Effective refractive error coverage in adults aged 50 years and older: estimates from population-based surveys in 61 countries

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Summary

Background **In 2021, WHO Member States endorsed a global target of a 40-percentage-point increase in effective refractive error coverage (eREC; with a 6/12 visual acuity threshold) by 2030. This study models global and regional estimates of eREC as a baseline for the WHO initiative.**

Methods **The Vision Loss Expert Group analysed data from 565 448 participants of 169 population-based eye surveys conducted since 2000 to calculate eREC (met need/[met need + undermet need + unmet need]). A binary logistic regression model was used to estimate eREC by Global Burden of Disease (GBD) Study super region among adults aged 50 years and older.**

Findings **In 2021, distance eREC was 79·1% (95% CI 72·4–85·0) in the high-income super region; 62·1% (54·7–68·8) in north Africa and Middle East; 49·5% (45·0–54·0) in central Europe, eastern Europe, and central Asia; 40·0% (31·7–48·2) in southeast Asia, east Asia, and Oceania; 34·5% (29·4–40·0) in Latin America and the Caribbean; 9·0% (6·5–12·0) in south Asia; and 5·7% (3·1–9·0) in sub-Saharan Africa. eREC was higher in men and reduced with increasing age. Global distance eREC increased from 2000 to 2021 by 19·0%. Global near vision eREC for 2021 was 20·5% (95% CI 17·8–24·4).**

Interpretation **Over the past 20 years, distance eREC has increased in each super region yet the WHO target will require substantial improvements in quantity and quality of refractive services in particular for near vision impairment.**

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Introduction

In 2020, uncorrected refractive error was the leading cause of moderate or severe vision impairment worldwide. Uncorrected refractive error accounted for 157 million of the 295 million people estimated to have moderate or severe vision impairment (presenting visual acuity [PVA] of <6/18 to 3/60 in the better eye). This was followed by cataract (83·5 million).[1] Moreover, uncorrected refractive error was the second most common cause of blindness (PVA <3/60 in the better eye), affecting 3·7 million of the 43·3 million people who are blind globally. These estimates were prepared by the Vision Loss Expert Group (VLEG), the international ophthalmic epidemiology reference group, and the Global Burden of Disease Study (GBD).

A further 257·8 million (3·3% of the global population) have mild vision impairment (PVA of <6/12 to 6/18 in the better eye) and globally an estimated 509·7 million people have near vision impairment from uncorrected or undercorrected presbyopia, representing 22·1% of people aged 50 years and older.[2] There is an epidemic of both myopia and high myopia in east and southeast Asia that might foreshadow an increase in vision loss due to pathological myopia,[3] while ageing populations are resulting in a substantial growth in presbyopia.[2]

In November, 2020, the resolution titled *Integrated people-centred eye care, including preventable vision impairment and blindness* was adopted by Member States at the 73rd World Health Assembly.[4] This resolution requested that WHO, in consultation with Member States, prepare recommendations on global targets for 2030 focusing on two metrics: effective refractive error coverage (eREC) and effective cataract surgical coverage (eCSC). Ambitious global targets for these two indicators (a 40-percentage-point and a 30-percentage-point increase, respectively) were endorsed by WHO

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For the **Global Vision Database** see https://www.globalvisiondata.org/

Research in context

Evidence before this study

Various approaches to measuring refractive error coverage (REC) have been used in the past, initially measuring whether vision-impairing refractive error has been corrected, regardless of whether a good (6/12 or better) outcome is achieved. In 2019, the concept of effective refractive error coverage (eREC) was introduced, defined as the proportion of people in need of refractive error services who have received services and have a good-quality outcome. In 2021, a limited analysis of four population-based samples from China, Nepal, South Africa, and the USA revealed that the use of presenting visual acuity to determine the met need leads to an overestimation of the true eREC value (best determined by involving measures of uncorrected visual acuity). We requested participant-level data from investigators of population-based studies of vision impairment and blindness conducted from the year 2000 onwards with summative data in the Global Vision Database (curated by the Vision Loss Expert Group, an international ophthalmic epidemiology reference group). Studies are regularly added to this database (Jan 1, 1980–Sept 9, 2020) following systematic review of Embase, SciELO, MEDLINE, WHOLIS, and Open Grey, and grey literature sources, and require studies to measure visual acuity with a vision chart that can be mapped to the Snellen scale and a sample representative of the population.

Added value of this study

This study has used population-based studies to establish estimates of eREC among adults aged 50 years and older. Per-participant data have been collated from 169 studies from all regions of the world, which permits more precise measurements by country, sex, and year. This analysis revealed gender inequity in eREC that varies between global regions and the fact that eREC declines with age. The study has revealed an increase in distance eREC from 2000 to 2021 in all super regions. The extent of the quality gap (the relative gap between REC and eREC) in refractive error services is often underestimated—in this analysis we have quantified this across many study populations.

Implications of all the available evidence

The greatest burden of vision impairment and blindness occurs among adults aged 50 years and older. Among those needing glasses to see with 6/12 vision or greater in this age group worldwide, the eREC was 42·9% for distance vision and 20·5% for near vision in 2021. Since 2000, distance eREC has increased by 19%. Considerable variation in eREC by super region exists with the lowest levels in sub-Saharan Africa, and the highest levels in the high-income super region, where eREC was still less than ideal. Women and older people have a greater unmet need. These inequities show that a renewed effort is needed to achieve the WHO target for this indicator.

Member States at the 74th World Health Assembly in 2021. These indicators not only capture the extent of coverage of corrective services, but also the concept of effective coverage, to ensure that people who need health services receive them with sufficient quality to produce the expected health outcome.[5,6]

In July 2021, the first UN General Assembly resolution on vision was adopted by Member States in recognition of the growing evidence that improving eye health and preventing vision impairment can directly contribute to the achievement of many other Sustainable Development Goals (SDGs) to reduce poverty and improve work productivity, education, and equity.[7,8] This resolution requests that the Inter-Agency Expert Group on SDG Indicators review and consider eREC and eCSC in the global indicator framework for the SDGs at the 56th session of the UN Statistical Commission to be held in 2025.

The rationale for the selection of these indicators, their recommended calculation methods, and other key considerations for measuring and reporting within population-based surveys were described by Keel and colleagues in 2021.[6] eREC is defined as the proportion of people in need of refractive error services who have received services (spectacles, contact lenses, or refractive surgery) and have a good outcome. Given the well established impact of near vision impairment on quality of life and productivity,[9–11] spectacle coverage for both distance vision impairment due to refractive error and near vision impairment due to presbyopia are considered in the global monitoring of eREC. In addition to the global target, the 74th World Health Assembly also recommended that countries with a baseline eREC of 60% or higher should strive for universal coverage.[12]

This paper provides the most comprehensive estimates of eREC to date from population-based surveys of eye disease known to the Global Vision Database (maintained by VLEG)—a continually updated repository of data for 5-yearly reports of vision loss prevalence in 2010,[13,14] 2015[15–17] and 2020.[1,2] Global, regional, and country-level eREC estimates and temporal trends are also investigated.

Methods

Data sources

The VLEG systematically reviewed scientific literature for population-based studies of vision impairment and blindness published between 1980 and 2020 by commissioning the York Health Economics Consortium, UK, to search Embase, SciELO, MEDLINE, WHOLIS, and Open Grey, and additional grey literature sources. After title and abstract screening, this process involved the sending of abstracts to regional committees of VLEG members to assess quality and make final inclusion decisions on whether to admit data to VLEG's Global Vision Database. To meet inclusion criteria, visual acuity data had to be measured using a vision chart that could be mapped to the Snellen scale and the sample had to be representative of the population. 528 data sources are currently included in the Global Vision Database, 243 (46%) of which are Rapid Assessment of Avoidable Blindness (RAAB) studies, which sample individuals aged 50 years and older in predominantly low-income and middle-income settings. The remaining 285 are comprehensive (non-RAAB) studies. A detailed summary of the data identification process for this database has been published previously.[2] The majority of the data are blindness and vision impairment prevalences summarised into age-specific and sex-specific categories, rather than data disaggregated to the level of the participant.

Eligible RAAB surveys were identified from the RAAB repository; any version of the RAAB survey conducted since 2000 (ie, RACSS, RAAB4.02, RAAB4.03, RAAB5, RAAB6, RAAB7) with a complete dataset available (ie, individual participant survey data and census population data showing age-sex group counts for people aged ≥50 years in the sampling area) and permission from the study's principal investigator for use of data was selected.

Ethics approval for analysis of RAAB repository data was obtained from the London School of Hygiene & Tropical Medicine Ethics Committee (ref 25471). Approval for analysis of data from comprehensive studies was obtained from representative principal investigators. All studies had individual ethics approval for when they were originally conducted.

Definition and calculation method for eREC

Participant-level fields required for the calculation of eREC include age, whether the participant presents to the eye survey with glasses or contact lenses for distance or for near vision, and whether there is a history of refractive surgery. The following distance visual acuity measurements are required in each eye separately: uncorrected, presenting, pinhole or best-corrected, and near visual acuity at 40 cm with both eyes open uncorrected and presenting. Finally, discernment of the cause of vision impairment in eyes with best-corrected visual acuity of less than 6/12 is required.

The recommended method[6] of calculation of distance vision eREC is outlined in panel 1 and that of near vision eREC in the appendix (p 5). An alternative method for distance vision eREC was also proposed, relying on PVA only (referred to hereon as PVA-based eREC, panel 2), to be used when measurements of uncorrected visual acuity were not available. When computing the eREC, two vision thresholds (6/12 and 6/18) were used.

The calculation of refractive error coverage (REC)[18] differs from eREC in that the term *c* for undermet need (individuals with uncorrected visual acuity <6/12 in the better eye who present with spectacles or contact lenses for distance vision and have PVA <6/12 in the better eye, but who improve to ≥6/12 on pinhole or refraction for best-corrected visual acuity; panel 1) is added to the numerator (and also remains part of the denominator). REC measures whether vision-impairing refractive error has been corrected, regardless of whether a good outcome is achieved (ie, it measures the element of access to refractive error correction, but not the element of quality). The gap between REC and eREC can be calculated to determine the extent of refractive error correction that is undermet which can be considered a quality gap;[18] we calculated the relative quality gap for each study as (REC–eREC)/REC, with lower values reflecting better quality of refractive error services.

Panel 1: Recommended calculation method for distance vision effective refractive error coverage

$$\frac{(a+b)}{(a+b+c+d)}\times 100$$

- *a*=individuals with UCVA <6/12 in the better eye who present with spectacles or contact lenses for distance vision and whose PVA is ≥6/12 in the better eye (met need)
- *b*=individuals with a history of refractive surgery whose UCVA is ≥6/12 in the better eye (met need)
- *c*=individuals with UCVA <6/12 in the better eye who present with spectacles or contact lenses for distance vision and have PVA <6/12 in the better eye, but who improve to ≥6/12 on pinhole or refraction (undermet need)
- *d*=individuals with UCVA <6/12 in the better eye who do not have distance vision correction and who improve to ≥6/12 on pinhole or refraction (unmet need)

UCVA=uncorrected visual acuity; if spectacles or contact lenses are worn to the assessment, visual acuity is measured with the person not wearing them. PVA=presenting visual acuity; if spectacles or contact lenses are worn to the assessment, visual acuity is measured with the person wearing them.

Panel 2: Alternate calculation method for distance vision effective refractive error coverage*

$$\frac{a}{(a+b+c)}\times 100$$

- *a*=individuals who present with spectacles or contact lenses for distance (or have a history of refractive surgery) and whose PVA is ≥6/12 in the better eye (met need)
- *b*=individuals who present with spectacles or contact lenses for distance (or have a history of refractive surgery) and whose PVA was <6/12 in the better eye, but who improve to ≥6/12 on pinhole or refraction (undermet need)
- *c*=individuals with PVA <6/12 in the better eye who do not have correction and who improve to ≥6/12 on pinhole or refraction (unmet need)

PVA=presenting visual acuity; if spectacles or contact lenses are worn to the assessment, visual acuity is measured with the person wearing them. *Based on PVA, used when uncorrected visual acuity measurements were not available (eg, Rapid Assessment of Avoidable Blindness studies).

For the **RAAB repository** see http://raabdata.info

See **Online** for appendix

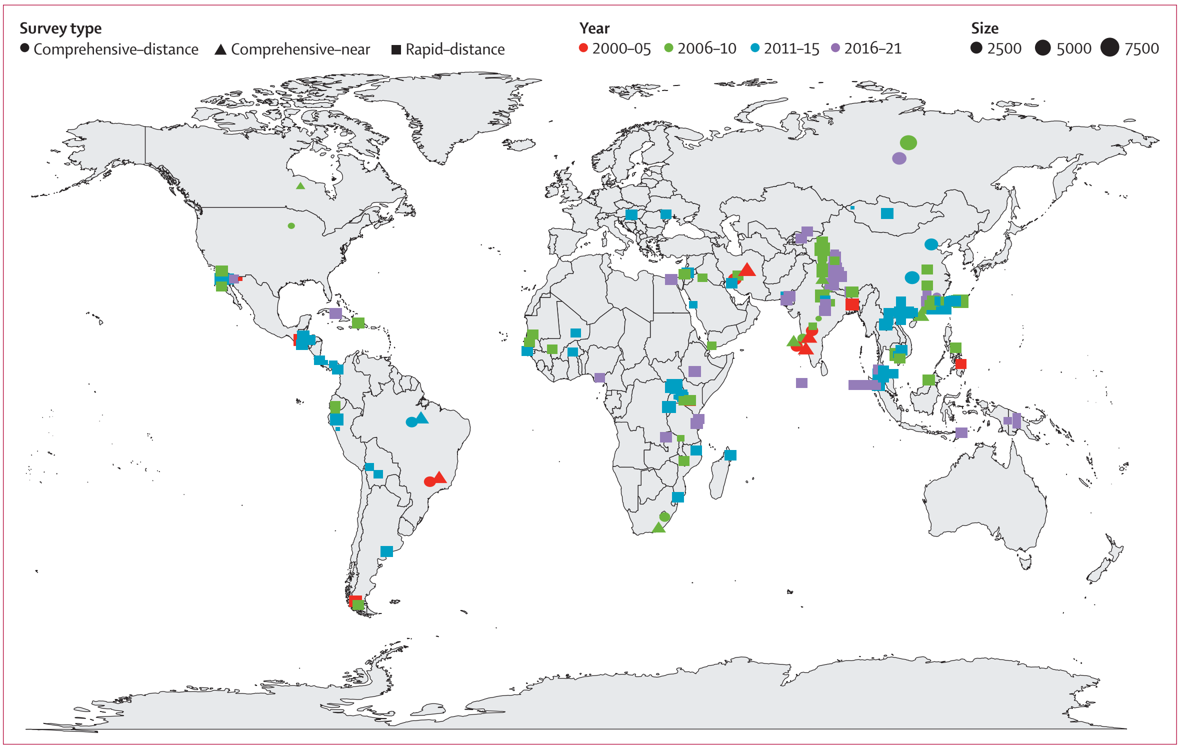

Figure 1: World map of all the data sources, both comprehensive and Rapid Assessment of Avoidable Blindness studies used in the analyses

Statistical analysis

After data preparation (age discretisation and data exclusions), a binary logistic regression model was used (brms package 2.15.0 in R 4.1.2) on respondents with met need, undermet need, and unmet need.[19] The model used the seven GBD regions as a random effect to account for differences in the intercept term for predicting the outcome (met need) using the predictor covariates (sex, age, and year of study) as a linear effect. Once the logistic regression model was fit using Markov Chain Monte Carlo methods, eREC predictions were made for any age, sex, region, or year. Results for age 50 years and older and both sexes were obtained using weighted averages over the age and sex population structure in each GBD region. We presented data for GBD super regions and also for World Bank income strata.[20]

Our main analysis used the 6/12 threshold for eREC and these results are given for eREC unless stated otherwise. For further details on statistical analysis see the appendix (p 6).

Role of funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

202 comprehensive studies with summative data in the Global Vision Database with a start date of the year 2000 onwards were identified and the per-participant data were requested from the principal investigators. We received participant-level data from 169 studies (22 comprehensive studies and 147 RAABs) in 61 countries. Comprehensive studies and the data fields supplied are given in the appendix (pp 1–4, 12–15). All 22 of the comprehensive studies were used for calculation of eREC. eREC for near vision was calculated for 12 comprehensive studies where the near visual acuity measurements were available. In rapid studies, the uncorrected visual acuity was not available and these studies in addition to all the 22 comprehensive studies were used to calculate the PVA-based eREC.

Participant-level data from 147 RAAB studies were received with all data fields required to calculate the PVA-based eREC at the 6/12 and 6/18 thresholds or 6/18 only (appendix pp 16–22). A flowchart describing the process of requesting data, investigator responses and the comprehensiveness of the data for the purposes of eREC calculation is given in the appendix (p 7). Figure 1 presents a world map of all the data sources, both comprehensive and RAAB, used in the analyses. As there was at least one study available, calculation of eREC was feasible from each GBD super region.

Distance and near vision eREC are shown disaggregated by age and sex in table 1 and the appendix (pp 23–25). Distance eREC values varied widely worldwide, ranging from 5·0% in Durban, South Africa, and 7·3% in Shunyi, China, to 81·8% in Los Angeles, CA, USA.

	Study name	Distance effective refractive error coverage (%)							Near effective refractive error coverage (%)						
		Both sexes	Men	Women	10–29 years	30–49 years	50–69 years	≥70 years	Both sexes	Men	Women	10–29 years	30–49 years	50–69 years	≥70 years
Central Europe, eastern Europe, and central Asia															
Russia	The Ural Eye and Medical Study (UEMS)	49·2% (47·9–50·5)	50·0%	48·6%	NA	50·0%	54·1%	30·0%	NA	NA	NA	NA	NA	NA	NA
High income															
USA	Prevalence and correction of near vision impairment at seven sites in China, India, Nepal, Niger, South Africa, and the United States (Los Angeles)	81·8% (78·7–84·6)	83·5%	80·9%	NA	57·1%	89·4%	78·0%	75·2% (71·8–78·3)	76·4%	74·6%	NA	47·4%	80·9%	75·7%
Latin America and Caribbean															
Brazil	Brazilian Amazon Region Eye Survey (BARES)	28·6% (26·8–30·4)	17·0%	36·2%	NA	43·5%	43·2%	49·1%	29·7% (27·9–31·6)	16·4%	22·6%	NA	15·5%	21·0%	18·3%
Caribbean	National Eye Survey of Trinidad and Tobago (NESTT)	NA	NA	NA	NA	NA	NA	NA	44·7% (43·0–46·4)	41·7%	51·8%	NA	43·1%	51·2%	41·4%
North Africa and Middle East															
Iran	Shahroud Eye Cohort Study 2010	62·9% (61·6–64·2)	67·5%	59·8%	NA	73·4%	58·7%	NA	NA	NA	NA	NA	NA	NA	NA
South Asia															
India	Corneal Opacity Rural Epidemiological Study (CORE)	4·5% (2·9–6·9)	7·8%	1·7%	NA	NA	5·6%	4·0%	NA	NA	NA	NA	NA	NA	NA
India	Prevalence and correction of near vision impairment at seven sites in China, India, Nepal, Niger, South Africa, and the United States (Madurai)	16·5% (15·2–17·9)	18·3%	15·4%	NA	14·4%	17·6%	17·3%	6·0% (5·2–6·9)	7·6%	4·8%	NA	4·0%	7·9%	10·8%
India	The Central India Eye and Medical Study (CIEMS)	10·9% (10·3–11·5)	13·9%	8·7%	NA	10·7%	11·5%	8·3%	NA	NA	NA	NA	NA	NA	NA
Nepal	Prevalence and correction of near vision impairment at seven sites in China, India, Nepal, Niger, South Africa, and the United States (Kaski)	17·5% (16·0–19·1)	16·8%	18·0%	NA	13·8%	16·7%	19·5%	5·2% (4·4–6·2)	10·1%	1·7%	NA	4·1%	5·6%	5·3%
Southeast Asia, east Asia and Oceania															
China	Prevalence and correction of near vision impairment at seven sites in China, India, Nepal, Niger, South Africa, and the United States (Shunyi)	7·3% (6·5–8·2)	11·6%	4·5%	NA	13·5%	7·1%	6·0%	0·2% (0·0–1·3)	0·4%	0·1%	NA	1·4%	0·1%	0·2%
China	Beijing Eye Study	61·8% (60·5–63·1)	72·8%	53·8%	NA	88·8%	63·9%	31·8%	NA	NA	NA	NA	NA	NA	NA
Sub-Saharan Africa															
South Africa	Prevalence and correction of near vision impairment at seven sites in China, India, Nepal, Niger, South Africa, and the United States (Durban)	5·0% (4·2–5·9)	0	6·5%	NA	2·2%	5·8%	6·1%	2·3% (1·8–2·9)	2·3%	2·3%	NA	0·5%	3·1%	4·3%

95% CI are given for distance effective refractive error coverage for both sexes combined. NA=not available. There was a statistically significant ($p<0·05$) difference in distance effective refractive error coverage between sexes in all studies except the Ural Eye and Medical Study ($p=0·2$).

Table 1: **Distance and near vision effective refractive error coverage, disaggregated by age and sex, for a 6/12 threshold**

	Men ≥50 years	Women ≥50 years	Both sexes ≥50 years	50–59 years	60–69 years	70–79 years	≥80 years
Super regions							
Central Europe, eastern Europe, and central Asia	53·0% (48·0–58·0)	47·0% (42·3–51·8)	49·5% (45·0–54·0)	54·7% (49·0–60·0)	56·6% (51·1–62·0)	42·5% (36·0–49·5)	22·0% (16·5–28·7)
High income	81·1% (74·6–86·6)	77·3% (70·3–83·5)	79·1% (72·4–85·0)	84·3% (77·8–89·5)	85·3% (79·4–90·2)	76·8% (68·2–84·2)	55·9% (44·3–67·2)
Latin America and Caribbean	36·7% (31·2–42·7)	32·7% (27·6–38·1)	34·5% (29·4–40·0)	37·7% (31·6–44·2)	39·6% (33·4–46·2)	27·1% (21·2–33·5)	12·4% (8·8–16·6)
North Africa and Middle East	64·2% (56·7–71·0)	60·0% (52·9–67·0)	62·1% (54·7–68·8)	65·1% (57·6–72·0)	66·8% (59·0–73·7)	53·3% (43·8–62·8)	30·4% (22·7–39·0)
South Asia	9·6% (7·0–13·0)	8·3% (5·9–11·1)	9·0% (6·5–12·0)	9·6% (6·8–13·1)	10·3% (7·3–14·0)	6·1% (4·1–8·7)	2·4% (1·6–3·4)
Southeast Asia, east Asia, and Oceania	42·2% (33·5–50·8)	37·9% (29·7–46·1)	40·0% (31·7–48·2)	42·6% (33·3–51·6)	44·5% (35·2–53·4)	31·3% (23·2–40·5)	14·8% (10·4–19·9)
Sub-Saharan Africa	6·1% (3·3–9·9)	5·2% (2·8–8·4)	5·7% (3·1–9·0)	6·0% (3·2–9·7)	6·4% (3·4–10·3)	3·7% (1·9–6·3)	1·4% (0·7–2·5)
World Bank income stratum							
High	77·1% (71·0–82·7)	71·4% (64·5–77·4)	74·1% (67·5–79·7)	81·7% (75·7–86·5)	80·3% (74·2–85·5)	67·3% (59·1–75·0)	52·7% (41·0–63·3)
Upper middle	33·0 % (30·5–35·6)	27·4 % (25·7–29·4)	30·1% (28·3–32·0)	34·7% (31·8–37·7)	32·6% (29·8–35·5)	19·6% (16·6–22·8)	11·7% (8·4–15·3)
Lower middle	15·1 % (13·5–16·8)	12·1 % (11·0–13·4)	13·6% (12·4–14·8)	15·6% (13·9–17·6)	14·5% (12·7–16·3)	7·8% (6·4–9·3)	4·4% (3·1–6·0)
Low	NA	NA	NA	NA	NA	NA	NA
Global	..	..	42·9% (38·0–47·8)	..	..	..	..

Data are % (95 CI). NA=not available.

Table 2: **Modelled distance effective refractive error coverage for 2021 disaggregated by age group and sex for Global Burden of Disease super regions and World Bank income strata**

There was considerable variation in eREC between sexes; some studies showed significantly higher eREC among men than women (eg, Shunyi China 11·6% men *vs* 4·5% women) and others showed reversed sex difference, with higher eREC among women than men (eg, Brazil 17·0% men *vs* 36·2% women). eREC was greater when the visual acuity threshold was set at a lower threshold (appendix pp 23–25).

PVA-based eREC was calculated for a dataset that included presenting visual acuity data for all the RAAB studies and most comprehensive studies. PVA-based eREC is displayed for each of these contributing studies disaggregated by age, sex, and visual acuity threshold in the appendix (pp 26–46). Comparison of table 1 and the appendix data (pp 43–46) shows the higher values of PVA-based eREC than eREC for each of the comprehensive studies.

The difference between REC and eREC varied greatly across regions, as indicated by the length of the line between point estimates for comprehensive studies (appendix p 10). To compare across a much larger number of studies, we calculated PVA-based REC versus PVA-based eREC among both comprehensive and RAAB studies (appendix p 11, 47–49). The smallest relative quality gap was 1·7% in Trinidad and Tobago (2013, PVA-based REC 91·5%, PVA-based eREC 89·9%), whereas the largest relative gap was in Vietnam (2015, PVA-based REC 1·7%, PVA-based eREC 0·6%). From all included studies, the median PVA-based eREC was 35·7% (IQR 20·6–61·8%) and the median PVA-based REC was 43·9% (26·1–71·5%). Using the smaller number of comprehensive studies, for which eREC could be calculated, the median eREC estimate was 17·5% (9·1–55·5%) and REC estimate 32·7% (12·8–62·7%).

Distance eREC was modelled for people aged 50 years and older globally and by super region between 2000 and 2021. Global distance eREC was estimated to be 42·9% (95% CI 38·0–47·8) in 2021, 9% higher than in 2010 (eREC 39·1% [95% CI 37·1–41·0]) and 19% higher than in 2000 (35·7% [32·2–39·2]). With a 97% posterior probability for each comparison, there was an increase. eREC is presented by super region and World Bank income level and by sex and age in table 2 and displayed graphically at sequential timepoints in figure 2.

There were marked differences between super regions, with much higher coverage in 2021 in high-income regions (79·1% [95% CI 72·4–85·0]) than in south Asia (9·0% [6·5–12·0]) and sub-Saharan Africa (5·7% [3·1–9·0]). North Africa and Middle East; central Europe, eastern Europe and central Asia; Latin America and Caribbean; and southeast Asia, east Asia, and Oceania occupy a position between these extremes. In all super regions, eREC was lower in women than men in 2021. Between 2000 and 2021, eREC increased by 73·0% in south Asia; 72·7% in sub-Saharan Africa; 47·4% in Latin America and Caribbean; 46·0% in southeast Asia, east Asia, and Oceania; 35·2% in central Europe, eastern Europe, and central Asia; 28·3% in north Africa and Middle East; and 13·3% in the high-income super region. A reduction in eREC with increasing age beyond 50 years was observed in men and women (appendix pp 8–9).

eREC was modelled for near vision impairment due to presbyopia using 10 data sources. Global near vision eREC for 2021 was estimated to be 20·5% (95% CI 17·8–24·4) for adults aged 50 years and older. Due to the scarce data sources, temporal trends were not analysed. By super region, high-income regions had the highest near vision eREC (64·7% [95% CI 59·8–69·2]), followed

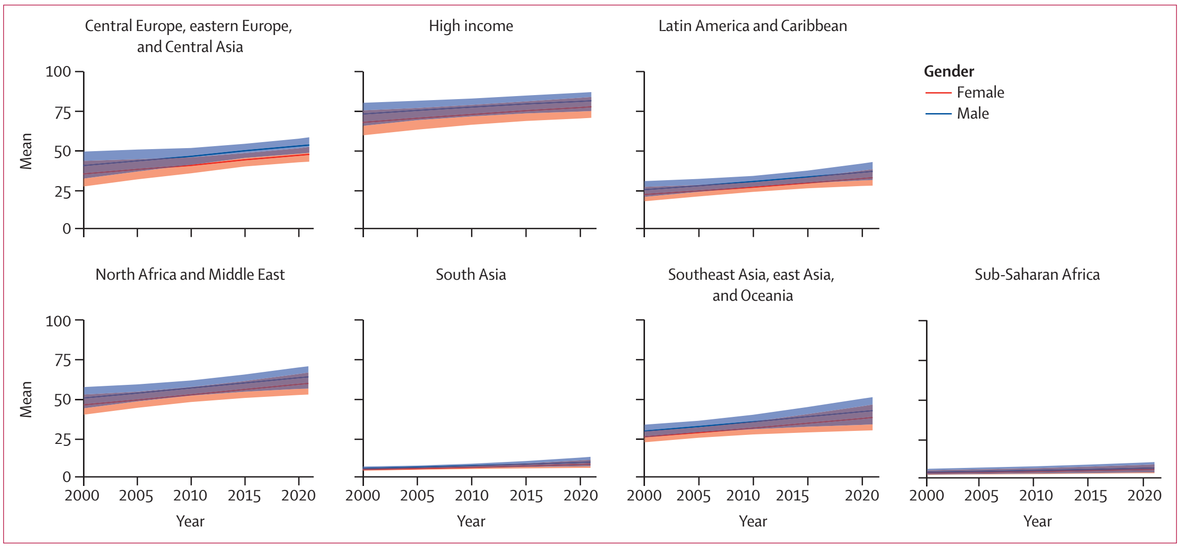

Figure 2: **Modelled distance effective refractive error coverage for people aged 50 years and older by super region in 2000–21**

by north Africa and Middle East (41·8% [37·9–45·9]), Latin America and Caribbean (15·5% [14·0–17·0]), south Asia (3·3% [2·5–4·2]), and sub-Saharan Africa (1·4% [0·0–8·4]). Lack of a data source precluded an estimate for southeast Asia, east Asia, and Oceania. Higher near vision eREC was estimated in women than men in all other super regions.

Discussion

Herein we have presented the most current and comprehensive analysis of eREC, an indicator endorsed by WHO Member States at the 74th World Health Assembly.[12] We have analysed eREC at study level and modelled estimates by super region, which have revealed associations with age and sex and wide variation in eREC and REC.

The greatest burden of vision impairment and blindness occurs in adults aged 50 years and older,[2] and within this age group we estimate that eREC was 42·9% for distance vision and 20·5% for near vision in 2021. These global estimates highlight the overall scale of the challenge, whereas the variation in eREC by super region gives an indication of those in greatest need, in particular south Asia and sub-Saharan Africa.

Multiple social and cultural determinants influence REC, of which lower coverage among women is most striking.[7] Lower distance eREC among women than among men was noted for each super region. Other than longer average life expectancy among women, there is little evidence that biological sex-based differences contribute significantly. Rather, differences in health-care access and use most probably explain the observed gender inequity.[7] Although there were fewer near sources with which to model near vision eREC, women had higher near vision eREC than men.

eREC declined with increasing age above 50 years. Explanations for the age pattern might include reduced access and use of refractive services among older adults, additional ocular comorbidities that reduce the benefits of refractive correction, and a perception that reduced vision is part of the normal ageing process. Improved distribution of refractive services, awareness of the benefits of refractive correction, and relative improvements in socioeconomic status might account for the increase in distance eREC over the past two decades. Additionally, increased resources provided by non-governmental organisations to address uncorrected refractive error, and recognition by organisations such as WHO that this is a public health problem, have probably contributed.

The REC versus eREC analysis shows the extent of the relative quality gap. There was no clear relationship between World Bank income stratum and size of the gap. Ranking super regions by size of the quality gap, this was widest in central Europe, eastern Europe, and central Asia (9%) followed by Latin America and Caribbean (7·8%); south Asia (7·4%); southeast Asia, east Asia and Oceania (6·0%); high-income regions (3·2%); north Africa and Middle East (3·0%); and sub-Saharan Africa (1·5%). These gaps highlight that future efforts to achieve the 2030 targets will need countries to consider interventions to improve both access to and the quantity and quality of services. These interventions are vastly different—for example, interventions to improve quality include better government oversight and clinical regulation for refraction and dispensing of spectacles and standardisation of training programmes for refraction,[21,22] whereas interventions to improve quantity require increasing the availability of qualified human resources to refract and dispense spectacles and increasing the number of access points in low-income and middle-income countries (LMICs) at community (eg, schools, workplace, etc) and primary care levels. Additionally, subsidised service provision for patients and accelerating the availability of affordable products that are of good quality are important considerations.

In defining eREC, the decision was made to use a visual acuity threshold of 6/12 rather than 6/18.[6] However, we have also presented the higher eREC estimates at study level that occur when the 6/18 threshold is used—a threshold used by many older RAAB studies. WHO has chosen 6/12 as the threshold for a good visual outcome, which is consistent with the definition of vision impairment given in the *International Classification of Diseases*, version 11. This threshold stimulates quality improvement and encourages providers to offer refractive correction to milder degrees of vision impairment, which have a substantial effect on quality of life. For example, in many countries, an individual with this level of vision is not permitted to drive.[23]

Limitations of the analysis include data scarcity in some regions and age ranges in many datasets that limit eREC measurement to only those aged 50 years and older.[24] Consideration is being given to additional data collection methods for those younger than 50 years. Future research should focus on measuring and reporting uncorrected visual acuity (ie, without spectacles or contact lenses), strengthening data from younger populations, and greater geographical coverage of data gaps, particularly in Europe, the eastern Mediterranean region, and the Americas. Although considerable effort was made to contact principal investigators of comprehensive eye surveys in the Global Vision Database, the authors were only able to obtain sufficient per-participant data for calculation of eREC from 22 studies (95 921 participants), whereas additional comprehensive studies contributed sufficient data for PVA-based eREC, which could be added to data from the RAAB studies to create a dataset of 169 studies (565 448 participants). Data from RAAB studies provided considerable geographical coverage for LMICs, although many studies listed on the RAAB repository were unavailable for this analysis. It should also be noted that the definition of eREC has limitations in that improvement to 6/12 or better is used as the threshold for refractive coverage. This approach excludes individuals who also have a need for refractive correction to achieve a best-corrected visual acuity that could be worse than 6/12 but which affords a substantial improvement in vision—for example, an individual with age-related macular degeneration and refractive error. 24 of a total of 169 included studies were nationally representative; the remainder were from subnational areas that might lead to underestimation or overestimation of coverage at the national level. We did not conduct individual study-level risk-of-bias assessments. Finally, among RAAB studies, there could be some degree of error introduced when using pinhole correction to define improvement—for example, in people with high myopia for whom even an adequate pinhole might not correct the visual acuity to 6/12 or better. Furthermore, the RAAB survey instrument does not include a field to indicate history of refractive surgery and therefore eREC might be underestimated.

Strengths of this analysis include the use of per-participant data from many population-based studies from all global super regions. Equally important was the ability to highlight existing inequities by presenting results in an age-stratified and sex-stratified form, and to elucidate clear and encouraging temporal trends. Although RAAB studies cannot be used for calculation of eREC, they were useful for calculation of PVA-based eREC to validate sex, age, and geographical variation.

Key recommendations include an increased focus on the collection of data on uncorrected visual acuity, strengthening data from younger populations (children as a priority but also working-age individuals), better balance between national and subnational surveys, strengthening data on near vision eREC, and addressing geographical and income level gaps. To this end, opportunities should be taken to incorporate this indicator in paediatric and general health surveys.

In summary, our analysis of eREC highlights inequitable access to high-quality refractive services among women and older persons, while encouragingly showing that access has improved globally and in some super regions over the last decade. Considerable regional variation exists, and our figures attempt to provide the most granular estimates that can be accurately calculated, in order to inform regional policy making. Uncorrected near vision impairment remains the leading cause of vision impairment globally, and the current analysis highlights the critical need for more high-quality studies assessing access to near refractive services.

Contributors

RRAB contributed to the methodology, data curation, formal analysis, project administration, and writing of the original draft. IHT, MVC, NGC, JR, KSN, TRF, MJB, and AM contributed to the methodology and review and editing of the manuscript. MMB, JMF, FK, MH, YXW, LV, VN, GB, MHE, AF, HH, RBK, SM, SS, RG, GK, TB, RJC, AI, NG, MHA, TYW, RV, and NW provided comprehensive survey data and provided validation of the findings. IM provided RAAB data and provided validation and contributed to review and editing of the manuscript. TS and SRF contributed to methodology and formal analysis. SK contributed to conceptualisation and review and editing of the manuscript. HRT contributed to funding acquisition and review and editing of the manuscript. SR and JBJ contributed to conceptualisation, methodology, funding acquisition, and review and editing of the manuscript. All authors contributed to interpretation of data. MVC, RRAB, SRF, and TS had access to and verified the data reported in the manuscript. RRAB had full access to all of the data and the final responsibility to submit for publication.

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Data sharing

Requests for access to data used for this analysis can be made by contacting the corresponding author. Source code for the statistical analysis is available at github: https://github.com/MLGlobalHealth/eREC/.

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