Effective refractive error coverage in adults: a systematic review and meta-analysis of updated estimates from population-based surveys in 76 countries modelling the path towards the 2030 global target

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Summary

Background In 2024, WHO included effective refractive error coverage (eREC) into the results framework of the 14th General Programme of Work, which sets a road map for global health and guides WHO's work between 2025 and 2028. eREC is a measure of both the availability and quality of refractive correction in a population. This study aimed to model global and regional estimates of eREC as of 2023 and evaluate progress towards the WHO global target of a 40 percentage-point absolute increase in eREC by 2030.

Methods For this systematic review and meta-analysis, the Vision Loss Expert Group analysed data from 237 population-based eye surveys conducted in 76 countries since 2000, comprising 815 273 participants, to calculate eREC (met need / met need + undermet need + unmet need]) and the relative quality gap between eREC and REC ([REC – eREC] / REC × 100, where REC = [met + undermet need] / [met need + undermet need + unmet need]). An expert elicitation process was used to choose covariates for a Bayesian logistic regression model used to estimate eREC by country–age–sex grouping among adults aged 50 years and older. Country–age–sex group estimates were aggregated to provide estimates according to Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) super-regions.

Findings Global eREC was estimated to be 65·8% (95% uncertainty interval [UI] 64·7–66·8) in 2023, 6 percentage points higher than in 2010 (eREC 59·8% [59·4–60·2]). There were marked differences in eREC between GBD super-regions in 2023, ranging from 84·0% (95% UI 83·0–85·0) in high-income countries to 28·3% (26·4–30·4) in sub-Saharan Africa. In all super-regions, eREC was lower in females than males, and decreased with increasing age among adults aged ≥50 years. Since 2000, the relative increase in eREC was 60·2% in sub-Saharan Africa, 45·7% in North Africa and the Middle East, 41·5% in southeast Asia, east Asia and Oceania, 40·3% in south Asia, 16·2% in Latin America and the Caribbean, 8·3% in central Europe, eastern Europe and central Asia, and 6·8% in the high-income super-region. The relative quality gap ranged from 2·9% to 78·3% across studies, with larger gaps characteristically in regions of lower eREC. Globally, the percentage of those with a refractive need that was undermet reduced between 2000 and 2023, from 10·0% (95% UI 9·5–10·5) to 5·3% (5·1–5·5).

Interpretation The current trajectory of improvement in eREC and the relative quality gap are insufficient to meet the 2030 target. Global efforts to equitably increase spectacle coverage, such as the WHO SPECS 2030 initiative, and to address equity failings associated with geography, age, and sex, are crucial to accelerating progress towards the 2030 targets. No region is close to achieving universal coverage.

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For the French translation of the abstract see **Online** for appendix 1

For the Chinese translation of the abstract see **Online** for appendix 2

For the Spanish translation of the abstract see **Online** for appendix 3

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Introduction

WHO member states endorsed the first-ever global target for refractive error at the 74th World Health Assembly in 2021.[1] Countries with a baseline effective coverage rate of less than 60·0% have been encouraged to adopt the national target of a 40 percentage-point increase in

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Research in context

Evidence before this study

We searched PubMed on July 16, 2024, without applying any language or date restrictions, for studies and meta-analyses of studies of effective refractive error coverage (eREC) using the term "effective refractive error coverage" or "eREC". Our search returned articles reporting individual studies that reported eREC (two local studies from India, another local study from Zanzibar, and a national study from Dubai); a limited analysis of four population-based samples from China, Nepal, South Africa, and the USA that tested the accuracy of two methods of calculating distance vision eREC; and one meta-analysis done in 2022 of eREC by the Vision Loss Expert Group, an international ophthalmic epidemiology reference group, based on per-participant data from 169 population-based studies of vision impairment and blindness conducted from 2000 onwards (identified by a systematic review to Sept 9, 2020). The meta-analysis modelled distance eREC for 2021 disaggregated by age group and sex for Global Burden of Disease super-regions and provided baseline eREC estimates for the 2022 WHO report of the 2030 targets on effective coverage of eye care. Recently, eREC was included in the results framework of the WHO's 14th General Programme of Work, which guides WHO's work for 2025–28.

Added value of this study

Our systematic review and meta-analysis synthesised data from more than 815 000 participants across 237 population-based eye surveys, making this the most comprehensive evaluation of eREC to date. Using rigorous selection criteria and current evidence synthesis methods that included selection of covariates for the statistical model, we provide robust global eREC estimates for 2023 and show a decrease of the percentage of those with a refractive need that was undermet between 2000 and 2023. Our model revealed a marked difference in the relative increase of eREC between super-regions and provides country-level data for the first time. We highlight the eREC change in the world's 16 most populous countries over the past 20 years, including the gap between projected eREC and the eREC 2030 targets set at the 74th World Health Assembly in 2021.

Implications of all the available evidence

Although there has been an approximate 5 percentage-point increase in eREC occurring per decade since 2000, the current trajectory of improvement in eREC and the relative quality gap is insufficient to meet the 2030 target. Considerable heterogeneity exists between countries with respect to the improvement in eREC between 2000 and 2020, and in the gap that these countries now need to close to achieve the WHO target. These findings highlight the importance of identifying factors that contribute to low coverage of refractive error within some countries. Implementing programmes that target these inequities in the delivery of refractive correction, such as the WHO SPECS 2030 initiative, is crucial to reduce the global burden of uncorrected refractive error.

effective refractive error coverage (eREC) by 2030. Countries with a baseline effective coverage rate of 60·0% or higher should strive for universal coverage, and to reduce inequalities countries should place a greater focus on increasing effective coverage in their traditionally underserved population subgroups. 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 the UN Sustainable Development Goals (SDGs) to reduce poverty and improve work productivity, education, and equity.[2]

eREC is a measure of both the availability and quality of refractive correction in a population. It is defined as the proportion of people in need of refractive error correction who have received services (spectacles, contact lenses, or refractive surgery) and have a good quality outcome.[3] Given the well established impact of near-vision impairment on quality of life and productivity,[4,5] 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. This indicator not only captures the extent of coverage (ie, REC), but also the concept of effective coverage, defined as near and distance vision with correction of 6/12 visual acuity or better.

eREC serves as an ideal indicator to track changes in the uptake and quality of eye care services at the global level, as well as to contribute to monitoring progress towards universal health coverage more broadly. Currently, there is a large unmet need for care associated with uncorrected refractive error;[2] spectacles provide a highly cost-effective intervention;[5] and the indicator measures ongoing access to, and uptake of, services across the life course.[3] In recognition of this, eREC has now been included in the results framework of WHO's 14th General Programme of Work, which sets the road map for global health and guides WHO's work between 2025 and 2028.[6]

Uncorrected refractive error is a major public health problem globally, with 3·7 million (95% uncertainty interval [UI] 3·1–4·3) people classified as blind (presenting visual acuity [PVA] <3/60 in the better eye) and 157 million (140–176) with moderate or severe vision impairment (PVA <6/18 to 3/60, as per 2020 estimates), and an estimated 509·7 million (371·1–666·7) people with near vision impairment due to uncorrected or under-corrected presbyopia.[7–9] There is a global epidemic of both myopia and high myopia (a more severe subset of myopia), most strikingly in east and southeast Asia that might foreshadow a future increase in vision loss due to pathological myopia and associated conditions that include cataract, retinal detachment, and glaucoma.[10] During the past two decades, increases in myopia have been particularly notable among younger people in east Asia.[10] Moreover, ageing of populations results in a substantial growth in the prevalence of presbyopia and near vision impairment due to a lack of refractive correction.[8] The rise in myopia rates, which increases the denominator of eREC, has resulted in calls and actions to institute myopia control programmes in many countries, such as the USA[11] and China.[12]

In 2022, the Vision Loss Expert Group (VLEG), an international ophthalmic epidemiology reference group, produced baseline estimates of eREC using per-participant data from population-based surveys of eye disease from the Global Vision Database (maintained by VLEG).[13] This database is a continually updated repository of data used for 5-yearly reports of vision loss prevalence (2010, 2015, and 2020).[7,8] The baseline eREC estimates provided global and regional data for the 2022 WHO report on effective coverage of eye care, which highlighted higher coverage among men and declining coverage in older age groups.[14]

With the availability of a larger number of studies since this initial report and access to more participant-level data, this new analysis offers better geographical coverage, especially the potential to generate country-level estimates that are essential for national planning and monitoring purposes. Additionally, the inclusion of new covariates allows for improved statistical modelling at various past and future timepoints. Following the adoption of the first-ever target on eREC at the World Health Assembly in 2021,[1] concerted global efforts and investments to address uncorrected refractive error as a public health problem have been initiated. The aim of the Article was to model global and regional estimates of eREC for 2023 and also to consider progress towards the global target of a 40 percentage-point increase in eREC by 2030, in order to help guide the focus of the global initiatives and investments, and form a robust basis for monitoring how these actions and investments are delivering on the goal of sustainably increasing access to refractive error services in low-income and middle-income countries.

Methods

Data sources

The VLEG systematically reviewed the scientific literature for population-based studies of vision impairment and blindness published between 1980 and 2023 by commissioning the York Health Economics Consortium (UK) to search Embase, SciELO, MEDLINE, WHOLIS, and OpenGrey, and additional grey literature sources. Of the 528 data sources currently included in the Global Vision Database, 243 (46%) are Rapid Assessment of Avoidable Blindness (RAAB) studies, which sample individuals aged 50 years or older in predominantly low-income and middle-income countries. The remaining 285 (54%) studies are more comprehensive in terms of wider age ranges and geographical areas sampled with more detailed ocular examinations. A detailed summary of the data identification process for this database has been published previously[8] (appendix 4 pp 3, 7–19). For the current analysis, principal investigators of studies included in the Global Vision Database with a start date of Jan 1, 2000, onwards were contacted and per-participant microdata requested. Eligible RAAB surveys were identified from the RAAB repository. Due to the paucity of additional studies reporting near vision since baseline, revised estimates of near vision eREC are not included in this report.

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

Definition and calculation method for distance vision eREC

Participant-level fields required for the calculation of distance eREC include whether the participant presented with corrected distance vision. Presenting and pinhole or best-corrected distance visual acuity measurements are compared for each eye to ascertain the better eye acuity. These data permit the calculation of eREC with the PVA-based method, as follows:

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

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

where “a” refers to individuals who present with spectacles or contact lenses for distance (or have a history of refractive surgery) and whose PVA is 6/12 or better in the better eye (met need), “b” refers to individuals who present with spectacles or contact lenses for distance (or have a history of refractive surgery) and whose PVA was worse than 6/12 in the better eye, but who improve to 6/12 or better on pinhole or refraction (undermet need), and “c” refers to individuals with PVA worse than 6/12 in the better eye who do not have correction and who improve to 6/12 or better on pinhole or refraction (unmet need). The unmet + undermet need = 100 – eREC; unmet need (c) = 100 – REC.

This method permits the use of many more data sources when compared to a method (appendix 4 p 3) that requires measures of uncorrected visual acuity.[13] WHO accepts both methods. When computing eREC,

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See **Online** for appendix 4

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

For the **RAAB repository** see https://www.raab.world/

the 6/12 vision threshold was used. If a participant from an included population-based survey had a need for refractive error coverage, then each was coded into the eREC model as a, b, or c (as per the formula above).

The calculation of REC[14] differs from eREC in that the term "b" for undermet need is added to the numerator. 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 measure the extent of refractive error correction that is undermet, which can be considered a quality gap.[15] We calculated the relative quality gap for each study as (REC−eREC)/eREC×100), with lower values reflecting better quality of refractive error services.

Covariate selection

We screened the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) database for covariates with a potential link to eREC and selected 20 covariates to include in an expert elicitation process with the intention of choosing covariates to include in the Bayesian statistical eREC model to augment and complement observational data. Expert participants, identified from VLEG, and previous participants in online research projects concerning the enhancement of access and quality of refractive error services, were invited to identify whether a potential covariate was likely to be associated with higher or lower effective coverage, or if there was no association. Subsequent questions asked about the strength of the association and whether it was direct or indirect (summary data from survey respondents are provided in appendix 4 pp 33–36). Responses from expert feedback were reviewed for consistency and the five most highly ranked covariates for strength of association with refractive error coverage were prioritised for inclusion: optometrists per person, level of development (Socio-demographic Index), health-care access and quality, the proportion of the population receiving education, and years spent in education.

Statistical analysis

After data preparation, the meta-analysis involved modelling eREC using a Bayesian generalised linear mixed model using Bernoulli likelihood and inverse logit link function (ie, logistic regression) with the brms package in R to analyse individual-level survey data (respondents with met need, undermet need, and unmet need). The model is a generalisation of logistic regression used to model prevalence of eREC, meaning that covariates (fixed or random effects consisting of country, year, age, and education) multiplicatively raise or lower the percentage of the population covered (ie, eREC prevalence). The predictor variables included in the analysis were age, sex, and country, and year of study ranging from 2000 to 2023, modelled as a linear trend. Education (average years of schooling) was included as a covariate. The collinearity of temporal trends in some of the other covariates resulted in unstable coefficient estimates, making it difficult to include any other covariates in the model in a stable way.

We fit the models, obtaining 4000 samples from the posterior distribution. For every country–year–sex–age group we calculated eREC according to the PVA-based method described in the equation above. Following the fitting of regression models, we generated predictions for eREC across any age group, sex, country, or year within the 2000–25 timeframe. Population data were obtained from World Population Prospects 2022.[16] Estimates for the population aged 50 years and older (the

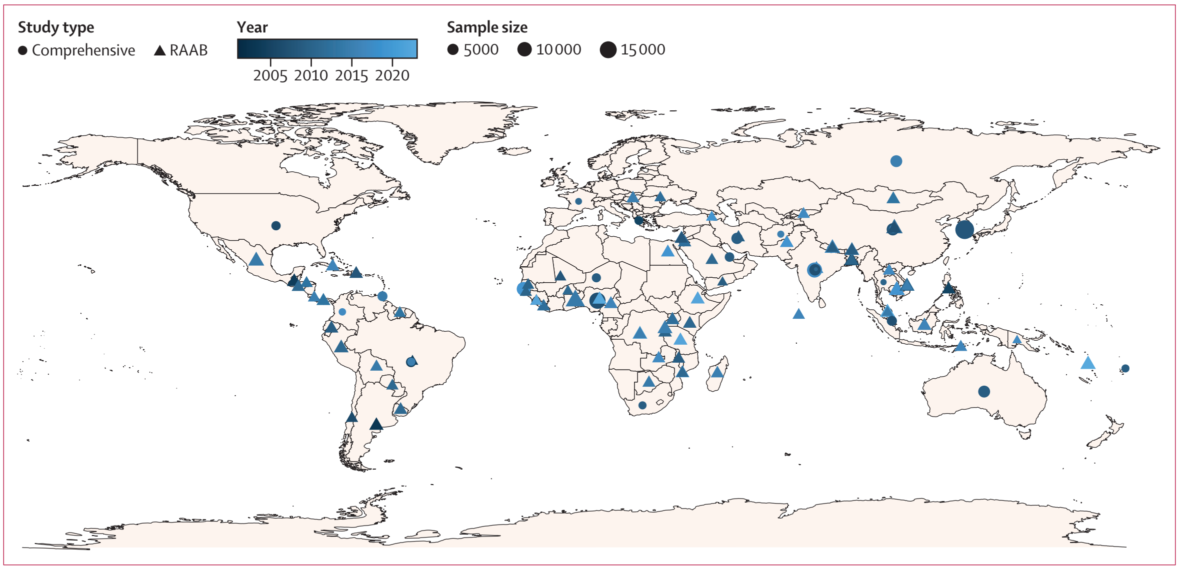

Figure 1: **World map of all the data sources, including 35 comprehensive studies and 202 RAAB studies, used in the analyses**
RAAB=Rapid Assessment of Avoidable Blindness.

age range of most RAAB studies) in 2000, 2020, 2023, and 2030 for each country were calculated with weighted averages based on the country's age and sex population structure.[16] Percentage point increase in eREC between 2020 and 2030 was calculated by region and country and the absolute difference between target and expected eREC estimated. Reported UIs are 95% Bayesian credible intervals (computed as the 2·5th and 97·5th percentile of the 4000 sampled eREC values). Outputs were arranged by country income level, sex, age, and region. Results are reported with eREC at the 6/12 threshold unless stated otherwise.

Role of the funding source

The funding sources had no role in study design or conduct, data analysis or interpretation, or in the writing of the manuscript.

Results

We included participant-level data from 237 studies in 76 countries from 35 comprehensive studies and 202 RAABs, comprising a total of 815 273 individuals. These studies and the data fields supplied are summarised in appendix 4 (pp 37–41). A world map of all the data sources is shown in figure 1.

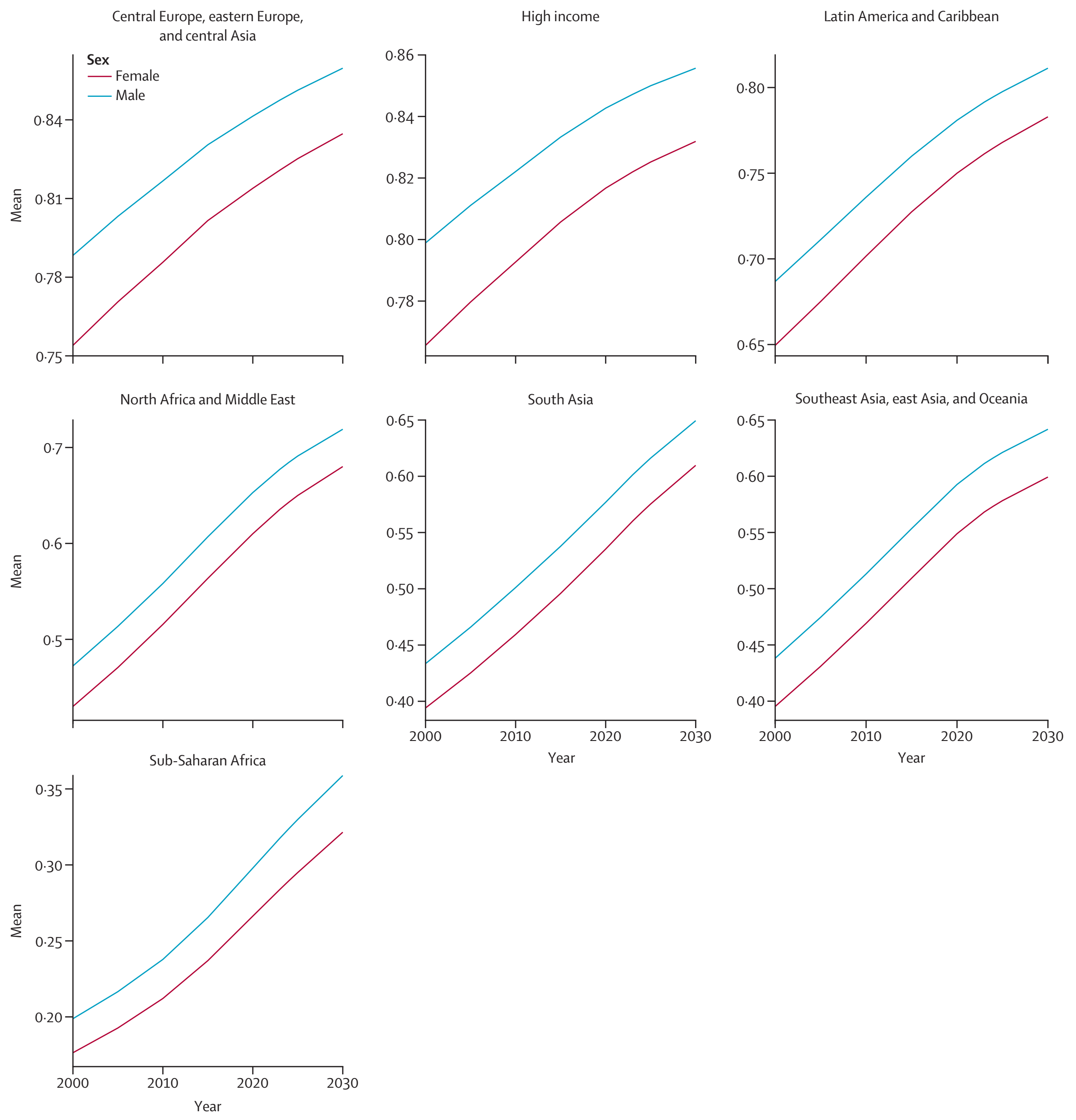

Figure 2: **Distance eREC (PVA-based, at 6/12 threshold) for people aged 50 years or older between 2000 and 2030 by GBD super-region**
eREC=effective refractive error coverage. PVA=presenting visual acuity. GBD=Global Burden of Diseases, Injuries, and Risk Factors Study.

	≥50 years	50–59 years	60–69 years	70–79 years	≥80 years
Males	67·4% (66·4–68·5)	69·2% (68·1–70·4)	67·0% (65·9–68·2)	63·9% (62·7–65·3)	65·4% (63·8–67·0)
Females	64·3% (63·2–65·3)	66·1% (64·9–67·3)	63·9% (62·8–65·1)	61·0% (59·7–62·3)	62·9% (61·3–64·6)
Both	65·8% (64·7–66·8)	67·7% (66·6–68·8)	65·4% (64·3–66·6)	62·3% (61·0–63·6)	63·9% (62·3–65·5)

Data in parentheses are 95% CIs.

Table 1: **Global modelled crude distance effective refractive error coverage disaggregated by age group and sex**

	Both sexes aged ≥50 years	Males aged ≥50 years	Females aged ≥50 years
Global	63·0% (62·0–64·0)	64·4% (63·4–65·5)	61·6% (60·6–62·6)
GBD super-region			
Central Europe, eastern Europe, and central Asia	82·6% (81·2–83·8)	83·7% (82·4–84·9)	81·5% (80·1–82·8)
High income	84·0% (83·0–85·0)	85·1% (84·1–86·0)	83·0% (81·9–84·0)
Latin America and Caribbean	78·6% (77·5–79·7)	79·9% (78·8–81·0)	77·3% (76·1–78·4)
North Africa and Middle East	65·3% (63·2–67·3)	67·0% (65·0 69·0)	63·5% (61·4–65·6)
South Asia	53·3% (51·9–54·6)	55·2% (53·8–56·6)	51·4% (50·0–52·7)
Southeast Asia, east Asia, and Oceania	54·6% (53·4–56·0)	56·5% (55·1–57·9)	52·8% (51·4–54·1)
Sub-Saharan Africa	28·3% (26·4–30·4)	29·9% (27·9–32·0)	26·8% (24·9–28·8)
World Bank income stratum			
Low income	31·3% (29·6–33·0)	32·8% (31·0–34·6)	29·8% (28·1–31·5)
Lower middle income	48·4% (47·1–49·7)	50·1% (48·8–51·5)	46·7% (45·4–48·1)
Upper middle income	70·3% (69·3–71·3)	71·8% (70·7–72·8)	68·9% (67·8–69·9)
High income	80·9% (80·0–81·7)	82·1% (81·2–82·9)	79·7% (78·8–80·6)

Data in parentheses are 95% CIs. GBD=Global Burden of Diseases, Injuries, and Risk Factors Study.

Table 2: **Age-standardised global effective refractive error coverage and by GBD super-region and World Bank income stratum by sex, 2023**

eREC at the 6/12 threshold was calculated for 124 studies and at the 6/18 threshold for 237 studies. These outputs are presented across each study's age range and by sex and age groups in appendix 4 for the 6/12 and 6/18 thresholds (pp 42, 47). eREC was greater when the visual acuity threshold was set at the lower threshold of 6/18.

eREC at the 6/12 threshold values varied widely globally, ranging from 2·1% (95% UI 1·6–2·6) in a RAAB study from Uganda (2023)[17] to 94·0% (93·0–95·0) in a comprehensive study done in France (2009–11).[18]

Additionally, we calculated REC and eREC for all studies with the 6/12 threshold (appendix 4 p 56). The smallest relative quality gap ([REC – eREC] / eREC × 100), was from a study in Thessaloniki, Greece (REC 92·5%, eREC 89·9%, relative quality gap 2·9%) conducted between 1999 and 2005[19] and the largest gap was drawn from a study in Punjab, Pakistan (REC 49·9%, eREC 10·8%, relative quality gap 78·3%) in 2019.[20] The mean relative quality gap across all studies was 7·2% (SD 8·8).

Globally, the percentage of those with a refractive need that was undermet reduced between 2000 and 2023, from 10·0% (95% UI 9·5–10·5) to 5·3% (5·1–5·5). There was no significant difference in undermet need between males and females at each of these timepoints, nor was there a significant change between these timepoints between sexes.

eREC was modelled for people aged 50 years and older globally and by GBD super-region between 2000 and 2030 (figure 2). Global crude eREC was estimated to be 65·8% (95% UI 64·7–66·8) in 2023 (table 1), 6 percentage points higher than in 2010 (eREC 59·8% [59·4–60·2]) and 10 percentage points higher than in 2000 (eREC 55·6% [54·7–56·5]), with a 97% posterior probability for an increase over this period. eREC in 2023 is presented by GBD super-region and World Bank income level and by sex and age in table 2. Global eREC for males was 67·4% (95% UI 66·4–68·5) and 64·3% (63·2–65·3) for females.

There were marked differences between super-regions in 2023, ranging from age-standardised eREC values of 84·0% (95% UI 83·0–85·0) in high-income countries to 28·3% (26·4–30·4) in sub-Saharan Africa. In all super-regions, eREC was lower among females than among males in 2023. eREC increased from 2000 to 2023 by 60·2% in sub-Saharan Africa; 45·7% in North Africa and the Middle East; 41·5% in southeast Asia, east Asia and Oceania; 40·3% in south Asia; 16·2% in Latin America and the Caribbean; 8·3% in central Europe, eastern Europe and central Asia; and 6·8% in the high-income super-region. A reduction in eREC with increasing age beyond 50 years was observed in males and females (table 1). Model outputs (2023 and 2030 forecasts) for eREC at the 6/12 threshold by country and by WHO region are given in appendix 4 (pp 50–55).

The 14 countries with more than 100 million people (accounting for 63% of the world's population) are shown in table 3, and we present modelled eREC values in 2020 and 2030, the term over which the global target was set and endorsed by WHO member states at the 74th World Health Assembly (2021).[1] Additionally, we have presented the absolute difference between expected and target eREC for these countries; Ethiopia is forecast to have the worst eRECs among males and females in 2030 (27·8% and 24·6%, respectively) and Russia is forecast to have the best (87·6% and 85·1%, respectively).

Discussion

This report represents a substantial advance in the analysis of eREC globally and by region in terms of the number of data sources and the geographical distribution of available data. Our baseline report[13] included 169 studies

	2000		2020		2030 projected		2030 target*		Absolute difference between target and expected 2030 eREC		Percentage improvement in eREC between 2000 and 2020		Percentage improvement in eREC estimated between 2020 and 2030	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Bangladesh	39·6% (38·3–40·9)	36·0% (34·7–37·3)	54·7% (53·4–55·9)	50·7% (49·5–52·0)	62·4% (60·5–64·2)	58·5% (56·5–60·5)	94·7%	90·7%	37·5%	37·4%	38·1%	40·8%	4·7%	5·0%
Brazil	67·2% (65·8–68·6)	63·4% (61·9–64·9)	78·0% (76·9–79·0)	74·8% (73·7–75·9)	81·7% (80·3–82·9)	78·8% (77·3–80·2)	100·0%	100·0%	20·8%	23·8%	16·0%	18·0%	1·6%	1·8%
China	43·8% (42·5–45·0)	39·5% (38·2–40·7)	60·1% (58·8–61·3)	55·8% (54·6–57·0)	65·3% (63·5–67·1)	61·2% (59·2–63·0)	100·0%	100·0%	37·9%	42·1%	37·2%	41·4%	3·4%	3·7%
DR Congo	22·7% (20·8–24·4)	19·8% (18·2–21·4)	36·0% (33·7–38·3)	32·2% (30·1–34·5)	42·5% (39·6–45·5)	38·4% (35·7–41·3)	76·0%	72·2%	37·7%	37·8%	58·9%	62·7%	6·4%	6·7%
Egypt	51·0% (48·9–53·3)	46·5% (44·3–48·8)	69·2% (67·2–71·1)	65·2% (63·1–67·2)	74·8% (72·6–76·9)	71·2% (68·8–73·4)	100·0%	100·0%	28·8%	32·7%	35·6%	40·1%	2·8%	3·2%
Ethiopia	14·4% (13·0–16·0)	12·5% (11·2–13·9)	21·7% (19·9–23·6)	19·1% (17·4–20·8)	27·8% (25·5–30·3)	24·6% (22·5–26·8)	61·7%	59·1%	38·2%	38·4%	50·5%	51·9%	8·3%	8·5%
India	44·2% (42·9–45·5)	40·1% (38·9–41·4)	58·4% (57·1–59·7)	54·3% (52·9–55·5)	65·5% (63·5–67·3)	61·6% (59·5–63·5)	98·4%	94·3%	37·6%	37·5%	32·1%	35·3%	4·1%	4·5%
Indonesia	43·6% (42·3–44·8)	39·6% (38·3–40·8)	56·8% (55·7–58·0)	52·4% (51·2–53·5)	61·5% (59·6–63·4)	57·2% (55·3–59·0)	96·8%	92·4%	38·4%	38·3%	30·3%	32·3%	2·9%	3·2%
Japan	81·4% (80·3–82·4)	78·2% (77·1–79·4)	85·3% (84·5–86·1)	82·7% (81·8–83·7)	86·6% (85·5–87·6)	84·2% (82·9–85·4)	100·0%	100·0%	14·2%	16·7%	4·8%	5·7%	0·6%	0·7%
Mexico	68·6% (67·2–69·9)	65·0% (63·6–66·5)	77·3% (76·1–78·3)	74·2% (73·0–75·3)	80·0% (78·6–81·4)	77·2% (75·6–78·7)	100·0%	100·0%	21·8%	24·7%	12·7%	14·3%	1·3%	1·4%
Nigeria	21·1% (19·3–22·8)	18·5% (16·9–20·0)	31·8% (29·8–34·0)	28·4% (26·5–30·4)	38·7% (36·0–41·4)	34·9% (32·5–37·6)	71·8%	68·4%	37·9%	38·0%	51·1%	54·1%	6·7%	7·1%
Pakistan	40·2% (38·9–41·5)	36·6% (35·3–37·9)	54·3% (53·0–55·5)	50·2% (49·0–51·4)	72·7% (60·8–64·5)	58·6% (56·6–60·6)	94·3%	90·2%	37·2%	37·2%	34·9%	37·0%	5·2%	5·5%
Philippines	48·9% (47·4–50·3)	44·5% (43·2–45·9)	59·9% (58·8–61·1)	55·6% (54·4–56·7)	64·6% (62·7–66·4)	60·4% (58·5–62·2)	100·0%	95·6%	38·6%	38·5%	22·6%	24·8%	2·4%	2·7%
Russia	80·4% (78·9–82·0)	76·8% (75·0–78·5)	85·6% (84·5–86·7)	82·7% (81·5–84·0)	87·6% (86·4–88·7)	85·1% (83·7–86·4)	100·0%	100·0%	13·8%	16·5%	6·4%	7·8%	0·8%	0·9%
USA	80·5% (79·4–81·5)	77·4% (76·2–78·5)	84·0% (83·1–84·9)	81·5% (80·5–82·5)	85·1% (83·9–86·3)	82·7% (81·3–84·1)	100·0%	100·0%	15·7%	18·1%	4·3%	5·4%	0·4%	0·5%
Viet Nam	43·8% (42·5–45·0)	39·4% (38·1–40·6)	57·1% (56·0–58·3)	52·5% (51·3–53·6)	61·4% (59·5–63·2)	56·7% (54·8–58·5)	94·7%	92·5%	36·2%	38·6%	30·4%	33·3%	2·5%	2·8%

Data in parentheses are 95% CIs. The 2030 target[1] is given and the absolute difference between projected and target eREC also displayed. PVA=presenting visual acuity. eREC=effective refractive error coverage. *WHO member states endorsed the first-ever global target for refractive error at the 74th World Health Assembly (2021),[1] a 40 percentage-point increase in eREC by 2030. Additionally, the World Health Assembly recommended that countries with a baseline eREC of 60% or higher should strive for universal coverage.

Table 3: **Modelled distance PVA-based (6/12 threshold) crude eREC for 2023 (aged ≥50 years) for the 16 most populous countries of the world,[16] each with more than 100 million inhabitants**

(22 comprehensive studies and 147 RAABs) across 61 countries while this updated analysis has increased this to 237 (35 comprehensive studies and 202 RAABs) across 76 countries. Additionally, the statistical model has been strengthened by including an additional covariate derived by an expert elicitation process, which has presented the opportunity to report on eREC by country—an important output given that the 74th World Health Assembly set 2030 targets at the country level.

Globally, eREC was estimated to be 65·8% (95% CI 64·7–66.8) in 2023, with an approximate 5 percentage-point increase occurring per decade since 2000. This steady increase is to be welcomed, yet there is a need for acceleration in order to meet the 2030 target. Global efforts to address refractive error include the WHO SPECS 2030 Initiative (since 2024),[21] the Clear Vision Coalition (since 2019), and the ATscale partnership (since 2018). Additional activities to expand data coverage for eREC in 2024 and beyond include inclusion of the eREC indicator in the WHO NCD STEPS Survey in 2023;[22] the upcoming launch and targeted implementation of a new WHO Sensory Impairment Interventions Survey (SENSIIS): Study Manual in 2025; and the inclusion of near vision assessment in RAAB surveys (enabling estimation of eREC for near vision).

For more on the **Clear Vision Coalition** see http://tccv.org

For more on the **ATscale partnership** see https://atscalepartnership.org/about-atscale

At the super-region level, this updated analysis confirmed the highest levels of distance eREC in 2023 are in the high-income super-region (85·1% [95% UI 84·1–86·0] for males *vs* 83·0% [81·9–84·0] for females) and lowest in sub-Saharan Africa (29·9% [95% UI

27·9–32·0] for males *vs* 26·8% [24·9–28·8] for females). Ranked between these extremes, from highest to lowest eREC, are central Europe, eastern Europe and central Asia; Latin America and the Caribbean; North Africa and the Middle East; southeast Asia, east Asia and Oceania; and south Asia. Improvements in eREC over time are occurring in all super-regions. There remain multiple social and cultural determinants of distance eREC, one of these being sex, with significantly higher levels of eREC in males than in females for all super-regions. Possible policy measures to address this sex inequality could involve the setting and monitoring of equity goals: for example, ensuring at least 50% of recipients of spectacles are women. Additionally, tackling stigma through existing community structures and gender-sensitive eye care services (eg, female eye-care workers to increase comfort and uptake among women especially in conservative communities) might be of benefit.

In keeping with our baseline analysis, we observed the decline of distance eREC with increasing age above 50 years. Possible explanations for this decline include reduced access to eye care, high costs of optical services, and a perception that vision impairment is part of the normal ageing process and therefore does not warrant intervention. Possible policy measures to address this could include inclusion of spectacles within health services packages and insurance for vulnerable populations such as older people, integration of vision and eye screening into accessible programmes for the care of older people that include dispensing of affordable near vision spectacles and appropriate referral, and health promotion initiatives to raise awareness of the importance of regular eye examinations among high-risk population groups, such as older adults. Super-regions other than the high-income region where the increase in eREC between 2000 and 2023 was smaller included Latin America and the Caribbean, and central Europe, eastern Europe and central Asia; these areas might need more intervention and data surveillance.

Although the global and super-region analyses offer useful context for understanding temporal changes in eREC, the 2030 targets are set at the country level. We selected 16 most populous countries to model expected and target eREC in 2030. Although these countries only represent 63% of the global population, this analysis reveals considerable heterogeneity between these countries regarding the increase in eREC since 2000 and the gap that these countries need to close to achieve the 2030 target. For example, in Bangladesh we estimated that eREC had increased by 15·1 percentage points in males and 14·7 percentage points in females between 2000 and 2020, yet the target of 94·7% in males and 90·7% in females means that there is still a need to increase eREC by 37·5 percentage points in males and 37·4 percentage points in females, from 2023 values. Other countries, such as the USA, already have a relatively high eREC (84·0% in males and 81·5% in females in 2020). Since this exceeds a 60% eREC threshold, these countries are expected to strive for 100% coverage by 2030. This is a much smaller gap to close than Bangladesh, yet the much more modest percentage-point increase in eREC between 2000 and 2020 (3·5 percentage points in males and 4·1 percentage points in females) in the USA reinforces the need to also strengthen efforts to reach underserved populations in high-income countries. A level of caution must be exercised in interpreting these country-level data, given the heterogeneity of data sources and data sparsity in some countries and at different timepoints.

In addition to the global programmes mentioned above, studies involving unannounced standardised patients (actors trained to covertly pose as patients in a standardised manner while observing clinical techniques and services) in individual countries have shown suboptimal quality in prescribing and dispensing of spectacles: 57% of people in a study from Pakistan had only the spherical component of distance spectacles tested[23] and only 35% of the single-vision distance spectacles dispensed to those in a study from Cambodia met all quality components in both lenses.[24] Recommended improvements include establishing or reforming regulatory mechanisms to ensure optical services employ appropriately qualified staff and efforts to eliminate unnecessary prescriptions,[24] in addition to refining dispensing and refraction skills, and emphasising the importance of effective communication skills among eye care staff.[23] Countries that have a low likelihood of meeting the targets at the current pace could consider innovative alternate methods of addressing uncorrected or undercorrected refractive error such as social entrepreneurship models,[25] task shifting,[26] and integration of technology such as telerefraction.[27] Additionally, expediting changes to the long process of becoming certified in refraction and dispensing and allowing greater use of autorefraction could improve refractive error coverage. As an example of specific country-level interventions, Pakistan—a lower-middle-income country—has implemented a series of national eye-care plans over the past 20 years that have increased spectacle coverage and reduced vision impairment caused by uncorrected refractive error.[14] Another example is that of France, a high-income country, where full reimbursement of spectacles was introduced as part of universal health insurance in 2021–22. It is estimated that as a result the "rate of forgone optical aids decreased from 12% to 6%".[28]

Achievement of the eREC and effective cataract surgery coverage[3] 2030 targets is closely linked. For example, approximately a third of people identified from health surveys from 2003 to 2021 who had received cataract surgery did not have a good quality outcome.[14] The available evidence consistently suggests that a large proportion of these poor outcomes are due to residual uncorrected refractive error following surgery. Therefore, strengthening refractive error services will not only result in an improvement in eREC but should also result in a notable increase in effective cataract surgical coverage. Likewise, improving the quality of cataract surgery (especially the biometric quality) will also reduce the number of people in need of refractive services.

Strengths of this new analysis include the larger number of data sources but also the decision to include additional covariates in the model. Unfortunately, only education (years of schooling) could be incorporated due to collinearity of temporal trends in the other covariates or data sparsity and the absence of longitudinal data. Notably, approximately half the data sources that provided eREC at the 6/18 threshold could be used for the 6/12 threshold, due to differences in the study protocols.

Only 17% of studies in our dataset were nationally representative (42 of 237), with the remainder being subnational. And only six countries had nationally representative studies at two timepoints (USA, 2006 and 2007; Sierra Leone, 2011 and 2022; Palestine, 2008 and 2018; Laos, 2007 and 2017; Cambodia, 2007 and 2019; Bhutan 2009 and 2017), each with a different cohort at each timepoint. This places limitations on the statistical model, particularly when a more recent subnational study in a country, such as in a more deprived area, might give the impression of a reduction in eREC compared with a previous national or subnational study in a more wealthy region. This further emphasises the importance of performing high-quality nationally representative population-based studies in countries as a baseline and subsequent resampling, to more accurately assess change. Given that most countries will not have the resources to conduct national surveys, subnational studies should at least be done in a cross-section of locations to avoid localised successes or setbacks skewing results. Although the inclusion criteria for the literature review aimed to limit biases associated with individual studies, we acknowledge that such biases exist (appendix 4 pp 3–6) and we did not conduct risk-of-bias assessments at the individual study level. 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 super-regions that had very few data sources, such as central Europe, eastern Europe and central Asia.

None of the 16 countries with more than 100 million inhabitants are on track to achieve the eREC target set by the 74th World Health Assembly on the basis of modelled per-decade increase in eREC. We have reported country-level distance eREC for the first time and countries with the largest populations have wide variation in progress towards this goal. These findings highlight the importance of recognising the factors that contribute to low coverage of refractive error within countries. Increasing eREC by 40 percentage points in the landscape of an increasing number of people with refractive error (particularly myopia) requires a major paradigm shift in how refractive error services are delivered. Implementing programmes that target these disparities in the delivery of refractive correction is crucial to reduce the burden of vision impairment due to under-corrected or uncorrected refractive error for both distance and near vision.

Correction of refractive error is the safest, most efficient, and most economical intervention to improve daily vision quality for the majority of individuals affected by vision impairment worldwide, contributing to the achievement of five SDGs: reducing poverty and improvements in well-being, work productivity, education, and equity. This analysis serves as an important update on our progress towards 2030 and the targets endorsed by WHO member states.

Contributors

All authors had final responsibility for the decision to submit the manuscript for publication. No authors were prohibited from accessing the data. RRAB contributed to the methodology, data curation, formal analysis, project administration, and writing of the original draft. IHT, MVC, NGC, JR, KSN, TRF, MJB, AM, JMF, and TB contributed to the methodology and review and editing of the manuscript. MMB, JMF, FK, MH, YXW, LV, VN, MHE, AF, HH, RBK, SM, SRS, RG, GK, TB, RJC, AI, NG, RCK, LCL, SM, MHA, HY, TYW, PR, YCT, RV, NW, MHA, VC, XH, CC-G, LBE, AF, and NW provided comprehensive survey data. IM provided RAAB data and contributed to review and editing of the manuscript. TS, DAS, and SRF contributed to methodology and formal analysis. SK contributed to the conceptualisation, 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. The corresponding author (RRAB) had full access to all the data in the study and had final responsibility for the decision to submit the manuscript for publication.

Declaration of interests

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

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