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Causes of childhood blindness in Ghana: results from a blind school survey in Upper West Region, Ghana, and review of the literature

Grace J. Huh · Judith Simon · S. Grace Prakalapakorn

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Abstract
Purpose Data on childhood blindness in Ghana are limited. The objectives of this study were to determine the major causes of childhood blindness and severe visual impairment (SVI) at Wa Methodist School for the Blind in Northern Ghana, and to compare our results to those published from other studies conducted in Ghana.
Methods In this retrospective study, data from an eye screening at Wa Methodist School in November 2014 were coded according to the World Health Organization/Prevention of Blindness standardized reporting methodology. Causes of blindness/SVI were categorized anatomically and etiologically, and were compared to previously published studies.
Results Of 190 students screened, the major anatomical causes of blindness/SVI were corneal scar/phthisis bulbi (CS/PB) ($n = 28$, 15%) and optic atrophy ($n = 23$, 12%). The major etiological causes of blindness/SVI were unknown ($n = 114$, 60%). Eighty-three (44%) students became blind before age one year. Of four published blind school surveys conducted in Ghana, CS/PB was the most common anatomical cause of childhood blindness. Over time, the prevalence of CS/PB within blind schools decreased in the north and increased in the south. Measles-associated visual loss decreased from 52% in 1987 to 10% in 2014 at Wa Methodist School.
Conclusions In a blind school in northern Ghana, CS/PB was the major anatomical cause of childhood blindness/SVI. While CS/PB has been the most common anatomical cause of childhood blindness reported in Ghana, there may be regional changes in its prevalence over time. Being able to identify regional differences may guide future public health strategies to target specific causes.

Keywords Childhood blindness · Visual impairment · Low vision · Blind school · Ghana · West Africa

G. J. Huh
Duke Global Health Institute, Duke University, Durham, NC, USA

J. Simon
Tamale Teaching Hospital, Tamale, Northern Region, Ghana

S. Grace Prakalapakorn (✉)
Department of Ophthalmology, Duke University, 2351 Erwin Rd, DUMC 3802, Durham, NC 27710, USA
e-mail: grace.prakalapakorn@duke.edu

Introduction

In 2010, an estimated 19 million children under 15 years of age were visually impaired, and over 1.4 million children were irreversibly blind [1, 2]. Of those blind, 1 million are in Asia and 300,000 in Africa [3]. A systematic review on the data for global pediatric blindness concluded that in developing

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countries, 7–31% of childhood visual impairment is avoidable, 10–58% treatable, and 3–28% preventable [4].

In Ghana, it is estimated that childhood blindness accounts for 5–10% of the national burden of blindness, affecting an estimated 0.9 per 1000 children [5, 6]. Without population-based studies, blind school surveys have become accepted methods to determine regional prevalence and main causes of childhood blindness [7]. Currently, there are two blind schools and one integrated school in Ghana. Of these schools, Wa Methodist School for the Blind is located in the Upper West Region of Northern Ghana, and Akropong School for the Blind is located near the country's capital, Accra, in Southern Ghana. Wenchi Methodist Secondary School, located in the Brong-Ahafo Region of Central Ghana, is an integrated school that enrolls both visually impaired and sighted students. The most recently published blind school survey in Ghana was conducted in 2003 [8].

The primary objective of this study was to determine the major causes of childhood blindness and severe visual impairment (SVI) in students at Wa Methodist School for the Blind. A secondary objective was to compare our results to those published from other studies conducted in Ghana.

Materials and methods

This study was granted exemption by the Institutional Review Board at Duke University and was approved by the Department of Research and Development at Tamale Teaching Hospital. For this retrospective study, formal written consent was not required by either institution. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

This retrospective study involved the analysis of data previously collected on students enrolled at Wa Methodist School for the Blind located in the Upper West Region of Northern Ghana. Students were eligible for inclusion in this study if they had participated in a school-wide eye screening performed in November of 2014. The screening team was comprised of one ophthalmologist (JS) and two optometrists.

Over a two-day period, the screening team conducted a basic eye screening on each student, recording both demographic and clinical data. The screening team trained the school staff to assess distance visual acuity (VA) using a Snellen VA chart to record each student's best uncorrected VA at 6 m for each eye independently. An ophthalmologist (JS) or optometrist performed clinical eye examinations on each student using a portable slit lamp, an iCare® tonometer, a direct and indirect ophthalmoscope. Each student's eyes were pharmacologically dilated if it was determined possible to view the fundus (e.g., phthisical eyes were not dilated). The study team also collected self-reported information on the past medical history of blindness, the onset of blindness, and family history of blindness. Family history of blindness included any known immediate or extended family members who were blind or had visual impairment.

For this study, we used the "World Health Organization (WHO)/Prevention of Blindness (PBL) Examination Record for Children with Blindness and Low Vision Coding Instructions" [9] to assign major anatomic causes of visual loss for each eye and then for each student. The etiological cause of blindness for each student was determined by an ophthalmologist (JS) according to the "WHO/PBL Eye Examination Record For Children with Blindness and Low Vision" [10].

Stata 13.1 (StataCorp LP, College City, TX, USA) was used for all data analysis. Per the WHO guidelines, "blindness" was defined as having a VA of <3/60 to no perception of light (NPL), "SVI" as a VA of <6/60–3/60, and "visual impairment" as a VA of <6/18–6/60 [11]. For each participant, best uncorrected VA was based on the vision in the better-seeing eye. The best uncorrected VA was used to determine the prevalence of blindness and SVI in our population according the WHO categories of visual loss [11]. We calculated the prevalence of the major anatomical and etiological causes of blindness, according to the categories listed in the "WHO/PBL Eye Examination Record for Children with Blindness and Low Vision" [10]. Based on data available for age at onset of blindness, students were categorized into two groups: those whose onset of visual loss occurred at birth and not-at-birth.

Literature review

To compare our results to those published from other studies conducted in Ghana, we performed a literature search on PubMed (MEDLINE) for English-language only articles for the period of 1946–2017, using combinations of the following search terms: *Ghana* AND/OR *childhood visual impairment* AND/OR *childhood blindness* AND/OR *childhood visual loss* AND/OR *blind schools* AND/OR *school screening* AND/OR *survey*. For inter-regional comparison, Wa Methodist School for the Blind was considered "Northern Ghana" and Akropong School for the Blind "Southern Ghana." We compared (1) major sites of anatomical abnormalities leading to visual loss (i.e., corneal scar (CS)/phthisis bulbi (PB), cataract, glaucoma, and optic atrophy) and (2) etiological causes of blindness across the studies. For the anatomical causes of blindness, CS and PB were grouped together in order to compare our findings to those of other published studies.

Results

Of the 190 students enrolled at Wa School for the Blind, 190 (100%) were examined during the school-wide screening in November 2014. Average student age was 15 years (range 6–24 years). Forty-one (22%) of the students reported a family history of blindness. Eighty-three (44%) students reported blindness since birth. Of the students screened, it was indeterminable for 18 (9%) students whether their onset of visual loss occurred before or after 16 years of age, and 5 (3%) students did not report age at onset of visual loss but were younger than 16 years of age at the time of the screening. Clinical examination results are shown in Table 1. One hundred and eighty-eight (99%) students were blind, and 2 (1%) had visual impairment (Table 1).

According to the WHO classification system [10], the main anatomical sites of abnormality that led to visual loss were whole globe ($n = 49$, 26%), cornea ($n = 38$, 20%), and lens ($n = 27$, 14%) (Table 2). The top five individual anatomic causes of visual loss were optic atrophy ($n = 23$, 12%), corneal scar ($n = 20$, 11%), microphthalmos ($n = 18$, 9%), glaucoma ($n = 18$, 9%), and cataract ($n = 18$, 9%) (Table 2).

According to the WHO classification system [10], the main etiological causes of blindness were unknown ($n = 114$, 60%), followed by postnatal/infancy/childhood factor ($n = 35$, 18%), and hereditary disease ($n = 28$, 15%) (Table 3). Of those with specified etiological causes of blindness, 19 cases (10%) were attributed to measles, 4 (2%) rubella, 3 (2%) trauma, and 2 (1%) toxoplasmosis (Table 3).

Table 1 Summary of the clinical findings of 190 students examined at Wa Methodist School for the Blind, Northern Ghana

Category of vision loss in the better-seeing eye		*n* (%)
Normal vision (6/18 or better)		0 (0)
Visual impairment (<6/18–6/60)		2 (1)
Severe visual impairment (<6/60–3/60)		0 (0)
Blind (<3/60 to light perception)		125 (66)
Blind (no light perception)		63 (33)
Intraocular pressure (IOP) (mmHg)[a]	Median (IQR)	Range (min, max)
Right eye	18 (13.5–25)	2, 64
Left eye	17 (15–24.5)	4, 62
		n (%)
Pupil reaction		
Right eye		
Normal		61 (32)
Slow		6 (3)
Irregular		1 (0.5)
Non-reactive		44 (23)
Indeterminable		78 (41)
Left eye		
Normal		62 (33)
Slow		6 (3)
Irregular		2 (1)
Non-reactive		42 (22)
Indeterminable		78 (41)
Ocular alignment		
Normal		125 (66)
Esotropia		19 (10)
Exotropia		36 (19)
Indeterminable		10 (5)
Nystagmus		
No		89 (47)
Yes		96 (51)
Indeterminable		5 (3)

[a] IOP indeterminable for 73 rights eyes and for 73 left eyes

Table 2 Anatomical causes of visual loss in 190 students at Wa Methodist School for the Blind, Northern Ghana

Anatomical cause of blindness, as defined by the WHO [10]	*n* (%)
Normal globe	16 (8)
Cortical blindness	13 (7)
Refractive error	3 (2)
Whole globe	49 (26)
Microphthalmos	18 (9)
Glaucoma	18 (9)
Phthisis bulbi	8 (4)
Anophthalmos	2 (1)
Enophthalmos	2 (1)
Removed	1 (0.5)
Cornea	38 (20)
Scar	20 (11)
Corneal dystrophy	9 (5)
Sclerocornea	5 (3)
Staphyloma	2 (1)
Pannus	2 (1)
Lens	27 (14)
Cataract	18 (9)
Aphakia	4 (2)
Poor quality cataract surgery	3 (2)
Haze/Opacity	2 (1)
Uvea	8 (4)
Uveitis	8 (4)
Retina	17 (9)
Scar	8 (4)
Retinitis pigmentosa (RP)	4 (2)
Albinism	4 (2)
Unknown	1 (0.5)
Optic Nerve	24 (13)
Atrophy	23 (12)
Hypoplasia	1 (0.5)
Other	11 (6)
Vitreous opacity	3 (2)
Unknown	8 (4)

In our review of the literature on childhood blindness in Ghana, we found four published blind school surveys. Two included data from Northern Ghana [12, 14] and three included data from Southern Ghana [8, 13, 14] (Table 4). For the following comparisons, we excluded one study (Study #3) [14] because it reported aggregated data from eye screenings in three countries (i.e., Togo, Benin, and Ghana).

The main anatomical causes of visual loss in all studies [8, 12, 13], including this study, were CS and PB as a group (Table 4). In Wa School for the Blind (Northern Ghana) in 1987, 63% of the cases were attributable to CS/PB [12], while in this study conducted in 2014, 15% ($n = 28$) of the cases were attributable to CS/PB (Table 4). In Akropong School for the Blind (Southern Ghana), in 1989, 28% ($n = 36$) of cases were attributable to CS/PB [13], while in 2003, 59.3% of the cases were attributable to CS/PB [8]. In Northern Ghana, cataract accounted for 5% of blindness in 1987 [12] and 9% ($n = 18$) in 2014 (Table 4). In Southern Ghana, 29% ($n = 38$) of blindness was attributable to cataract in 1989 [13] and 23.1% in 2003 [8] (Table 4). In Northern Ghana, blindness caused by glaucoma was seen in 8% in 1987 [12] and 9% ($n = 18$) in 2014 (Table 4). In Southern Ghana, blindness caused by glaucoma was seen in 12% ($n = 16$) in 1989 [13] and 15.6% in 2003 [8]. In Northern Ghana, optic atrophy caused 5% of the blindness in 1987 [12] and 13% ($n = 23$) in 2014 (Table 4), while in Southern Ghana, optic atrophy caused 5% ($n = 6$) of the blindness in 1989 [13] (Table 4).

For etiological causes of blindness, two of the previous studies reported cases of visual loss due to measles [8, 12]. In Northern Ghana, visual loss associated with measles infection was seen in 52% in 1987 [12] and 10% in 2014 (Table 4), and in Southern Ghana, visual loss associated with measles infection was seen in 26.6% ($n = 53$) in 2003 [8] (Table 4).

Only two of the previous studies reported timing of the onset of visual loss [8, 13]. At Akropong School for the Blind (Southern Ghana), in 1989, 91% ($n = 63$) of those under 16 years of age at the time of the blind school screening reported onset of visual loss before age 6 years [13], and in 2003, 66% were reported becoming blind before 6 years of age (17% between the ages 1 and 5 years and 49% within the first year of life) [8] (Table 4). At Wa Methodist School for the Blind (Northern Ghana) in 2014, 44% ($n = 83$) became blind within the first year of life (Table 4).

Discussion

At the Wa Methodist School for the Blind, the major anatomical causes of blindness/SVI among the students screened in 2014 in descending order were optic atrophy, corneal scar, microphthalmos, glaucoma, and

Table 3 Etiological causes of blindness in 190 students at Wa Methodist School for the Blind, Northern Ghana

Etiological cause of blindness, as defined by the WHO [10]	*N* (%)
Hereditary disease	28 (15)
Intrauterine factor	6 (3)
Rubella	4 (2)
Toxoplasmosis	2 (1)
Perinatal/neonatal factor	7 (4)
Postnatal/infancy/childhood factor	35 (18)
Measles	19 (10)
Trauma	3 (2)
Other	13 (7)
Cannot determine (unknown etiology)	114 (60)
Cataract	25 (13)
Glaucoma/Buphthalmos	14 (7)
Abnormality since birth	33 (17)
Other	42 (22)

cataract. The major etiologic causes of blindness were unknown and childhood factor, with measles accounting for 10% of the cases of blindness in our study population. Of those who reported age of onset of visual loss, about half of the students became blind within the first year of life.

Causes of childhood blindness

Comparing our findings to those of previously conducted blind school surveys in Ghana, overall CS/PB was the most common anatomical cause of blindness. Corneal scarring is primarily seen in low socioeconomic settings with poor public health infrastructure that cannot effectively combat known preventable causes of corneal pathology (i.e., measles, vitamin A deficiency, and ophthalmia neonatorum) [15–18]. Many of these causes often lead to subsequent corneal scarring or phthisis bulbi [8, 19, 20]. In West Africa, nutritional deficiencies and ocular infections continue to be significant risk factors for childhood blindness, but much progress has been made with public health campaigns in measles vaccinations and vitamin A supplementation [21, 22].

While CS/PB continues to be the most common cause of childhood blindness in blind schools in Ghana, we found over time that the percentage of cases attributable to CS/PB decreased in Northern Ghana from 1987 to 2014 [12], but increased in Southern Ghana from 1989 to 2003 [8, 13]. Interestingly, this decrease in the proportion of CS/PB cases in Northern Ghana coincides with the decrease in measles-associated visual loss in the north from 1987 to 2014 [12]. One study that analyzed the progress of measles control in Ghana found that coverage increased after a period of health sector reform which began in 1997 [23]. This could possibly explain the decrease in prevalence of measles-associated blindness in Northern Ghana from 1987 to 2014. One explanation for the increase in prevalence of CS/PB attributable to measles in Southern Ghana could be due to differences in measles immunization coverage regionally. According to the World Bank database of measles immunization rates in Ghana, coverage fell from 90% in 2000 to 78% by 2001, and the majority of the districts that had rates fall below 80% were in Central and Southern Ghana [24, 25].

The next most preventable causes of childhood blindness in Ghana across all studies were cataract and glaucoma. In Northern Ghana, rates of glaucoma and cataract were lower than in Southern Ghana. While the onset of blindness due to these causes can be prevented through early and effective management, common barriers include late presentation and poor management due to limited resources, as well as the use of traditional medicines [8]. Solutions may include training community health workers, traditional birth attendants, and primary care providers to help identify children with preventable causes of blindness and refer them early before permanent visual loss occurs. Even after timely referral for early treatment, numerous barriers such as lack of transportation, insufficient financial resources, fear of biomedicine, lack of health education, language barriers, and healthcare provider absenteeism all prevent patients from receiving appropriate care [6, 8, 26]. In addition to early screenings for childhood visual impairment, improving infrastructure and expanding training programs in pediatric ophthalmology as well as community eye health are needed to increase human, financial, and material resources for medical outreaches. Community health education would also strengthen the initiative to make referrals and treatment timelier.

Onset of visual loss

Globally, most blind children are blind at birth or become blind before their fifth birthday [21]. We also

Table 4 Summary of published blind school surveys conducted in Ghana compared to this study

Study Number	Author(s)	Year conducted	School	Area of Ghana	Study type	Sample size (total number screened)	Number of students with visual loss[a], age at onset of visual loss <16 years	Main anatomic causes of visual loss for all students screened				Association of visual loss with measles infection *n* (%)	Other Comments
								CS/PB *n* (%)	Cataract *n* (%)	Glaucoma *n* (%)	Optic atrophy *n* (%)		
1	Foster [12]	1987	WMSB	North	Review article	NR	$n = 65$ BL: 65 SVI: NR VI: NR	n = NR (63)	n = NR (5)	n = NR (8)	n = NR (5)	n = NR (52)	–
2	Akafo and Hagan [13]	1989	ASB	South	Blind school survey	$N = 129$[b] BL: 103 SVI/VI: 26	$n = 116$ BL: NR SVI: NR VI: NR	n = 36/129 (28)	n = 38/129 (29)	n = 16/129 (12)	n = 6/129 (5)	–	63 (91%) of 69 screened students under 16 years at time of the screening reported onset of visual loss before age 6 years
3	Gilbert et al. [14]	1993	Includes schools from Togo, Benin, and Ghana. Within Ghana: WMSB WSS ASB	 North Central South	Blind school survey	$N = 315$[c] BL: 83.6% SVI: 6.6% VI: 7.9% Normal vision: 1.9%	$n = 284$ BL: NR SVI: NR VI: NR	n = 102/284 (35.9)	n = 28/284 (10)	n = 37/284 (13)	–	–	–

Table 4 continued

Study Number	Author(s)	Year conducted	School	Area of Ghana	Study type	Sample size (total number screened)	Number of students with visual loss[a], age at onset of visual loss <16 years	Main anatomic causes of visual loss for all students screened				Association of visual loss with measles infection *n* (%)	Other Comments
								CS/PB *n* (%)	Cataract *n* (%)	Glaucoma *n* (%)	Optic atrophy *n* (%)		
4	Ntim-Amponsah and Amoaku [8]	2003	ASB	South	Blind school survey	$N = 199$	$n = 199$[d] BL: 108 SVI: 85 VI: 2	n = NR (59.3)	n = NR (23.1)	n = NR (15.6)	–	$n = 53$ (26.6)	96 students (49%) became blind within their first year of life; 33 (17%) became blind between ages 1 and 5 years, inclusive
5	This study	2014	WMSB	North	Blind school survey	$N = 190$	$n = 172$[e] BL: 171 SVI: 0 VI: 2	$n = 28/190$ (15)	$n = 18/190$ (9)	$n = 18/190$ (9)	$n = 23/190$ (13)	$n = 19/190$ (10)	83 students (44%) became blind within the first year of life

ASB Akropong School for the Blind, *BL* blindness, *CS/PB* corneal scar/phthisis bulbi, *NR* not reported, *SVI* severe visual impairment, *WMSB* Wa Methodist School for the Blind, *WSS* Wenchi Secondary School

[a] For visual loss, BL defined as a visual acuity of <3/60 to no perception of light; SVI defined as visual acuity of <6/60–3/60; and VI is defined as a visual acuity of <6/18–6/60

[b] Sixty-nine students were <16 years of age at the time of the screening, and of those students, 56 were blind. Separate data not available for the visual acuities of the 116 students who reported onset of visual loss before age 16 years

[c] Total number of students examined in West Africa; no data available on students from Ghana alone

[d] The visual acuity of 4 students was not reported

[e] Eighteen students older than 16 years reported onset of blindness as "late" or "not at birth," and thus, it could not be determined whether onset of visual loss was before or after 16 years of age

found this to be true in our study. Of the studies that reported age of onset of blindness [8, 13], almost half of the students became blind within the first year of life. Because the majority of blindness in children occur within the first year of life, strategies aimed to reduce childhood blindness need to focus on identifying at-risk infants at an early age.

Study limitations

This study has several limitations. The data analyzed in this study were collected to identify children with cataracts who were surgical candidates and not for the purposes of this study. Due to the retrospective nature of this study, some variables were not measured, and other variables (i.e., the onset of blindness) did not strictly fit into the categories listed on the WHO/PBL form. Despite these limitations, one strength of this study was the 100% participation of enrolled students, meaning that there was no selection bias.

Additionally, our findings must be taken in light of the implicit biases of research conducted in blind schools. Because blind school studies tend to exclude certain populations, extrapolating overall childhood blindness statistics from these types of studies is limited. One study suggests that across the globe, only 10% of blind children are in special disabilities schools and children with multiple disabilities do not meet enrollment criteria of some blind schools [16]. Furthermore, pre-school children are underrepresented in blind schools [14], and the high mortality rate associated with certain causes of blindness would result in underrepresentation of the actual prevalence of those causes of blindness in blind schools. Despite these limitations, blind school surveys have become important and accepted methods for collecting epidemiological data to determine regional prevalence and main causes of childhood visual impairment. While blind school surveys have their limitations, their advantages include greater conformity in reporting data by a single team of researchers and inclusion of a large number of blind children during a single screening, which would not be possible for population-based studies [14].

Conclusion

We found CS/PB to be the major anatomical cause of childhood blindness/SVI in a blind school in Northern Ghana. Reviewing the literature on published studies on childhood blindness in Ghana, we found that CS/PB has remained the most common anatomical cause of childhood blindness in blind schools over time, though there were regional differences. With the hope of developing national databases on childhood blindness, we encourage all screeners to use a standardized form (i.e., WHO/PBL Eye Examination Record) to enable results to be more comparable between sites and over time. Being able to identify unique regional differences in disease prevalence may guide future public health strategies to more specifically target known causes of avoidable childhood blindness.

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Compliance with ethical standards

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent For this type of study, formal consent is not required.

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