

Review

Comparison of the pediatric vision screening program in 18 countries across five continents

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Abstract

Purpose: Incorporating mass pediatric vision screening programs as part of a national agenda can be challenging. This review assessed the implementation strategy of the existing pediatric vision screening program.

Methods: A search was performed on PubMed, EBSCO host MEDLINE Complete, and Scopus databases encompassing the past ten years for mass pediatric screening practice patterns that met the selection criteria regarding their objectives and implementation. Results were analyzed from 18 countries across five continents.

Results: Eight countries (44%) offered screening for distance visual acuity only, where the majority of the countries (88%) used either Snellen or Tumbling E chart. High-income countries initiated screening earlier and applied a more comprehensive approach, targeting conditions other than reduced vision only, compared with middle-income countries. Chart-based testing was most commonly performed, with only three countries incorporating an instrument-based approach. Lack of eyecare and healthcare practitioners frequently necessitated the involvement of non-eyecare personnel (94%) as a vision screener including parent, trained staff, and nurse.

Conclusions: Implementation of a vision screening program was diverse within countries preceded by limited resources issues. Lack of professional eyecare practitioners implied the need to engage a lay screener. The limitation of existing tests to detect a broader range of visual problems at affordable cost advocated the urgent need for the development of an inexpensive and comprehensive screening tool.

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Keywords: Mass screening; Vision screening; Vision tests; Pediatric

Introduction

Pediatric vision screening programs are intended to identify pediatric populations with vision disorders. Their emphasis is on early detection and facilitation of appropriate visual rehabilitation to prevent or minimize visual disability.¹ Vision screening has a remarkably long history dating back over 1000

years ago where vision screening was performed by using the separation of two stars.² A vision screening can be performed either in the community or in a specialized clinical setting and is a common practice in preventive eyecare programs for both adults and children.^{3–5} In pediatric eyecare, the “mass screening” approach (usually for preschool and school-aged children)^{6,7} competes with limited resources that may target more specific conditions such as retinopathy of prematurity.⁸ Mass screening approaches offer broad coverage to all of the target population, while more opportunistic screening occurs in a clinical-based setting. Selective screening targets high-risk groups or specific populations.⁹ Subsequently, the nature of mass screening programs as high budget items attracts considerable debate.^{10,11} Mass pediatric vision screening had been widely reviewed but has evaded concise analysis due to

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divisive opinions regarding operational efficiencies and benefits despite collective agreement on its importance.^{1,7,12–15} Specifically, studies on pediatric vision screening lacked generalizable conclusions because of inconsistencies in their program objectives and implementations.⁷

Objectives of existing pediatric vision screening programs varied with different age groups and conditions.^{3,6,16} Inconsistencies in implementation were commonly observed in the testing approach^{3,17–19} and vision screeners.^{3,20,21} Pediatric vision screening programs often received an ad hoc level of support from governing authorities and financial allocation due to lack of evidence in the cost findings and the effectiveness of the program.¹⁰ The program policies varied within and among countries.²² Therefore, the incorporation of pediatric vision screening as a national priority can be challenging.

The impact of existing disparities in pediatric vision screening programs across countries challenges the effort towards an international coherent pediatric vision care ecosystem. Implementing a strategic approach to such a program poses enormous challenges considering the complexity and current variations in the approaches; determining which screening approach to perform together with the decision on ‘when and how’ is still controversial. Deficiency in a mass vision screening approach could still lead to a high percentage of children not receiving vision screening.²³

Despite longstanding implementation and extensive research, the best practice in the implementation of vision screening remains unclear.²⁴ Due to extensive research and rapid transformation of the pediatric vision screening program, our review focused on the analysis of mass vision screening practicing pattern within the last ten-year period to highlight the most current issues. The practicing pattern analysis intended to identify gaps in the planning and implementation of existing pediatric vision screening programs and identify areas of improvement. The review aimed to contribute to the understanding of pediatric vision screening programs worldwide with a specific focus on the practice patterns of mass screening programs regarding their objective and implementation.

Methods

A systematic computerized literature search was conducted to attain all accessible published information on mass pediatric vision screening provided to a whole population or subgroup following a research protocol that followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.⁹ The search was using the Population, Intervention, Comparison, and Outcome (PICO) framework²⁵ based on the main question: “What are the practice patterns of existing pediatric mass vision screening program according to their objective?” (Table 1). A search was performed based on PubMed, EBSCO host MEDLINE Complete, and Scopus database in December 2018. A combination of database-specific terms and keywords searched were dependent on the PICO element. Since the target population in this review were children aged from birth to 17 years and 11

Table 1
Population, Intervention, Comparison, and Outcome (PICO) search strategy.

Research question based on PICO framework	Description	Keyword
Population		
What are the practice patterns of existing pediatric vision screening program pertaining to target population?	1) Children	Child*
	2) Age ranged from birth to 17 years and 11 months old	Pediatr* Infant Toddler
Intervention		
How are the implementations of existing pediatric vision screening program?	1) Test	Screening
	2) Screener	
Comparison		
Not required for this search	Not required for this search	Not required for this search
Outcome		
What are target conditions of the practice pattern?	Vision problems	Vision

PICO: Population, Intervention, Comparison, and Outcome.

months old, the keywords used were including “child*,ediatr*, infant, and toddler”. For the “Intervention” component, the general keyword of “screening” was used to cover both aspects of screener and test in the implementation of screening. The keyword for the “Comparison” component was not required for this search since this review was not intended to compare the efficacy of screening but only to report the distribution pattern in the implementation of the vision screening program. Keyword “vision” was used for the “Outcome” component to cover a broader range of target vision problems. At least one term of every type had to be met. The search techniques utilized were Boolean operators, truncation, subject headings, and filters. The reference list and citations of the included article were screened to distinguish additional relevant information. Articles that reported availability and implementation of mass screening program were selected as this program approached all children in the major age subgroups (infant, toddler, preschool, and school age) where the eligibility is broad and not based on risk factors of specific vision condition.⁹ Due to the objective that focuses on the implementation of the regional or nationwide screening program, review articles that summarized the implementation of the vision screening program and gray literature were also included for this review. Research articles on epidemiology and validation of new technique or instrument or involved small sample size less than 200 were excluded, as the screening protocol might not reflect the actual regional or national practice of pediatric vision screening.

Full articles that were not available in English and were published before 2008 were filtered. All abstracts and full articles that matched keywords searched were inspected for their appropriate inclusion in the practice pattern analysis. Initially, one (N.F.A.B.) of the authors checked the search results and selected all reports of studies that made reference to refractive error, any eye disease, and vision screening. Any reports that were not relevant were excluded at first viewing. Two authors (C.A.H and N.F.A.B.) then screened for the inclusion criteria. All authors had more than ten years of

experience in the pediatric optometry research to screen all titles and abstracts to identify relevant articles. A Critical Appraisal Skills Programme (CASP) Diagnostic Checklist was completed for each study to identify eligible articles.²⁶ Any discrepancies were resolved through consensus. Reasons for articles not being selected were recorded.

Results

A total of 8356 abstracts in PubMed (*n* = 2665), EBSCO host MEDLINE Complete (*n* = 1772), and Scopus (*n* = 3669) were examined (Fig. 1). The final analysis was performed on 36 articles that reported implementation in 18 countries from 5 continents (Table 2), comprising North America (*n* = 2),^{19,27–35} Asia (*n* = 8),^{3,21,36–46} Oceania (*n* = 2),^{16,17} Europe (*n* = 4),^{6,20,47–50} and Africa (*n* = 2).^{51,52} Objectives of screening program were dissected based on target age groups according to their learning stages and target conditions. Target age groups comprised infants, preschools (including toddlers), and school-aged. Despite the fact that school enrollment age might have varied among countries (for example five years old in Australia and seven years old in Malaysia), children in similar learning stages might have experienced and been exposed to a similar environment. About 22% of the countries (Canada, Italy, the Netherlands, and the United States)^{6,28,32,47} initiated vision screening during

infancy (from one month old) and throughout the schooling period while 39% (Taiwan, India, Malaysia, South Africa, Egypt, Israel, and Oman)^{3,36,37,40,41,44,51,52} applied screening at school-aged (age ranged from seven years old to 16 years old).

Vision screening programs were divided into three categories: Type I – vision only; Type II – vision and ocular alignment or ocular health; Type III – risk factor (Table 3). Type I approach was implemented in approximately 44% (8 out of 18) of the countries.^{3,17,20,36,37,41,44,52} Screening for risk factors (Type III) was applied in three countries (Canada, the United States, and Iran).^{19,29,31,38} Since the implementation of a mass pediatric vision screening program involves significant economic investment, further analysis was performed comparing the implementation approach with socioeconomic status (based on per capita gross national income in 2014).⁵³ Approximately 46% of countries in the high-income category (5 countries out of 13 countries)^{6,27,32,47,50} included vision screening for infants, while the rest of the countries under high-income category covered preschool and school-aged children. High-income countries implemented diverse vision screening approaches comprising all types. About 62% of countries under the high-income category implemented a more comprehensive approach other than testing vision only.^{6,16,27,34,45–47,50} Specialist-level (physician, optometrist, ophthalmologist, orthoptist, or pediatrician) screeners were involved in 33% of the countries^{6,20,28,47,48,54} while others assigned nurses or non-clinicians as vision screeners (Table 3). Non-eyecare practitioners, including trained staff, nurses, and parents, were involved in 94% of the countries.^{3,16,17,36,37,39,42,44–46,51,52} The most diverse background of vision screeners was engaged in Canada, Italy, the Netherlands, the United Kingdom, and the United States that comprising specialist-level (pediatricians, general practitioners, orthoptist, and physician), nurses, and lay screeners (trained technicians, teachers, and parents).^{6,28,30,35,47,49,50,55} Orthoptists were involved as vision screeners in Italy and the United Kingdom.^{6,48} Japan and Korea engaged parents as vision screeners in a home-based screening program.^{45,46}

All countries (100%) used a chart-based approach to screen conditions related to reduce vision (Types I and II) specifically among children at preschool and school-aged. Screening for risk factors (Type III) using the instrument-based approach was applied in three countries (11%).^{19,29,38} Screening for binocular vision and/or ocular health (Type II) including general observation, Hirschberg test, pupillary reflex, red reflex, stereotest, and questionnaire were implemented in ten countries (Australia, Canada, Italy, Japan, South Korea, the Netherlands, the United Kingdom, the United States, Egypt, and Iran).^{6,16,27,45–48,55} Analysis on vision charts used and the testing distance (Table 4) revealed that seven countries (39%) used either Snellen or Tumbling E chart only^{3,37,39,43,44,51,52}; while six countries (33%) used an age-appropriate vision chart (Lea symbol, Sheridan Gardiner, HOTV, and Keeler Crowded LogMAR).^{6,16,20,28,33,50} Two countries (the Netherlands and New Zealand) used non-validated vision charts (Amsterdam Picture Chart and Parr Chart) where the outcome might be

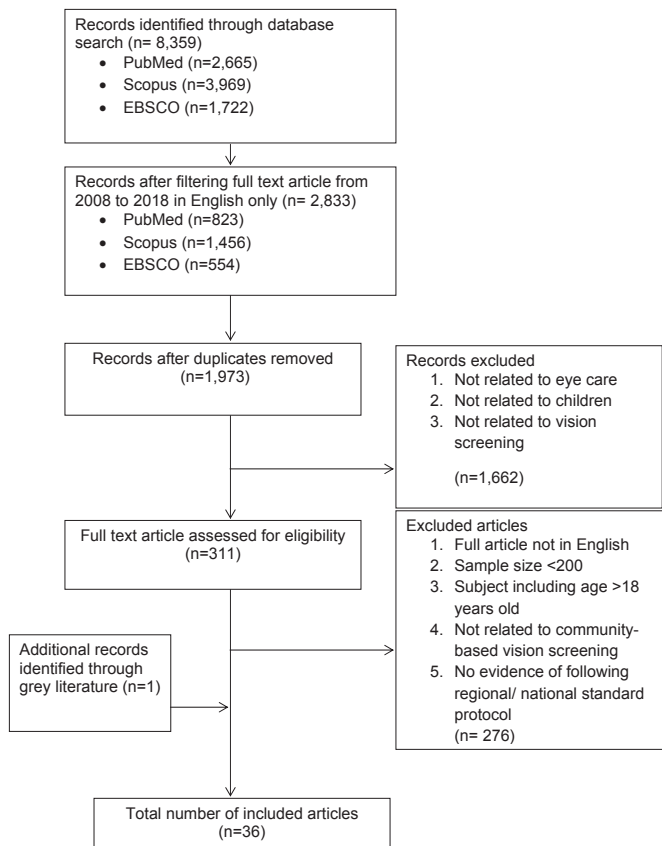


Fig. 1. PRISMA diagram of systematic review process. PRISMA: Preferred reporting items for systematic reviews and meta-analyses.

Table 2
Dissemination of 36 articles used in the review that consisted of 18 countries across five continents.

Continents	Countries	Year of publication	Target population	VSC ^a	Screeener	References	
Oceania	Australia	2014	4 years old	II	Trained staff	16	
	New Zealand	2015	3–5 years	I	Trained staff	17	
North America	Canada	2012	Infant, 3–5 years	II	Nurse, trained staff	27	
		2012	2 months to 6 years old	II	Physician, nurse, trained staff	28	
	The United States	2017	18 months to 5 years old	III	Trained staff	29	
		2012	5–9 years	II	Nurse, trained staff	34	
		2013	6 months to 5 years old	III	Trained staff	32	
		2013	3–5 years	II	Pediatrician, trained staff	55	
		2014	Preschool	III	Trained staff	19	
		2014	6 months to 6 years old	III	Trained staff	31	
		2015	6 months to 6 years old	III	Pediatrician	30	
		2016	5–12 years	II and III	Trained staff	33	
		2016	3–5 years	III	Trained staff	18	
		2016	3–11 years	II	Trained staff, optometrist	35	
Europe	Croatia	2016	4–5 years	I	Ophthalmologist	20	
	Italy	2010	7 months, 3 and 5 years old	II	Nurse, physician, orthoptist	6	
	The Netherlands	2013	1 month to 6 years old	II	Physician, nurse	47	
	The United Kingdom	2014	4–5 years old	II	Orthoptist	48	
		2015	6–8 weeks, 4–5 years	II	General practitioner, orthoptist	50	
	2017	4–5 years old	II	Nurse	49		
Africa	Egypt	2014	6–12 years old	II	Trained staff	51	
	South Africa	2013	School-age	I	Trained staff	52	
Asia	India	2009	School-age	I	Trained staff	41	
		2016	School-age	I	Trained staff	40	
		2017	School-age	I	Trained staff	21	
		2018	School-age	I	Trained staff	39	
		Iran	2009	3–6 years old	II	Trained staff	42
			2012	2–6 years old	II	Nurse, trained staff	43
	2015		3–6 years	II and III	Nurse, trained staff	38	
	Israel	2009	6–14 years old	I	Nurse	44	
	Japan	2009	3.5 years old	II	Parent	45	
	Malaysia	2012	7–15 years old	I	Nurse, assistant medical officer	3	
	Oman	2018	School-age	I	Nurse	36	
	South Korea	2014	3–6 years old	II	Parent	46	
	Taiwan	2017	11–12 years	I	Nurse	37	

^a Vision screening categories (VSC): Type I – vision only; Type II – vision and ocular health or ocular alignment; Type III – risk factor (vision referred to any screening for reduced vision, refractive error or amblyopia).

doubtful and limit comparison with clinical findings using other validated vision chart.^{17,47} Eleven countries (61%) were found to have used cut-off referral of 6/9 or 6/12 regardless of the target age group.^{3,16,17,20,21,43–45,51,56} Three countries (the United States, Italy, and South Korea)^{6,33,46} lowered the cut-off referral criteria with an increasing target age group, and one country (the United Kingdom) used a lower cut-off referral criteria for uncrowded LogMAR chart.⁵⁰

Discussion

Analysis of practice pattern of the pediatric vision screening program in 18 countries showed that the implementation, such as the selection of screener and methods, link to the objective and socioeconomic status of the country. There was variation in the scope of vision screening and vision screeners depending on the target population (Table 5). The vision screening program for infants usually involved a specialist-level screener, but more involvement of a lay screener could be seen in the vision screening program for the preschool and school-age groups. Vision screening for infant

and preschool was designed to detect vision and ocular health problems while vision screening for school-age children was mainly focused on vision only. Development of a pediatric vision screening program might need proper planning due to its implication towards the overall healthcare budget of the country.

Need for early detection targeting a wide-range of vision problems

Vision screening was ideally recommended to be performed on all neonates, infants, and children before discharge from the neonatal nursery and during all subsequent routine health supervision visits.⁵⁷ Many countries adopted this recommendation despite variations in the implementation.^{6,28,47} However, in some instances, due to limited resources, vision screening was recommended to be conducted soon after the child was able to respond to the test or at school entry age.¹² A vision screening program was initiated in infancy in many high-income countries such as Canada, the United States, the Netherlands, the United Kingdom, and Italy.

Table 3
Apportionment of vision screening categories, target age groups, and its relation to economic status of 18 countries.

GNI ^a	Country	Target age group	VSC ^b
High-income	Australia	Preschool	II
	Canada	Infants and preschool	II and III
	Croatia	Preschool	I
	Italy	Infants and preschool	II
	Israel	Preschool and school-aged	I
	Japan	Infants and preschool	II
	The Netherlands	Infant and preschool	II
	New Zealand	Preschool	I
	Oman	School-age	I
	South Korea	Preschool	II
	Taiwan	School-aged	I
	The United Kingdom	Infant and preschool	II
	The United States	Infants, preschool and school-aged	II and III
	Middle-income	Egypt	Preschool and school-aged
India		School-aged	I
Iran		Preschool and school-aged	II and III
Malaysia		School-aged	I
South Africa		School-aged	I

^a GNI: Per capita gross national income in 2014.

^b Vision screening categories (VSC): Type I – vision only; Type II – vision and ocular health or ocular alignment; Type III – risk factor (vision referred to any screening for reduced vision, refractive error or amblyopia).

Eye screening among infants may necessitate professional care and appropriate facilities, which might involve higher costs. Despite the fact that a simple red reflex examination was

Table 5
Implementation of vision screening categories and screener in 18 countries according to the target age group.

Target age group	Screener			VSC ^d		
	Specialist ^a	PHC ^b	Lay screener ^c	Type I	Type II	Type III
Infant	28%	22%	11%	0%	22%	11%
Preschool	33%	39%	44%	17%	56%	11%
School age	0%	28%	22%	33%	11%	6%

^a Specialist level screeners were including physician, pediatrician, ophthalmologist, optometrist, and orthoptist.

^b Primary health care (PHC) level screeners included general practitioner and nurse.

^c Lay screener level screeners were including parent, teacher and trained staff.

^d Vision screening categories (VSC): Type I – vision only; Type II – vision and ocular health or ocular alignment; Type III – risk factor (vision referred to any screening for reduced vision, refractive error or amblyopia).

proven to be highly sensitive in identifying cataract, glaucoma, high refractive error and also life-threatening conditions such as retinoblastoma and other systemic diseases with ocular manifestations,^{58,59} the cost of eye examination in clinic-based setting was reported to be 4.8 times higher than a school-based setting.⁶⁰ Therefore, eye screening initiated in infancy could be afforded by most of the high-income countries targeting ocular health problems, specifically congenital disorders. About 60% of the middle-income countries tailored vision screening programs for children at an older age (school-aged). In such cases, the screening could be performed by non-eyecare personnel in a public setting with basic

Table 4
Implementation breakdown based on the types of visual acuity tests used in vision screening, testing distance, and screeners in 18 countries.

Country	Screener	Visual acuity chart	Testing distance	Cut-off referral
Australia	Trained staff	HOTV chart Sheridan Gardiner	3 or 6 m	6/9
Canada	Physician, nurse, trained staff	HOTV chart, Lea symbols	Not mentioned	Not mentioned
Croatia	Ophthalmologist	Lea Symbol	3 m	6/9
Egypt	Trained staff	Snellen, Tumbling E	Not mentioned	6/12
India	Trained staff	Tumbling E	3 m or 6 m	6/12 or 6/9
Iran	Nurse, Trained staff	Tumbling E	6 m	6/9 or 6/12
Italy	Nurse, physician, orthoptist	Lea symbol	3 m	6/9 (3 years old) 6/7.5 (5 years old)
Israel	Nurse	Tumbling E	6 m	6/12
Japan	Parent	Landolt C	2.5 m	6/12
Malaysia	Nurse	Snellen	6 m	6/9
The Netherlands	Orthoptist, physician and nurse	Landolt C/Amsterdam Picture Chart ^a	5 m	6/7.5
New Zealand	Trained technician	Parr Chart ^a	4 m	6/12
Oman	Nurse	Snellen chart, LogMAR chart	3 m	Not mentioned
South Africa	Nurse	Snellen, Tumbling E	Not mentioned	6/12
South Korea	Trained technician			
	Parent	Picture chart	3 m	6/12 (3 years old) 6/9.5 (4 and 5 years old)
Taiwan	Nurse	Tumbling E	6 m	6/9
The United Kingdom	Orthoptist, nurse, general practitioner	Sonksen chart Keeler crowded logMAR, Kay picture	Not mentioned Not mentioned	6/9.5 (Crowded logMAR) 6/7.5 (Uncrowded logMAR) 6/7.5 (Kay picture) 6/9.5 (Keeler)
The United States	Pediatrician, trained staff, nurse, optometrist	Lea Symbol, Snellen, Kindergarten Eye Charts, Lea Symbols, or ClearChart 2 Digital Acuity System, Allen figures	3 m	6/12 6/9 (preschool) 6/12 (school-age)

^a Vision chart not validated.

instrumentation at a relatively low cost. Higher prevalence of amblyopia reported in a middle-income country compared to high-income countries implied the importance of applying timely and appropriate screening method.⁶¹ Screening initiated at later age might be too late for early treatment since there was evidence that early detection led to early treatment and better prognosis.^{62,63}

More comprehensive vision screening approaches might be able to detect a broader range of vision disorders that might affect the learning of children.⁶⁴ The screening program for infants usually focused on ocular health while screening program for older children emphasized reduced vision and refractive error.^{3,57,65} Type I approach might miss conditions that related to other than reduced visual acuity. Children who failed comprehensive vision screening were associated with poorer academic performance.⁶⁴ Microstrabismic amblyopia was reported to impair binocular reading performance compared with aged-matched normal-sighted controls despite no significant difference in the binocular visual acuity and reading acuity between the two groups.⁶⁶

Despite the importance of more comprehensive vision screening procedures, its implementation proves difficult in low and middle-income countries due to lack of financial and human resources. The more comprehensive screening approach also involves a substantially higher cost that low and middle-income countries may struggle to afford due to the instrumentation and the highly-skilled screeners required. These findings suggest that socioeconomic gaps could influence service delivery. Implementing eye/vision screening program nationwide involves a strong commitment in terms of budget allocation and planning. Ideally, the decision around the planning and implementation of a pediatric vision screening program should, therefore, take into account the early detection of a wide range of vision conditions at an affordable cost.

Limitation in implementation of chart-based and instrument-based in real setting urges a more efficient approach

Since the first reported government funded vision screening program more than 100 years ago, implementation of vision screening evolved from chart-based to instrument-based approach.^{15,67} In this review, 44% of the countries used the single-test design of visual acuity testing only despite its limitation in detecting other types of vision disorders among children apart from reduced vision. Chart-based vision screening is a better option than instrument-based to fit tight budget allocation.⁶⁸ However, the implementation of such a program does lower the screening rate in busy pediatric offices compared to instrument-based.⁶⁹ In addition, the use of the Snellen chart might not be suitable for young children as they have difficulty in communicating a verbal response to the test.³ The Illiterate or 'Tumbling' E' chart might not be the best alternative because laterality confusion is common in preschool children.⁶⁸ Age-appropriate vision test such as Lea symbols or HOTV letter-matching test might improve the

accuracy of vision screening.⁷⁰ Despite the recommendation of a testing distance of between 1.5 m and 3 m being used to improve the child's attention and avoid distractions, five countries (Australia, New Zealand, the Netherlands, Israel, and Iran) were still practicing more than 3 m testing distance for visual acuity test among preschool children.⁶⁵ Non-validated chart (Parr Chart and Amsterdam Picture Chart) and non-recommended chart (Tumbling E, Allen figures) are still being used in pediatric vision screening.⁶⁵ Variation in the type of chart used and the fact that many charts commonly used in screenings do not comply with standard guideline might affect screening efficacy.^{65,68} The optotype selections, heights, spacing, and designs deviated from standard guidelines.⁶⁸ About 44% of the countries tested visual acuity at a distance more than 3 m despite the recommendation of the testing distance of 3 m or less for young children due to attention and distraction issues.⁶⁸ Despite the fact that age and type of chart used can affect response toward visual acuity testing, the decision to set cut-off referral should be made with precaution as lowering the threshold might increase the sensitivity of the test but can lead to high over referral cases.⁷¹

The instrument-based screening was used widely in Canada and the United States and is an objective method capable of screening more children than a chart-based system. However, the operational cost is more prohibitive. The start-up cost for photoscreening per child is assumed to be \$14 compared to \$2 for conventional visual acuity screening.⁷² The performance of both vision screening approaches in relation to the target condition is also uncertain.^{3,73,74} Auto-refraction in the non-cycloplegic condition was associated with an increased tendency to over diagnosis myopia due to proximal accommodation,⁷⁵ and a photoscreener might miss the low magnitude of refractive error as it was designed to detect risk factor of amblyopia rather than the refractive error itself.⁷⁶ Despite the advantage of shorter testing duration involved and successful performance of the test by non-eyecare professionals, these instruments were much more expensive than other tests with similar sensitivity, such as Lea Symbols.⁷⁰

A questionnaire, included in home-based vision screening battery in Japan and South Korea, seemed to provide quantifiable information. Broader conditions might be able to be identified through a questionnaire, such as vision problems associated with physical symptoms and behavioral changes.⁷⁷ The prevalence of behavioral disorders among children with refractive error was higher than those with emmetropia.⁷⁷ The use of a questionnaire might assist children or parents to perceive oblivious symptoms and risk factors of vision problems. Detection of risk factors (physical or behavioral adaptation) aligns with the concept of a screening procedure.⁹ However, the performance of existing questionnaires as a vision screening instrument was inconclusive, suggesting proper validation is required prior to implementation.^{78–80}

Chart-based vision screening might have limitations in the real setting due to factors such as competency of the screeners, child ability to response, and types of test used.^{3,81} Despite the fact that instrument-based vision screening improved coverage and testability compared with chart-based vision screening,⁶⁹

the accuracy and cost of screening remained a major setback to the implementation. The potential of the questionnaire as a vision screening tool warrants further investigation.

Lack of eyecare and healthcare practitioners advocated the involvement of non-clinical personnel as screeners

Eyecare professionals such as ophthalmologists, optometrists, and orthoptists are more skilled in the detection of vision disorders in young children compared with other personnel. Vision screening performed by eyecare professional reported very high testability, sensitivity, and specificity (99%, 100%, and 97%, respectively).²⁰ However, the lack of professional eyecare is a significant issue in providing appropriate eyecare programs. Vision screening performed by a pediatrician or a general practitioner is usually paid by statutory health insurance such as in the Netherlands and Croatia. However, the effectiveness of this program, with respect to the detection of amblyopia, was considered insufficient and not cost-effective, due to the lack of skill in these specific practitioners.⁸² Nurses, on the other hand, are trained to carry out preventive and health promotion work in their basic nursing program. Participation of nurses might be more practical and cost-effective since they are already a part of the health system.³ Even so, a shortage of healthcare providers adversely affects the coverage of a vision screening program. In South Africa, employment of 310 nurses was reportedly unable to cover 46% of 12,000 schools in the national school health program in 2012.⁵²

Involvement of lay screeners, such as teachers and parents, could be another option to overcome this issue. A study in Iran reported higher cost-effectiveness of assigning teachers as vision screeners than orthoptist-led vision screening program, as is practiced in Germany.⁴³ Despite the accuracy of vision screening assessment conducted by teachers or lay volunteers, the outcomes were uncertain depending on screening tests and target age group, but their performance was found to be similar with that of nurses.⁸³ In Japan, parents are involved as vision screeners in home-based screening programs to reduce workload among healthcare providers.⁴⁵

While eyecare professionals would be more competent to perform pediatric vision screening compared to other personnel, their involvement at a primary care level might not be practical due to the shortage of qualified personnel and the fact that it is not cost-effective.³ The involvement of other healthcare personnel in either the specialist level or primary care level might not be able to resolve the problems, as discussed earlier. Lay screeners should be considered an alternative source of personnel considering their accessibility, timely contact with children, and cost-effectiveness.

Pediatric vision screening programs advocate early detection and preventive care. Chart-based and instrument-based approaches suffer limitations in a real setting. Due to the inadequate eyecare practitioners' availability, consideration of the involvement of lay screeners is necessitated. Further research into the design of sustainable screening programs by the adaptation of models in high-income countries to be

effective in low-income and middle-income countries is crucial. Designing a new mass screening program that encompasses public involvement, perhaps using personal digital devices might be a possible alternative to resolve cost and labor issues. The addition of a questionnaire to report possible physical and behavioral adaptations to vision problems would be a worthwhile addition to the screening battery. In considering such alternatives, a more practical and sustainable vision screening program could potentially transform the global eyecare/public health ecosystem and begin to overcome existing discrepancies in accessibilities, facilities and funding.

In conclusion, the implementation of a vision screening program was diverse within countries preceded by limited resources issues. Lack of professional eyecare practitioners implied the need to engage a lay screener. Limitations of the existing tests to detect a broader range of visual problems at affordable cost advocated the urgent need for the development of an inexpensive and comprehensive screening tool.

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