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RESEARCH

The practise of paediatric optometry in a low-resource environment

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Background: The role of optometrists in paediatric visual assessment must compliment the role of other eye-care practitioners at all levels of care. This study was undertaken to determine if optometrists in Ghana screen, diagnose and manage paediatric ocular conditions (for example, strabismus, amblyopia), and further assessed if optometrists in Ghana have the requisite paediatric instrumentation in their practices.

Methods: This was a cross-sectional descriptive survey involving optometrists in both public and private eye-care sectors in Ghana. A paediatric visual assessment questionnaire was sent to all registered optometrists in Ghana. The contents of the questionnaire evaluated areas of vision assessment, refraction, and previous diagnosis and management, which were matched with practice characteristics such as location, type of practice and type of employment. Chi-squared statistic was used to test associations between variables.

Results: Responses were obtained from 140 optometrists out of the 326 registered optometrists, representing a response rate of 46 per cent. Overall, less than half of respondents (64 which represents 46 per cent) assessed themselves as practising full-scope paediatric eye care. These self-assessment views were more common among optometrists at the regional level (111: 79.3 per cent), followed by the district (20: 14.3 per cent) and sub-district levels (nine: 6.4 per cent) ($\chi^2 = 4.774$, $p < 0.05$), but was not influenced by type of employment, type of practice and level of training ($p > 0.05$). In addition, the study revealed that many respondents were more likely to assess pre-schoolers' visual acuity (VA) (121: 96.0 per cent), do refraction (109: 88.6 per cent) and perform binocular vision (BV) assessment (93: 76.9 per cent) compared to the toddlers' VA (72: 55.4 per cent), refraction (57: 46 per cent) and BV assessment (68: 56.2 per cent).

Conclusion: Full-scope paediatric eye care services among optometrists in Ghana is limited.

Key words: childhood blindness, eye care, paediatric optometry, refraction, visual acuity

It is estimated that 19 million children below the age of 15 years worldwide are visually impaired.[1,2] Of these, 12 million have vision impairment due to refractive error and approximately 1.5 million have irreversible blindness. Global epidemiology of visual impairment and blindness in children is said to reflect the level of socio-economic development and resource allocation by countries.[3,4] In many developing countries, poor distribution of public health resources including human resources results in many ocular conditions in children being left untreated, causing impairment and blindness. Seventy-five per cent of visually impaired children are said to be living in resource-limited countries and only 6.5 per cent live in developed countries or affluent societies.[2–7]

In 1998, the World Health Organization (WHO) and the International Agency for the Prevention of Blindness launched VISION 2020: The Right to Sight. The program aimed to eliminate avoidable blindness by the year 2020. Recognising the difficulties in targeting all causes of blindness, the program identified the control of childhood blindness (which accounts for 3.9 per cent of all blindness globally) as one of the five priority areas.[5] Ghana subscribed to the VISION 2020 initiative by launching the National Eye Health Program (on 31 October 2000) and has made progress in aspects of adult vision care as much of the national eye care programs have focused on adults.[8] However, the visual needs of adults are different from those of children both in terms of diagnosis and management and therefore require special attention.[5] According to the Ghana Statistical Service (GSS),[9] children from birth to 14 years account for 38.32 per cent (10,277,690) of Ghana's population.

There are a total of 326 registered optometrists (ratio of one optometrist to 31,526 children) and 74 ophthalmologists (ratio of one ophthalmologist to 138,887 children), practising at all levels of eye care in Ghana. To address the challenges of avoidable blindness in developing countries, paediatric eye care has to be in synergy with all levels of care, from primary to tertiary.[10–12] Optometrists, by their training and higher ratio, are relatively well placed to screen for childhood eye conditions to either manage or refer to an ophthalmologist for appropriate treatment.

The practise of full-scope paediatric optometry is uncommon especially in many

developing countries,[4,12] notwithstanding recent advances in clinical practice and an expanded scope. In Ghana, paediatric eye care is not yet well established and the practice is rudimentary in many parts of the country,[13–15] despite recommendations that children should undergo periodic comprehensive eye and vision examination.[16,17] This study was undertaken to determine if optometrists in Ghana screen, diagnose and manage paediatric ocular conditions (for example, strabismus, amblyopia), and further assessed if optometrists in Ghana have the requisite paediatric instrumentation in their practices. This study is of clinical and public health importance as it will provide information on the status of paediatric eye practise in Ghana, and reveal challenges that face many developing countries in the area of paediatric eye care. Knowledge of the status of paediatric eye care will allow health-care practitioners to effectively approach the problem of childhood blindness and have the greatest impact in resolving it.

Methods

Ethical considerations

To ensure confidentiality, names were not assigned to the forms, but only city codes and the facilities in which they were trained as optometrists were included. The study conformed to the Declaration of Helsinki and was approved by the University of Cape Coast (UCC) Institutional Review Board (IRB) (UCCIRB/CHAS/2017/10). Participants provided written consent after receiving information documentation and after having the opportunity to ask questions via telephone.

Study design

A descriptive cross-sectional survey was conducted in both public and private eye-care facilities in Ghana to assess the practise of paediatric optometry. A paediatric visual assessment questionnaire (Appendix S1) was used to collect data from practising optometrists. The development of the questionnaire was based on questions used in a previous survey[11] of paediatric visual assessment by optometrists in New South Wales. In formulating the new questionnaire used in this study, first, a pilot study was conducted among 20 randomly selected optometrists on paediatric oculo-visual examinations regarding tests/procedures used for children's vision assessment and management of paediatric patients. In the previous study,[11] paediatric patients were categorised as toddlers (under four years) and pre-schoolers (four to under eight years). From the pilot study, most practitioners indicated they could communicate with children above the age of six years during testing, therefore, many respondents reported using adult techniques in assessing their vision.

The study aimed to investigate whether the optometrists practised full-scope paediatric optometry using age-appropriate techniques. In this study, therefore, paediatric optometric practice was defined as the visual examination of toddlers (from birth to two years, 11 months) and pre-schoolers (from three to six years), using age-appropriate techniques. In paediatric visual assessment, some tests are recommended as important to do whenever toddlers and pre-school children's visual examinations are being carried out. In the design of the paediatric visual assessment questionnaire, respondents were therefore required to answer 'Yes' or 'No' if they have ever performed a number of recommended tests/procedures on each of the paediatric age groups. However, during the pilot survey, it was also realised that some respondents indicated that some of the named recommended tests and/or equipment were either not available in their practices, often not available or not available all the time. In the final version of the questionnaire, therefore, respondents apart from indicating 'Yes' or 'No' to the question if they had ever performed activities under specified areas on a paediatric assessment were further required to indicate the frequency (that is, very often, often, not too often, and not at all) at which they used the recommended techniques, diagnosed certain ocular conditions, and managed paediatric conditions in their practices.

Based on the composite feedback from the pilot study, the final version of the questionnaire used in this study consisted of five sections (A–E). In section A, the optometrists were to indicate information about themselves (demographic/professional information) and their practice characteristics such as location, type of practice, type of employment and qualification. In section B, respondents were to indicate to each item if they had ever measured the visual acuity (VA), performed refraction and assessed the binocular vision and ocular motility of a toddler or pre-schooler. They were also asked to indicate which of a number of specific tests were used, and the frequency at which those tests were used in each age group. Answers to these questions were therefore not mutually exclusive as respondents could pick more than one test. In section C, questions which dealt with diagnoses and management of paediatric patients were asked. Respondents were required to indicate how often they have diagnosed each named condition and administered each named management option in both paediatric age groups based on the number of times they had seen such cases. In section D, due to the varied background of respondents and their practices, respondents were also asked to self-assess themselves if they could confidently say that they have been practising full-scope paediatric optometry based only on their working experience and guidance from responses to previous sections (sections A to C) of the questionnaire. Respondents self-assessed themselves on the practise of full-scope paediatric services by indicating 'Yes' or 'No' after a statement that explained the practise of 'full-scope' paediatric optometry as 'In order to practise paediatric optometry, the optometrist must be familiar with all the approved age-appropriate techniques and instruments to be able to accurately measure VA, do refraction, and perform binocular vision assessments, diagnose and initiate proper management/treatments procedures. A paediatric practice involves the examination of children from birth to six-years-old using the age-appropriate techniques listed above'. Lastly, in the pilot study, many respondents pointed out a number of challenges and made suggestions which they felt would improve their practise of paediatric eye care. Because this survey was designed to quantify and understand the provision of paediatric optometric services in Ghana and highlight issues that may face other low-resource countries, in the final questionnaire, a section was inserted that elicited information on the common challenges faced by optometrists in their paediatric practice and possible solutions to address those challenges from the viewpoint of the optometrists. Section E therefore collected information on the opinions of the optometrists regarding the challenges confronting paediatric eye care.

A potential confounding factor identified during the questionnaire design was the possibility of practitioners misconstruing their perceived competence or training in specified areas of paediatric optometry to mean actual practise of paediatric optometry (that is, confusion between the actual

practise and capability). This was addressed by incorporating a statement in the information section preceding the questions which clearly stated that 'every answer should be in terms of actual practise and not capabilities'.

Sample and procedure

In Ghana, public health services including eye care services are provided by the Ghana Health Service (GHS), an independent public agency in 10 administrative regions and 216 districts. There are four teaching hospitals (national hospitals), eight regional hospitals, 95 district hospitals and numerous sub-district level care with health centres as well as outreach and screening services to communities. The majority of both preventive and curative services take place at the district and sub-district levels, with the regional level providing tertiary referral services.[18] There is a large involvement of non-governmental faith-based organisations and the private sector that control eight per cent of all health facilities (that is, 20 per cent of all hospitals).[18] The Ministry of Health at the national level, through the Ghana Eye Care Secretariat, provides overall strategic direction by formulating and implementing policies and standards in eye care. Governance of optometry in Ghana is administered by the Allied Health Professions Council on behalf of the state.

The questionnaire was distributed to optometrists registered and licensed by the Allied Health Professions Council of Ghana. Optometry interns were excluded because they were not licensed to practise independently. A list of all optometrists in Ghana, their contact addresses, emails, and physical addresses were obtained from the Ghana Optometry Association. Then, a list of addresses of eye clinics, hospitals, and private practices was prepared with inputs from different sources, including the national eye-care secretariat, regional and district directorate of health services and the professional optometry association. During the annual general meeting of the professional optometry association, members were briefed on the importance of this study and were encouraged to voluntarily participate. The questionnaires were then distributed by hand and by email to the participants over a period of six months to improve the response rate. The validity of information provided was crosschecked by ensuring observational visits to 90 per cent of randomly selected respondents' practices.

Data analysis

Data collected were analysed using the Statistical Package for the Social Sciences (SPSS Version 23; IBM, Armonk, NY, USA). In most sections of the questionnaire, categorical questions were used and respondents indicated 'Yes' or 'No' if they had ever performed specified visual tests or assessments on paediatric patients. Questions which required categorical answers as 'Yes' or 'No' were analysed as descriptive data using frequencies and percentages. Where follow-up questions were asked, respondents indicated the frequency at which specified diagnostic assessments or management options were administered by scoring their answers between 'very often', 'often', 'not too often' and 'not at all'. Likert-scale answers were assigned numeric values so that each response could be computed and reported as a single average response for each item. The following numeric points were assigned: very often (four points), often (three points), not too often (two points) and not at all (one point). The total number of points aggregated for each question item was then calculated and divided by the total number of respondents for each question item to derive the reported averages. In some instances, as will be indicated, the distribution of responses was converted to percentages by dividing the number of responses for each item option (that is, the frequencies of selecting each option by respondents) by the total number of responses for that question item and multiplied by 100 to enable meaningful comparisons. Open-ended responses (for example, Q 26 and 27) were analysed by grouping the responses into common issues in a tabular format. Chi-squared test was used to test associations between practice characteristic variables and respondents' categorical responses to named paediatric assessment techniques, management options and their self-assessment of full-scope optometric practise. A two-tailed p-value of less than 0.05 was considered statistically significant.

Results

Location and practice characteristics

Responses were obtained from 140 out of the 326 optometrists contacted, yielding a 46 per cent response rate. The majority of optometrists (n = 111) practised at the regional capitals, followed by those who practised at the district (n = 20) and sub-district (n = 9) levels. Among those who practised at the regional capitals, approximately two-thirds (75.0 per cent) practised in the two most urbanised regions of Ghana, that is, Greater Accra (58 respondents, an equivalence of 41.4 per cent), and the Ashanti Region (47 respondents, 33.6 per cent), and the rest in seven other regions. Figure 1 shows the distribution of respondents in the 10 administrative regions across Ghana. Regarding the type of practice, a greater proportion of participants were full-time practitioners (133 respondents, 95 per cent of total), with the remaining practising either part-time (six: 4.3 per cent of total) or locum (one: 0.7 per cent of total). Most respondents were employed in the private sector (73: 52.1 per cent of total) working as private practitioners (57: 78.1 per cent), self-employed (nine: 12.3 per cent), partnership (five: 6.9 per cent) or locum (two: 2.7 per cent). A relatively few worked in the public sector in government or government-assisted facilities (64: 45.8 per cent of total), and a few were in academia (three: 2.1 per cent of total).

A large proportion of respondents (116: 92.1 per cent) had an undergraduate Doctor of Optometry (OD) degree but only 12 (8.6 per cent) confirmed they had post-basic optometry degrees. These included Masters in Health Science (two), Masters in Public Health (four), Masters in Public Administration (five) and Masters in Clinical Optometry (MSc) (one). None of the respondents had a post-graduate qualification specifically in paediatric optometry.

Methods of assessment of paediatric patients' VA and refraction

Respondents were asked whether they had either measured the VA or performed refractions on toddlers or pre-schoolers and which of a number of tests were used in VA measurement and refraction in each of the two age groups. Most optometrists (121: 96.0 per cent) confirmed they had ever assessed the VA of pre-schoolers compared to those (72: 55.4 per cent) who indicated they had ever assessed the VA of toddlers. The most common VA technique used for toddlers was fixation preference (77.1 per cent), but varied for pre-schoolers, with Lea symbol (45 per cent), Tumbling E (35 per cent) and Snellen's chart (15.8 per cent) being the most often used. A few (five per

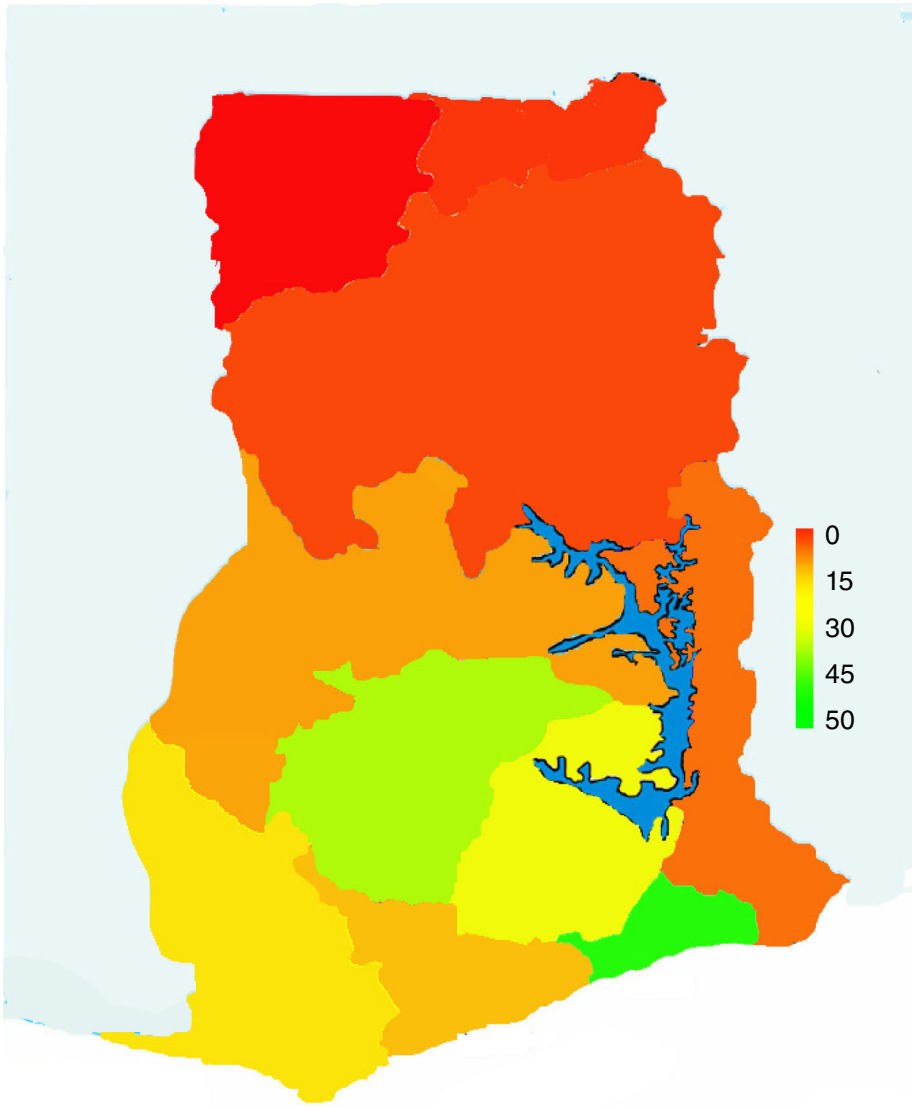

Figure 1. A heat map showing the distribution of respondents in the 10 administrative regions in Ghana

cent) indicated they used all these three techniques combined. Interestingly only one individual (0.7 per cent) had used the broken wheel or the HOTV letters chart. Participants in full-time practice were more likely to use Lea symbols and those in part-time preferred the Tumbling E (χ^2 = 22.7, $p < 0.05$). Table 1 shows a detailed profile of techniques and materials used for assessing the visual acuity and performing refraction by respondents. Respondents were asked whether they had ever refracted a toddler or a pre-schooler before. Less than half (57: 46 per cent) affirmed having refracted toddlers while the majority (109: 88.6 per cent) responded in the affirmative for pre-school patients. The most common technique used for refraction was cycloplegic retinoscopy for both toddlers (85.7 per cent) and pre-school (87.3 per cent) children. Only a few used near (dynamic) retinoscopy for toddlers (10.7 per cent) and pre-schoolers (10 per cent). Autorefraction was used in 3.6 per cent and 2.7 per cent of toddlers and pre-school patients respectively. Respondents in full-time practice had more experience in refraction of toddlers and pre-school patients ($\chi^2 = 8.1$, $p < 0.01$) compared to those practising part-time and casual, and the self-employed were also more likely to refract the pre-school children who visited their practices ($\chi^2 = 16.6$, $p < 0.01$).

Binocular vision assessment

Respondents were asked whether they routinely assessed the binocular vision status of toddlers and pre-schoolers. Out of a total of 107, more than half (61: 57.0 per cent) said they have performed binocular assessment on toddlers and 46 (43.0 per cent) responded in the negative. Comparatively, more optometrists (86: 80.4 per cent) had performed binocular assessment on pre-schoolers compared to only a few (21: 19.6 per cent) who had not done so. The most commonly used techniques for binocular vision assessment of toddlers were simple techniques such as Cover test, Hirschberg test, and the Bruckner test. Versions test, near point of convergence (NPC) and Krimsky tests, were not popular among the respondents. Similarly, the most commonly used technique for binocular vision assessment of pre-schoolers was the Cover test (Table 2).

Diagnosis and management of ocular conditions

Respondents were asked to indicate how often they diagnosed named conditions in either toddlers or pre-schoolers. The distribution of the responses (Figure 2) shows that the most common diagnoses among toddlers were refractive error (25 per cent), ophthalmia neonatorum (24 per cent), strabismus (20 per cent), and the least often reported were congenital pathologies such as cataract and retinoblastoma (18 per cent) followed by amblyopia (13 per cent). Comparatively, the most often reported diagnoses for pre-school patients were ocular pathologies (33 per cent), especially acute haemorrhagic conjunctivitis and allergic conjunctivitis followed by refractive error (28 per cent), and strabismus (21 per cent), while the least often reported diagnosis was amblyopia. Figure 2 shows the commonly reported diagnoses made among toddlers and pre-schooler paediatric patients by respondents.

In accordance with the diagnosis, respondents were asked to indicate how often they administer named treatments for toddler and pre-school patients. The 'most often' reported management administered to both toddlers and pre-schoolers were ophthalmic solutions (being 61 and 51 per cent in toddlers and pre-schoolers respectively), while spectacles were 'often' being prescribed (31 and 29 per cent in toddlers and pre-schoolers respectively), and occlusion therapy 'not too often' being done and

Parameters*	Visual acuity Toddlers		Visual acuity Pre-school						Refraction Toddler		Refraction Pre-school	
Type of employment	FP	PL	LS	BW	HOTV	TE	LC	SC	CR	NR	SR	CR
Self-employment	6 (100.0)	0 (0.0)	5 (55.6)	0 (0.0)	0 (0.0)	3 (33.3)	0 (0.0)	1 (11.1)	4 (100.0)	0 (0.0)	1 (11.1)	8 (88.9)
Partnership	3 (75.0)	1 (25.0)	3 (60.0)	0 (0.0)	1 (20.0)	1 (20.0)	0 (0.0)	0 (0.0)	3 (100.0)	0 (0.0)	1 (50.0)	1 (50.0)
Government	25 (73.5)	7 (20.6)	23 (37.1)	1 (1.6)	0 (0.0)	26 (41.9)	2 (3.2)	9 (14.5)	28 (90.3)	3 (9.7)	4 (1.0)	52 (91.2)
Private practitioner	19 (86.4)	3 (13.6)	17 (47.2)	0 (0.0)	0 (0.0)	11 (30.6)	0 (0.0)	8 (22.2)	12 (75.0)	4 (25.0)	5 (14.3)	28 (80.0)
Academics	1 (50.0)	1 (50.0)	2 (66.7)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	3 (100.0)
Locum	0 (0.0)	1 (100.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)
Total	54 (77.1)	13 (18.6)	54 (45.0)	1 (0.8)	1 (0.8)	42 (35.0)	2 (1.7)	19 (15.8)	48 (85.7)	6 (10.7)	11 (10.0)	96 (87.3)
Other	3 (4.3)	–	1 (0.8)	–	–	–	–	–	2 (3.6)	–	3 (2.7)	–

BW: broken wheel, CR: cycloplegic retinoscopy, FP: fixation preference, HOTV: HOTV chart, LC: Landolt C, LS: Lea symbol, NR: near retinoscopy, PL: preferential looking, SC: Snellen chart, SR: static retinoscopy, TE: Tumbling E.

*Responses were not mutually exclusive as there were multiple responses.

Table 1. Responses on the techniques and materials used for assessing visual acuity and performing refraction

Test (toddler)	Cover test	Hirschberg	Krimsky	Bruckner	Version	NPC		
Average score*	3.6	3.6	2.1	3.6	2.3	2.3		
Test (pre-school)	**Cover test**	**P & N fusional vergence**	**Stereopsis**	**MEM**	**Version**	**NPC**	**Phoria**	**Suppression**
Average score	3.8	1.0	1.0	1.0	2.1	2.3	2.3	1.0

MEM: monocular estimation method, NPC: near point of convergence, P & N: positive and negative.

*Responses were assigned the following numeric values: Very often = four points, Often = three points, Not too often = two points, and Not at all = one points to compute a single average response for each test item.

Table 2. Methods and frequency of assessing binocular vision of toddlers and pre-schoolers

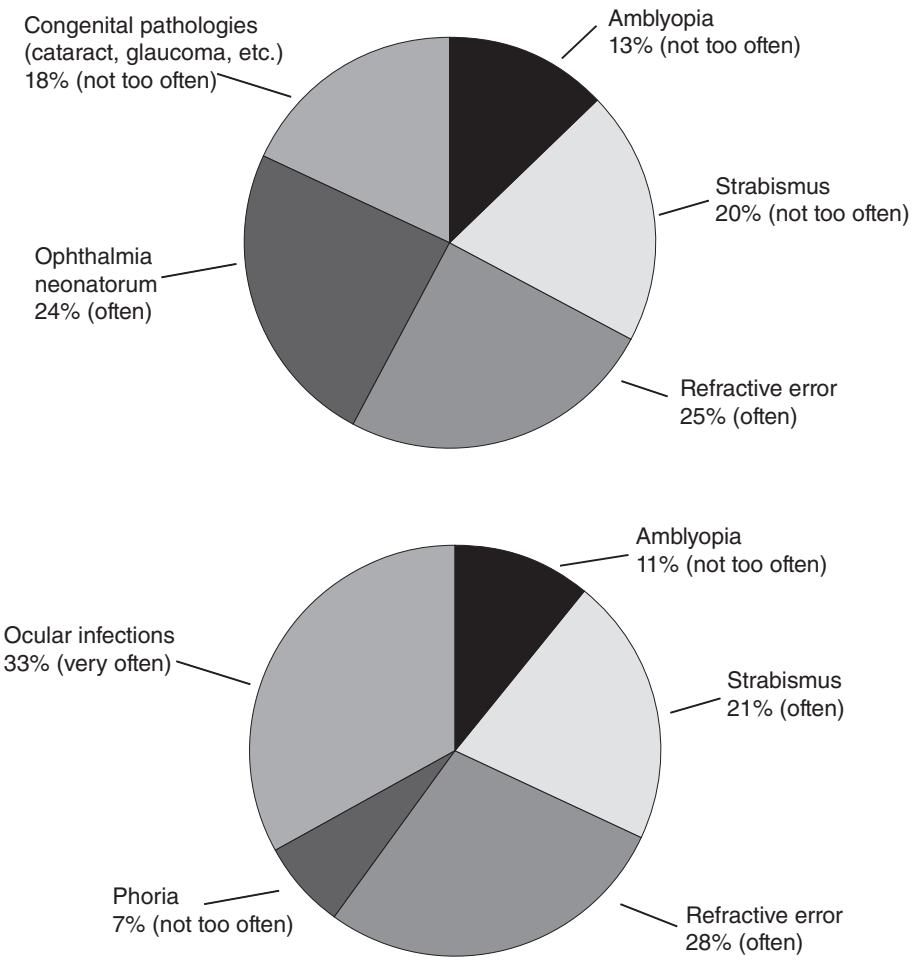

Figure 2. A pie chart showing the percentage of respondents who selected named common diagnoses for toddler (top) and pre-school (below) patients, calculated by dividing the number of responses for each condition (that is, the frequencies of selecting each option by respondents) by the total number of responses for that question item and multiplied by 100. Also shown in brackets are average number of times the diagnoses were made, calculated by assigning numeric values: Very often = four points, Often = three points, Not too often = two points, and Not at all = one point to derive an average and translated back to ordinal scale.

orthoptics 'not at all' administered. Figure 3 indicates common management options reported by respondents for toddlers and pre-schoolers.

Management of anisometropic and strabismic amblyogenic factors

Respondents were asked to indicate the actions taken when confronted with paediatric patients with strabismus or anisometropia, the two most common causes of amblyopia. Table 3 shows the detailed profile on the management of amblyogenic factors by respondents. For the management of strabismic amblyogenic factors, the majority indicated that they consult ophthalmologists to either co-manage (38.8 per cent) or refer entirely to the ophthalmologist (23.1 per cent). There was a statistical association between the type of practice and the management option ($\chi^2 = 46.5$, $p < 0.01$). Participants working in government facilities were willing to co-manage with the ophthalmologists as opposed to a complete referral to the ophthalmologists by private practitioners. For anisometropic amblyogenic factors, many (44.1 per cent) indicated they treat in their practices. Others confirmed that they would consult other optometrists to co-manage (28.8 per cent) or co-manage with an ophthalmologist (16.9 per cent). There was a statistically significant association between the location of practice and the management options ($\chi^2 = 31.2$, $p < 0.01$). Respondents practising at the sub-district level were more willing to co-manage with other optometrists as opposed to managing themselves.

When participants were asked, in their opinion, by what age (in years or months) amblyogenic factors must be detected for treatment to be most effective, the majority of the respondents (79 per cent) indicated ages from birth to five years, with 35.3 per cent indicating ages between one to two years, 11 months. However, a considerable proportion of them (21 per cent) indicated ages above five years.

Self-assessment

When asked if based on their working experience and from the guidance of the questions they had responded to, they could report that they have been practising full-scope paediatric optometry, responses given were mixed. Of the total number of respondents, 76 (54 per cent) assessed themselves as not practising paediatric optometry compared to 64 (46 per cent) who reported that they practised full-scope paediatric optometry based on previous clinical practice experience. The rate of paediatric optometric practise declined from the regional level to the sub-district level ($\chi^2 = 4.8$, $p < 0.05$). However, the practise of paediatric optometry was not influenced by practice characteristics such as the type of employment, training, and type of practice.

Challenges associated with the practice

Although all respondents indicated that they had received some basic training in paediatric care during their undergraduate course, a greater proportion of the them (125 of 140) also admitted that they wished paediatric optometry would be introduced as post-graduate specialist training in Ghana. More than half of optometrists surveyed admitted to not practising full-scope paediatric optometry. Respondents subsequently were asked to indicate barriers to the provision of paediatric optometric services. Table 4 presents those challenges reported by respondents to be affecting the

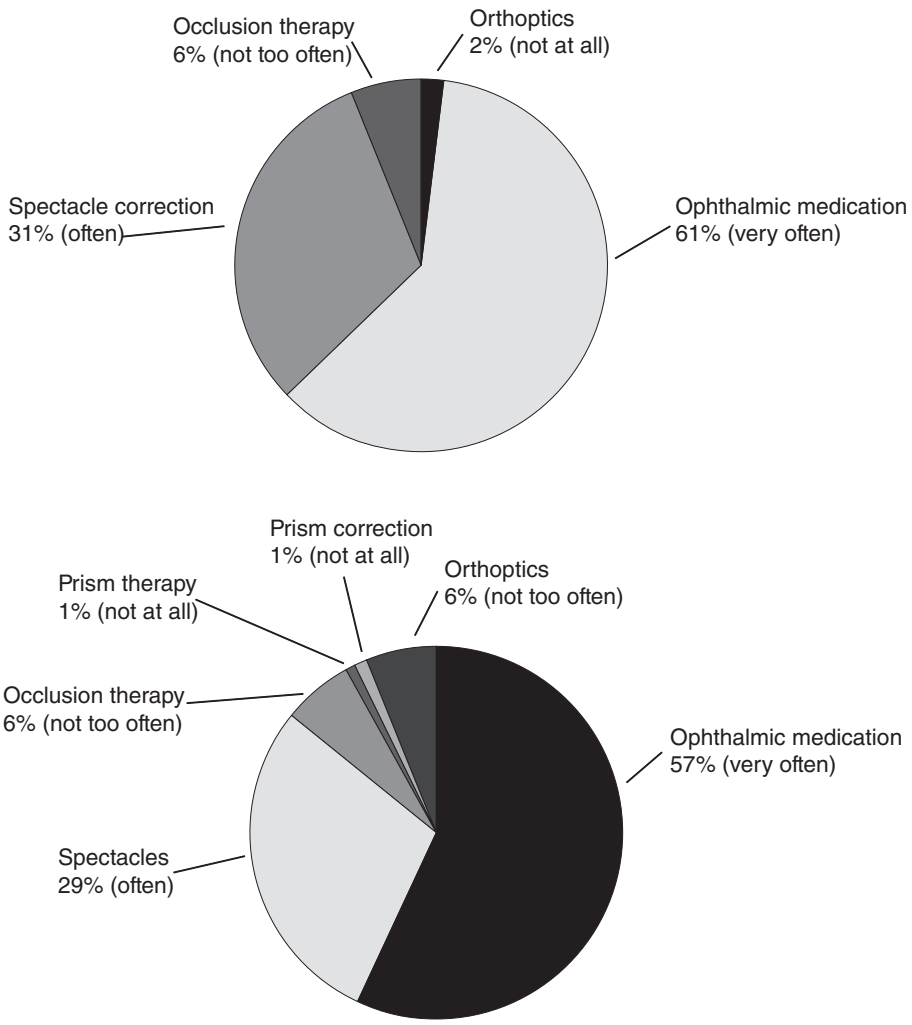

Figure 3. A pie chart showing the percentage of respondents who selected named common management options for toddler (top) and pre-school (below) patients, calculated by dividing the number of responses for each management option (that is, the frequencies of selecting each option by respondents) by the total number of responses for that question item and multiplied by 100. Also shown in brackets are average number of times the management option was administered, calculated by assigning numeric values: Very often = four points, Often = three points, Not too often = two points, and Not at all = one point to derive an average and translated back to ordinal scale.

effective practise of full-scope paediatric optometry. Nearly all respondents (92 per cent) identified the lack of basic equipment as the main challenge hindering their practice. Other challenges reported included inadequate exposure to the skills and techniques during their undergraduate training in the subject hence do not have the confidence to practise. Table 4 also shows the recommended approaches reported by participants to improve the practise of full-scope paediatric optometry in Ghana.

Discussion

Optometric paediatric services must complement services offered by ophthalmologists for effective delivery of paediatric eye-care services. The WHO[10] strongly recommends a team approach to be successful, and identifying modalities of practise of personnel involved in eye-care needs to be ascertained. The study revealed that many optometrists were more likely to examine the eyes of preschoolers (from three to six years) compared to toddlers (under three years). For instance, optometrists were more likely to assess preschoolers' VA (96.0 per cent), do refraction (88.6 per cent) and perform binocularity assessment (76.9 per cent) compared to toddlers' VA (55.4 per cent), refraction (46 per cent) and BV assessment (56.2 per cent). Our findings are similar to the findings by Suttle et al.[11] which indicated that optometrists measured more pre-school VA (76 per cent) compared to toddlers (69 per cent). In the Australian study, they also found that optometrists surveyed only assessed 20 per cent of the one- to four-year-old population in New South Wales, but the percentage increased to 10–40 per cent for the preschool age group. While it is possible that at least some children in this age group receive regular vision care from ophthalmologists, the number of ophthalmologists in Ghana is small and inadequate. In Ghana, specialist paediatric ophthalmology services are available in only two teaching hospitals, namely the Korle Bu Teaching Hospital in the capital Accra and Komfo Anokye Teaching Hospital in the second largest city Kumasi.[18] It is advocated by WHO that there should be one paediatric ophthalmology tertiary service centre per 10 million population. This finding raises concerns by the unmet or neglected eye-care needs in this important paediatric group. As plasticity of the visual system decreases with age over the first few years of life, it is important that the eyes of toddlers are examined for factors that can prevent normal development, including strabismus and anisometropia.[11,16,17] More than half of the optometrists surveyed in this study confirmed that they did not practise full-scope paediatric optometry, leaving a gap in the number of children who have access to the needed optometric services. A large proportion of respondents did not have post-graduate qualifications in paediatric optometry or other fields. Although this study did not attempt to establish a link between further training and paediatric practise, the lack of post-graduate qualifications cannot wholly be correlated with the lack of practise of paediatric optometry.[11] Given the low rate of paediatric practise among optometrists in

	Management of strabismic amblyogenic factors						Management of anisometropic amblyogenic factors					
	Treat	**Refer 1**	**Refer 2**	**Co-manage 1**	**Co-manage 2**	**Defer treatment**	**Treat**	**Refer 1**	**Refer 2**	**Co-manage 1**	**Co-manage 2**	**Defer treatment**
Location												
Regional	12 (13.0)	8 (8.7)	23 (25.0)	12 (13.0)	35 (38.0)	2 (2.2)	41 (45.6)	5 (5.6)	2 (2.2)	28 (31.1)	14 (15.6)	0 (0.0)
District	4 (20.0)	3 (15.0)	3 (15.0)	3 (5.0)	9 (45.0)	0 (0.0)	10 (50.0)	2 (10.0)	1 (5.0)	1 (5.0)	5 (25.0)	1 (5.0)
Sub-district	0 (0.0)	0 (0.0)	2 (25.0)	2 (25.0)	3 (37.5)	1 (12.5)	1 (14.3)	0 (0.0)	0 (0.0)	4 (57.1)	1 (14.3)	0 (0.0)
Type of employment												
Self-employment	1 (12.5)	0 (0.0)	3 (37.5)	1 (12.5)	3 (37.5)	0 (0.0)	4 (50.0)	0 (0.0)	0 (0.0)	4 (50.0)	0 (0.0)	0 (0.0)
Partnership	0 (0.0)	1 (20.0)	1 (20.0)	0 (0.0)	3 (60.0)	0 (0.0)	1 (20.0)	0 (0.0)	0 (0.0)	2 (40.0)	2 (40.0)	0 (0.0)
Government	9 (14.3)	7 (11.1)	11 (17.5)	7 (11.1)	28 (44.4)	1 (1.6)	27 (43.5)	3 (4.8)	2 (3.2)	19 (30.6)	9 (14.5)	1 (1.6)
Private practitioner	5 (13.5)	2 (5.4)	12 (32.4)	7 (18.9)	11 (29.7)	0 (0.0)	17 (48.6)	2 (5.7)	1 (2.9)	8 (22.9)	7 (20.0)	0 (0.0)
Academics	1 (33.3)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	1 (33.3)	2 (66.7)	0 (0.0)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)
Locum	0 (0.0)	0 (0.0)	0 (0.0)	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)
Total	16 (13.6)	10 (8.5)	28 (23.7)	16 (13.6)	45 (38.1)	3 (2.5)	51 (44.3)	6 (5.2)	3 (2.6)	34 (29.6)	19 (16.5)	1 (0.9)
Training												
Training	15 (14)	11 (10.3)	26 (24.4)	11 (10.3)	41 (38.3)	3 (2.8)	46 (43.8)	7 (6.7)	3 (2.9)	30 (28.6)	18 (17.1)	0 (0.0)
No training	0 (0.0)	0 (0.0)	1 (10.0)	4 (40.0)	5 (50.0)	0 (0.0)	5 (50.0)	0 (0.0)	0 (0.0)	3 (30.0)	1 (10.0)	1 (10.0)
Total	15 (12.8)	11 (9.4)	27 (23.1)	15 (12.8)	46 (39.3)	3 (2.6)	51 (44.3)	7 (6.1)	3 (2.6)	33 (28.7)	19 (16.5)	1 (0.9)
Post-graduate												
Post-graduate	1 (8.3)	0 (0.0)	2 (16.7)	1 (8.3)	7 (58.3)	1 (8.3)	4 (36.4)	0 (0.0)	0 (0.0)	4 (36.4)	3 (0.0)	0 (0.0)
No post-graduate	14 (13.2)	11 (10.4)	25 (23.6)	14 (13.2)	40 (37.7)	2 (1.9)	46 (44.2)	7 (6.7)	3 (2.9)	30 (28.8)	16 (15.4)	1 (1.0)
Total	15 (12.7)	11 (9.3)	27 (22.9)	15 (12.7)	47 (39.8)	3 (2.5)	50 (43.5)	7 (6.1)	3 (2.6)	34 (29.6)	19 (16.5)	1 (0.9)
Type of practice												
Full-time	15 (13.2)	11 (9.6)	28 (24.0)	13 (38.6)	44 (38.6)	3 (2.6)	51 (45.9)	7 (6.3)	3 (2.7)	30 (27.0)	18 (16.2)	1 (0.9)
Part-time	1 (16.7)	0 (0.0)	0 (0.0)	2 (33.3)	3 (50.0)	0 (0.0)	1 (16.7)	0 (0.0)	0 (0.0)	3 (50.0)	2 (33.3)	0 (0.0)
Casual	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)
Total	16 (13.2)	11 (9.1)	28 (23.1)	16 (13.2)	47 (38.8)	3 (2.5)	52 (44.1)	7 (5.9)	3 (2.5)	34 (28.8)	20 (16.9)	1 (0.8)

Data were analysed according to number of responses.

Treat: treat at practice, Refer 1: refer to other optometrist, Refer 2: refer to ophthalmologist, Co-manage 1: co-manage with optometrist, Co-manage 2: co-manage with ophthalmologist, Defer treatment: defer treatment to a later age.

Table 3. Details of respondents' management of amblyogenic factors

	Number of comments
Challenges	
Unavailability of paediatric equipment/materials	129
Inadequate training from training institutions	82
Limited time for proper paediatric examination	17
Lack of child-friendly office settings	14
Lack of education on the part of parents on the importance of eye screening	12
Non-compliance from parents	9
General lethargy among other practitioners to take paediatric cases	5
Lack of referral centres for complex conditions	2
Difficulty in co-managing cases with ophthalmologist	1
Suggestions	
Make available paediatric equipment/materials	80
Students should be adequately exposed to instruments and intensive training during training	32
Post-graduate fellowship programs	23
Post-graduate specialty in the local training institutions	10
Set up of paediatric specialty clinics	8
More emphasis on paediatric care through workshops and continuous professional development (CPD)	6
Providing hands-on CPD and further training to optometrists	1

Table 4. Named challenges associated with the practise of paediatric optometry and some suggested remedies by respondents

Ghana, it does not augur well for achieving the aim of preventing avoidable blindness among children in the country. Ghana is known to have an inequitable distribution of eye-care professionals, with a bias toward the more urbanised southern regions.[18]

Similar to other reports,[14,18] over two-thirds of respondents in this study practised at the regional level (79 per cent), the majority of whom also practised in private clinics. Similar to our findings, in the Australian study nearly two-thirds (68 per cent) of respondents practised in urban locations, and 32 per cent practised in rural locations.[11] In the same study,[11] the majority of respondents were in full-time practice (78 per cent), with the remainder practising on a part-time basis (17 per cent) or on a casual basis (five per cent). However, the reported location of respondents in this study reflects a highly uneven distribution of optometrists in Ghana which leaves many areas of the country without optometry services.[14] The national ratios of eye-care professionals are ophthalmologists 1:379,000, optometrists 1:86,000 and ophthalmic nurses 1:93,000, but these figures mask wide geographical variations as more than 70 per cent of eye-care professionals are located in urban areas.[14,18]

The uneven distribution of optometric services means that first, access to refraction, including paediatric vision screening services, is a problem in Ghana, in terms of availability of appropriately trained optometrists in rural areas and consumables such as spectacles and other optical devices. Second, in urban areas where some services are available, it raises issues of affordability as most private eye-care services and optical aids are not specifically covered by the National Health Insurance Scheme, the main financier of health care in Ghana.[18–20] Private access and purchasing items such as spectacles can constitute a significant proportion of individual or household income.

The study also found there was a low rate of refraction and management of ocular conditions such as strabismus and amblyopia. It further revealed that refractive services and management were influenced by practice characteristics such as the location of the practice. The decline in the provision of refractive services from the regional level to the sub-district level reflects the allocation of limited resources to health-care facilities in Ghana, which decreases from the regional level to the sub-district level. This could be due to the general unavailability of equipment in practices outside the regional levels. The unavailability of age-specific equipment is a challenge facing many health-care institutions in developing countries.[21,22] Respondents identified the lack of basic tools and equipment as a major challenge affecting the delivery of required paediatric care. This, therefore, suggests that a large proportion of optometrists in Ghana irrespective of having received some training in paediatric eye care may be constrained by the lack of appropriate equipment reducing their confidence with time. Inadequate exposure to skills and specialised equipment will constrain the provision of full-scope paediatric services.

There is no national inventory on the state of eye-care equipment across the country. However, Ghana's total spending on health is just over five per cent of gross domestic product, and only 12 per cent of total government expenditure (60 per cent from government sources, the remaining 40 per cent in private sector expenditure).[10,18] Eye-care equipment forms a negligible proportion of government spending on health at both national and local levels. There is an infrequent supply of eye-care equipment to the regional hospitals and some selected districts by the GHS, but there is a general perception that equipment for specialty services like eye care are to be borne by donors due to the large presence of international agencies and foreign non-government organisations in the field, leaving the government divested of responsibility.[10,18,23] The general lack of age-specific equipment affected screening test such as VA measurement to detect vision impairment.[24–26]

The study found that most optometrists do not exclusively use tests specifically designed for toddlers and pre-school VA assessment. Interestingly, in contrast to a study in Australia[11] where Snellen charts, preferential looking cards and Lea symbol acuity cards were relatively used, most respondents reported using fixation preference in patients younger than three years of age but changed to Lea symbols in the older pre-school patients. Not surprisingly, respondents reported using Snellen acuity in a few older pre-school patients, but none in the younger toddler age group. It is likely that most optometrists used fixation preference in toddlers for two reasons. First, the test can easily be done at different settings and second, it can be modified to use a penlight as a target instead of the usual preferential looking cards. For Lea symbol acuity cards, the cheaper cost and usefulness in young children who do not know letters,

perhaps influenced its choice in the pre-school age group.

Uncorrected refractive errors are the most common cause of visual impairment in children.[27] Although the majority of optometrists reported refraction experience with pre-schoolers, the sharp decline in the number who refracted toddlers suggests that toddlers with significant refractive errors (> 2.00 D) could develop strabismus and amblyopia.[28] Consistent with findings in a similar study in Australia which surveyed paediatric visual assessment by optometrists,[11] this study found that in both toddlers and pre-schoolers, retinoscopy was used by nearly all respondents in each group (Table 1). The differences in refraction experience may be attributable to time-consuming procedures for toddlers and poor compliance from parents for follow-up with toddlers.[29]

Binocular vision screening in paediatrics is crucial in the detection of ocular conditions (for example strabismus, anisometropia) which may cause amblyopia.[30] Binocular vision assessments were found to be inadequate and the most commonly used method for assessing the binocular vision status of toddlers and pre-schoolers was the Cover test. In contrast to the study in Australia,[11] this study found that other important tests such as the NPC, suppression and stereopsis measures, which are widely used as part of the assessment of binocular visual status of children, were not used by optometrists in Ghana. It was not surprising that the least diagnosed conditions reported among the optometrists were amblyopia and phoria. The most diagnosed condition of ophthalmia neonatorum among toddlers and allergic conjunctivitis among pre-schoolers is also not surprising. Post-natal infections are common among infants when antibiotics are not used after delivery while a dusty and unhygienic environment precipitates infections among pre-schoolers when exposed. Moreover, since infections exhibit more severe and noticeable signs, parents find it more appropriate to send their children for care compared to binocular or refractive anomalies. Perhaps if more optometrists were performing binocular vision assessment, the proportion of diagnosed binocular and refractive anomalies such as phoria and amblyopia could have been higher than reported. The gap in treatment/management options could be attributed to inadequate exposure to the skill during training since the majority expressed adequate knowledge of the sensitive period for detecting amblyopia.

The study also found that optometrists were ready to refer special cases to more experienced colleagues or co-manage cases which required surgical intervention with an ophthalmologist. Consistent with other results,[11] optometrists were more likely to treat anisometropic amblyogenic cases than strabismic amblyogenic patients in their own practices (Table 3). This difference in management options of anisometropia and strabismus cases probably reflect specialisation or competence levels of optometrists. Optometrists are highly competent in non-surgical refractive correction but correcting strabismus surgically is not part of their scope of practise. In accordance with the above finding, respondents were more likely to co-manage and less likely to refer anisometropic amblyogenic than strabismic amblyogenic cases to another optometrist or to an ophthalmologist. These results may indicate that the optometrists were aware of the plasticity in visual development in early stages in life and therefore were cautious about the type of cases to treat or refer. Failure to detect and treat strabismic amblyogenic factors early before neural adaptations set in will likely result in intractable diplopia, if the incipient anomalous retinal correspondence is well established. Optometrists who work with ophthalmologists in government facilities were more likely to co-manage cases compared to those in private facilities. More specialised paediatric centres will, therefore, promote collaboration among eye-care professionals to deliver effective treatment/management and make the needed care accessible.

A limitation of this study is its predominantly quantitative nature. Therefore, the results are subject to all the shortcomings of a quantitative survey, such as limited in-depth understanding and investigation of the optometrists' responses. Also, similar to the Suttle study,[11] less than half of the practising optometrists in Ghana responded to the questionnaires that were distributed across the country which may limit the ability to make more generalised comments about paediatric practice in Ghana. However, the findings of this survey are of clinical and public health importance in the light of the fact that optometrists have an important role to play in the prevention of childhood visual impairment and blindness.

Conclusion

In order for optometrists to play a vital role in blindness prevention, consistent and effective use of all paediatric optometry procedures should be applied. The major reasons for this deficit were attributed to the unavailability of the age-specific equipment/materials and a gap in skills. The lack of appropriate equipment impacts negatively on confidence and ability to keep practical skills up-to-date, requiring continuous professional development in paediatric eye care. In order to improve paediatric eye care, all stakeholders must come together to address the issue.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's website:

Appendix S1. A paediatric visual assessment questionnaire used.