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Prevalence of Refractive Errors in Nepalese Children and Adults: A Systematic Review With Meta-Analysis

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Prevalence of refractive errors in Nepalese children and adults: a systematic review with meta-analysis

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ABSTRACT

Clinical relevance: Country-specific estimates of the prevalence of refractive errors are important to formulate national eye health policies for refractive care services.

Background: The purpose of this study was to systematically synthesise available literature and estimate the prevalence of refractive errors in the Nepalese population.

Methods: PubMed, Scopus, and Web of Science databases were systematically searched for articles on refractive errors and presbyopia published in English language until 27 September 2022. Population and school-based quantitative, cross-sectional prevalence studies and Rapid Assessment of Avoidable Blindness survey repository data were included. The quality of the included studies was assessed using the Newcastle Ottawa scale adapted for cross-sectional studies. Data extraction was performed with consensus among the reviewers. Meta-analysis of the prevalence was performed using the Random effects model to estimate the pooled proportions.

Results: A total of 38 studies with 101 701 participants were included: 18 studies in children (n = 31 596) and 20 in adults (n = 70 105). In children, the estimated pooled prevalence of overall refractive errors was 8.4% (95% CI: 4.8 to 12.9) with myopia, hypermetropia and astigmatism prevalent in 7.1% (95% CI: 3.7 to 11.4), 1.0% (95% CI: 0.7 to 1.3) and 2.2% (95% CI: 0.9 to 3.9), respectively. In adults, the prevalence of refractive errors, uncorrected refractive errors, and uncorrected presbyopia were 11.2% (95% CI: 8.0 to 14.9), 7.3% (95% CI: 5.4 to 9.5) and 78.9% (95% CI: 69.1 to 87.3), respectively.

Conclusions: The pooled prevalence of refractive errors is relatively low while uncorrected refractive errors and presbyopia are high in Nepalese population suggesting a need for better access to refractive care services in the country. The paucity of quality evidence on prevalence of refractive errors, particularly in children, indicates a need for a well-designed population-based study to accurately estimate the current prevalence of refractive errors.

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Introduction

Uncorrected refractive errors (URE) and presbyopia are the leading causes of visual impairment globally.[1] The Global burden of Disease study estimated that there were about 596 million people with distance vision impairment due to uncorrected refractive errors and 510 million with uncorrected presbyopia in 2020.[1,2] The prevalence of both uncorrected distance refractive errors and presbyopia in the South East Asian region is significantly higher than that in the high-income regions.[3,4] These numbers are expected to increase substantially over the coming decades as a result of population ageing and lifestyles.[2] This is particularly true for myopia, the prevalence of which is rising alarmingly.[5,6] Temporal trends of myopia show that by 2050, almost half of the world's population will be myopic.[5] In parallel, there is an enormous burden of presbyopia which is largely neglected and remains uncorrected.[3,7]

Vision impairment and blindness due to uncorrected refractive error pose a significant negative impact on the quality of life and a loss in productivity.[8–12] Refractive errors, particularly myopia, if uncorrected affect visual functioning, such as reading street signs, recognising friends and watching television.[13] Similarly, uncorrected presbyopia has been found to have a significant negative impact on daily living, both in urban and rural populations.[14]

The 74th World Health Assembly set a global target of a 40% increase in effective coverage of refractive errors to be achieved by 2030.[15] To achieve such a target, it is essential to understand the current burden of refractive errors at a local and national level.

Nepal is a topographically diverse country with mountains, hills and the flat plains, also called as Terai. It has a population of 29.2 million with 66.08% residing in urban and semi-urban areas.[16] About forty per cent of the Nepalese population are children and about sixteen per cent of population are over 50 years of age. Several studies have reported the prevalence of refractive errors and presbyopia from different regions of Nepal; however, the national average figures based on the defined set of quality criteria is unknown. This systematic review and meta-analysis aimed to estimate the population-based pooled prevalence of refractive errors in the Nepalese population. These epidemiological data provide important information for national planning and resource allocation and to improve refractive care services in Nepal.

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Methods

This systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[17] The review protocol was registered in the PROSPERO database [Protocol ID: CRD42021253402].

An initial systematic search was performed on PubMed, Scopus, and Web of Science databases for articles published in English language until 5 May 2021. The search was updated on 27 September 2022 to include papers that may have been published between the initial search and submission of the review. In the initial search, the search terms were organised into three concepts: 1) prevalence, 2) refractive errors and 3) Nepal. Keywords used were: prevalence, epidemiology, magnitude, burden, refractive error, morbidity, vision, visual impairment, blindness, myopia, hyperopia, astigmatism, presbyopia, and Nepal. The detailed search strategy is presented in Appendix A. In addition, the reference lists of the included articles were screened to identify further relevant studies. Rapid assessment of avoidable blindness (RAAB) survey reports from Nepal that are published in the RAAB repository (https://www.raab.world/) were also included.[18]

We included only population and school-based quantitative, cross-sectional studies conducted in the Nepalese population. All groups of people irrespective of age, gender, or ethnicity and residing in different geographical locations (mountains, hills, and the plains) in all seven provinces of Nepal were included. However, studies that were conducted on specific populations such as children with special needs (e.g. Down syndrome) and studies conducted exclusively on occupational, sports or hospital settings were excluded. Hospital-based refractive error prevalence studies were purposefully excluded because such studies provide an overestimation of refractive errors and are not representative of the general population.[19–21] In contrast, all school-based studies were included because nearly 85% of the Nepalese children attend school[16] therefore such studies can be considered a true representation of the total children population. Qualitative studies, case reports, and reviews were also excluded. All predatory publications were excluded because of citation issues with these journals.[22] The predatory publications were identified by searching through the 'Beall's list of potential predatory journals publishers'.[23]

The thresholds of refractive errors (Dioptres; D) included in the review were as follows: a cycloplegic spherical equivalent (sphere+ ½ cylinder power) value of ≤ −0.50 D for myopia[24] and ≥ +1.00 D for hypermetropia[25] for children and a non-cycloplegic spherical equivalent refractive error ≤ −0.50 D for myopia and ≥ +0.50 D for hypermetropia for adults.

The prevalence of uncorrected refractive error in adult population was taken directly from the studies as reported. The uncorrected refractive error in children was not determined as most studies lacked such data. For presbyopia, studies reporting uncorrected presbyopia as a binocular presenting near vision of < N8 or <20/40 at 40 cm and improving to ≥ N8 or ≥20/40 with correction were included.[7]

Selection of studies, data extraction and quality assessment

All studies retrieved from different resources were first imported to Covidence,[26] a web-based systematic review management software. Potential articles were screened by two independent reviewers (JB and SM) using inclusion and exclusion criteria. Data extraction was performed by two reviewers (JB & RA) independently and any disagreements were resolved through discussion.

The methodological quality of each included study was assessed using an updated Newcastle-Ottawa Scale modified for cross-sectional studies.[27,28] The Newcastle-Ottawa scale uses a 10-point star system that assesses the study quality against three domains: selection, comparability, and the outcome along with statistical analysis. The studies were categorised as 'very good quality' if they scored 9 or 10 (of 10 points), 'good quality' (score 7–8 points), satisfactory (score 5–6) and unsatisfactory when the score was 0–4 points.[28] The quality assessment was performed by three reviewers (JB, SM & HK) and a consensus was reached.

Outcome measures

The outcome measures were the prevalence of overall and specific types of refractive errors (myopia, hypermetropia and astigmatism), uncorrected refractive error, and presbyopia.

Data synthesis

Data analysis was performed in R statistical software (version 4.1.0, The R Foundation, Vienna, Austria)[29] using the 'metafor' and the 'meta' packages.[30,31] The pooled prevalence of refractive errors was estimated and forest plots generated. The individual raw proportions in our study were small (<0.1); therefore, we used the Freeman-Tukey double arcsine transformation to pool the data.[32] Random-effects model using the DerSimonian and Laird (DL) method was used to estimate the pooled prevalence and 95% confidence intervals (CI).

The presence of heterogeneity was identified through a χ^2 test with Q-statistic and quantified using I^2 statistics. Heterogeneity was categorised as low, moderate, and high for I^2 values of 25%, 50%, and 75%, respectively.[33] A leave-one-out test, subgroup analysis, and metaregression were performed to investigate the potential sources of heterogeneity. Subgroup analysis and metaregression were performed only when the number of studies included was more than ten.[34]

In children, subgroup analyses were conducted using the place of the study (within or outside Kathmandu valley), type of school (private or public) and geographic location of the study (mountain, hill or plain). For metaregression, the outcome variable was the effect size (prevalence of refractive error, uncorrected refractive error or presbyopia) while the independent covariates (moderators) were the place of study (within or outside the Kathmandu valley), type of school (private or public), geographic location of the study (mountain/hills or terai) in children while in adults the moderators were the study year and the study province. The effect of a moderator on the pooled prevalence was conducted through a test of a moderator (QM) and by assessment of the regression coefficient significant at $p < 0.05$. The value of R^2 denoted the amount of true heterogeneity accounted for by the moderator. Publication bias has often been assessed in a meta-analysis by performing Egger's test,[35] Begg's test[36] and by inspection of the Funnel plot asymmetry.[37] However, we did not assess publication bias because the proportion data do not adequately adjusts for these tests and are not recommended for meta-analysis of proportion.[38]

Results

Initial database search yielded 397 citations with 121 duplicates. A further 14 articles from the RAAB repository,[39] three articles from the bibliographic search, and two unpublished (but results disseminated) RAAB survey reports[40,41] were included. There were four articles published between our initial search and completion of the final manuscript. After screening for titles and abstracts, 56 papers were read in full and finally, 38 studies were included in the review. The detailed study selection process is provided in the PRISMA flow diagram '(Figure 1)' and the characteristics of the excluded studies with reasons are provided in 'Table 1'.

Quality (Risk-of-bias) assessment

All included population-based studies were rated as 'very good quality' while the school-based studies were either 'good quality' or 'satisfactory'. The quality rating of each analysed study is provided in the 'Appendix B'. Only two studies[57,61] (of 18 studies) in children were assessed as 'very good quality' evidence (low risk-of-bias). These two studies adopted rigorous sampling procedures to recruit participants. In contrast, all other studies either employed 'non-probability' sampling methods or were conducted in selected group of participants.

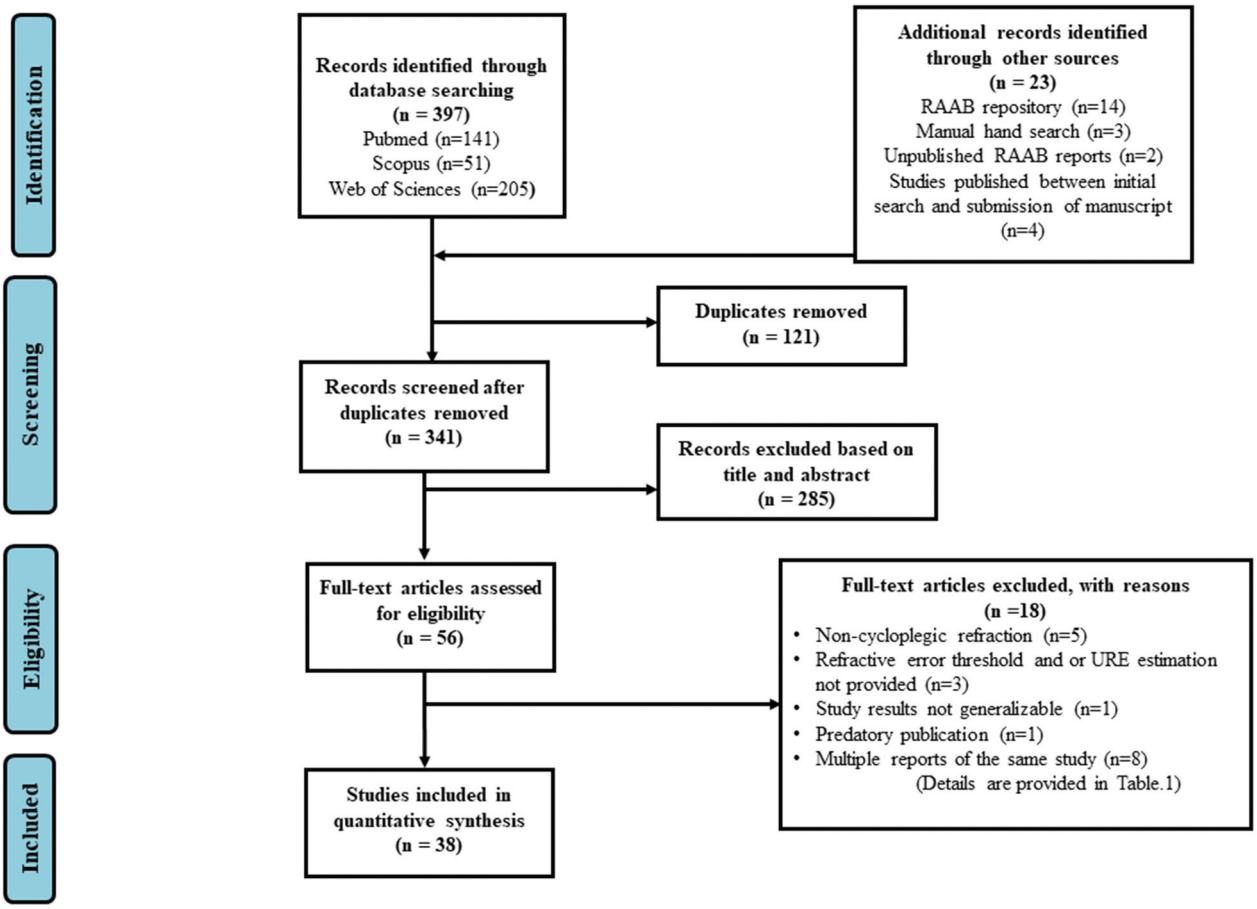

Figure 1. PRISMA flow diagram.

Table 1. Characteristics of excluded studies after reading the full-text.

SN	First author/year	Reason for exclusion
Studies in children excluded after reading the full-text		
1	Chaudhary, NP 2022[42]	Non-cycloplegic refraction
2	Bhandari, KR 2021[43]	Non-cycloplegic refraction
3	(*n*=1)	Predatory publication
4	Sherpa, ATL 2020[44]	Non-cycloplegic refraction
5	Byanju, RN 2019[45]	Refractive error pevalence and/or URE not available
6	Adhikari, S 2014[46]	Refractive error threshold not available
7	Shrestha, RK 2011[47]	Non-cycloplegic refraction
8	Awasthi, S 2010[48]	Non-cycloplegic refraction
Studies in adults excluded after reading the full-text		
1	Thapa, R 2018[49]	Sampling conducted taking into account the prevalence of retinal diseases (not generizable)
2	Brilliant, LB 1985[50]	Refractive error prevalence and/or URE not available
Multiple reporting of a single study		
RAAB Gandaki 2002[39,51]; RAAB Lumbini 2006[39,52]; RAAB Narayani 2006[39,53]; RAAB Karnali 2008[39,54]; RAAB Narayani 2015[39,55]; Adhikari, S 2015[46,56]; Gilbert, CE 2008[57,58]; Sapkota, YD 2012[59,60]		

Characteristics of included studies

In children, seventeen school-based and one population-based study were included. A total of 31,596 children from 117 schools were analysed. The characteristics of the included studies of children are presented in 'Table 2'.

Twenty studies in adults met the inclusion criteria.[39–41,51–55,59,62–64] All of these studies were population-based including 16 Rapid Assessment of Blindness (RAAB) surveys. We did not include the Nepal Blindness survey conducted in 1981[50] because the survey did not report refractive errors. A total of 70,105 adult participants were included. The characteristics of the included studies in adults are presented in 'Table 3'.

Prevalence of refractive errors in children

In children, only eight school-based[61,65–71] and one population-based study[57] met the threshold refractive errors inclusion criteria set in our study. The prevalence of refractive errors in the included studies ranged from 2.6%[57] to 20.9%[61] and the pooled prevalence was 8.4% (95% CI: 4.8 to 12.9). The forest plot for the pooled prevalence of refractive errors in children is shown in 'Figure 2'.

A high heterogeneity ($I^2 = 99\%$, $Q = 1133.5$, $df = 8$, $p < 0.001$) was observed between studies. However, screening for the outlying studies showed that none of the study had potential influence on the pooled prevalence. Subgroup analysis and meta-regression were not performed because of the small number of studies.

Myopia was reported in 15,[61,66–80] hypermetropia in seven[57,61,66–69] and astigmatism in ten studies.[57,61,66–70,72,73,76] The pooled prevalences for myopia, hypermetropia and astigmatism from these studies were 7.1% (95% CI: 3.7 to 11.4), 1.0% (95% CI: 0.7 to 1.3) and 2.2% (95% CI: 0.9 to 3.9) respectively. In individual studies, the prevalence of myopia ranged from 0.6%[72] to 27.1%,[75] hypermetropia from 0.3%[68] to 1.4%[67] and astigmatism from 0.6%[75] to 9.0%.[76] A high heterogeneity was observed between studies in all three analyses while the investigation of outlying studies showed no significant influence of individual studies on the pooled prevalence. A forest plot of the pooled prevalence of myopia in children is presented in 'Figure 3'.

Meta-regression analysis for myopia prevalence showed that the place of study (within or outside the Kathmandu valley) accounted for 29.6% of between-study heterogeneity with a statistically significant moderating effect [QM (df = 1) = 6.68; p = 0.009 & regression coefficient −0.16]. The type of school (private versus public) also showed a statistically significant effect on the pooled prevalence [QM (df = 3) 12.28, p < 0.015 & regression coefficient of 0.19] and accounted for 38.2% of true heterogeneity. The geographic location of the study (mountain/hills versus the plains) [QM (df = 1) 1.72; p = 0.189 & regression coefficient −0.11] and study year [QM (df = 1) 0.22; p = 0.638 & regression coefficient 0.003] had no statistically significant moderating influence, and these two moderators also did not account for the between-study heterogeneity.

A further subgroup analysis showed a significantly higher prevalence of myopia in children living in Kathmandu valley (12.0%; CI 6.3 to 19.3) as compared to those outside the valley (3.8%; CI 1.7 to 6.7) (p < 0.0001). Similarly, a significantly higher prevalence of myopia in private-school children (13.7%; CI 8.5 to 20.0) than the public-school children (5.2%; 2.5 to 8.8) was observed (p < 0.0001).

Prevalence in adults: refractive errors, uncorrected refractive errors, and uncorrected presbyopia

Information on overall refractive errors prevalence in adults was available in 13 studies,[39–41,54,55] uncorrected refractive errors in 20 studies[39–64] and uncorrected presbyopia in four studies.[39–41,59]

The pooled prevalence of refractive errors in adults was 11.2% (95% CI: 8.0 to 14.9) with prevalence ranging from 5.3%[54] to 24.2%[40] in individual studies '(Figure 4)'. High heterogeneity was observed between studies; however, there was no influence of individual studies on the pooled prevalence. A leave-one-out analysis did not show a significant change in the pooled prevalence.

The prevalence of uncorrected refractive errors in individual studies ranged from 2.5%[39] to 21.3%[53] and the pooled prevalence was estimated at 7.3% (95% CI: 5.4–9.5) '(Figure 5)'. Screening for the outliers showed no influence of individual studies on the pooled prevalence.

Meta-regression suggested that both the study year [QM (df = 1) = 0.07; regression coefficient −0.001; p = 0.784] and the study province [QM (df = 1) = 0.29; regression coefficient −0.006; p = 0.590] had no statistically significant influence on the pooled prevalence and also these moderators did not account for any observed true heterogeneity.,

Uncorrected presbyopia in the four included studies ranged from 66.1%[39] to 87.5%[40] and the pooled prevalence was 78.9% (95% CI: 69.1 to 87.3) '(Figure 6)'. Removing an outlying study[39] with potential influence, the resultant pooled prevalence was 82.7% (95% CI: 75.2 to 89.1).

Discussion

This is the first systematic review and meta-analysis that estimated the pooled prevalences of refractive errors, uncorrected refractive errors, and uncorrected presbyopia in Nepalese population. The prevalence of refractive errors in children and adults was estimated separately because of the methodological differences in measuring and/or estimating refractive errors between the two groups. The pooled refractive errors prevalence of 8.4% in children and 11.2% in adult population and a high uncorrected refractive error (nearly 65%) suggests a need for better planning and provision of quality refractive error services in the country. Similarly, the inconsistent refractive errors reporting across studies, as evident from the variations in the methodology, procedures and refractive errors criteria across the studies, suggest the need for uniform protocol for future studies to be endorsed by the eye health institutions and organisations.

The prevalence of refractive errors (8.4%) estimated in children in the present study is consistent with that reported in South-East Asian neighbouring countries. For example, the results from a recent systematic review in Indian children reported a prevalence of 8.0% refractive errors.[81] Similarly, a recent nationwide school survey in Bhutan found a similar prevalence of overall refractive errors in 8.1%.[82] Therefore, it can be stated that the estimated refractive errors prevalence in Nepalese children is similar to that in the South Asian region while it is in the lower range of the global estimate.[6,83,84]

The prevalence of myopia was found to be higher in children living in Kathmandu valley, the capital city of Nepal (P < 0.0009), and those studying in private schools (P <

Table 2. Characteristics of included studies of children.

SN	First author /publish year	Study year	Place of study	No. of schools included	Geographic location (mountain/ hill/plains)	Type of school (public/ private)	Refractive error cut-off for myopia	Refractive error cut-off for hyperopia	Refractive error cut-off for astigmatism	Instrument used for refraction	Age range (years)	Sample size	No. of participants included for analysis	No. of males	No. of females	Refractive errors no. (%)	Myopia (%)	Hyperopia (%)	Astigmatism (%)
1	Garner, LF 1995[66]	1992	Kathmandu	3	Hill	Private	≤-0.50	NA	NA	Retinoscopy	6-16	404	404	212	192	NA	3.9	NA	NA
2	Garner, LF 1999[67]	1998	Kathmandu	1	Hill	Private	≤-0.50	NA	NA	Autorefractor	7-18	555	555	273	282	NA	21.7	NA	NA
3	Pokharel, GP 2000[42]	1998	Jhapa	NA	Plains	Population-based	≤-0.50	≥+2.00	≥0.75	Autorefractor	5-15	5526	(5067) 4974	2622	2445	129 (2.6)	1.2	1.4	2.3
4	Nepal, BP 2003[58]	2003	Kathmandu valley	3	Hill	Public	<-0.50	>+1.00	>0.50	Retinoscopy	5-16	1100	1100	505	595	89 (8.1)	4.3	1.3	2.5
5	Shrestha, RK 2006[65]	2005	Kathmandu	2	Hill	Private	<-0.50	>+0.75	>0.50	Retinoscopy	5-16	1816	1816	959	857	395 (21.8)	10.1	2.8	9.0
6	Sapkota, YD 2008[43]	2006	Kathmandu	43	Hill	Private	≤-0.50	≥+2.00	≥0.75	Autorefractor	9-16	4501	4282	2278	2004	894 (20.9)	19.0	0.7	7.4
7	Niroula, DR 2009[62]	2006	Pokhara	6	Hill	Both	≤-0.50	≥+0.50	≥0.50	Retinoscopy	10-19	1000	964	474	490	62 (6.4)	4.1	1.2	1.1
8	Pokharel, A 2010[63]	NA	Sunsari	2	Plains	Public	<-0.50	≥+0.50	≥0.25	Retinoscopy	7-15	440	440	208	232	87 (19.8)	11.8	6.1	1.8
9	Marasini, S 2010[55]	2010	Kavre	8	Hill	Public	≤-0.50	≥+1.00	≥1.00	Retinoscopy	3-22	1802	1802	843	959	53 (2.9)	2.2	0.7	0.8
10	Sherpa, D 2011[61]	2007	Dhulikhel, Kavre	5	Hill	Public	<-0.50	>+0.75	>0.50	Retinoscopy	0-15	466	466	223	243	11 (2.4)	0.6	0.8	0.6
11	Shrestha, GS 2011[54]	2009	Jhapa	3	Plains	Public	≤-0.50	≥+1.00	≥0.75	Retinoscopy	5-16	1150	1150	596	554	80 (6.9)	NA	NA	NA
12	Adhikari, S 2013[64]	NA	Kathmandu	1	Mountain	Private	≤-0.50	NA	NA	Retinoscopy	4-18	140	140	85	55	NA	27.1	NA	NA
13	Adhikari, S 2013[56]	2003	Kathmandu valley	4	Hill	Public	<-0.50	>+1.00	>0.50	Retinoscopy	5-16	2054	2000	1127	873	172 (8.6)	6.9	1.4	0.7
14	Rai, SK 2015[68]	2011	Rupandehi	15	Plain	Both	≤-0.50	≥+0.50	≥0.25	Retinoscopy	5-15	5428	5428	2969	2459	128 (2.4%)	0.6	0.5	1.1
15	Shrestha, RK 2017[69]	2013	Kathmandu	5	Hill	Public	≤-0.50	≥+0.50	≥0.75	Retinoscopy	5-16	2412	2412	1114	1298	241 (10.0)	7.5	2.5	NA
16	Awasthi, S 2020[57]	2009	Dadeldhura	2	Hill	Public	≤-0.50	≥+2.00	NA	Retinoscopy	12-16	700	590	280	310	25 (4.2)	3.6	0.3	1.0
17	Gurung, J 2021[59]	2021	Pokhara	3	Hills	Private	≤-0.50	≥+2.00	≥0.50	Retinoscopy	5-16	1034	1034	564	470	107 (10.4)	8.0	1.1	1.3
18[1]	Shrestha, A 2021[60]	2021	Kavre	9	Hill	Public	<-0.50	≥+1.00	≥0.50	Retinoscopy	5-19	953	953	465	487	183 (19.2)	NA	NA	NA

1. Analysis for refractive errors was performed in 4974 of 5067 children examined.
2. NA = not available.

Table 3. Characteristics of included studies of the adult population.

SN	First author /publish year	Study year	Place of study	Nature of study	Province no.	Study Design	Age range	Sample size	No. of participants included for analysis	No. of males	No. of females	Refractive errors no. (%)	Uncorrected refractive errors no. (%)	Uncorrected presbyopia (%) <20/40
1	He, M 2012[47]; Sapkota, YD 2012[90]	NA	Kaski	Population	4	Cross-sectional	≥35	2360	2156	814	1342	NA	NA	84.3
2	Pokharel, GP 1998[44]	NA	Lumbini & Bheri zones	Population	5	Cross-sectional	≥45	5112	4602	2253	2349	NA	460 (10.0)	NA
3	Thapa, SS 2011[45]	NA	Bhaktapur	Population	3	Cross-sectional	≥40	4800	3979	1811	2168	NA	564 (14.2)	NA
4	Sapkota,YD 2006[46]; RAAB Gandaki 2002[39]	2002	Kaski, Lamjung, Syngja	Population	4	Cross-sectional	≥45	5863	5002	2242	2760	NA	400 (8.0)	NA
5	Sherchan, A 2010[48]; RAAB Lumbini 2006[39]	2006	Chitwan district	Population	3	Cross-sectional	≥50	5916	5138	2437	2701	NA	807 (13.8)	NA
6	Sapkota, YD 2010[50]; RAAB Narayani 2006[39]	2006	Rautahat district	Population	2	Cross-sectional	≥50	5533	4717	2158	2559	NA	1005 (21.3)	NA
7	RAAB Bagmati 2008[39]	2008	Bagmati	Population	3	Cross-sectional	≥50	2050	1908	866	1042	233 (12.2)	48 (2.5)	NA
8	RAAB Janakpur 2008[39]	2008	Janakpur	Population	2	Cross-sectional	≥50	1800	1705	785	920	230 (13.5)	164 (9.6)	NA
9	Dulal, S 2012[52]; RAAB Karnali 2008[39]	2008	Karnali zone	Population	6	Cross-sectional	≥50	1197	1171	646	525	62 (5.3)	48 (4.1)	NA
10	RAAB Seti & Mahakali 2008[39]	2008	Seti & Mahakali	Population	7	Cross-sectional	≥50	2751	2513	1169	1344	226 (9.0)	123 (4.9)	NA
11	RAAB Bheri 2009[39]	2009	Bheri	Population	5	Cross-sectional	≥50	3049	2993	1459	1534	233 (7.8)	123 (4.1)	NA
12	RAAB Koshi 2009[39]	2009	Koshi	Population	1	Cross-sectional	≥50	3050	2895	1344	1551	518 (17.9)	217 (7.5)	NA
13	RAAB Mechi 2009[39]	2009	Mechi	Population	1	Cross-sectional	≥50	3050	3041	1573	1468	271 (8.9)	146 (4.8)	NA
14	RAAB Sagarmatha 2009[39]	2009	Sagarmatha	Population	1 & 2	Cross-sectional	≥50	3050	2914	1372	1542	181 (6.2)	82 (2.8)	NA
15	RAAB Daulagiri 2010[39]	2010	Dhaulagiri	Population	4	Cross-sectional	≥50	3000	2990	1388	1602	173 (5.8)	102 (3.4)	NA
16	RAAB Rapti 2010[39]	2010	Rapti	Population	5	Cross-sectional	≥50	2998	2921	1386	1535	193 (6.6)	143 (4.9)	NA
17	Pradhan, S 2018[49]; RAAB Narayani 2015[39]	2015	Narayani zone	Population	2 & 3	Cross-sectional	≥50	5000	4771	2270	2501	964 (20.2)	472 (9.9)	87.5
18	RAAB Bagmati 2019[40]	2019	Bagmati	Population	3	Cross-sectional	≥50	5740	5472	2307	3165	1324 (24.2)	388 (7.1)	75.4
19	RAAB Karnali 2020[41]	2020	Karnali	Population	6	Cross-sectional	≥50	4067	3983	1869	2114	625 (15.7)	446 (11.2)	87.1
20	Shrestha MK 2021[51]	2011	Dolakha, Dhading, Sarlahi	Population	2 & 3	Cross-sectional	≥15	5428	5234	NA	NA	NA	214 (4.1)	NA

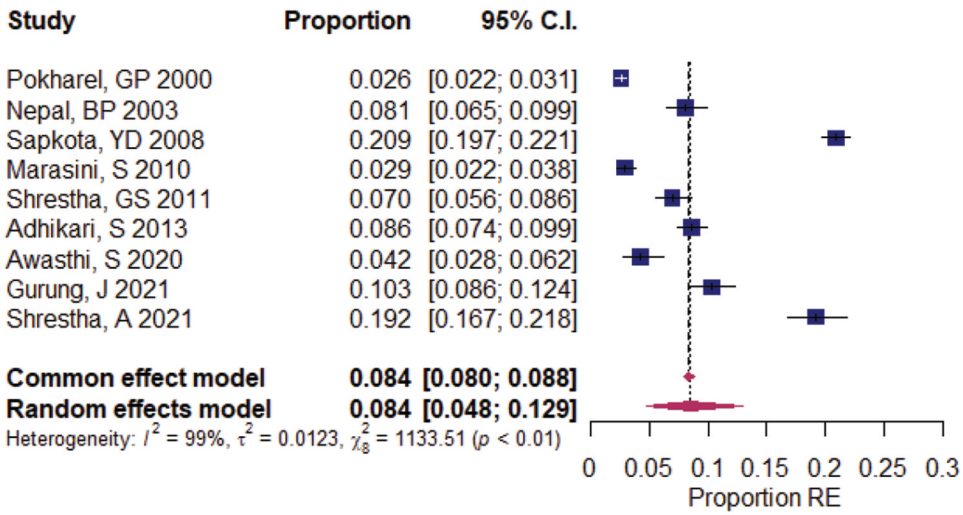

Figure 2. Pooled prevalence of refractive errors in children.

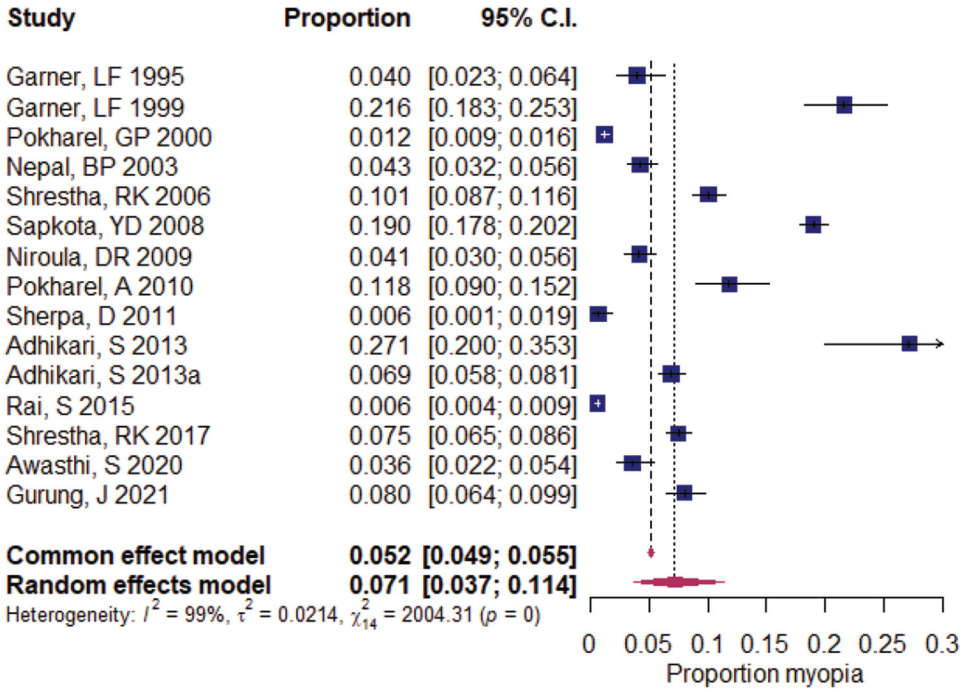

Figure 3. Pooled prevalence of myopia in children.

0.0001). The higher prevalence of myopia in these two groups resonates with the previously reported risk factors for myopia i.e., increased urbanisation, less green space in the cities, and increased educational burden leading to spending more time indoors and increased near work in children studying in private schools.[85]

The pooled prevalence of refractive errors (11.2%) in adult population in present study is relatively low compared to prevalence reported from the studies in South East Asia region.[86] The RAAB surveys conducted prior 2010 in Nepal show a relatively lower prevalence of refractive errors compared to those conducted after 2010. For example, the 2008 RAAB survey conducted in the Karnali zone of the country estimated a prevalence of 5.8% while a more recent 2020 RAAB survey in the same region showed a higher prevalence (15.7%). Similarly, the RAAB surveys conducted in Narayani and Bagmati zones in 2015 and 2019 showed 20.2% and 24.2% prevalence rates, respectively, which are higher than our pooled prevalences or RAAB surveys conducted before 2010. It therefore appears that there may be a temporal increase in refractive error prevalence in Nepalese adults. Further study assessing the temporal trends in the prevalence of refractive errors may provide more accurate estimates.

Nearly two-thirds of the refractive errors (7.3 of 11.2%) in the Nepalese adult population remained uncorrected. The uncorrected refractive error estimation in this study is almost similar to that of the Indian population (10.2% CI 6.9 to 14.8)[87] but considerably higher than that of high-income countries, which report a prevalence of only 3.03%.[88]

This review identified four studies reporting uncorrected presbyopia. The pooled prevalence of uncorrected presbyopia (79.7%) obtained in the current meta-analysis is remarkably higher than the global estimate of 45%[3] and the Indian estimate of 33%.[87] Although there were limited numbers of studies reporting uncorrected presbyopia that were included in the present review, the better design and quality

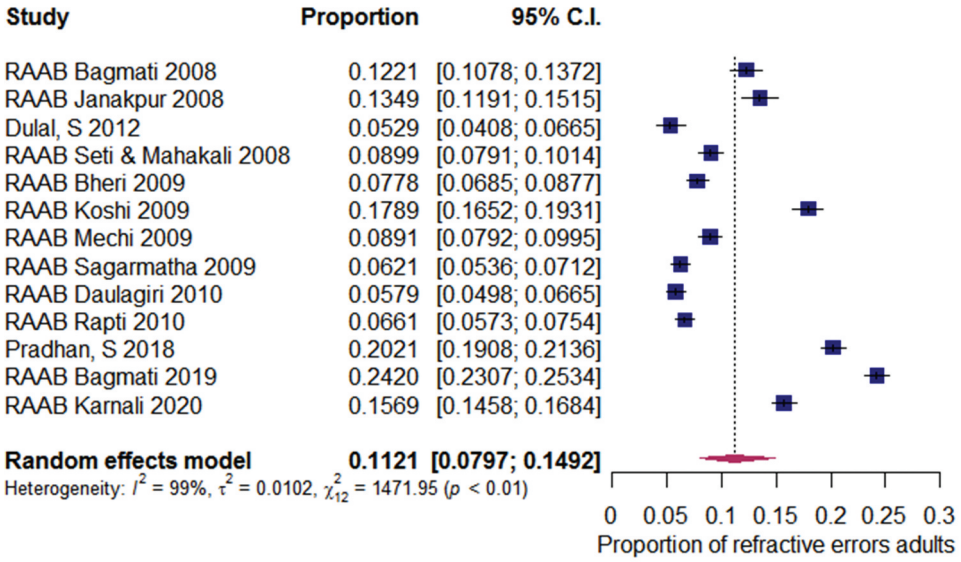

Figure 4. Pooled prevalence of refractive errors in adults.

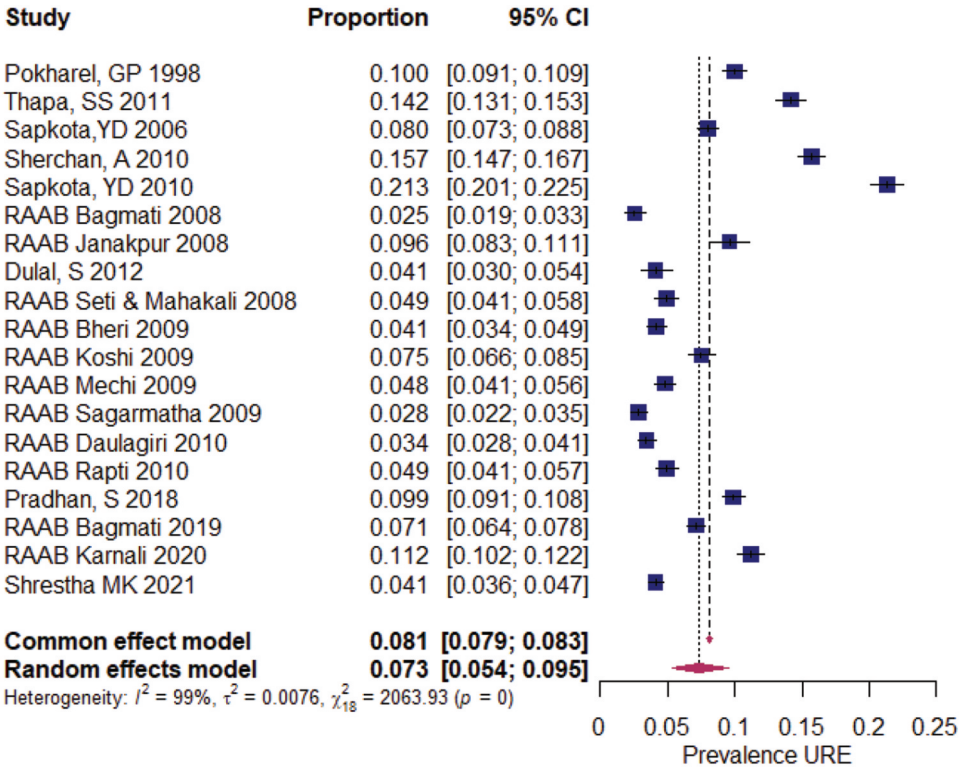

Figure 5. Pooled prevalence of uncorrected refractive errors in adults.

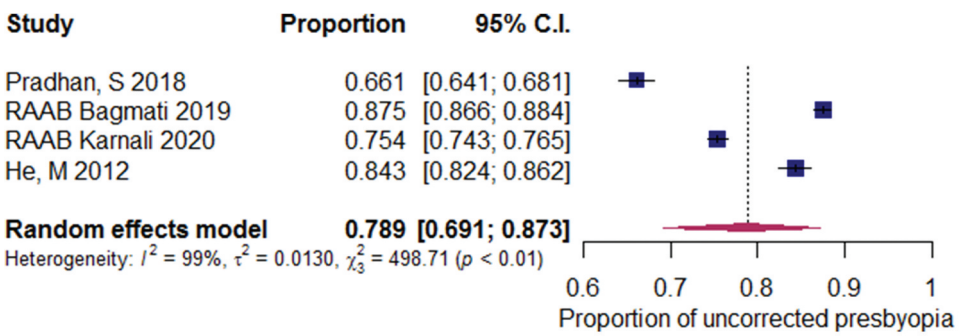

Figure 6. Pooled prevalence of uncorrected presbyopia in adults.

of the included studies provide robust evidence of a huge burden of uncorrected presbyopia in the Nepalese population. Further studies representing different populations and regions of Nepal, under a uniform study protocol, are warranted to fully understand the magnitude of uncorrected presbyopia.

Nepal has made a remarkable progress in reducing cataract-related blindness over the last few decades. Since the first national blindness survey in 1981,[50] the prevalence of blindness has reduced from 0.84% in 1981[50] to 0.35% in 2012.[89] However, the considerable burden of uncorrected refractive error and presbyopia evident from this meta-analysis indicates a need for better access to refractive error services in the country. A better understanding of the potential barriers in refractive error service may be the foremost step to be adapted in solving the persistent issues of uncorrected refractive error. This should be followed by an appropriate planning of a better access and coverage of the service.

There are a few limitations in this review. First, a high heterogeneity was noted in estimating the prevalence of refractive errors in both adults and children. A great caution was employed in selection of the studies in order to reduce the heterogeneity. For example, the refractive errors were estimated separately for adults and children. Similarly, studies adopting uniform refractive errors threshold criteria and cycloplegic refraction (in children) were included. Therefore, we assume that heterogeneity, particularly in adults, may have resulted from the true variation in the prevalence of refractive errors in different geographical locations at different point in time and also because of the diversity in ethnicity. However, in children, because of few good-quality studies, both methodological and clinical factors may have accounted for the heterogeneity. In addition, this variation may have also been present because of poor access and the inequitable distribution of eye care services in the country.[90] Despite heterogeneity, we have interpreted the results conservatively because heterogeneity in meta-analysis of proportion is of lesser concern as opposed to meta-analysis of randomised controlled trials and therefore does not necessarily mean the inconsistency of the data.[38]

Second, we were unable to include all identified school-based studies in children because of a non-uniform refractive error threshold criteria used. It is recommended that future studies adopt a common refractive errors threshold (such as those used by Refractive Error Studies in Children; RESC studies[57] for the ease of comparison between studies. Nevertheless, the result of this review offers an aggregate prevalence data of refractive errors and uncorrected refractive errors which may be used as a baseline for future epidemiological studies and also for better planning of refractive error services.

Conclusion

This review estimated a pooled prevalence of refractive errors of 8.4% in children and 11.2% in adults. The pooled prevalence of myopia in children was 7.1%. Extrapolating the refractive errors figures to the current population of the country, about 981 000 children of 4–19 years of age and over 520 000 adults aged 50 and above in Nepal would need regular refractive error services. The population of myopic children of school age category in the country is 829 000.

The review also identified a paucity of quality evidence on the prevalence of refractive errors in Nepalese children. Only two 'good quality' studies with robust sampling methodology were identified indicating a pressing need for well-designed population-based studies to accurately estimate the prevalence of refractive errors in Nepalese children.

Disclosure statement

One of the included studies was authored by a co-author (SM) of this review.

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Appendix

Appendix A. Detailed search strategy

Search Strategy
Key concepts
Concept 1: Prevalence
Key terms used:prevalence, burden, magnitude, epidemiology, morbidity
Concept 2: Refractive errors
Key terms used:refractive error, vision, visual impairment, blindness, myopia, hypermetropia, hyperopia, astigmatism, presbyopia
Concept 3: Population
Key term used: Nepal

PubMed (141)

#1 ((((prevalence[Title/Abstract]) OR (burden[Title/Abstract])) OR (magnitude[Title/Abstract])) OR (epidemiology[Title/Abstract])) OR (morbidity[Title/Abstract])	1,612,746 results
#2 (((((((refractive error*[Title/Abstract]) OR (vision[Title/Abstract])) OR (visual impairment[Title/Abstract])) OR (blindness[Title/Abstract])) OR (myopi*[Title/Abstract])) OR (hypermetropi*[Title/Abstract])) OR (hyperopi*[Title/Abstract])) OR (astigmati*[Title/Abstract])) OR (presbyopi*[Title/Abstract])	190,854 results
#3 Nepal*[Title/Abstract]	11846 results
((#1) AND (#2)) AND (#3)	141 results

Search yield: 141
Search date: 6 May 2021

Scopus (51)

TITLE-ABS-KEY ((prevalence OR burden OR magnitude OR epidemiology OR morbidity) AND ("refractive AND error*" OR vision OR "visual AND impairment" OR blindness OR myopi* OR hypermetropi* OR hyperopi* OR astigmati* OR presbyopi*) AND (nepal*))

Search yield: 51
Search date: 8 May 2021

Web of Science (Core collection)
(prevalence OR burden OR magnitude OR epidemiology OR morbidity) AND ("refractive error*" OR vision OR "visual impairment" OR blindness OR myopi* OR hypermetropi* OR hyperopi* OR astigmati* OR presbyopi*) AND (Nepal*)

Search yield: 205
Search date: 8 May 2021
(Note: searched for: title, abstract, keywords)

Appendix B. Quality assessment results using the New-Castle Ottawa (NOS) scale[temp]

		Selection				Comparability	Outcome		
#	Study (first author/year)	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of exposure	Based on design and analysis	Assessment of outcome	statistical test	Total Score (stars)
1	Nepal, BP 2003[58]	c	b	a*	a**	a**	a**	b	7
2	Adhikari, S 2013[56]	c	b	a*	a**	a**	a**	a*	8
3	Awasthi, S 2020[57]	c	b	a*	a**	a**	a**	a*	8
4	Garner, LF 1995[66]	c	b	c	a**	a**	a**	a*	7
5	Garner, LF 1999[67]	c	b	c	a**	a**	a**	a*	7
6	Rai, SK 2015[68]	c	b	c	a**	a**	a**	a*	8
7	Marasini, S 2010[55]	c	b	c	a**	a**	a**	a*	7
8	Shrestha, RK 2006[65]	c	b	c	a**	a**	a**	b	6
9	Sherpa, D 2011[61]	c	b	c	a**	a**	a**	b	6
10	Adhikari, S 2013[64]	c	b	c	a**	a**	a**	b	6
11	Sapkota, YD 2008[43]	a*	a*	a*	a**	a**	a**	a*	10
12	Niroula, DR 2009[62]	c	b	a*	a**	a**	a**	a*	8
13	Pokharel, A 2010[63]	c	b	c	a**	a**	a**	a*	7
14	Shrestha, RK 2017[69]	c	b	a*	a**	a**	a**	a*	8
15	Shrestha, GS 2011[54]	c	b	c	a**	a**	a**	a*	7
16	Gurung, J 2021[59]	c	b	c	a**	a**	a **	a*	7
17	Shrestha, A 2021[60]	c	b	c	a**	a**	a **	a*	7
18	Pokharel, GP 2000[42]	a*	a*	a*	a**	a**	a**	a*	10
quality assessment of studies in adults									
19	He, M 2012[47]	a*	a*	a*	a**	a**	a**	a*	10
20	Pokharel, GP 1998[44]	a*	a*	a*	a**	a**	a**	a*	10
21	Thapa, SS 2011[45]	a*	a*	a*	a**	a**	a**	a*	10
22	Sapkota,YD 2006[46]; RAAB Gandaki 2002[39]	a*	a*	a*	a**	a**	a**	a*	10
23	Shrestha MK 2021[51]	a*	a*	a*	b*	a**	a**	a*	9
24	Pradhan, S 2018[49]; RAAB Narayani 2015[39]	a*	a*	a*	b*	a**	a**	a*	9
25	Sherchan, A 2010[48]; RAAB Lumbini 2006[39]	a*	a*	a*	a**	a**	a**	a*	10
26	Sapkota, YD 2010[50]; RAAB Narayani 2006[39]	a*	a*	a*	a**	a**	a**	a*	10
27	Dulal, S 2012[52]; RAAB Karnali 2008[39]	a*	a*	a*	b*	a**	a**	a*	9
28	RAAB Bagmati 2008[39]	a*	a*	a*	b*	a**	a**	a*	9
29	RAAB Janakpur 2008[39]	a*	a*	a*	b*	a**	a**	a*	9
30	RAAB Seti & Mahakali 2008[39]	a*	a*	a*	b*	a**	a**	a*	9
31	RAAB Bheri 2009[39]	a*	a*	a*	b*	a**	a**	a*	9
32	RAAB Koshi 2009[39]	a*	a*	a*	b*	a**	a**	a*	9
33	RAAB Mechi 2009[39]	a*	a*	a*	b*	a**	a**	a*	9
34	RAAB Sagarmatha 2009[39]	a*	a*	a*	b*	a**	a**	a*	9
35	RAAB Daulagiri 2010[39]	a*	a*	a*	b*	a**	a**	a*	9
36	RAAB Rapti 2010[39]	a*	a*	a*	b*	a**	a**	a*	9
37	RAAB Bagmati 2019[40]	a*	a*	a*	b*	a**	a**	a*	9
38	RAAB Karnali 2020[41]	a*	a*	a*	b*	a**	a**	a*	9

Newcastle - Ottawa Quality Assessment Scale

(adapted version for cross sectional studies) [28]

Selection: (Maximum 5 stars)

1) Representativeness of the sample:

(a) Truly representative of the average in the target population. * (all subjects or random sampling)
(b) Somewhat representative of the average in the target population. * (non-random sampling)
(c) Selected group of users.
(d) No description of the sampling strategy.

2) Sample size:

(a) Justified and satisfactory. *
(b) Not justified.

3) Non-respondents:

(a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. *
(b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.
(c) No description of the response rate or the characteristics of the responders and the non-responders.

4) Ascertainment of the exposure (risk factor):

(a) Validated measurement tool. **
(b) Non-validated measurement tool, but the tool is available or described.*
(c) No description of the measurement tool.

Comparability: (Maximum 2 stars)

1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.

(a) The study controls for the most important factor (select one). *
(b) The study control for any additional factor. *

Outcome: (Maximum 3 stars)

1) Assessment of the outcome:

(a) Independent blind assessment. **
(b) Record linkage. **
(c) Self report. *
(d) No description.

2) Statistical test:

(a) The statistical test used to analyse the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (*p* value). *
(b) The statistical test is not appropriate, not described or incomplete.

Scoring:

Very Good Studies: 9-10 points

Good Studies: 7-8 points

Satisfactory Studies: 5-6 points

Unsatisfactory Studies: 0 to 4 points

This scale is an adapted version of the Newcastle-Ottawa Quality Assessment Scale to assess the quality of cross-sectional studies. (Modesti PA, Reboldi G, Cappuccio FP, et al. Panethnic differences in blood pressure in Europe: A systematic review and meta-analysis. *PLoS One*. 2016;11(1). doi:10.1371/journal.pone.0147601)