana) and cost per child examined by mobile refraction team ($1678 in Cambodia and $14 in Ghana). The analysis shows that although the two pilots had similar overall expenditure (just over $61,000), the allocation of resources between the activities was different due to different priorities/needs identified and the stage at which the vision screening program is. Thus, in Cambodia, where the approach of integrating vision screening into school health and nutrition program had been piloted prior to the SHIP project, there was no need to spend significant resources on capacity building and stakeholder sensitisation, as the majority of relevant stakeholders were already familiar with the approach. In Ghana, where the SHIP approach was relatively new, almost a third of the total expenditure of the pilot was due to the initial partner engagement and capacity building. Some differences were also due to the variability in prices of the inputs required to organise teachers training or possibly the differences in how the training was organised. Thus, although the personnel costs were the main cost driver in both countries, in Ghana, the cost of transportation was higher than in Cambodia, while in Cambodia, the cost of venue hire was significantly higher than in Ghana.

The costs of school based screening and treatment of refractive error itself were relatively modest, around $9,000-10,000 or 15%-16% of the total expenditure of each pilot. This is mainly because vision screening was performed by teachers and the project used donated, ready-mades spectacles (ready to clip). This confirms that vision screening integrated into school health programs can be an efficient approach to identify and treat children with visual impairments. Project coordination, however, was an additional important expense accounting for about a quarter of the total expenditure and requiring an additional $15,000 per country.

The analysis of the unit costs of the standardised SHIP package made cross-country comparisons more accurate. Nevertheless, even after the standardisation, there were a number of differences between the two settings. The unit costs, which were similar in

Cambodia and Ghana, included community sensitisation, teacher/trainer training and most inputs of the screening and treatment activity. The only differences observed in this activity were the daily costs of the refraction mobile team, which were 22% higher in Cambodia; and the costs of custom-made spectacles, which were significantly (4 times) higher in Ghana.

Other unit costs, which differed significantly between the two countries, were: i) the cost of the capacity building workshop per participant day (5 times higher in Ghana), ii) the cost of annual national coordination (3.5 times higher in Ghana), and iii) the cost of annual per region coordination (2 times higher in Ghana). These differences between the countries are likely to be due to differences in salary levels, per diem rates, accommodation costs, and custom-made spectacle costs.

An interesting observation was that although a number of unit costs were higher in Ghana, the cost per child screened and the cost per RE case corrected was higher in Cambodia. The larger geography and population of Ghana is likely to be more advantageous to economies of scale with higher numbers of outputs, lower per unit fixed costs and possibly higher efficiencies.

Comparison of cost and cost-effectiveness estimates with other studies

Evidence on cost of school-based vision screening is scarce and the differences in methodological approaches of the few studies available limit opportunities for meaningful comparisons. In addition, this analysis did not aim to calculate the number of DALYs averted by correction of RE, and therefore at this stage it is not possible to do a comparison with the WHO cost-effectiveness thresholds [32] or existing studies that estimate cost per DALY [15, 16].

For this analysis, we compared our estimates with the economic analysis of the essential package for health and development for school-age children, which includes vision screening and provision of spectacles as presented in the DCP3 Child and Adolescent Health and Development volume [18]. The cost of the intervention is estimated at between $0.71 and $1.07 (2012 US$) per case averted/year, assuming a cost of $2-3 for ready-made spectacles with a useful lifespan of 4 years. This is equivalent to $2.97 to $4.47 per case averted (in US$

2016)[3]. The cost per case of RE averted (calculated based on the data of the pilots in Ghana and Cambodia) is significantly higher (on average $230 in Cambodia and $238 in Ghana). Even if we take into account that the first year of the program is most expensive due to program start-up costs and calculate the cost per case averted at a more advanced stage of the program(e.g. Year 4 or 5), the costs remain high. The differences between the costs estimated in this study and DCP3 estimates are likely due to several reasons. First, DCP3 estimates focus on average annual costs incurred in delivering screening and provision of spectacles; the estimates exclude teacher training, sensitisation and coordination. Evidence from the SHIP pilots shows that the costs of teacher training and coordination (including supervision) represents a large share of the total expenditure (46% and 33% respectively). When we consider the cost of screening, examination and provision of spectacles, the cost per case of RE averted decreases to 150$ and 109$ in Cambodia and Ghana respectively.

Secondly, this study calculated costs of providing custom-made spectacles for children with more complex prescriptions. The cost of providing custom-made versus ready-made spectacles can be twelve times higher (the custom-made spectacles in Ghana were 12 times higher than ready-made) (see Table 3).

Thirdly, we do not know which model of examination of children referred to optometrists was used in DCP3 school-age essential package estimates. The estimates made in this analysis are based on the mobile team model where the program was delivered, and the estimates were based on the current market prices at the time of the study.

Finally, it is not clear which denominator was used to calculate the cost per case averted in the DCP3 school-age essential package; it is possible that the prevalence of visual impairment in children used in DCP3, which determines the number of expected outputs (cases averted), was much higher than the prevalence found in our pilots.

In terms of cost-effectiveness, WHO-CHOICE poses initial guidelines on thresholds for acceptable costs per DALY defined interventions. In this case, when the cost per DALY averted is less than GDP per capita, it is considered very cost-effective. Between one and three times GDP per capita is cost-effective, and greater than three times GDP per capita is

[3] Obtained using the following formula: (CPI 2016/CPI 2012)*2012 USD value (consumer price index was 229.594 in 2012 and 240.007 in 2016 based on data from the US Bureau of Labor Statistics (source: http://www.in2013dollars.com/2012-dollars-in-2016?amount=4.28)

not cost-effective [32]. Our study does not calculate number of DALYs averted by the intervention, so at this stage it is not possible to do a comparison with WHO threshold. However, Baltussen et al. (2009) calculated the cost per child of screening and correcting refractive errors in schoolchildren in different WHO regions [27]. Although figures for all regions included in the study are not presented in the paper; the authors found that the cost per child treated in Africa (Afr-D) ranges between strategies, from I$204 for screening of 11-15 years old to I$450 for screening of 13 years old. When converting our estimated cost per child treated into the same currency (international dollars, base year 2000), we obtained I$513 for Cambodia and I$453 for Ghana. These are similar to those calculated by Baltussen et al. (2009) [27].

Affordability

One of the main purposes of conducting a Budget Impact Analysis is to assess the affordability of a new intervention in a specific setting. The total budgets required to implement the national school-based vision screening programs in Cambodia and Ghana were $7,285,244 and $16,706,133 over 5 years (2018-2023) respectively. It is important to put the projected budget estimates in the perspective of the education and health sector financing in each country, as school health programs are usually implemented and funded between these two ministries.

In Cambodia, the total national budget approved for 2018 amounts to $6.018billion, including $485m for the health sector and $848m for the education sector. The total budget estimated to implement the five-year vision screening program ($7,285,244) represents about 0.9% of the education and 1.5% of the health sector budget, or 0.5% of the combined budgets ($1.333billion). The budget for the first year of the program ($2,919,843) represents 0.2% of the combined budget (0.3% of education and 0.6% of health). For the following years, the maximum annual budget of $1,104,401 would constitute 0.08% of the combined annual budget, assuming the government budgets in the next five years are similar to 2018.

In Ghana, total government budget for 2018 is equivalent to US$15,074billion; including a budget of $991m and $2.074billion for the health and education sectors,[4] respectively. The estimated five-year vision screening program budget ($16,706,133) would represent 0.8% of the education sector and 1.7% of the health sector government's budget for 2018. This is an

[4]Obtained using the average exchange rate for 2018 (GHS to USD 0.2241); Source: https://uk.investing.com/currencies/ghs-usd-historical-data

equivalent of 0.5% of the health and education sector budgets combined. Assuming that the government budget for the health and education sectors remains constant in the coming years, the first year of the program is projected to be the most expensive ($7,288,381) amounting to 0.2% of the combined budget (0.4% of education and 0.7% of health). For the next four years, the highest budget required per year would be $2,488,328 or 0.07% of the combined annual budget (0.11% of education and 0.23% of health).

When considering the current government budgets for health and education in Ghana and Cambodia, implementing a national school-based vision screening program appears to be affordable for in both countries. However, more detailed information on the breakdown of these budgets by programmes and cost type is required. In addition, information on the specific budgets allocated to different departments involved in the implementation of the school-based screening needs consideration. Given that a setup of such programs would require substantial investments for the first year of the project, support from external donors may be required to cover start-up costs in the first year, while government funding could cover recurrent, annual expenditures.

Opportunities for reducing costs and maximising the effectiveness and efficiency of school-based vision screening programs

The SHIP program was designed using best practices for school-based vision screening drawn from existing literature and experiences from organisations implementing similar programmes in LMICs [22]. This information helped draft the SHIP guidelines, which provide technical guidance for policy-makers and planners to conduct vision screening as a component of their integrated school health programs. These guidelines also provide advice on the most cost-effective interventions and can facilitate scalability and sustainability of vision screening programs.

For example, the use of conventional or clip in and out ready-made spectacles is recommended based on the existing evidence on using ready-made spectacles in children. Clear eligibility criteria based on the prescription and frame sizes are set for the use of ready-made spectacles. Based on the data from the SHIP project, the majority of children with refractive error were eligible for ready-made spectacles (0.4% in Cambodia and 0.54% in Ghana versus 0.18% and 0.23% for custom-made spectacles). Considering the price difference between ready-made and custom-made spectacles ($2 vs $6 in Cambodia and $2 vs $25 in Ghana), the use of ready-made spectacles that can be provided on site can generate substantial savings for school-based vision screening programs.

Another example is the use of teachers for conducting vision screening of schoolchildren. Training of teachers by skilled eye care personnel and screening of children by trained teachers has been tested in various contexts. Existing evidence shows that the efficiency of school screening programs is maximised when teachers receive quality training, leading to a low number of false positive children (children incorrectly referred to refraction teams). Testing teachers' skills and measuring accuracy of their screening (to minimise both false positives and false negatives) is also critical [20, 23]. We estimate that the cost per child treated would rise to $500 in Cambodia and $549 in Ghana if screening of schoolchildren were done by mobile refraction teams only, compared to $230 in Cambodia and $238 in Ghana. This would represent more than a two-fold increase in both countries.

Additionally, the recommendation from the SHIP guidelines to screen and distribute spectacles to teachers is important as it can maximise the benefits of the program. Although the provision of spectacles to teachers represents an additional cost for the vision screening program (assuming that the spectacles are provided free of charge), doing so can increase the overall efficiency of the program. Children often refuse to wear spectacles for a variety of reasons, including no perceived benefit, parental disapproval, and fear of being teased [9]. The experiences from the SHIP project show that providing spectacles to teachers with uncorrected refractive error or presbyopia can help sensitize teachers about the importance of vision problems in schoolchildren. Teachers will also act as role models and help increase uptake of screening and compliance with spectacles [9].

Furthermore, using the best practices recommended in the SHIP guidelines would maximise program effectiveness and efficiency. Policy-makers and planners need to consider opportunities for minimising costs of the activities and inputs, which showed to be the key cost drivers in this analysis. Training of teachers, eye examinations by mobile teams and program coordination were the primary cost drivers in the actual expenditure of the pilots, standardised cost estimates and budget impact analysis. Local contexts of the programmes need to be carefully considered to identify the most cost-effective ways to deliver these activities, find opportunities for cost minimisation, and scale up. The number of children screened and the number of children with RE identified was also a significant variable. It is therefore essential to analyse the prevalence of RE in children in each specific setting and identify age groups where the benefits of screening will be maximised. Such information on the cost drivers is important for policy makers and planners to design efficient programs and strategies to reduce the cost of the program by focusing on the activities that have the largest potential impact on total cost.

Finally, given that teacher training and coordination constituted a significant part of the overall budget of the program at scale, further integration of vision screening with other school-based interventions will maximise the benefits of the economies of scale. For example, training of teachers could cover other interventions recommended in the essential package for school-aged child health such as vision screening, deworming, and health education. The annual cost of delivering an integrated school-age essential package was estimated by DCP3 Child and Adolescent Health and Development volume at $10.30 per child in low-income countries and $24.43 in lower-middle countries (2012 US$) [18]. Further economies of scale could be realised by using schools as platforms to reach out and deliver health services to out-of-school children.

Strengths and limitations of the study

Our cost and budget impact analysis is based on the detailed analysis of actual program expenditures and outputs from two countries. Cost estimates for vision screening in low- and-middle income countries often rely on information from secondary sources and/or following WHO-CHOICE standardized unit costs.

This study, however, has a number of limitations. Firstly, budget impact analysis is based on an important assumption that eye care services and skilled eye health personnel are available and sufficient for implementing the program at national level. Availability of quality eye care services and trained eye health personnel is a pre-requisite for starting or scaling up school-based vision screening. However, that assumption may not hold for all provinces or regions covered. Our estimates of the budget impact do not take the costs required for training eye care personnel or establishing and refurbishing eye care units into account. Secondly, we do not take into account existing programs or initiatives currently implemented in Ghana and Cambodia or any resources that may be already available to cover the costs of such program.

Thirdly, there are limitations regarding the availability of data used in the model, including national surveys on the prevalence of visual impairment and refractive error in school age children (both in and out of school). Prevalence and education data for specific administrative units (region or province) were not always available. In this case, national averages were applied to calculate the budget impact for specific regions or provinces.

Fourthly, official projections for the number of new entrants and enrolment of children in primary and secondary education could not be obtained from the respective Ministries of Education for school years 2018/19 to 2022/23. We made our own projections using flow model assumptions on flow rates and trends based on historical data. Furthermore, our analysis estimates the budget impact of integrating vision screening in government schools only. An increasing number of children in both countries enrol in private schools; the budgets projected here will not cover the costs of screening for these children.

Finally, this study presents the incremental cost of including vision screening and does not calculate the true economic cost of the intervention, as existing capacity and opportunity costs, such as the time spent by teachers for screening activities, were not taken into account.

Conclusion

There is a lack of quality evidence on the cost of school-based vision screening programs in LMICs. Findings from this analysis contribute to the evidence base that will enable education planners and international partners to improve their planning and budgeting processes for school-based vision screening programs in these LMICs. This study assesses the costs of the screening pilots in Ghana and Cambodia and estimates the budget impact for the scale up of such programmes in all primary and lower secondary schools in the two countries. Results confirm that vision screening of schoolchildren as part of a school-based health package is a cost-effective way to identify and provide spectacles to children with URE. The analysis suggests that the scale up of the programs in Ghana and Cambodia is affordable based on an analysis of the current health and education budgets, provided that there is sufficient in-country capacity to deliver such interventions at scale. The report highlights a number of policy and program implications and provides suggestions for minimising costs and maximising efficiencies of vision screening programmes in a school setting. Integrating vision screening with other school-based interventions identified in the essential package of school age child health and delivering it at scale can maximize economies of scale and scope, ultimately reducing the unit cost of individual school-based interventions such as vision screening.

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Annexes

Field visit Ghana (15th – 18th January 2018)

- **Meetings on the 15th of January 2018 in Accra:**
    - Mr. David Agyemang, Program Manager and Mr. Enoch Amoah, Finance and Support Services Officer, Sightsavers
    - Dr Benjamin Kofi Marfo, Deputy Program Manager, Neglected Tropical Disease and intestinal worm, Ghana
    - Dr James Addy, Head of Eye Care unit of Ghana Health Service
- **Trip to Akwatia (Eastern Region), meeting on the 16th of January 2018:**
    - Mr. Christian Fiadjor, Director, Akwatia St. Dominic Hospital
    - Dr. Dawson, Ophthalmologist, Akwatia St. Dominic Hospital
    - Group meeting with the education district unit
    - Dr. Nkuvi**,** NTDs' District Director
- **Meetings on the 17th of January 2018 in Accra:**
    - Mr. Jeremiah Badu Shayar, Training Officer, Special Education Division
    - Group meeting with Special Education Division
- **Meetings on the 17th of January 2018 in Accra:**
    - Ms. Esi Nkoom, Director, School Health Education Programme
    - Ms. Durcas, Program Officer, School Health Education Programme
    - Ms. Gyekye, Program Officer, School Health Education Programme
    - Chief Statistician, Bureau of statistics

Field visit Cambodia (12th – 14e February 2018)

- **Meeting on the 12th of February 2018 in Phnom Penh:**
    - Mr. Kann Puthy, Deputy Director Primary Education Department, MoEYS
    - Mr. Sith Sam Ath, Country manager, The Fred Hollows Foundation
- **Meeting on the 14th of February 2018 in Phnom Penh:**
    - Mr. Tep Phyorith, Finance department
    - Mr. Wuthy, Special Education Department

Dissemination of costing study preliminary results

Presentation at:

- The 7th Annual Course on School Health and Nutrition Programs in Asia &The School Health Integrated Programming (SHIP) Symposium;
  Bangkok, 16th of February 2018
- Mainstreaming Inclusive School Health, African Regional Workshop
  Addis Ababa, 13th of April 2018

Supplementary tables

Table 7: Multivariate sensitivity analysis - Cambodia

	# of schools covered per day	Min (3)			Median (4)			Max (5)		
Cost of mobile team per day	Cost per teachers / Cost of coordination (regional)	Min ($9,983)	Median ($13,310)	Max ($16638)	Min ($9,983)	Median ($13,310)	Max ($16638)	Min ($9,983)	Median ($13,310)	Max ($16638)
Min ($237)	Min ($70)	6,473,321	6,889,259	7,305,198	5,616,719	6,032,658	6,448,597	5,102,758	5,518,697	5,934,636
	Median ($93)	6,869,306	7,285,244	7,701,183	6,012,704	6,428,643	6,844,582	5,498,743	5,914,682	6,330,621
	Max ($116)	7,265,290	7,681,229	8,097,168	6,408,689	6,824,628	7,240,566	5,894,728	6,310,667	6,726,606
Median ($315)	Min ($70)	7,615,456	8,031,395	8,447,333	6,473,321	6,889,259	7,305,198	5,788,040	6,203,978	6,619,917
	Median ($93)	8,011,441	8,427,380	8,843,318	6,869,306	7,285,244	7,701,183	6,184,024	6,599,963	7,015,902
	Max ($116)	8,407,426	8,823,364	9,239,303	7,265,290	7,681,229	8,097,168	6,580,009	6,995,948	7,411,887
Max ($399)	Min ($70)	8,757,591	9,173,530	9,589,469	7,329,922	7,745,861	8,161,800	6,473,321	6,889,259	7,305,198
	Median ($93)	9,153,576	9,569,515	9,985,454	7,725,907	8,141,846	8,557,784	6,869,306	7,285,244	7,701,183
	Max ($116)	9,549,561	9,965,500	10,381,438	8,121,892	8,537,831	8,953,769	7,265,290	7,681,229	8,097,168

Go back to document

Table 8: Multivariate sensitivity analysis - Ghana

	# of schools covered per day	**Min (3)**			**Median (4)**			**Max (5)**		
Cost of mobile team per day	**Cost of coordination (regional)** / **Cost per teachers**	**Min ($21,554)**	**Median ($28,738)**	**Max ($35,923)**	**Min ($21,554)**	**Median ($28,738)**	**Max ($35,923)**	**Min ($21,554)**	**Median ($28,738)**	**Max ($35,923)**
Min ($191)	**Min ($54)**	15,399,818	15,759,047	16,118,277	13,235,234	13,594,464	13,953,694	11,936,484	12,295,714	12,654,944
	Median ($72)	16,346,903	16,706,133	17,065,363	14,182,320	14,541,550	14,900,779	12,883,570	13,242,800	13,602,029
	Max ($90)	17,293,989	17,653,218	18,012,448	15,129,405	15,488,635	15,847,865	13,830,655	14,189,885	14,549,115
Median ($255)	**Min ($54)**	18,285,929	18,645,159	19,004,388	15,399,818	15,759,047	16,118,277	13,668,151	14,027,381	14,386,611
	Median ($72)	19,233,014	19,592,244	19,951,474	16,346,903	16,706,133	17,065,363	14,615,236	14,974,466	15,333,696
	Max ($90)	20,180,100	20,539,330	20,898,559	17,293,989	17,653,218	18,012,448	15,562,322	15,921,552	16,280,781
Max ($319)	**Min ($54)**	21,172,040	21,531,270	21,890,500	17,564,401	17,923,631	18,282,861	15,399,818	15,759,047	16,118,277
	Median ($72)	22,119,125	22,478,355	22,837,585	18,511,487	18,870,716	19,229,946	16,346,903	16,706,133	17,065,363
	Max ($90)	23,066,211	23,425,441	23,784,670	19,458,572	19,817,802	20,177,032	17,293,989	17,653,218	18,012,448

Go back to document