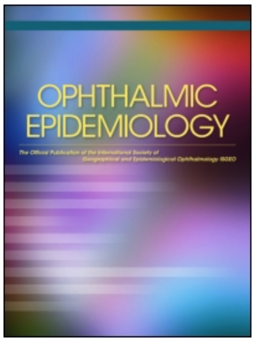

Ophthalmic Epidemiology

ISSN: 0928-6586 (Print) 1744-5086 (Online) Journal homepage: https://www.tandfonline.com/loi/iope20

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OPHTHALMIC EPIDEMIOLOGY
https://doi.org/10.1080/09286586.2019.1604976

Childhood blindness and visual impairment in the Narayani Zone of Nepal: a population-based survey

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ABSTRACT

Purpose: To estimate the prevalence and causes of blindness (BL), severe visual impairment (SVI), moderate visual impairment (ModVI) and mild visual impairment (MildVI) in children in Narayani Zone, Nepal.

Methods: In 2017, 100 population clusters within the Narayani Zone of Nepal were selected using RAAB software. Children (aged 0–15 years) suspected of having visual problems were identified using Key Informants (KIs) and school teachers and were referred for ophthalmologic examination. Eye care staff actively sought children who failed to present for examination. Causes of BL/SVI/ModVI/MildVI were categorized using standard World Health Organization definitions.

Results: Of 76,588 children selected, 72,900 (95%) were screened. Of 2,158 children referred for examination, 1,322 were referred by teachers and 836 by KIs. A total of 1,617 (75%) children received a detailed examination, of whom 128 children [65 girls (51%)] mean age of 9.4 (± 4.1 years) were confirmed to have BL 7 (5.5%), SVI 16 (12.5%), ModVI 19 (15%) or MildVI 86 (67%). The combined prevalence of BL/SVI/ModVI/MildVI was 175/100,000 (95% CI 172–178/100,000); BL/SVI/ModVI was 55/100,000 (95% CI 53–57/100,000) and the combined BL/SVI estimate was 30/100,000 (95% CI 29–31/100,000). The leading causes of BL/SVI/MVI were refractive error 23 (55%) and whole globe disorders 5 (12%). Total avoidable causes were 31 (74%).

Conclusion: The prevalence of BL/SVI/ModVI among children in Narayani Zone was moderate and included a high proportion of avoidable and treatable cases. Pediatric ophthalmic services need improvement, mainly refractive error correction in rural areas of Nepal.

ARTICLE HISTORY
Received 22 August 2018
Revised 12 February 2019
Accepted 2 April 2019

KEYWORDS
Blindness survey; population based; childhood; Narayani Zone; Nepal

Introduction

In 2010, approximately 1.26 million children were blind (visual acuity [VA]<3/60) worldwide.[1] While the prevalence of childhood blindness is relatively low, 2 to 78/100,000, its impact is almost equal to that of cataract in adults, in terms of blind years.[2] Childhood blindness has an inverse association with socioeconomic status, with a higher prevalence in low-income countries with elevated under-5 mortality rates.[1,3] Up to 50% of childhood blindness is preventable or treatable, and its control is a high priority in the VISION 2020 initiative of the International Agency for the Prevention of Blindness.[4]

A study in Nepal in 2014 estimated a childhood blindness and severe visual impairment (VA <6/60) prevalence of 70/100,000.[5] The present study provides additional, population-based estimates of the prevalence and causes of blindness and visual impairment among children in Narayani Zone, Nepal.

Methods

This study utilized the rapid assessment of avoidable blindness (RAAB) sampling methodology.[6] The sample was taken from the 100 clusters identified in a 2017 RAAB study (of adults aged at least 50 years) in the Narayani Zone.[7] The 2011 Nepal National Census (http://cbs.gov.np) enumerated Ward populations as the smallest population units. The 3,276 Wards in the Narayani Zone varied from 16 to 21,844 people. Wards with more than 800 people were segmented while Wards with small populations were joined to create study cluster sizes of approximately 800 people. A total of 100 clusters were selected by systematic

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random sampling proportional to size using the RAAB software.

As per the World Health Organization, blindness was defined as presenting VA in the better eye of less than 3/60, severe visual impairment (SVI) as VA of 3/60 or better and less than 6/60, moderate visual impairment (ModVI) as VA of 6/60 or better and less than 6/18 and mild visual impairment (MildVI) as 6/18 or better and less than 6/12.

Sample size calculation

According to the 2011 census, the population of the Narayani Zone was 2.99 million with 1.16 million children (<16 years). Estimating the prevalence of SVI/BL as 0.05% and using a confidence interval of 0.025%, the number of children needed for the study was calculated as follows: $(1.96)^2 \ (0.0005)(0.9995)/(0.00025)^2 = 30{,}717$. However, because of the anticipated difficulty finding and examining children in this setting, all children living in the 100 adult RAAB clusters were included in the sample (estimated as about 76,000 using the 2011 census data).

Case finding and referral

Following Muhit[8] and Shirma[9] case finding of preschool children depended on female community health volunteers (FCHVs). FCHVs are a part of a long-standing national program in Nepal whereby local women provide a range of primary health care roles including health education and health system support particularly for women and children. In this case, each FCHV was responsible for about 2–300 households (1000–1500 people) and acted in a one-time key informant (KI) role and will be referred to as KIs hereinafter. As KIs, they were trained by the coordinator of the present study to go house-to-house to recognize signs and symptoms of blinding eye diseases, and refer children suspected of having visual problems to ophthalmic personnel. Training was carried out in a staggered sequence so that KIs began case finding in one district while training occurred in the next district. The KIs encouraged parents to bring referred children to a scheduled outreach eye camp, a primary eye care centre or an eye hospital.

For this survey, the KIs enumerated and referred only preschool aged children, not the typical KI program that includes children of all ages. Nevertheless, the KIs did refer 26 school age children, with suspected eye problems for ophthalmologic evaluation, who happened to be home when they conducted household visits. The KIs did not enumerate or track school aged children who were not attending school.

Case finding of school age children occurred in the 117 schools in the clusters. In each school, teachers that were selected by the head master screened the VA of students of their own school and referred children whose VA was < 6/12 in the best eye to a planned diagnostic visit to the school by ophthalmic personnel, a primary eye centre or an eye hospital. Teachers were taught to recognize obvious ocular abnormalities including squint, nystagmus, corneal opacities, ptosis, conjunctivitis and external hordeolum. They were asked to refer children with the above conditions even if their visual acuity was normal. Visual acuity (VA) was measured by teachers using the "E Chart" or the Snellen Number Chart at a distance of 6 meters. One student was examined at a time keeping others waiting outside the classroom. Students were asked to occlude one eye with the palm of their hand and to read from 20/200 (6/60 Snellen) downward. A line was considered as "pass" if all the letters were read correctly. If one letter was not identified, then the previous line was recorded as the VA. Children wearing glasses were tested wearing their glasses. In schools with more than 200 children, ophthalmic assistants assisted with vision screening. Ophthalmic assistants collected referral data from each school.

The pediatric team of the Bharatpur Eye Hospital (a pediatric ophthalmologist, a pediatric optometrist and a childhood blindness coordinator) conducted pediatric eye camps in all 100 clusters to examine referred cases. On the designated examination day, referred children were brought into the examination centre in their community by their care givers (using their own transport). Eye care personnel followed-up to find children unable to present for examination both in their community and school.

Children were also sought in schools for the blind in the Narayani Zone. Of a total of 86 children who attended the blind schools, only 2 were from the study clusters.

Clinical examination

The pediatric eye camps involved the pediatric team as well as the KIs of the cluster who referred the children. Presenting VA was measured using a logMAR E chart at 3 meters and dry (and when appropriate, cycloplegic) refraction was performed by the optometrist or ophthalmic assistant, using retinoscopy and trial lenses. Cardiff acuity cards were used at 1 meter or 50 centimeters for pre-school children. Caregivers of children with VA < 6/12 were interviewed for demographic and other relevant history, before undergoing anterior segment examination by an ophthalmologist using a magnifying loupe and torch. Posterior segments were examined by direct ophthalmoscope, after dilation.

Classification of causes

The WHO Prevention of Blindness (PBL) Eye Examination Record for Children was used. Any previous surgery or treatment for eye conditions was noted. All structural abnormalities were recorded for each eye, and one primary diagnosis selected for each eye according to the WHO Coding Instructions. Avoidable causes of visual impairment were divided into treatable and preventable causes. Treatable causes were conditions where surgical, medical or optical interventions may have preserved or restored sight (for example, glaucoma). Preventable causes were conditions that could potentially have been prevented through health promotion (for example, rubella immunization). Unavoidable causes were those that could not have been prevented or treated (such as Leber's congenital amaurosis).

Ethical approval and consent

Ethical approval was obtained from Nepal Health Research Council. A letter of introduction describing the activities was sent to community leaders of towns and villages prior to visits. Necessary permission from the concerned health authorities was obtained. Written consent was obtained from the caregivers of all children who were examined. Children who needed surgical treatment were referred to an ophthalmologist at Bharatpur Eye Hospital.

Data management and statistical analysis

Data for each child were recorded on the WHO/PBL form. An SPSS (version 16.0) database was used by for statistical analysis.

Results

Of the 76,588 children in the study sample, 72,900 (95%) were screened, 53,424 (70%) by teachers in schools, 19,474 (25%) by KIs in the community, and 2 by the pediatric team in blind schools (Figure 1).

School teachers referred 1,322 children for eye examination, of whom 813 (61.5%) attended (mean

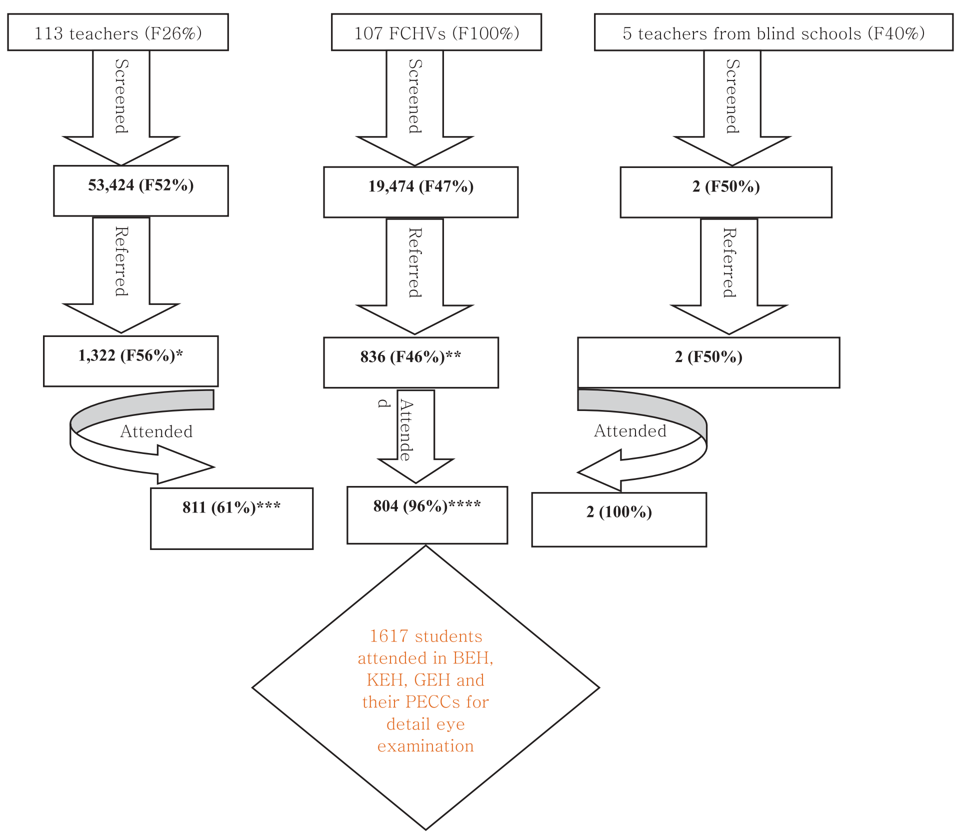

Figure 1. Flow chart screening, referral, examination by source.

Legend:F = female; FCHV = female community health volunteer; BEH = Bharatpur eye hospital; KEH = Kedia eye hospital; GEH = Geta Eye Hospital; PECC = primary eye care centerNotes* More girls than boys referred ($p < .05$)** Key Informants 1.46 (95% CI 1.2–1.73) more likely than teachers to refer boys*** mean age 12.4 yrs (±3.1) and 11.5 (+/3.0) yrs for children seen and not seen, respectively; range 4–19 yrs**** mean age 2.5 yrs (± 1.9); range 1 –15 yrs age 12.1 years [±3.1] and 11.5 years [±2.9] for children seen and not seen, respectively; both groups 56% female). Significantly more girls than boys were referred by teachers (56% girls; p < .05).

The KIs referred 836 children, 804 attended (784 examined by the pediatric team during visits to the clusters and 20 attended an eye hospital or PECC). Key Informants were more likely than teachers to refer boys than girls (sex ratio: 1.46 [95% CI 1.2–1.73])

Of the total of number of children, 2,158 (1,322 + 836) who were referred, 1,617 (75%) children received a diagnostic eye examination (Figure 1).

Of the 813 children (mean age 2.5 years [± 1.9]) that the KIs referred and were examined, 339 (80%) were under age 3 years. Of the children that the teachers referred and were examined, 720 (87%) were between age 6 and 15 years. A total of 821 (51%) of children were under age 6 years, and 796 (49%) were 6 years and older (Table 1).

A total of 1,617 (75%) children received a detailed examination, of whom 128 children (65 girls [51%] mean age of 9.4 ± 4.1 years) were found to have BL 7 (5.5%), SVI 16 (12.5%), ModVI 19 (15%) or MildVI 86 (67%). The combined prevalence of BL/SVI/ModVI/MildVI was 175/100,000 (95% CI 172–178/100,000); BL/SVI/ModVI was 55/100,000 (95% CI 53–57/100,000) and the combined BL/SVI estimate was 30/100.000 (95% CI 29–31/100,000) (Table 2).

The leading anatomical cause of blindness or visual impairment was refractive error (95 cases), followed by conditions affecting the whole globe such as micropthalmos (7 cases) and other anatomical causes such as optic atrophy (3 cases), cortical blindness (1 case), lens-related (8 cases), uveal coloboma (3 case) and nystagmus (7 cases). Of the 128 MildVI cases, 18 were caused by unavoidable congenital conditions and 110 by potentially avoidable causes (Table 3). Out of 8 children with lens-related problems, 2 had received surgery.

Discussion

The present study estimated the prevalence of BL/SVI as 30/100,000 and ModVI as 25/100,000. A recent population-base study in Nepal by Adhikari estimated the prevalence of SVI/BL (combined VA<6/60) as 70/100,000 and ModVI as 100/100,000.[5] The reasons for the different prevalence estimates remains unclear. Both studies were recent, included random samples of children from the plain and hill districts and conducted door-to-door

Table 1. Children referred and examined by source, age and sex.

Sex	Referral Source	Age range, years <3 N (%)	3–5 N (%)	6–15 N (%)	>15 N (%)	Total
Male	KIs	339 (80)	77 (18)	10 (2)	0	426 (100)
	Teachers	3 (1)	7 (2)	332 (92)	19 (5)	361 (100)
	Total	342 (44)	84 (11)	342 (44)	19 (2)	787 (100)
Female	KIs	312 (83)	50 (13)	16 (4)	0	378 (100)
	Teachers	2 (0.5)	31 (7)	388 (86)	31 (4)	452 (100)
	Total	314 (38)	81 (10)	404 (49)	31 (4)	830 (100)
Total	KIs	651 (81)	127 (16)	26 (3)	0	804 (100)
	Teachers	5 (0.5)	38 (5)	720 (87)	50 (6)	813 (100)
	Total	656 (41)	165 (10)	746 (46)	50 (3)	1617 (100)

Table 2. Children with BL, SVI, ModVI, or MildVI by age, sex, referral source.

	Male	Female	Total N (%)
Age (years)			
<3	1	3	4 (3)
3<6	3	4	7 (6)
>6–15	54	57	111 (87)
>15	5	1	6 (5)
Total	63	65	128 (100)
Visual acuity			
EVI	42	44	86 (67)
		Prevalence of MildVI = 0.117% (95% CI 0.114–0.119)	
MVI	7	12	19 (15)
	Prevalence of ModVI = 0.025% (95% CI 0.022–0.027)		
SVI	8	8	16 (13)
	Prevalence of SVI = 0.020% (95% CI 0.019–0.021)		
BL	6	1	7 (5)
	Prevalence of BL = 0.01% (95% CI 0.0092–0.0107)		
Total	63	65	128 (100)
	Prevalence of BL/SVI/ModVI/MildVI = 0.175% (95% CI 0.172–0.178)		
Source of referral			
KIs	5	7	12 (9)
Teachers	58	58	116 (91)
Total	63	65	128 (100)

Table 3. Preventable, treatable and unavoidable causes of BL, SVI, ModVI, or MildVI.

Types of blindness	MildVI N (%)	ModVI N (%)	BL/SVIN (%)
Preventable			
Optic nerve atrophy		1 (5)	2 (9)
Cortical blindness			1 (4)
Sub-total		1 (5)	3 (13)
Treatable			
Lens related	4 (5)	1 (5)	3 (13)
Amblyopia due to refractive error	72 (84)	14 (74)	9 (39)
Glaucoma	1 (1)		
Corneal scar	2 (2)		
Uveitis	1 (1)		
Sub-total	80 (93)	15 (79)	12 (52)
Total-avoidable			
Unavoidable			
Micropthalmos	3 (4)	0	5 (22)
Uvealcoloboma	1 (1)		1 (4)
Idiopathic nystagmus	2 (2)	3 (16)	2 (9)
Total unavoidable	6 (7)	3 (16)	8 (35)
Total	**86 (100)**	**19 (100)**	**23 (100)**

screening and referral of children by community volunteers. Unfortunately, Adhikari did not provide data on the causes of low vision and blindness.

Our blindness estimate of 10/100,000 is lower than that reported by Muhit in Bangladesh (30/100,000)[10] and lower than estimates based on infant mortality rates in Nepal (50/100,000).[1] This is likely due, in part, to the almost complete absence of corneal blindness found in our study (27% in Bangladesh). Low corneal blindness is in keeping with Nepal's strong public health program distributing vitamin A and consistent with global trends,[2,11] however, keratomalacia due to Vitamin A deficiency was found as a cause of blindness in blind school populations in Nepal from 2008–2011.[12] The low prevalence of blindness and corneal blindness in our study is also likely due to high measles vaccine coverage in Nepal as demonstrated by Adhikari, where over 96% of children sampled in his population-based assessment of factors associated with low vision and blindness in Nepal had received measles vaccine.[5]

The leading *anatomical* cause of BL/SVI in our study was refractive error (55%). Refractive error as the leading treatable cause of BL/SVI contrasts with a study in a middle-income setting such as Iran that identified retinal diseases (44%) as the primary cause of BL/SVI.[13] The high proportion of refractive error in our study indicates the need for improved access to timely refractive correction in this setting. However, major challenges are anticipated in preventing amblyopia in the context of low levels of parental education, long distances to eye care providers, and lack of relevant expertise.

The prevalence of BL/SVI due to cataract in our study (4/100,000) is at the low end of the global prevalence of cataract estimates for low-income countries which ranges from 4 to 20 per 100,000.[14] In Bangladesh, lens conditions accounted for substantially more blindness (33% versus 13% in our study).[10] However, with only 3 children found in our sample, the prevalence estimate is subject to major change with a small change in the number of children identified.

The higher proportion of boys among BL/SVI cases (14/23, 61%) was similar to that of other childhood blindness studies'[15,16] including a 2007 Bangladesh study in which 63% were boys.[10] In the Bangladesh study, but not in ours, boys were more likely to have treatable causes of BL/SVI due to lens disorders. Other studies also show that gender inequity favors boys when treatment is available.[17] In addition, the higher proportion of boys than girls referred by KIs is in keeping with other settings.[18]

About two-thirds of the cases of BL/SVI/ModVI (31, 74%) were due to avoidable causes, in line with global trends in childhood blindness.[2,3,11] These results are slightly higher than those of the 2007 Zahedan Eye Study in Iran, where 39.5% of the cases of visual impairment were treatable.[19] Of the treatable cases (65%) in our study only 1 had been (unsuccessfully) treated and 8 had never undergone treatment. The low proportion of treatable cases that actually received treatment in Nepal shows the need to improve access to pediatric ophthalmic services.

The children from school screening who missed ophthalmic evaluation in our study, mostly came from 2 of the 5 districts of the Narayani Zone near to the Indian border. In these districts, the school teachers conducted visual acuity screening, similarly to all school teachers in the study, and referred a similar proportion (with similar age and sex to other districts) for examination by the ophthalmic team. However, follow-up examination was not possible because, by the time of follow-up team arrived, about half of the children were absent from school primarily to work as agricultural laborers at home or in nearby India. Follow-up phone calls to the families and visits to the schools did not result in additional children being examined.

As first described by Muhit[8], the "Key Informant Method" (KIM) is an important tool to help to overcome the challenge of identifying a rare condition, such blindness and visual impairment, in children in rural populations, and to facilitate referral to ophthalmic personnel. The KIM has been used in research as part of prevalence studies in Tanzania[9] Ghana,[20] Malawi,[21] Nigeria[22] and Iran.[13] The Bangladesh study found that the children recruited by the KIs were similar to children found through a population survey, including the proportions of female, pre-school age, multiply-impaired and rural-based children.[8]

Our study supports use of Female Community Health Volunteers in the KI role, with 96% of children they identified receiving examination. Female Community Health Volunteers were able to mobilize children using their close connections to individual communities and familiarity with government health and eye programs. However, many children with mild and even moderate vision impairment due to anisometropia and astigmatism are likely to have been missed, as they can usually function normally and the parents may not have noticed a problem.

In summary, the prevalence estimate of visual impairment and blindness in children in the Narayani Zone of Nepal of 55/100,000 included a high proportion of avoidable cases. This indicates the need for improved access to pediatric ophthalmic services, mainly refractive error correction in rural areas. The Key Informant Method is feasible and effective for finding and referring pre-school children to eye care services in Nepal.

Acknowledgments

We thank Seva Canada for funding this research, Lumbini Eye Institute and Bharatpur Eye Hospital for providing logistical and personnel support and David de Wit who helped us in language editing services.

Funding

This paper was funder by Seva Canada.

Conflict of interest

None

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