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Global estimates on the number of people blind or visually impaired by Uncorrected Refractive Error: a meta-analysis from 2000 to 2020

Vision Loss Expert Group of the Global Burden of Disease Study* and the GBD 2019 Blindness and Vision Impairment Collaborators*

BACKGROUND: Uncorrected refractive error (URE) is a readily treatable cause of visual impairment (VI). This study provides updated estimates of global and regional vision loss due to URE, presenting temporal change for VISION 2020
METHODS: Data from population-based eye disease surveys from 1980–2018 were collected. Hierarchical models estimated prevalence (95% uncertainty intervals [UI]) of blindness (presenting visual acuity (VA) < 3/60) and moderate-to-severe vision impairment (MSVI; 3/60 ≤ presenting VA < 6/18) caused by URE, stratified by age, sex, region, and year. Near VI prevalence from uncorrected presbyopia was defined as presenting near VA < N6/N8 at 40 cm when best-corrected distance (VA ≥ 6/12).
RESULTS: In 2020, 3.7 million people (95%UI 3.10–4.29) were blind and 157 million (140–176) had MSVI due to URE, a 21.8% increase in blindness and 72.0% increase in MSVI since 2000. Age-standardised prevalence of URE blindness and MSVI decreased by 30.5% (30.7–30.3) and 2.4% (2.6–2.2) respectively during this time. In 2020, South Asia GBD super-region had the highest 50+ years age-standardised URE blindness (0.33% (0.26–0.40%)) and MSVI (10.3% (8.82–12.10%)) rates. The age-standardized ratio of women to men for URE blindness was 1.05:1.00 in 2020 and 1.03:1.00 in 2000. An estimated 419 million (295–562) people 50+ had near VI from uncorrected presbyopia, a +75.3% (74.6–76.0) increase from 2000
CONCLUSIONS: The number of cases of VI from URE substantively grew, even as age-standardised prevalence fell, since 2000, with a continued disproportionate burden by region and sex. Global population ageing will increase this burden, highlighting urgent need for novel approaches to refractive service delivery.

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INTRODUCTION

Uncorrected refractive error (URE) is the leading cause of vision impairment globally among both adults and children, and contributes to reduced educational and economic opportunities [1–6], decreased quality of life [7] and an increased burden of mortality [8–10]. Visual impairment is a significant global health concern and the financial burden with global productivity losses is estimated to be 411 billion US dollars annually [11]. URE is readily treated with spectacles, making it one of the most cost-effective healthcare interventions, alongside cataract surgery [12–15]. Thus, it is a global priority to improve access to refraction services [11], as set out in 'Towards universal eye health: Global Action Plan 2014–2019 of the World Health Assembly (WHA) in 2013 [16]. and more recently in the 'World Report on Vision' by the World Health Organisation (WHO) in 2019 [17], which called for the routine measurement of refractive error services coverage as a means to address the United Nations (UN) Sustainable Development Goals [18] target 3.8 to "achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all". Furthermore, these recommendations have been adopted in a resolution by the 73rd WHA member states in 2021, which set global targets for a 40% increase in effective refractive error coverage (eREC) by 2030. As we transition from the efforts of VISION 2020: the Right to Sight initiative to tackle avoidable blindness, these focused targets are fundamental to eliminate avoidable vision loss in future.

Refractive error is a common ocular condition which occurs throughout the lifespan [19], and chiefly falls into the following categories: myopia (affecting mostly distance vision), hyperopia (potentially causing impaired vision at distance and near), which may both be accompanied by an astigmatic component, and presbyopia (characterised by poor near vision). The last 20 years have seen rapid increases in the prevalence of myopia across the world, particularly in East Asia [20–23].

Nearly all individuals, even those without significant refractive error in childhood and earlier adult years will acquire presbyopia by the 5th decade of life, necessitating refractive correction for near work. Presbyopia occurs due to reduced flexibility of the human crystalline lens to accommodate (focus) on near targets, resulting in blurred near vision. It is an essentially universal phenomenon, with age of onset determined by factors such as the presence of latent hyperopia. Without refractive correction, vision deteriorates for near activities, resulting in near visual impairment. Where uncorrected hyperopia is common, due to

*Lists of authors and their affiliations appear at the end of the paper.

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lack of access to both education (which induces myopia [24]) and refractive services, the onset of presbyopia may even occur in the 30 s, which is a critical working age for those in industries such as garments and textiles [25, 26]. With an ageing global population, the burden of presbyopia and near visual impairment will increase. Coupled with the impact of the increased prevalence of myopia, the burden of URE is likely to grow in the future.

The Vision Loss Expert Group (VLEG) curate a comprehensive, continuously updated, online database of ophthalmic epidemiological data and have made important contributions to knowledge about the burden and causes of vision impairment and blindness globally [27–29]. These estimates have been used in the WHO Report on Vision in 2019 [17] and the recent Lancet Global Health commission on Global Eye Health Report [15]. Updated analyses are required to reflect rapidly increasing sources of new population data, and to monitor progress in reduction of avoidable sight loss. The need for new population data on vision impairment has been emphasised in a recent paper highlighting the grand challenge priorities for global eye health [30], and will be vital to monitor and measure success against the WHA global target of a 40% increase in eREC.

Thus, the aim of the current study is to provide updated estimates of the global burden of vision loss due to URE, disaggregated by sex, age, year and region, for the period from 2000 to 2020 covered by VISION 2020: The Right to Sight initiative. For the first time, temporal trends will be calculated to present the burden of visual impairment resulting from uncorrected presbyopia in those 50+ years.

METHODS

A systematic review of population-based studies of vision impairment and blindness published between Jan 1, 1980, and Oct 1, 2018, was carried out, which included grey literature sources. Eligible studies from this review were then combined with data from Rapid Assessment of Avoidable Blindness (RAAB) studies and finally, data from the US National Health and Nutrition Examination Survey and the WHO Study on Global Ageing and Adult Health were added. More detailed methods are published elsewhere [30, 31], and outlined below.

In total, the VLEG review identified 243 studies (73% were rapid studies) across 73 countries from which data relating to the contribution of URE to vision loss could be extracted: with 70 studies from the 2010 review [28], and a further 173 studies in an extension of the literature review to 2018 [29]. Studies were primarily national and subnational cross-sectional surveys. By the seven World Global Burden of Disease (GBD) super regions, 43 studies were from Sub-Saharan Africa, 100 from Southeast Asia, East Asia, and Oceania, 44 from South Asia, 16 from North Africa and the Middle East, 25 from Latin America and the Caribbean, 9 from High income, and 6 from Central Europe, Eastern Europe, and Central Asia. Additionally, the VLEG commissioned the preparation of 5-year age-disaggregated RAAB data from the RAAB repository. Studies were included if they met the following criteria: visual acuity data had to be measured using a test chart that could be mapped to the Snellen scale, and the sample had to be representative of the population. Studies based on self-report of vision loss were excluded. The International Classification of Diseases 11th edition [32] criteria for vision loss, as suggested by WHO, was employed, categorizing individuals according to vision in their better eye on presentation. This classification defines moderate vision loss as visual acuity of 6/60 or better but less than 6/18, severe vision loss as a visual acuity of 3/60 or better but less than 6/60, and blindness as visual acuity of less than 3/60 or less than 10° visual field around central fixation (although the visual field definition is rarely used in population-based eye surveys). Moderate and severe visual impairment (MSVI) was combined to present prevalence data. Vision impairment from uncorrected presbyopia was defined as presenting near vision of worse than <N6 or <N8 at 40 cm where best-corrected distance visual acuity was 6/12 or better. Prevalence of near VI from uncorrected presbyopia was based on 25 studies.

The global and regional prevalence and burden of blindness and MSVI due to URE were gathered from the all-cause meta-analysis and modelling. First, we separated raw data into datasets including so-called vision loss envelopes (see Flaxman et al. [28]. for explanation) for all-cause mild, moderate, and severe vision loss, and blindness. Data were input into a mixed-effects meta-regression tool developed by the Institute for Health Metrics and Evaluation and called MR-BRT (meta-regression; Bayesian; regularised; trimmed) [33]. Presenting vision impairment was the reference definition for each level of severity. Prevalence data for URE were extracted directly where available and otherwise calculated by subtracting best-corrected vision impairment from presenting vision impairment prevalence for each level of severity in studies that reported both measures for a given location, sex, age group, and year. All other causes were quantified as part of the best-corrected estimates of vision impairment at each level of severity.

We modelled distance vision impairment and blindness attributable to the following causes: cataract, URE, age-related macular degeneration, myopic macular degeneration, glaucoma, diabetic retinopathy, and other causes of vision impairment (in aggregate).

We produced location-, year-, age-, and sex-specific estimates of MSVI and blindness using Disease Modelling Meta-Regression (Dismod-MR) 2.1 [34]. The details of the data processing steps are described elsewhere [29]. Briefly, Dismod-MR 2.1 models were run for all vision impairment stratified by severity (moderate, severe, blindness) regardless of cause and, separately, for MSVI and blindness due to each modelled cause of vision impairment. Then, models of MSVI due to specific causes were split into moderate and severe vision loss estimates using the ratio of overall prevalence in the all-cause moderate presenting vision impairment and severe presenting vision impairment models. Next, prevalence estimates for all causes stratified by severity were scaled to the models of all-cause prevalence by severity. This produced final estimates by age, sex, year, and location for each individual cause of vision impairment stratified by severity, including refractive error. Model projection was to the year 2020, coincident with the end of VISION 2020: the Right to Sight initiative, and estimates were age-standardised using the GBD standard population [35]. All generated estimates for visual impairment due to URE are accompanied by 95% uncertainty intervals (UI), which represent the 25th and 975th ordered estimates of 1000 draw estimates of the posterior distribution. We considered estimates to be significantly different if the 95% UIs did not overlap. Data are presented for the total population and also for individuals aged 50+ years, as data sources such as RAAB surveys are major sources of data for low-income and low- or middle-income countries (LICs and LMICs) and these surveys are conducted on individuals aged 50 years and older. The data estimates reported in this study were produced in compliance with the Guidelines for Accurate and Transparent Health Estimates Reporting [36].

Data are presented for the seven World super-regions based on the GBD regional classification system [37], and sub-divided into the 21 GBD world regions. These seven super regions are drawn together based on two criteria: epidemiological similarity and geographic proximity.

RESULTS

We used 243 data sources from 73 countries to calculate the global and regional prevalence and burden of blindness and MSVI due to URE. Table 1 presents the number of people, men and women, with blindness (<3/60) or MSVI (<6/18 to >/=3/60) due to URE in 2020 in the seven super-regions based on the GBD classification system. Appendix 1 contains supplementary tables for all 21 GBD world regions in 2020. These estimates reveal that in 2020, 3.70 million people (95% UI 3.10–4.29 million) in the world were blind and 157 million (95% UI 140–175 million) had MSVI due to URE. Focusing on those 50+ years of age, 2.29 million people (95% UI 1.79–2.80 million) were blind due to URE globally and 86.1 million (95% UI 74.2–101 million) had MSVI.

As a percentage of all types of blindness, the burden of blindness due to URE globally is 8.60% (95% UI 7.22–9.99%) and is greatest for the super regions of South Asia (12.71%, 95% UI 10.58–14.82%) and Southeast Asia, East Asia and Oceania (9.34%, 95% UI 7.67–10.94%). These updated data estimate that URE is the leading cause of MSVI globally, accounting for 53.39% (95% UI 47.56–59.51%) of all cases. Focusing on blindness due to URE in those aged 50+ years, South Asia accounts for the largest age-standardised prevalence (0.33% (95% UI 0.26–0.40%)), followed by the super-regions of Southeast Asia, East Asia and Oceania (0.15% (95% UI 0.12–0.18%)) and Sub-Saharan Africa (0.11% (95% UI 0.09–0.14%)).

Table 1. Number and age-standardised prevalence of people with blindness (<3/60) or MSVI (<6/18 to >/=3/60) due to URE in 7 Super Regions in 2020.

	GLOBAL	Central Europe, Eastern Europe, and Central Asia	High income	Latin America and Caribbean	North Africa and Middle East	South Asia	Southeast Asia, East Asia, and Oceania	Sub-Saharan Africa
Total population 2020 (thousands)	7,890,000	417,000	1,090,000	602,000	632,000	1,840,000	2,190,000	1,110,000
Number of people with blindness (thousands)	**3700 (3100–4290)**	**29.4 (23.3–36.0)**	**80.0 (63.6–97.6)**	**218 (180–258)**	**190 (156–229)**	**1520 (1260–1770)**	**1410 (1150–1650)**	**254 (212–303)**
Number of Men with blindness (thousands)	1750 (1480–2020)	13.7 (10.8–17.1)	36.9 (29.1–44.8)	96.1 (78.6–114)	90.4 (73.6–109)	728 (606 –847)	657 (539–769)	123 (102–146)
Number of Women with blindness (thousands)	1950 (1620–2280)	15.7 (12.4–19.2)	43.1 (34.6–52.3)	122 (101–144)	99.8 (81.8–120)	789 (658–925)	750 (616–879)	132 (110–157)
Number of people with blindness aged 50+ years (thousands)	**2290 (1790–2800)**	**16.8 (12.8–21.1)**	**46.1 (35.7–56.9)**	**126 (97.5–153)**	**84.2 (63.8–103)**	**976 (762–1190)**	**933 (728–1140)**	**111 (84.5–136)**
Number of Men with blindness aged 50+ years (thousands)	1050 (816–1270)	7.05 (5.27–8.88)	21.1 (16.2–26.1)	53.8 (41.3–65.7)	39.3 (29.6–48.3)	459 (358–558)	415 (325–509)	52.5 (40.2–65.0)
Number of Women with blindness aged 50+ years (thousands)	1250 (975 –1520)	9.76 (7.35–12.4)	25.0 (19.3–30.9)	72.5 (56.4–87.6)	44.9 (34.1–55.3)	517 (402–633)	518 (406–632)	58.2 (44.3–71.9)
Age-standardised prevalence of blindness	**0.04% (0.04–0.05)**	**0.01% (0.00–0.01)**	**0.01% (0.00–0.01)**	**0.04% (0.03–0.04)**	**0.03% (0.03–0.04)**	**0.10% (0.08–0.12)**	**0.05% (0.04–0.06)**	**0.04% (0.03–0.04)**
Age-standardised prevalence of blindness: Men	0.04% (0.04–0.05)	0.01% (0.00–0.01)	0.01% (0.00–0.01)	0.03% (0.03–0.04)	0.03% (0.03–0.04)	0.10% (0.08–0.11)	0.05% (0.04–0.06)	0.04% (0.03–0.05)
Age-standardised prevalence of blindness: Women	0.05% (0.04–0.05)	0.01% (0.00–0.01)	0.01% (0.00–0.01)	0.04% (0.03–0.04)	0.04% (0.03–0.04)	0.10% (0.09–0.12)	0.06% (0.05–0.06)	0.04% (0.03–0.04)
Age-standardised prevalence of blindness 50+ years	**0.12% (0.10–0.15)**	**0.01% (0.01–0.02)**	**0.01% (0.01–0.01)**	**0.09% (0.07–0.11)**	**0.09% (0.07–0.11)**	**0.33% (0.26–0.40)**	**0.15% (0.12–0.18)**	**0.11% (0.09–0.14)**
Age-standardised prevalence of blindness in Men 50+ years	0.12% (0.09–0.14)	0.01% (0.01–0.02)	0.01% (0.01–0.01)	0.09% (0.07–0.11)	0.08% (0.06–0.10)	0.32% (0.25–0.38)	0.14% (0.11–0.17)	0.12% (0.09–0.14)
Age-standardised prevalence of blindness in Women 50+ years	0.13% (0.10–0.15)	0.01% (0.01–0.01)	0.01% (0.01–0.01)	0.10% (0.08–0.12)	0.09% (0.07–0.12)	0.34% (0.27–0.42)	0.16% (0.12–0.19)	0.11% (0.09–0.14)
Percentage of all blindness	**8.60% (7.22–9.99)**	**2.07% (1.64–2.54)**	**2.66% (2.11–3.24)**	**5.96% (4.92–7.04)**	**6.15% (5.03–7.40)**	**12.71% (10.58–14.82)**	**9.34% (7.67–10.94)**	**5.00% (4.17–5.96)**
Number of people with MSVI (thousands)	**157,000 (140,000–176,000)**	**9660 (8560–10,900)**	**17,100 (15,200–18,900)**	**14,700 (13,000–16,300)**	**12,800 (11,400–14,400)**	**53,900 (47,800–60,900)**	**39,700 (35,400–44,600)**	**9620 (8480–10,900)**
Number of Men with MSVI (thousands)	73,300 (65,400–81,900)	3830 (3380–4310)	8240 (7300–9150)	6550 (5820–7300)	6380 (5660–7120)	25,600 (22,700–28,900)	18,200 (16,200–20,400)	4520 (3970–5120)
Number of Women with MSVI (thousands)	84,100 (74,900–93,900)	5830 (5180–6600)	8850 (7900–9810)	8140 (7180–9070)	6460 (5740–7240)	28,200 (25,000–31,900)	21,500 (19,200–24,200)	5100 (4500–5760)

Table 1. continued

	GLOBAL	Central Europe, Eastern Europe, and Central Asia	High income	Latin America and Caribbean	North Africa and Middle East	South Asia	Southeast Asia, East Asia, and Oceania	Sub-Saharan Africa
Number of people with MSVI aged 50+ years (thousands)	**86,100 (74,200–101,000)**	**6340 (5400–7480)**	**8940 (7680–10,400)**	**5780 (4950–6780)**	**4680 (3960–5550)**	**32,150 (27,500–37,900)**	**25,050 (21,500–29,300)**	**3210 (2730–3800)**
Number of Men with MSVI aged 50+ years (thousands)	39,000 (33,600–45,810)	2270 (1920–2710)	3720 (3200–4310)	2610 (2240–3070)	2280 (1900–2690)	15,600 (13,300–18,400)	11,100 (9550–13,100)	1480 (1260–1750)
Number of Women with MSVI aged 50+ years (thousands)	47,100 (40,600–55,200)	4070 (3470–4780)	5220 (4490–6010)	3170 (2720–3710)	2400 (2030–2840)	16,600 (14,200–19,500)	13,900 (12,000–16,200)	1730 (1470–2050)
Age-standardised prevalence of MSVI	**1.91% (1.71–2.13)**	**1.85% (1.65–2.06)**	**1.37% (1.21–1.53)**	**2.39% (2.12–2.65)**	**2.24% (2.00–2.50)**	**3.37% (2.99–3.81)**	**1.60% (1.43–1.78)**	**1.24% (1.10–1.38)**
Age-standardised prevalence of MSVI: Men	1.83% (1.63–2.04)	1.69% (1.50–1.88)	1.41% (1.25–1.60)	2.22% (1.97–2.46)	2.17% (1.93–2.42)	3.25% (2.89–3.65)	1.49% (1.33–1.66)	1.21% (1.08–1.35)
Age-standardised prevalence of MSVI: Women	2.00% (1.78–2.23)	1.98% (1.76–2.22)	1.31% (1.16–1.47)	2.56% (2.27–2.86)	2.32% (2.07–2.59)	3.51% (3.11–3.97)	1.70% (1.52–1.90)	1.27% (1.12–1.42)
Age-standardised prevalence of MSVI 50+ years	**4.58% (3.96–5.37)**	**4.51% (3.85–5.31)**	**1.94% (1.67–2.25)**	**4.28% (3.68–5.00)**	**4.73% (4.02–5.54)**	**10.28% (8.82–12.06)**	**3.94% (3.39–4.56)**	**3.16% (2.73–3.70)**
Age-standardised prevalence of MSVI in Men 50+ years	4.41% (3.80–5.16)	3.97% (3.41–4.70)	1.80% (1.55–2.10)	4.21% (3.62–4.92)	4.57% (3.88–5.36)	10.19% (8.74–11.89)	3.66% (3.16–4.26)	3.13% (2.70–3.65)
Age-standardised prevalence of MSVI in Women 50+ years	4.75% (4.09–5.56)	4.89% (4.18–5.76)	2.05% (1.76–2.38)	4.35% (3.74–5.09)	4.88% (4.14–5.72)	10.40% (8.93–12.18)	4.19% (3.62–4.87)	3.19% (2.74–3.74)
Percentage of all MSVI	**53.39% (47.56–59.51)**	**53.69% (47.61–60.63)**	**55.00% (49.02–60.95)**	**60.00% (53.21–66.69)**	**58.76% (52.21–65.72)**	**55.99% (49.64–63.32)**	**47.84% (42.61–53.69)**	**47.06% (41.49–53.29)**

Data are presented for the whole population (bold), by sex breakdown and for those 50+ years. Figures in parentheses reflect 95% uncertainty intervals. Count data are presented to three significant figures, and percentages to two decimal places.

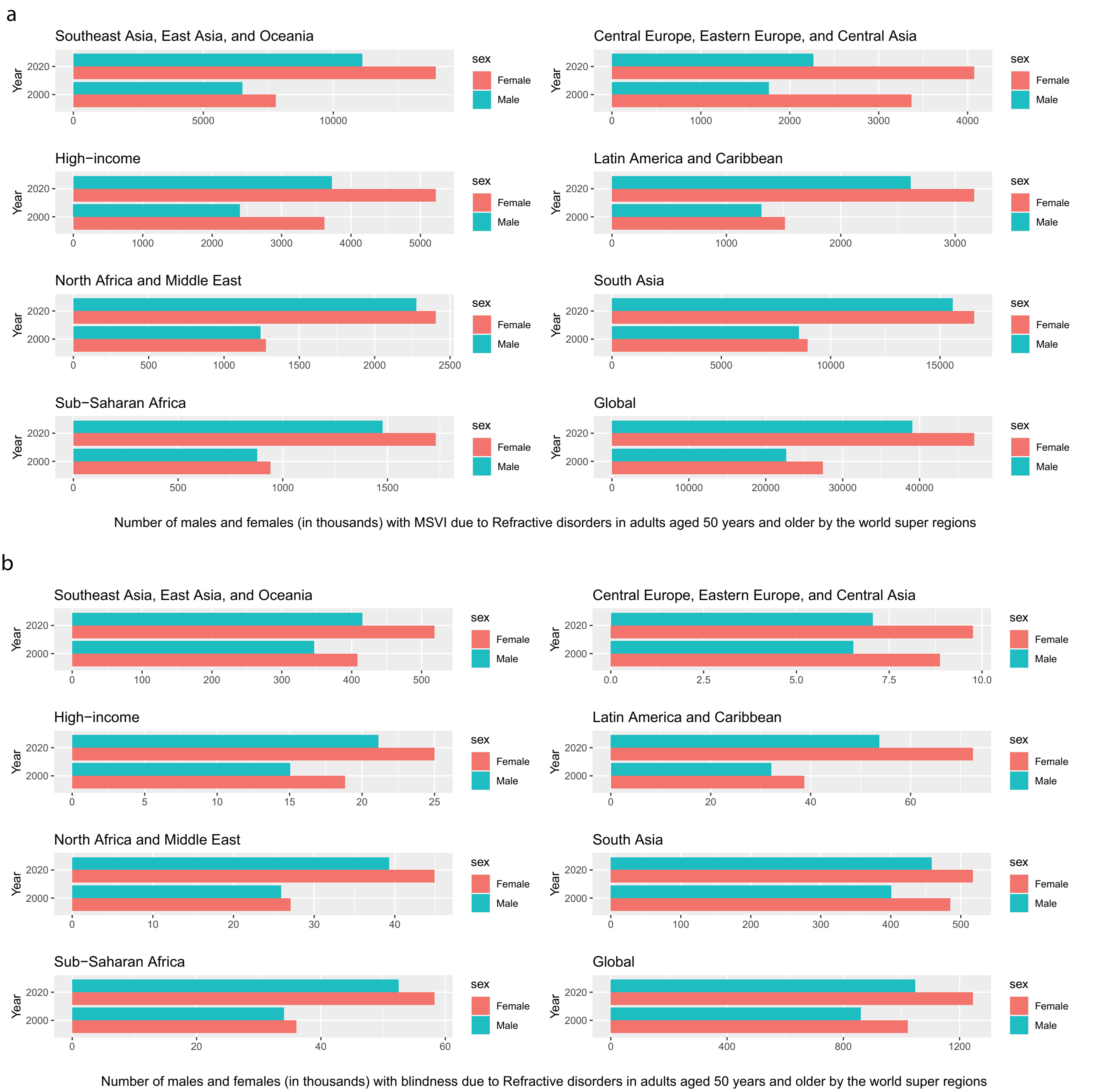

Fig. 1 Bar charts demonstrating the number of men and women with blindness and MSVI due to URE in 2000 and 2020 by seven World GBD super-regions and globally. a indicates numbers for MSVI and **b** blindness. Note that scales (values should be multiplied by 1000) are not the same between charts, but rather serve to highlight the differences across the time period and sex differences within GBD super-regions.

The overall age-standardised prevalence of blindness due to URE in those aged 50+ years was 0.12% (95% UI 0.10–0.15%), and 4.58% for MSVI (95% UI 3.96–5.37%). Figure 1 shows the number of men and women aged 50+ years with blindness and MSVI due to URE in 2020 in the seven World GBD super regions, and includes the global total for overall comparison. Figure 2 presents the crude prevalence of blindness and MSVI due to URE in 2020 across super regions.

Table 2 presents the percentage change in crude prevalence of MSVI and blindness due to URE in men and women aged 50 years and older between 2000 and 2020 for the seven World GBD super regions (see Appendix 1 for all 21 GBD World regions). Over this time period the number of cases of blindness and MSVI increased by +21.8% and +72.0%% respectively, with the greatest increase in the Latin America and Caribbean super-region for both blindness and MSVI. However, the age-standardised prevalence of URE blindness in those 50+ years decreased significantly, by −30.5% (95% UI −30.7 to −30.3) during this time period. The global age-standardised prevalence of MSVI due to URE in those aged 50+ years modestly decreased by −2.4% (95% UI −2.6 to −2.2%) between 2000 and 2020, but with some regional variations. The Latin America and Caribbean super-region demonstrated a slight increase in age-standardised prevalence of MSVI due to URE of +0.8% (95% UI + 0.7 to +1.0%), and the High-Income super-region had no change (+0.1%, 95% UI −0.1 to +0.3).

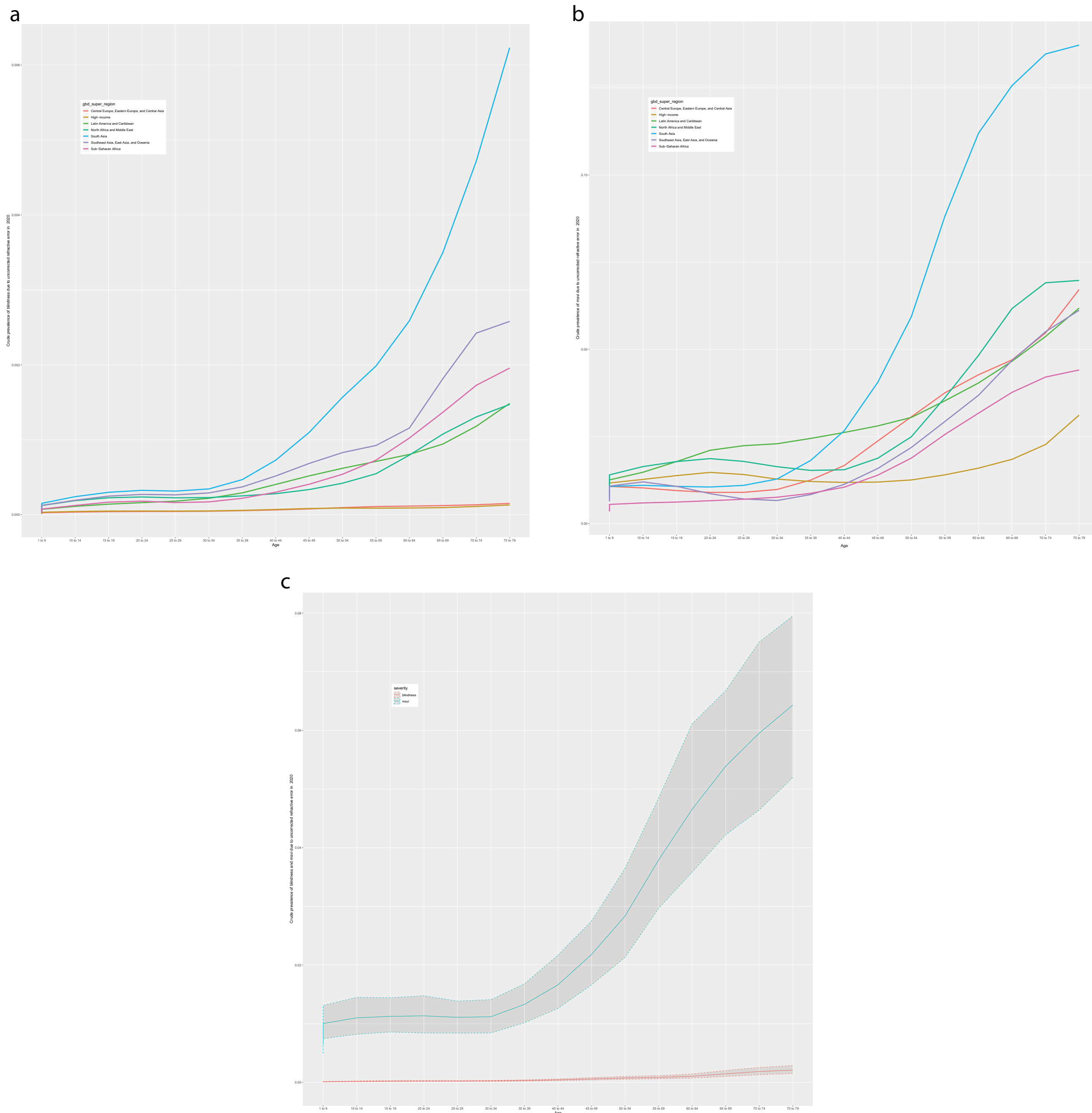

Fig. 2 Crude prevalence of blindness and MSVI due to URE by region and globally by age. **a** Crude prevalence of blindness due to URE in 2020 by seven World GBD super regions by age. **b** Crude prevalence of MSVI due to URE in 2020 by seven World GBD super regions by age. **c** Crude prevalence of Blindness (red) and MSVI (cyan) due to URE in 2020 globally by age, with 95% UI indicated as shading.

By a clear margin, South Asia had the highest regional 50+ years age-standardised URE blindness and MSVI prevalence in 2020 (blind: 0.3%, 95% UI 0.3–0.4; MSVI: 10.3%; 95% UI 8.8–12.1%) (Table 1), but also demonstrated the greatest reductions in age-standardised URE blindness between 2000 and 2020 (−46.3% (95% UI −46.5 to −46.2%)) (Table 2).

Globally, the age-standardized ratio of women to men for URE blindness was 1.05:1.00 in 2020 and 1.03:1.00 in 2000. For MSVI, this ratio was 1.08:1.00 in 2020 and 1.06:1.00 in 2000. Thus, in 2020, women continue to suffer an excess burden, with the age-standardized prevalence of women exceeding that of men by 4.76% for URE blindness and 7.40% for URE MSVI. Men exhibited a greater 20-year reduction in age-standardised prevalence compared to women for both blindness and MSVI: MSVI −3.0% (95% UI −3.1 to −2.8) in men, −2.0% (95% UI −2.2 to −1.8) in women; blindness −31.6% (95% UI −31.8 to −31.4) in men, −29.9% (95% UI −30.0 to −29.7) in women. Regionally, women have made smaller gains than men in the reduction of age −standardised prevalence of MSVI due to URE, particularly in the super regions of Central Europe, Eastern Europe and Central Asia, North Africa and Middle East, and Latin America and Caribbean. In the High-Income super-region, age-standardised prevalence of blindness has actually increased modestly for woman at +1.0% (95% UI 0.8 to 1.2%) compared to men −0.1% (95% UI −0.3 to 0.0). However, it is notable that in South Asia, there has been a greater reduction in age-standardised prevalence of both

Table 2. Percentage change in crude prevalence, case number and age-standardised prevalence of MSVI and blindness due to URE in adults aged 50 years and older in the 7 Super Regions between 2000 and 2020.

	MSVI caused by URE									Blindness caused by URE								
	Percentage change in Crude Prevalence between 2000 and 2020			Percentage Change in Number of Cases between 2000 and 2020			Percentage Change in Age-standardised prevalence between 2000 and 2020			Percentage Change in Crude Prevalence between 2000 and 2020			Percentage Change in Number of Cases between 2000 and 2020			Percentage Change in Age-standardised prevalence between 2000 and 2020		
Region	Men	Women	**Both**	Men	Women	**Both**	Men	Women	**Both**	Men	Women	**Both**	Men	Women	**Both**	Men	Women	**Both**
GLOBAL	−2.2% (−2.4 to −2.0)	−2.3% (−2.5 to −2.1)	**−2.3% (−2.5 to −2.1)**	+72.5% (72.2 to 72.8)	+71.6% (71.3 to 71.9)	**+72.0% (71.7 to 72.3)**	−3.0% (−3.1 to −2.8)	−2.0% (−2.2 to −1.8)	**−2.4% (−2.6 to −2.2)**	−31.0% (−31.2 to −30.8)	−30.6% (−30.8 to −30.5)	**−30.8% (−31.0 to −30.6)**	+21.7% (21.4 to 22.1)	+21.9% (21.6 to 22.2)	**+21.8% (21.5 to 22.2)**	−31.6% (−31.8 to −31.4)	−29.9% (−30.0 to −29.7)	**−30.5% (−30.7 to −30.3)**
Central Europe, Eastern Europe & Central Asia	−1.1% (−1.3 to −0.9)	−2.2% (−2.4 to −2.0)	**−2.1% (−2.3 to −1.9)**	+28.3% (28.1 to 28.6)	+21.0% (20.7 to 21.2)	**+23.5% (23.3 to 23.7)**	−2.3% (−2.5 to −2.1)	−2.3% (−2.5 to −2.2)	**−2.8% (−2.9 to −2.6)**	−16.8% (−17.0 to −16.5)	−11.1% (−11.4 to −10.8)	**−13.5% (−13.8 to −13.2)**	+8.0% (7.6 to 8.3)	+10.0% (9.7 to 10.4)	**+9.2% (8.8 to 9.5)**	−17.4% (−17.8 to −17.5)	−10.7% (−10.4 to −11.1)	**−13.8% (−14.1 to −14.4)**
High Income	+5.3% (5.1 to 5.5)	+3.6% (3.4 to 3.8)	**+4.0% (3.8 to 4.2)**	+55.0% (54.7 to 55.2)	+44.3% (44.1 to 44.6)	**+48.6% (48.3 to 48.8)**	−0.1% (−0.3 to 0.0)	+1.0% (0.8 to 1.2)	**+0.1% (−0.1 to 0.3)**	−4.6% (−4.9 to −4.3)	−4.6% (−4.9 to −4.4)	**−4.7% (−4.9 to −4.4)**	+40.4% (40.0 to 40.8)	+32.9% (32.5 to 33.2)	**+36.2% (35.8 to 36.6)**	−7.9% (−8.2 to −7.7)	−6.9% (−7.1 to −6.8)	**−7.2% (−7.5 to −7.0)**
Latin America and Caribbean	+1.4% (1.2 to 1.6)	+2.3% (2.1 to 2.5)	**+1.9% (1.8 to 2.1)**	+99.8% (99.4 to 100.2)	+109.4% (109.1 to 109.8)	**+105.0% (104.6 to 105.4)**	+0.4% (0.2 to 0.5)	+1.2% (1.0 to 1.4)	**+0.8% (0.7 to 1.0)**	−15.0% (−15.2 to −14.8)	−8.5% (−8.7 to −8.3)	**−11.3% (−11.5 to −11.1)**	+67.5% (67.1 to 68.0)	+87.3% (86.8 to 87.8)	**+78.3% (77.9 to 78.8)**	−15.9% (−16.1 to −15.7)	−10.4% (−10.6 to −10.1)	**−12.7% (−12.9 to −12.5)**
North Africa and Middle East	−11.8% (−12.0 to −11.6)	−9.6% (−9.8 to −9.4)	**−10.7% (−10.9 to −10.5)**	+83.2% (82.9 to 83.6)	+88.1% (87.8 to 88.5)	**+85.7% (85.4 to 86.1)**	−9.0% (−9.2 to −8.8)	−8.1% (−8.3 to −7.9)	**−8.5% (−8.7 to −8.3)**	−27.0% (−27.2 to −26.8)	−20.2% (−20.5 to −20.0)	**−23.5% (−23.8 to −23.3)**	+51.7% (51.3 to 52.2)	+66.0% (65.5 to 66.4)	**+59.0% (58.5 to 59.5)**	−23.2% (−23.4 to −23.0)	−18.3% (−18.5 to −18.1)	**−20.7% (−20.9 to −20.5)**
South Asia	−3.3% (−3.5 to −3.2)	−8.5% (−8.7 to −8.3)	**−5.9% (−6.1 to −5.7)**	+82.4% (82.1 to 82.8)	+85.0% (84.7 to 85.4)	**+83.8% (83.4 to 84.1)**	−4.3% (−4.5 to −4.1)	−8.9% (−9.1 to −8.8)	**−6.7% (−6.8 to −6.5)**	−39.4% (−39.5 to −39.2)	−47.2% (−47.4 to −47.1)	**−43.6% (−43.7 to −43.4)**	+14.5% (14.2 to 14.8)	+6.7% (6.4 to 7.0)	**+10.2% (9.9 to 10.5)**	−42.1% (−42.2 to −41.9)	−50.0% (−50.2 to −49.9)	**−46.3% (−46.5 to −46.2)**
Southeast Asia, East Asia and Oceania	−13.5% (−13.7 to −13.4)	−12.2% (−12.3 to −12.0)	**−12.7% (−12.8 to −12.5)**	+71.0% (70.7 to 71.3)	+79.2% (78.9 to 79.5)	**+75.5% (75.1 to 75.8)**	−14.9% (−15.1 to −14.8)	−12.3% (−12.5 to −12.2)	**−13.5% (−13.7 to −13.4)**	−39.4% (−39.5 to −39.2)	−37.8% (−37.9 to −37.6)	**−38.4% (−38.6 to −38.3)**	+19.9% (19.6 to 20.2)	+27.0% (26.6 to 27.3)	**+23.7% (23.4 to 24.0)**	−39.8% (−39.9 to −39.6)	−37.6% (−37.8 to −37.5)	**−38.8% (−38.9 to −38.6)**
Sub−Saharan Africa	−4.9% (−5.1 to −4.7)	−5.2% (−5.3 to −5.0)	**−4.9% (−5.1 to −4.7)**	+68.3% (68.0 to 68.6)	+84.0% (83.6 to 84.4)	**+76.4% (76.1 to 76.8)**	−3.7% (−3.8 to −3.5)	−3.3% (−3.5 to −3.1)	**−3.4% (−3.5 to −3.2)**	−12.8% (−13.0 to −12.6)	−16.7% (−17.0 to −16.5)	**−14.8% (−15.1 to −14.6)**	+54.3% (53.8 to 54.7)	+61.5% (61.1 to 62.0)	**+58.0% (57.6 to 58.4)**	−10.6% (−10.8 to −10.4)	−14.0% (−14.2 to −13.7)	**−12.5% (−12.7 to −12.2)**

Percentage change to 1 decimal place and figures in parentheses reflect 95% uncertainty intervals. Data in bold indicate totals for both sexes.

Table 3. Number and age-standardised prevalence of people with uncorrected presbyopia aged 50+ years (>N6/N8 at 40 cm when best-corrected distance visual acuity was 6/12 or better) in 7 Super Regions in 2020.

	GLOBAL	**Central Europe, Eastern Europe, and Central Asia**	**High income**	**Latin America and Caribbean**	**North Africa and Middle East**	**South Asia**	**Southeast Asia, East Asia, and Oceania**	**Sub-Saharan Africa**
Total population 2020 (thousands)	7,890,000	417,000	1,090,000	602,000	632,000	1,840,000	2,190,000	1,110,000
Number of people with uncorrected presbyopia (aged 50+ years) (thousands)	**419,000 (295,000–562,000)**	**39,800 (28,300–53,500)**	**11,400 (7700–15,900)**	**24,910 (17,600–33,600)**	**12,200 (8410–16,800)**	**124,000 (86,600–166,000)**	**169,000 (118,000–227,000)**	**37,800 (27,200–49,700)**
Number of Men with uncorrected presbyopia (thousands)	186,000 (130,000–251,000)	14,500 (10,200–19,600)	5020 (3400–6970)	11,200 (7820–15,100)	5800 (3900–8020)	57,900 (40,500–78,300)	75,000 (52,000 to 102,000)	17,000 (12,200–22,400)
Number of Women with uncorrected presbyopia (thousands)	233,000 (164,000–311,000)	25,300 (18,200–33,900)	6350 (4300–8900)	13,700 (9700–18,500)	6440 (4470–8770)	66,300 (46,310 to 88,100)	93,700 (66,000–125,000)	20,700 (15,000 to 27,200)
Age-standardised prevalence of uncorrected presbyopia	**22.33% (15.81–29.91)**	**27.81% (19.89–37.41)**	**2.37% (1.59–3.31)**	**18.85% (13.33–25.38)**	**13.18% (9.23–17.89)**	**38.89% (28.30–53.17)**	**26.63% (18.81–35.78)**	**37.54% (27.33–49.08)**
Age-standardised prevalence of uncorrected presbyopia: Men	21.11% (14.92–28.29)	25.89% (18.51–34.58)	2.35% (1.57–3.28)	18.66% (13.19–25.16)	12.60% (8.72–17.27)	37.78% (26.71–50.35)	24.71% (17.51–33.29)	36.30% (26.31–47.28)
Age-standardised prevalence of uncorrected presbyopia: Women	23.43% (16.52–31.36)	29.10% (20.93–39.08)	2.38% (1.60–3.33)	19.01% (13.44–25.69)	13.74% (9.66–18.68)	41.93% (29.63–55.68)	28.36% (19.94–38.00)	38.62% (28.12–50.22)

Data in parentheses are 95% uncertainty intervals. Count data are presented to three significant figures, and percentages to two decimal places. Data in bold indicate totals for both sexes.

blindness and MSVI for women compared to men (percentage reduction blindness; women −50.0% (95% UI −50.2 to −49.9), men −42.1% (95% UI −42.2 to −41.9): percentage reduction MSVI; women −8.9% (95% UI −9.1 to −8.8), men −4.3% (95% UI −4.5 to −4.1)), although the burden remains substantial.

Table 3 presents the number of people, men and women with near VI from uncorrected presbyopia in the seven super regions. In 2020, an estimated 419 million (95% UI 295–562 million) people aged 50+ had near VI from uncorrected presbyopia globally, with an age-standardised prevalence of 22.3% (95% UI 15.8–29.9%). Approximately 70% of global near VI from presbyopia occurred in two super regions: South Asia and Southeast Asia, East Asia and Oceania (293 million).

Table 4 presents the percentage change in crude prevalence of near VI due to uncorrected presbyopia in men and women aged 50 years and older between 2000 and 2020. Over this time period, the number of cases of near VI due to presbyopia increased substantially (+75.3% (95% UI + 74.6 to +76.0)), while the crude prevalence demonstrated a modest reduction for men (−1.8% (95% UI −2.2 to −1.4%)), but an increase of +0.8% (95% UI 0.4–1.2%) for women. Figure 3 further illustrates these sex differences across super regions, demonstrating significant increases in the number of cases in the 20-year period, with a disproportionate increase for women. The number of cases of near VI due to presbyopia increased in all super regions, ranging from 25.5% (95% UI + 25.0 to +25.9%) in Central Europe, Eastern Europe, and Central Asia to 101% (95% UI + 100.2 to +101.7%) in Latin America and Caribbean super-region. However, the percentage change in crude prevalence decreased in all super regions over the 20-year period except for the High-Income super-region which had a +4.3% (95% UI + 3.9 to +4.7) increase.

DISCUSSION

This study provides up-to-date global and regional, sex-specific and age-specific estimates and temporal trends for vision impairment due to URE, both for distance and near vision impairment. Our study reveals that URE remains a leading cause of MSVI, affecting 157 million individuals worldwide in 2020, and MSVI due to URE accounts for 57% of all MSVI globally. Notably, although there is some variation across the super regions, the percentage of MSVI due to URE remains above 47% in all areas, underscoring the persistent and substantial global burden of avoidable vision loss caused by URE.

In the 20-year period up to 2020, VISION 2020: the Right to Sight initiative sought to prevent avoidable sight loss, and the subsequent Global Action Plan adopted by the WHA in 2013 set a target for a 25% reduction in the prevalence of avoidable vision impairment by 2019 from the baseline of 2010. While progress in reducing the global burden has been made, this target was not achieved [29], highlighting the need for continued focus and effort to eliminate avoidable sight loss.

Encouragingly, the age-standardised prevalence of blindness due to URE in those aged 50+ years has decreased substantially from 2000 to 2020, potentially reflecting the targeted efforts countries have adopted to tackle severe sight loss. This may in part be explained by the increased use of intra-ocular lenses in cataract surgery over the last 20–30 years, leading to a reduction in blindness due to aphakia [38]. In contrast, the age-standardised prevalence of MSVI due to URE in those aged 50+ years only decreased modestly between 2000 and 2020.

The reductions we observed in age-standardised prevalence are counterbalanced by a striking increase in the unadjusted burden of blindness and MSVI due to URE, meaning that the total number of affected persons in the world has risen. This is driven by two key factors: continued global population growth, which is estimated to reach 10.4 billion in 2100, and an ageing population [39]. In common with the majority of vision-impairing ocular diseases, the likelihood of MSVI and blindness due to URE rapidly increases with age, as shown in Fig. 2. UN projections report that between 2020 and 2050 the global population of those aged 65+ years is expected to double from 703 million to 1.5 billion, and that by 2050, one in six people in the world will be aged ≥ 65 years [40].

The super-region of South Asia, comprising countries including India and Pakistan, had the greatest burdens of blindness and MSVI, with a disproportionately high prevalence of older age groups. While globally there was a reduction in age-standardised prevalence of MSVI due to URE, the super-region of Latin America and Caribbean actually demonstrated an increase of +0.8% (95% UI 0.4–1.3). These regional differences in the prevalence of vision loss are likely due to variations in availability of affordable refractive services, particularly in rural locations, and in social conditions. This is evidenced by a recent study investigating the eREC across regions, which demonstrated substantial differences in eREC between super regions in 2021, with 79.1% coverage in the High-Income super-region (95% CI 72·4–85·0), compared to 6.7% in Sub-Saharan Africa (95% CI 3·1–9·0) and 9.0% in South Asia (95% CI 6·5–12·0%) [41].

New eyecare service development has not kept pace with the increasing population demands in any region of the world, and continued population ageing will further increase existing burdens. Alleviating this shortfall will require a combination of capacity-building of trained eyecare personnel, expansion of community-based screening services for diagnosis of refractive errors, development of infrastructure for spectacle provision, outreach efforts to drive demand, and novel technical approaches to allow more services to be delivered by available, less fully-trained cadres. The WHO World Report on Vision, 2019 [17] sets out four key areas to increase access to eyecare services: (i) Increase of the availability of services through training and improved infrastructure; (ii) Increase the accessibility of services to those who need them; (iii) Increase the affordability of services, and (iv) Increase of the acceptability of refractive services, through awareness raising.

While the burden of vision impairment increases with age, focusing only on the population aged 50 years and above provides an incomplete view of vision impairment due to URE, which also frequently affects younger persons. While we report that those aged 50+ years with MSVI total 86 million in 2020, this only accounts for 55% of all MSVI (167 million). For younger people, the burden of URE is likely driven by the concerning global increase in myopia [42], with recent evidence showing these trends are not only confined to Asian populations [43]. However, there remains a paucity of data on vision impairment due to URE in children and younger adults, which needs to be redressed.

A disproportionate number of women continue to be affected by vision impairment due to URE. This is observed globally and across the majority of super regions. Interestingly for presbyopia, while the global crude prevalence decreased for men by −1.8% (−2.2 to −1.4%) from 2000 to 2020, there was an increase for women of +0.8% (+0.4 to +1.2%). It is important to emphasise that these differences persist after age adjustment, and are not simply an artefact of women living longer. This unfair burden among women is likely driven by cultural and social inequities, with less financial autonomy, male prioritisation, and child- and home-care responsibilities [44]. This persistent gap must be addressed through targeted strategies to increase their access to refractive care.

The burden of near visual impairment due to uncorrected presbyopia is another critical area of concern highlighted by our study, with nearly 420 million people aged 50+ years affected by uncorrected presbyopia. There are huge disparities in the age-standardised prevalence of uncorrected presbyopia across super

Table 4. Percentage change in crude prevalence and case number of uncorrected presbyopia in adults aged 50 years and older in the 7 Super Regions between 2000 and 2020.

	Near VI caused by uncorrected presbyopia					
	Percentage Change in Crude Prevalence between 2000 and 2020			Percentage Change in Number of Cases between 2000 and 2020		
Region	Men	Women	Both	Men	Women	Both
GLOBAL	−1.8% (−2.2 to −1.4)	+0.8% (+0.4 to +1.2)	−0.4% (−0.8 to 0.0)	+73.2% (+72.5 to +73.8)	+77.1% (+76.4 to +77.7)	+75.3% (+74.6 to +76.0)
Central Europe, Eastern Europe & Central Asia	0.0% (−0.4 to +0.4)	−0.5% (−0.9 to −0.1)	−0.6% (−0.9 to −0.2)	+29.8% (+29.3 to +30.3)	+23.1% (+22.7 to +23.6)	+25.5% (+25.0 to +25.9)
High Income	+8.1% (+7.6 to +8.5)	+1.9% (+1.5 to +2.3)	+4.3% (+3.9 to +4.7)	+59.0% (+58.3 to +59.7)	+41.9% (+41.3 to +42.5)	+49.0% (+48.4 to +49.6)
Latin America and Caribbean	−1.2% (−1.6 to −0.8)	+0.8% (+0.4 to +1.2)	−0.1% (−0.4 to 0.3)	+94.8% (+94.0 to +95.5)	+106.3% (+105.5 to +107.1)	+101.0% (+100.2 to +101.7)
North Africa and Middle East	−11.2% (−11.6 to −10.9)	−10.1% (−10.5 to −9.8)	−10.7% (−11.0 to −10.3)	+84.5% (+83.7 to +85.2)	+87.0% (+86.2 to +87.7)	+85.8% (+85.0 to +86.6)
South Asia	−8.0% (−8.3 to −7.6)	−7.0% (−7.3 to −6.6)	−7.3% (−7.6 to −6.9)	+73.7% (+73.1 to +74.4)	+88.1% (+87.4 to +88.8)	+81.1% (+80.4 to +81.8)
Southeast Asia, East Asia and Oceania	−6.5% (−6.9 to −6.2)	−6.6% (−6.9 to −6.2)	−6.4% (−6.8 to −6.1)	+84.8% (+84.1 to +85.6)	+90.6% (+89.8 to +91.3)	+88.0% (+87.3 to +88.7)
Sub-Saharan Africa	−8.7% (−9.0 to −8.4)	−9.4% (−9.7 to −9.0)	−8.9% (−9.2 to −8.5)	+61.5% (+61.0 to +62.1)	+75.9% (+75.2 to +76.5)	+69.1% (+68.5 to +69.7)

Percentage change to 1 decimal place and figures in parentheses reflect 95% uncertainty intervals.

regions, with for example, only a 2.4% prevalence in the High-Income super-region compared with 38.9% in South Asia. This finding is supported by a systematic review reporting the greatest burden of presbyopia in rural areas in low-resource countries [45]. Looking at temporal data, some super regions demonstrated a reduction in crude prevalence but in all areas the number of cases increased significantly, likely due to the ageing population globally and also improvements in data availability in the last 20 years. It was not possible to generate age-standardised estimates due to sparsity of data. The combination of high, rapidly rising burden and the paucity of data underscores the need for more attention to presbyopia among both researchers and health service planners.

The large burden of uncorrected presbyopia may in part reflect a view that correction for near VI is somehow less important than for distance VI, but studies have shown that vision impairment from URE affects the quality of life to a similar degree whether at distance or near VI [14]. Furthermore, a recent study [46] reported on the considerable productivity loss from un- and under-corrected presbyopia in LICs and LMICs. Using GBD data, the authors estimated 238 million people of working age (15–65 years) in LMICs had uncorrected presbyopia, and estimated the resulting direct productivity loss at $54 billion dollars, using productivity-adjusted-life-years. The potential for presbyopic correction to improve real-world work productivity is underscored by recent trials [2].

The strengths of this updated review and data analysis up to 2020 include the addition of new data sources, particularly more RAAB surveys, which enable improvements in disaggregation by cause and a wider coverage of geographical regions in our analysis. This is also the first time we combine reports on the impact of distance and near visual impairment due to URE and presbyopia. However, there remain several LICs and LMICs in regions such as central sub-Saharan Africa, Central Asia, and central and eastern Europe, with scant population-based data where estimates rely on extrapolation from other regions. While our modelling has controlled for a range of confounding factors, it is possible that blindness and MSVI due to URE are under-reported. Furthermore, due to data sparsity, we did not include mild visual impairment in this dataset but used a definition of <6/18 for MSVI, so again these data underreport the potential burden of distance vision impairment compared to other studies. Finally, it is possible that the trajectory of the prevalence of vision impairment due to URE might be altered owing to the COVID-19 global pandemic, with reports emerging of an increase in the prevalence of myopia attributed to changes in lifestyle during the pandemic [47]. Future directions for research and policy should be develop population screening services, accurate reporting mechanisms and registries to effectively measure the burden of avoidable vision impairment due to URE, to strengthen data from younger populations, and focus efforts on developing refractive services in LICs and LMICs to fill the data gaps to achieve greater geographical coverage.

CONCLUSIONS

Data from the last 20 years show that the absolute number of people with URE is rising due to population growth and ageing. URE remains a leading global cause of MSVI among persons aged 50+ years, affecting 86 million individuals and accounting for 53.4% of the total figure. This, coupled with the huge burden of near vision impairment due to uncorrected presbyopia, highlights the urgent need for novel and fresh approaches to refractive service delivery. While progress has been made in the last two decades, a reduction in the burden of vision impairment from URE can be realised by adding refractive services to universal health coverage and otherwise improving availability of, and access to, spectacle provision. Though the

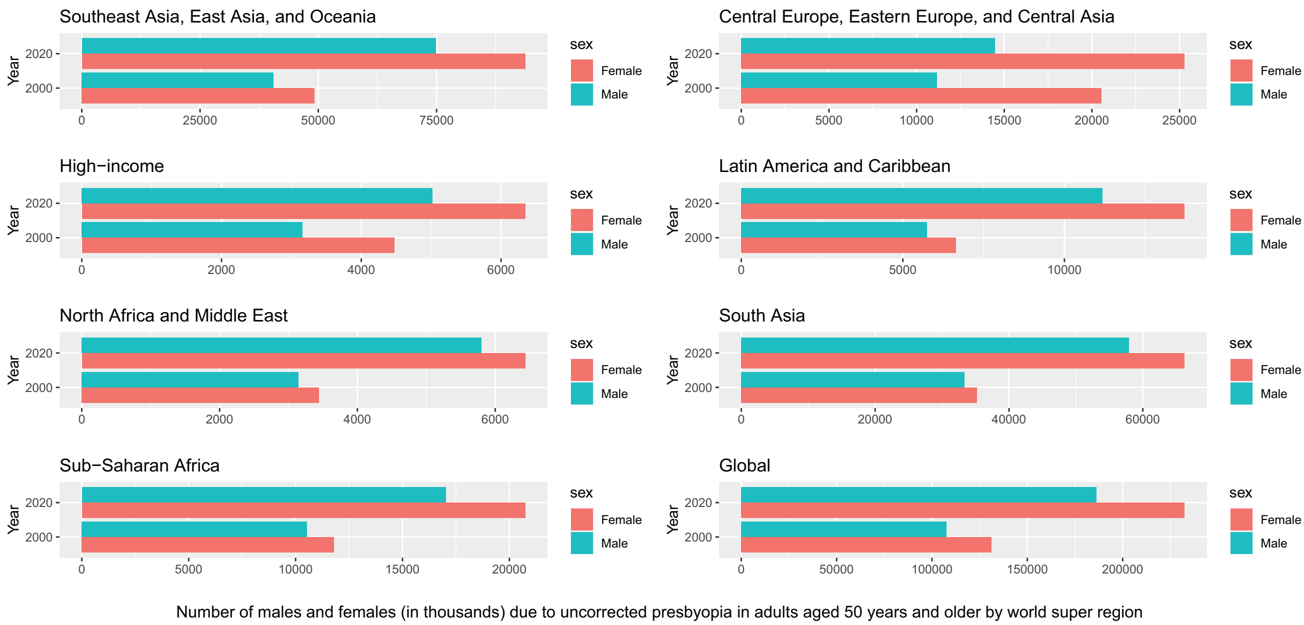

Fig. 3 Comparison of the number of men and women with near vision impairment due to uncorrected presbyopia in 2000 and 2020 by seven World GBD super regions, with Global total bottom right panel. Note scales (values should be multiplied by 1000) are not the same between charts, but rather serve to highlight the differences across the time period and sex differences within GBD super regions.

need is greater in some global regions, URE has not been fully addressed anywhere, and the resulting productivity losses and reduction in quality of life should not be overlooked for any country. Over this decade, the target set by the 73rd WHA member states in 2021, a 40% increase in eREC by 2030, will provide critical leverage to accelerate our efforts to tackle avoidable blindness due to URE.

URE remains the leading cause of MSVI, though spectacle provision is the simplest and least invasive treatment available for any ocular condition. This is a source of frustration after decades of work on VISION 2020, but it underscores the opportunity to accelerate progress towards what is arguably the most attainable goal in vision care, that of eliminating URE.

SUMMARY

What was known before

- Uncorrected refractive error (URE) is the leading cause of vision impairment globally among both adults and children, and contributes to reduced educational and economic opportunities, decreased quality of life and an increased burden of mortality
- Visual impairment is a significant global health concern, and the 'World Report on Vision' by the World Health Organisation in 2019 called for the routine measurement of refractive error services coverage as a means to address the UN Sustainable Development Goal 3.8 of universal health coverage
- Uncorrected refractive error (URE) is readily treated with spectacles, making it one of the most cost-effective healthcare interventions, both for distance visual impairment and near visual impairment due to presbyopia
- The need for new population data on vision impairment is vital to monitor and measure success against global targets to increase the coverage of refractive error services by 40% by 2030

What this study adds

- This study provides up-to-date global and regional, sex-specific and age-specific estimates and temporal trends for vision impairment due to uncorrected refractive error, both for distance and near vision impairment.
- We examined age-adjusted and sex-adjusted differences in the contribution of uncorrected refractive error to vision impairment, with a focus on older age groups
- We incorporated studies from an updated systematic review for a total of 243 sources from 73 countries
- Our study reveals that over the last 20 years, the absolute number of people with URE has risen due to population growth and ageing, with a continued disproportionate burden by region and sex
- Uncorrected refractive error (URE) remains a leading cause of MSVI, affecting 157 million individuals worldwide in 2020, and MSVI due to URE accounts for 57% of all MSVI globally
- Furthermore, an estimated 419 million people aged 50+ had near VI from uncorrected presbyopia globally in 2020
- These data underscore the persistent and substantial global burden of avoidable vision loss caused by uncorrected refractive error, highlighting the urgent need for novel and fresh approaches to refractive service delivery.

DATA AVAILABILITY

The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the coordinator of the Vision Loss Expert Group (Professor Rupert Bourne; rb@rupertbourne.co.uk) upon reasonable request. Data are located in controlled access data storage at Anglia Ruskin University.

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AUTHOR CONTRIBUTIONS

Please see Appendix 2 for more detailed information about individual author contributions to the research, divided into the following categories: managing the overall research enterprise; writing the first draft of the manuscript; primary responsibility for applying analytical methods to produce estimates; primary responsibility for seeking, cataloguing, extracting, or cleaning data; designing or coding figures and tables; providing data or critical feedback on data sources; developing methods or computational machinery; providing critical feedback on methods or results; drafting the manuscript or revising it critically for important intellectual content; and managing the estimation or publications process.

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Correspondence and requests for materials should be addressed to .

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VISION LOSS EXPERT GROUP OF THE GLOBAL BURDEN OF DISEASE STUDY

Julie-Anne Little[1] ✉, Nathan G. Congdon[2,3,4], Serge Resnikoff[5,6], Tasanee Braithwaite[7,8], Janet Leasher[9], Kovin Naidoo[10,11], Tim Fricke[12,13,14], Ian Tapply[15], Arthur G. Fernandes[16,17], Maria Vittoria Cicinelli[18,19], Alessandro Arrigo[20], Nicolas Leveziel[21,22], Hugh R. Taylor[23], Tabassom Sedighi[24], Seth Flaxman[25], Maurizio Battaglia Parodi[26], Mukkharram M. Bikbov[27], Alain Bron[28], Ching-Yu Cheng[29,30], Monte A. Del Monte[31,32], Joshua R. Ehrlich[33,34], Leon B. Ellwein[35], David Friedman[36], João M. Furtado[37], Gus Gazzard[38], Ronnie George[39], M. Elizabeth Hartnett[40], Jost B. Jonas[41], Rim Kahloun[42], John H. Kempen[43,44,45,46], Moncef Khairallah[47], Rohit C. Khanna[11,48,49,50], Judy E. Kim[51], Van Charles Lansingh[52,53,54], Vinay Nangia[55], Michal Nowak[56], Konrad Pesudovs[57], Tunde Peto[58], Pradeep Ramulu[59], Fotis Topouzis[60], Mitiadis Tsilimbaris[61], Ya Xing Wang[62], Ningli Wang[63] and Rupert R. A. Bourne[24]

[1]Biomedical Sciences Research Institute, Ulster University, Coleraine BT52 1SA, UK. [2]Queen's University Belfast, Northern Ireland, UK. [3]Orbis International, New York, USA. [4]Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou, China. [5]Brien Holden Vision Institute, Sydney, NSW, Australia. [6]School of Optometry and Vision Sciences, Faculty of Medicine, University of New South Wales, Sydney, NSW, Australia. [7]School of Life Course and Population Sciences, King's College London, London, UK. [8]The Medical Eye Unit, Guy's and St Thomas' NHS Foundation Trust, London, UK. [9]Nova Southeastern University College for Optometry, Fort Lauderdale, Florida, USA. [10]African Vision Research Institute, University of KwaZulu-Natal (UKZN), Durban, South Africa. [11]School of Optometry and Vision Science, University of New South Wales, Sydney, Australia. [12]Australian College of Optometry, Vic, Australia. [13]University of Melbourne, Vic, Australia. [14]UNSW Sydney, Sydney, NSW, Australia. [15]Department of Ophthalmology, Cambridge University Hospitals, Cambridge, UK. [16]Federal University of Sao Paolo, Sao Paolo/SP, Brazil. [17]University of Calgary, Calgary/AB, Canada. [18]School of Medicine, Vita-Salute San Raffaele University, Milan, Italy. [19]Department of Ophthalmology, IRCCS San Raffaele Scientific Institute, Milan, Italy. [20]Scientific Institute San Raffaele Hospital, Vita-Salute University, Milan, Italy. [21]University of Poitiers, Poitiers, France. [22]CHU de Poitiers, Poitiers, France. [23]School of Population and Global Health, University of Melbourne, Carlton, VIC, Australia. [24]Vision and Eye Research Institute, Anglia Ruskin University, Cambridge, UK. [25]Department of Computer Science, University of Oxford, Oxford, UK. [26]Department of Ophthalmology, Vita-Salute San Raffaele University, Milano, Italy. [27]Ufa Eye Research Institute, Ufa, Russia. [28]University Hospital, Dijon, France. [29]National University of Singapore, Singapore, Singapore. [30]Singapore Eye Research Institute, Singapore, Singapore. [31]University of Michigan, Singapore, Singapore. [32]Kellogg Eye Center, Ann Arbor MI 48105, USA. [33]Institute for Social Research, University of Michigan, Michigan, USA. [34]Department of Ophthalmology and Visual Sciences, University of Michigan, Michigan, USA. [35]National Eye Institute, Bethesda, MD, USA. [36]Mass Eye and Ear, Harvard Medical School, Boston MA 02115, USA. [37]Ribeirão Preto Medical School, University of São Paulo, São Paulo, Brazil. [38]Institute of Ophthalmology UCL & NIHR Biomedical Research Centre, Bethesda, MD, USA. [39]Sankara Nethralaya, Medical Research Foundation, Chennai 600006, India. [40]Stanford University, Stanford CA 94305, USA. [41]Department of Ophthalmology, Medical Faculty Mannheim, Heidelberg University, Heidelberg, Germany. [42]Associated Ophthalmologists of Monastir, Monastir, Tunisia. [43]Department of Ophthalmology, Harvard University, Boston, MA, USA. [44]Eye Unit, MyungSung Medical College, Addis Ababa, Ethiopia. [45]Department of Ophthalmology, Addis Ababa University, Addis Ababa, Ethiopia. [46]Sight for Souls, Bellevue, WA, USA. [47]Fattouma Bourguiba University Hospital,

University of Monastir, Monastir 5000, Tunisia. [48]Allen Foster Community Eye Health Research Centre, Gullapalli Pratibha Rao International Centre for Advancement of Rural Eye care, L.V. Prasad Eye Institute, Hyderabad, India. [49]Brien Holden Eye Research Centre, L.V. Prasad Eye Institute, Banjara Hills, Hyderabad, India. [50]University of Rochester, School of Medicine and Dentistry, Rochester, NY, USA. [51]University of Texas Southwestern Medical Center, Dallas, TX 75390, USA. [52]HelpMeSee, Instituto Mexicano de Oftalmologia, New York, NY 10018-8005, USA. [53]University of Miami, Coral Gables, FL 33146, USA. [54]University of Utah, Salt Lake City, UT 84112, USA. [55]Suraj Eye Instate, 559, New colony, Nagpur, India. [56]Institute of Optics and Optometry, University of Social Science, 121 Gdanska str., Lodz 90-519, Poland. [57]Medicine & Health, University of New South Wales, Sydney, NSW, Australia. [58]Centre for Public Health, Queens University Belfast, Northern Ireland, Belfast BT15 1ED, UK. [59]John Hopkins Wilmer Eye Institute, Baltimore, USA. [60]1st Department of Ophthamology, Medical School, Aristotle University of Thessaloniki, Ahepa Hospital, Thessaloniki 546 36, Greece. [61]University of Crete Medical School, Giofirakia 715 00, Greece. [62]Beijing Institute of Ophthamology, Beijing Tongren Hospital, Capital Medical University, Beijing Ophthamology and Visual Sciences Key Laboratory, Beijing, China. [63]Beijing Institute of Ophthamology, Beijing Tongren Eye Center, Beijing Tongren Hospital, Capital Medical University, Beijing, China. ✉email: ja.little@ulster.ac.uk

THE GBD 2019 BLINDNESS AND VISION IMPAIRMENT COLLABORATORS

Julie-Anne Little[64], Nathan G. Congdon[65,66], Serge Resnikoff[4,67], Tasanee Braithwaite[68,69], Janet L. Leasher[70], Kovin S. Naidoo[67,71], Nina Tahhan[67], Timothy Fricke[67,72], Ian Tapply[14], Arthur G. Fernandes[73], Maria Vittoria Cicinelli[74], Alessandro Arrigo[75], Nicolas Leveziel[76,77], Paul Svitil Briant[78], Theo Vos[78,79], Hugh R. Taylor[22], Tabassom Sedighi[23], Seth Flaxman[24,80], Yohannes Habtegiorgis Abate[81], Zahra Abbasi Dolatabadi[82], Michael Abdelmasseh[83], Mohammad Abdollahi[84,85], Ayele Mamo Abebe[86], Olumide Abiodun[87], Richard Gyan Aboagye[88], Woldu Aberhe Abrha[89], Hiwa Abubaker Ali[90], Eman Abu-Gharbieh[91], Salahdein Aburuz[92,93], Tadele Girum Girum Adal[94], Lawan Hassan Adamu[95], Nicola J. Adderley[96], Isaac Yeboah Addo[97,98], Tayo Alex Adekiya[99], Kishor Adhikari[100,101], Qorinah Estiningtyas Sakilah Adnani[102], Saira Afzal[103,104], Shahin Aghamiri[105], Antonella Agodi[106], Williams Agyemang-Duah[107], Bright Opoku Ahinkorah[108], Aqeel Ahmad[109], Hooman Ahmadzadeh[110], Ayman Ahmed[111,112], Haroon Ahmed[113], Fares Alahdab[114], Mohammed Albashtawy[115], Mohammad T. AlBataineh[116], Tsegaye Alemu[117,118], Ahmad Samir Alfaar[119,120], Fadwa Alhalaiqa Naji Alhalaiqa[121,122], Robert Kaba Alhassan[123], Abid Ali[124], Syed Shujait Shujait Ali[125], Louay Almidani[126,127], Karem H. Alzoubi[128,129], Sofia Androudi[130], Rodrigo Anguita[131,132], Abhishek Anil[133,134], Anayochukwu Edward Anyasodor[135], Jalal Arabloo[136], Aleksandr Y. Aravkin[78,79,137], Damelash Areda[138,139], Akeza Awealom Asgedom[140], Mubarek Yesse Ashemo[141,142], Tahira Ashraf[143], Seyyed Shamsadin Athari[144], Bantalem Tilaye Tilaye Atinafu[145], Maha Moh'd Wahbi Atout[146], Alok Atreya[147], Haleh Ayatollahi[136,148], Ahmed Y. Azzam[149,150], Sara Bagherieh[151], Ruhai Bai[152], Atif Amin Baig[153], Freddie Bailey[154], Ovidiu Constantin Baltatu[155], Shirin Barati[156], Martina Barchitta[157], Mainak Bardhan[158], Till Winfried Bärnighausen[159,160], Amadou Barrow[161,162], Maurizio Battaglia Parodi[163], Nebiyou Simegnew Bayileyegn[164], Alemshet Yirga Berhie[165], Abhishek Bhadra[166], Akshaya Srikanth Srikanth Bhagavathula[167], Pankaj Bhardwaj[168,169], Sonu Bhaskar[170,171], Ajay Nagesh Bhat[172], Gurjit Kaur Bhatti[173], Mukharram Bikbov[174], Marina G. Birck[175,176], Yasser Bustanji[177,178], Zahid A. Butt[179,180], Florentino Luciano Caetano dos Santos[181], Vera L. A. Carneiro[182,183], Muthia Cenderadewi[184,185], Gashaw Sisay Chanie[186], Nicolas Cherbuin[187], Dinh-Toi Chu[188], Kaleb Coberly[78], Natália Cruz-Martins[189,190], Omid Dadras[191,192], Xiaochen Dai[78,79], Lalit Dandona[78,193,194], Rakhi Dandona[78,79,193], Ana Maria Dascalu[195,196], Anna Dastiridou[197,198], Tadesse Asmamaw Dejenie[199], Dessalegn Demeke[200], Diriba Dereje[201], Nikolaos Dervenis[202,203], Vinoth Gnana Chellaiyan Devanbu[204], Daniel Diaz[205,206], Mengistie Diress[207], Thanh Chi Do[208], Thao Huynh Phuong Do[209], Arkadiusz Marian Dziedzic[210], Hisham Atan Edinur[211], Joshua R. Ehrlich[212,213], Michael Ekholuenetale[214,215], Hala Rashad Elhabashy[216], Muhammed Elhadi[217], Mohammad Hassan Emamian[218], Mehdi Emamverdi[219], Azin Etemadimanesh[220], Adeniyi Francis Fagbamigbe[214,221], Hossein Farrokhpour[222,223], Ali Fatehizadeh[224], Alireza Feizkhah[225], Lorenzo Ferro Desideri[226], Getahun Fetensa[227], Florian Fischer[228], Ali Forouhari[229,230], João M. Furtado[231], Muktar A. Gadanya[232,233], Abhay Motiramji Gaidhane[234], Aravind P. Gandhi[235], Tilaye Gebru Gebi[236], Mesfin Gebrehiwot[237], Gebreamlak Gebremedhn Gebremeskel[238,239], Yibeltal Yismaw Gela[207], Bardiya Ghaderi Yazdi[240], Khalil Ghasemi Falavarjani[241], Fariba Ghassemi[242], Sherief Ghozy[243], Ali Golchin[244,245], Mahaveer Golechha[246], Pouya Goleij[247,248], Shi-Yang Guan[249], Sapna Gupta[250], Vivek Kumar Gupta[251], Rasool Haddadi[252], Teklehaimanot Gereziher Haile[238], Billy Randall Hammond[253], Mehdi Harorani[254], Ahmed I. Hasaballah[255], Ikramul Hasan[256], Hamidreza Hasani[257], Hossein Hassanian-Moghaddam[258,259], Golnaz Heidari[260], Demisu Zenbaba Heyi[261], Ramesh Holla[262], Mehdi Hosseinzadeh[263,264], Chengxi Hu[265], Hong-Han Huynh[266], Bing-Fang Hwang[267,268], Ivo Iavicoli[269], Irena M. Ilic[270], Mustapha Immurana[123], Sheikh Mohammed Shariful Islam[271,272], Louis Jacob[273,274], Abdollah Jafarzadeh[275,276], Mihajlo Jakovljevic[277,278], Manthan Dilipkumar Janodia[279], Sathish Kumar Jayapal[280], Shubha Jayaram[281], Jost B. Jonas[282,283], Nitin Joseph[284], Charity Ehimwenma Joshua[285], Sagarika Kamath[286], Himal Kandel[287,288], Ibraheem M. Karaye[289,290], Hengameh Kasraei[241,291], Soujanya Kaup[292], Harkiran Kaur[293], Navjot Kaur[294], Gbenga A. Kayode[295,296], John H. Kempen[42,43], Yousef Saleh Khader[297], Himanshu Khajuria[298], Rovshan Khalilov[299,300], Ajmal Khan[301], Moawiah Mohammad Khatatbeh[302], Mahalaqua Nazli Khatib[303], Biruk Getahun Kibret[304], Yun Jin Kim[305], Adnan Kisa[306,307], Sezer Kisa[308], Soewarta Kosen[309], Ai Koyanagi[310], Kewal Krishan[311], Burcu Kucuk Bicer[312], Nithin Kumar[284], L. V. Simhachalam Kutikuppala[313], Chandrakant Lahariya[314,315], Tri Laksono[316,317], Dharmesh Kumar Lal[193], Van Charles Lansingh[318,319], Munjae Lee[320], Seung Won Lee[321], Wei-Chen Lee[322], Stephen S. Lim[78,79], Xuefeng Liu[323,324], Sandeep B. Maharaj[325,326], Alireza Mahmoudi[327], Kashish Malhotra[328], Ahmad Azam Malik[153,329], Iram Malik[330], Tauqeer Hussain Mallhi[331], Vahid Mansouri[332], Roy Rillera Marzo[333,334], Andrea Maugeri[157], Gebrekiros Gebremichael Meles[335], Abera M. Mersha[336], Tomislav Mestrovic[78,337], Ted R. Miller[338,339], Mehdi Mirzaei[340], Awoke Misganaw[79,341], Sanjeev Misra[342], Prasanna Mithra[284], Soheil Mohammadi[222], Abdollah Mohammadian-Hafshejani[343], Maryam Mohammadzadeh[344], Hoda Mojiri-forushani[345], Ali H. Mokdad[78,79], Hamed Momeni-Moghaddam[346,347], Fateme Montazeri[348,349], Maryam Moradi[350], Parsa Mousavi[348], Christopher J. L. Murray[78,79], Ganesh R. Naik[351,352], Gurudatta Naik[353], Zuhair S. Natto[354,355], Muhammad Naveed[356], Biswa Prakash Nayak[298], Hadush Negash[357], Seyed Aria Nejadghaderi[349,358], Dang H. Nguyen[359,360], Duc Hoang Nguyen[361,362], Hien Quang Nguyen[363], Phat Tuan Nguyen[364], Van Thanh Nguyen[365], Robina Khan Niazi[366], Efaq Ali Noman[367,368], Bogdan Oancea[369], Osaretin Christabel Okonji[370], Andrew T. Olagunju[371,372], Isaac Iyinoluwa Olufadewa[215,373], Obinna E. Onwujekwe[374], Abdulahi Opejin Opejin[375], Michal Ordak[376], Uchechukwu Levi Osuagwu[377,378], Nikita Otstavnov[379], Mayowa O. Owolabi[380,381], Jagadish Rao Padubidri[382], Songhomitra Panda-Jonas[383], Anamika Pandey[193], Shahina Pardhan[23], Amirhossein Parsaei[348], Jay Patel[384,385], Shrikant Pawar[386], Arokiasamy Perianayagam[387], Navaraj Perumalsamy[388,389], Konrad Pesudovs[67], Ionela-Roxana Petcu[390], Hoang Tran Pham[391], Mohsen Pourazizi[229], Elton Junio Sady Prates[392], Ibrahim Qattea[393], Pankaja Raghav Raghav[168], Mohammad Hifz Ur Rahman[394], Mosiur Rahman[395], Shakthi Kumaran Ramasamy[396], Premkumar Ramasubramani[397], Mohammad-Mahdi Rashidi[258,348], Elrashdy Moustafa Mohamed Redwan[398,399], Nazila Rezaei[348], Jefferson Antonio Buendia Rodriguez[400,401], Zahra Saadatian[402,403], Siamak Sabour[404], Basema Saddik[405], Umar Saeed[406,407], Sare Safi[408,409], Amene Saghazadeh[410], Fatemeh Saheb Sharif-Askari[411], Narjes Saheb Sharif-Askari[412], Amirhossein Sahebkar[413,414], Mohammad Ali Sahraian[415], Joseph W. Sakshaug[416,417], Mohamed A. Saleh[418,419], Sara Samadzadeh[420,421], Yoseph Leonardo Samodra[422,422], Abdallah M. Samy[423,424], Mete Saylan[425], Siddharthan Selvaraj[426], Yashendra Sethi[427], Allen Seylani[428], Moyad Jamal Shahwan[429], Masood Ali Shaikh[430], Muhammad Aaqib Shamim[133], Bereket Beyene Shashamo[336], Wondimeneh Shibabaw Shiferaw[431], Mika Shigematsu[432], Aminu Shittu[433], Parnian Shobeiri[434,435], Seyed Afshin Shorofi[436,437], Migbar Mekonnen Sibhat[438], Emmanuel Edwar Siddig[439,440], Juan Carlos Silva[441], Jasvinder A. Singh[442,443], Paramdeep Singh[444], Houman Sotoudeh[445], Raúl A. R. C. Sousa[446], Chandrashekhar T. Sreeramareddy[447], Mohammad Tabish[448], Majid Taheri[449,450], Yao Tan[451], Birhan Tsegaw Taye[145], Mohamad-Hani Temsah[452], Jansje Henny Vera Ticoalu[453], Tala Tillawi[454], Misganaw Guadie Tiruneh[455], Aristidis Tsatsakis[456], Guesh Mebrahtom Tsegay[238], Miltiadis K. Tsilimbaris[457], Sree Sudha Ty[458], Chukwudi S. Ubah[459,460], Muhammad Umair[461,462], Sahel Valadan Tahbaz[463,464], Rohollah Valizadeh[465], Maria Viskadourou[466], Gizachew Tadesse Wassie[467], Nuwan Darshana Wickramasinghe[468], Guadie Sharew Wondimagegn[469,470], Galal Yahya[471,472], Lin Yang[473,474], Yao Yao[475,476], Arzu Yiğit[477], Yazachew Yismaw[478,479], Naohiro Yonemoto[480,481], Yuyi You[287,340], Mikhail Sergeevich Zastrozhin[482,483], Getachew Assefa Zenebe[484], Zhi-Jiang Zhang[485], Hanqing Zhao[486], Magdalena Zielińska[487], Mohammad Zoladl[488], Jaimie D. Steinmetz[78] and Rupert Bourne[23]

[64]School of Biomedical Sciences, Ulster University, Coleraine, UK. [65]Centre for Public Health, Queen's University, Belfast, UK. [66]ORBIS International, New York, NY, USA. [67]School of Optometry and Vision Science, University of New South Wales, Sydney, NSW, Australia. [68]Ophthalmology Department, Moorfields Eye Hospital NHS Foundation Trust, London, UK. [69]International Centre for Eye Health, London School of Hygiene & Tropical Medicine, London, UK. [70]College of Optometry, Nova Southeastern University, Fort Lauderdale, FL, USA. [71]Discipline of Optometry, University of KwaZulu-Natal, Durban, South Africa. [72]Department of Optometry and Vision Sciences, University of Melbourne, Melbourne, VIC, Australia. [73]Department of Ophthalmology and Visual Sciences, Federal University of São Paulo, Sao Paulo, Brazil. [74]Department of Ophthalmology, San Raffaele Scientific Institute, Milano, Italy. [75]Scientific Institute San Raffaele Hospital, Vita-Salute San Raffaele University, Milan, Italy. [76]Ophthalmology Department, CHU de Poitiers (Poitiers University Hospital), Poitiers, France. [77]Unité 1084, National Institute of Health and Medical Research (INSERM), Poitiers, France. [78]Institute for Health Metrics and Evaluation, University of Washington, Seattle, WA, USA. [79]Department of Health Metrics Sciences, School of Medicine, University of Washington, Seattle, WA, USA. [80]Department of Mathematics, Imperial College London, London, UK. [81]Department of Clinical Governance and Quality Improvement, Aleta Wondo Hospital, Aleta Wondo, Ethiopia. [82]Department of Medical-Surgical Nursing, Tehran University of Medical Sciences, Tehran, Iran. [83]Department of Surgery, Marshall University, Huntington, WV, USA. [84]The Institute of Pharmaceutical Sciences (TIPS), Tehran University of Medical Sciences, Tehran, Iran. [85]School of Pharmacy, Tehran University of Medical Sciences, Tehran, Iran. [86]Pediatrics Nursing Department, Debre Berhan University, Debre Berhan, Ethiopia. [87]Department of Community Medicine, Babcock University, Ilishan-Remo, Nigeria. [88]Department of Family and Community Health, University of Health and Allied Sciences, Ho, Ghana. [89]Department of Adult Health Nursing, Aksum University, Aksum, Ethiopia. [90]Department of Banking and Finance, University of Human Development, Sulaymaniyah, Iraq. [91]Clinical Sciences Department, University of Sharjah, Sharjah, United Arab Emirates. [92]Department of Therapeutics, United Arab Emirates University, Al Ain, United Arab Emirates. [93]College of Pharmacy, University of Jordan, Amman, Jordan. [94]Department of Public Health, Wolkite University, Wolkite, Ethiopia. [95]Department of Human Anatomy, Federal University Dutse, Dutse, Nigeria. [96]Institute of Applied Health Research, University of Birmingham, Birmingham, UK. [97]Centre for Social Research in Health, University of New South Wales, Sydney, NSW, Australia. [98]Quality and Systems Performance Unit, Cancer Institute NSW, Sydney, NSW, Australia. [99]Department of Pharmaceutical Sciences, Howard University, Washington, DC, USA. [100]School of Public Health, Chitwan Medical College and Teaching Hospital, Bharatpur, Nepal. [101]Public Health Section, Himalayan Environment and Public Health Network (HEPHN), Chitwan, Nepal. [102]Faculty of Medicine, Padjadjaran University, Bandung, Indonesia. [103]Department of Community Medicine, King Edward Memorial Hospital, Lahore, Pakistan. [104]Department of Public Health, Public Health Institute, Lahore, Pakistan. [105]Department of Biotechnology, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [106]Department of Medical and Surgical Sciences and Advanced Technologies "G.F. Ingrassia", University of Catania, Catania, Italy. [107]Department of Geography and Planning, Queen's University, Kingston, ON, Canada. [108]School of Public Health, University of Technology Sydney, Sydney, NSW, Australia. [109]Department of Medical Biochemistry, Shaqra University, Shaqra, Saudi Arabia. [110]Bascom Palmer Eye Institute, University of Miami, Miami, FL, USA. [111]Institute of Endemic Diseases, University of Khartoum, Khartoum, Sudan. [112]Swiss Tropical and Public Health Institute, University of Basel, Basel, Switzerland. [113]Department of Biosciences, COMSATS Institute of Information Technology, Islamabad, Pakistan. [114]Evidence-Based Practice Center, Mayo Clinic Foundation for Medical Education and Research, Rochester, MN, USA. [115]Community and Mental Health Department, Al al-Bayt University, Mafraq, Jordan. [116]Department of Molecular Biology and Genetics, Khalifa University, Abu Dhabi, United Arab Emirates. [117]Department of Public Health, Hawassa University, Hawassa, Ethiopia. [118]Department of Public Health, Ministry of Health (MOH), Hawassa, Ethiopia. [119]Department of Ophthalmology, University of Leipzig Medical Center, Leipzig, Germany. [120]Department of Ophthalmology, Charité Medical University Berlin, Berlin, Germany. [121]College of Nursing, Qatar University, Doha, Qatar. [122]Psychological Sciences Association, Amman, Jordan. [123]Institute of Health Research, University of Health and Allied Sciences, Ho, Ghana. [124]Department of Zoology, Abdul Wali Khan University Mardan, Mardan, Pakistan. [125]Center for Biotechnology and Microbiology, University of SWAT, Swat, Pakistan. [126]Wilmer Eye Institute, Johns Hopkins University School of Medicine, Baltimore, MD, USA. [127]Doheny Image Reading and Research Lab (DIRRL), University of California Los Angeles, Los Angeles, CA, USA. [128]Department of Pharmacy Practice and Pharmacotherapeutics, University of Sharjah, Sharjah, United Arab Emirates. [129]Department of Clinical Pharmacy, Jordan University of Science and Technology, Irbid, Jordan. [130]Department of Medicine, University of Thessaly, Volos, Greece. [131]Department of Ophthalmology, Inselspital, Bern, Switzerland. [132]Department of Vitreoretinal, Moorfields Eye Hospital, London, UK. [133]Department of Pharmacology, All India Institute of Medical Sciences, Jodhpur, India. [134]All India Institute of Medical Sciences, Bhubaneswar, India. [135]School of Dentistry and Medical Sciences, Charles Sturt University, Orange, NSW, Australia. [136]Health Management and Economics Research Center, Iran University of Medical Sciences, Tehran, Iran. [137]Department of Applied Mathematics, University of Washington, Seattle, WA, USA. [138]College of Art and Science, Ottawa University, Surprise, AZ, USA. [139]School of Life Sciences, Arizona State University, Tempe, AZ, USA. [140]Department of Environmental Health, Mekelle University, Mekelle, Ethiopia. [141]Department of Public Health, Jimma University, Jimma, Ethiopia. [142]Department of Public Health, Wachemo University, Hossana, Ethiopia. [143]University Institute of Radiological Sciences and Medical Imaging Technology, The University of Lahore, Lahore, Pakistan. [144]Department of Immunology, Zanjan University of Medical Sciences, Zanjan, Iran. [145]School of Nursing and Midwifery, Debre Berhan University, Debre Berhan, Ethiopia. [146]Faculty of Nursing, Philadelphia University, Amman, Jordan. [147]Department of Forensic Medicine, Lumbini Medical College, Palpa, Nepal. [148]Department of Health Information Management, Iran University of Medical Sciences, Tehran, Iran. [149]Department of Neurovascular Research, Nested Knowledge, Inc., Saint Paul, MN, USA. [150]Faculty of Medicine, October 6 University, 6th of October City, Giza Governorate, Egypt. [151]School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran. [152]School of Public Affairs, Nanjing University of Science and Technology, Nanjing, China. [153]University Institute of Public Health, The University of Lahore, Lahore, Pakistan. [154]Big Data Institute - GRAM Project, University of Oxford, Oxford, UK. [155]Center of Innovation, Technology and Education (CITE), Anhembi Morumbi University, Sao Jose dos Campos, Brazil. [156]Department of Anatomy, Saveh University of Medical Sciences, Saveh, Iran. [157]Department of Medical and Surgical Sciences and Advanced Technologies "GF Ingrassia", University of Catania, Catania, Italy. [158]Miami Cancer Institute, Baptist Health South Florida, Miami, FL, USA. [159]Heidelberg Institute of Global Health (HIGH), Heidelberg University, Heidelberg, Germany. [160]T.H. Chan School of Public Health, Harvard University, Boston, MA, USA. [161]Department of Epidemiology, University of Florida, Gainesville, FL, USA. [162]Department of Public & Environmental Health, University of The Gambia, Brikama, The Gambia. [163]Department of Ophthalmology,

Vita-Salute San Raffaele University, Milan, Italy. [164]Department of Surgery, Jimma University, jimma, Ethiopia. [165]School of Health Science, Bahir Dar University, Bahir Dar, Ethiopia. [166]Department of Pharmacology, Popular Medical College, Dhaka, Bangladesh. [167]Department of Public Health, North Dakota State University, Fargo, ND, USA. [168]Department of Community Medicine and Family Medicine, All India Institute of Medical Sciences, Jodhpur, India. [169]School of Public Health, All India Institute of Medical Sciences, Jodhpur, India. [170]Global Health Neurology Lab, NSW Brain Clot Bank, Sydney, NSW, Australia. [171]Department of Neurology and Neurophysiology, South West Sydney Local Heath District and Liverpool Hospital, Sydney, NSW, Australia. [172]Department of General Medicine, Manipal Academy of Higher Education, Mangalore, India. [173]Medical Lab Technology, Chandigarh University, Mohali, India. [174]Epidemiology Department, Ufa Eye Research Institute, Ufa, Russia. [175]Division of Clinical Epidemiology, McGill University, Montreal, QC, Canada. [176]Centre for Outcomes Research and Evaluation, Research Institute of the McGill University Health Centre, Montreal, QC, Canada. [177]Department of Biopharmaceutics and Clinical Pharmacy, The University of Jordan, Amman, Jordan. [178]Department of Basic Biomedical Sciences, University of Sharjah, Sharjah, United Arab Emirates. [179]School of Public Health and Health Systems, University of Waterloo, Waterloo, ON, Canada. [180]Al Shifa School of Public Health, Al Shifa Trust Eye Hospital, Rawalpindi, Pakistan. [181]Harvard Business School, Harvard University, Boston, MA, USA. [182]School of Sciences, University of Minho, Braga, Portugal. [183]Association of Licensed Optometry Professionals, Linda-a-Velha, Portugal. [184]College of Public Health, James Cook University, Townsville, QLD, Australia. [185]Department of Public Health, University of Mataram, Mataram, Indonesia. [186]Department of Clinical Pharmacy, University of Gondar, Gondar, Ethiopia. [187]Research School of Population Health, Australian National University, Canberra, ACT, Australia. [188]Center for Biomedicine and Community Health, VNU-International School, Hanoi, Vietnam. [189]Therapeutic and Diagnostic Technologies, Cooperativa de Ensino Superior Politécnico e Universitário (Polytechnic and University Higher Education Cooperative), Gandra, Portugal. [190]Institute for Research and Innovation in Health, University of Porto, Porto, Portugal. [191]Department of Addiction Medicine, Haukland University Hospital, Bergen, Norway. [192]Department of Global Public Health and Primary Care, University of Bergen, Bergen, Norway. [193]Public Health Foundation of India, Gurugram, India. [194]Indian Council of Medical Research, New Delhi, India. [195]Ophthalmology Department, Carol Davila University of Medicine and Pharmacy, Bucharest, Romania. [196]Ophthalmology Department, Emergency University Hospital Bucharest, Bucuresti, Romania. [197]dummy2nd University Ophthalmology Department, Aristotle University of Thessaloniki, Thessaloniki, Greece. [198]Ophthalmology Department, University of Thessaly, Larissa, Greece. [199]Department of Medical Biochemistry, University of Gondar, Gondar, Ethiopia. [200]Department of Physiology, Bahir Dar University, Bahir Dar, Ethiopia. [201]Department of Biomedical Sciences, Jimma University, Jimma, Ethiopia. [202]St Paul's Eye Unit, Royal Liverpool University Hospital, Liverpool, UK. [203]Department of Ophthalmology, Aristotle University of Thessaloniki, Thessaloniki, Greece. [204]Department of Community Medicine, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Chennai, India. [205]Center of Complexity Sciences, National Autonomous University of Mexico, Mexico City, Mexico. [206]Faculty of Veterinary Medicine and Zootechnics, Autonomous University of Sinaloa, Culiacán Rosales, Mexico. [207]Department of Human Physiology, University of Gondar, Gondar, Ethiopia. [208]Department of Medicine, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam. [209]Department of Medicine, Can Tho University of Medicine and Pharmacy, Can Tho, Vietnam. [210]Department of Conservative Dentistry with Endodontics, Medical University of Silesia, Katowice, Poland. [211]School of Health Sciences, University of Science Malaysia, Kubang Kerian, Malaysia. [212]Department of Ophthalmology and Visual Sciences, University of Michigan, Ann Arbor, MI, USA. [213]Institute for Health Care Policy and Innovation, University of Michigan, Ann Arbor, MI, USA. [214]Department of Epidemiology and Medical Statistics, University of Ibadan, Ibadan, Nigeria. [215]Faculty of Public Health, University of Ibadan, Ibadan, Nigeria. [216]Neurophysiology Department, Cairo University, Cairo, Egypt. [217]Faculty of Medicine, University of Tripoli, Tripoli, Libya. [218]Ophthalmic Epidemiology Research Center, Shahroud University of Medical Sciences, Shahroud, Iran. [219]Department of Ophthalmology, University of California Los Angeles, Los Angeles, CA, USA. [220]Department of Physical Medicine and Rehabilitation, Johns Hopkins University, Baltimore, MD, USA. [221]Research Centre for Healthcare and Community, Coventry University, Coventry, UK. [222]School of Medicine, Tehran University of Medical Sciences, Tehran, Iran. [223]Endocrinology and Metabolism Research Institute, Non-Communicable Diseases Research Center, Tehran, Iran. [224]Department of Environmental Health Engineering, Isfahan University of Medical Sciences, Isfahan, Iran. [225]Department of Social Medicine and Epidemiology, Guilan University of Medical Sciences, Rasht, Iran. [226]University Eye Clinic, University of Genoa, Genoa, Italy. [227]Department of Nursing, Wollega University, Nekemte, Ethiopia. [228]Institute of Public Health, Charité Medical University Berlin, Berlin, Germany. [229]Department of Ophthalmology, Isfahan University of Medical Sciences, Isfahan, Iran. [230]Emergency Department, Isfahan University of Medical Sciences, Isfahan, Iran. [231]Division of Ophthalmology, University of São Paulo, Ribeirão Preto, Brazil. [232]Community Medicine Department, Bayero University, Kano, Kano, Nigeria. [233]Department of Community Medicine, Aminu Kano Teaching Hospital, Kano, Nigeria. [234]Department of Community Medicine, Datta Meghe Institute of Medical Sciences, Wardha, India. [235]Department of Community Medicine, ESIC Medical College & Hospital, Hyderabad, India. [236]Health Sciences Department of Oncology Nursing, Haramaya University, Harar, Ethiopia. [237]Department of Environmental Health, Wollo University, Dessie, Ethiopia. [238]Department of Nursing, Aksum University, Aksum, Ethiopia. [239]Department of Nursing, Mekelle University, Mekelle, Ethiopia. [240]Department of Neurology, Tehran University of Medical Sciences, Tehran, Iran. [241]Eye Research Center, Iran University of Medical Sciences, Tehran, Iran. [242]Ophthalmology Department, Tehran University of Medical Sciences, Tehran, Iran. [243]Department of Radiology, Mayo Clinic, Rochester, MN, USA. [244]Department of Applied Cell Sciences, Urmia University of Medical Sciences, Urmia, Iran. [245]Cellular and Molecular Medicine Institute, Urmia University of Medical Sciences, Urmia, Iran. [246]Health Systems and Policy Research Department, Indian Institute of Public Health, Gandhinagar, India. [247]Department of Genetics, Sana Institute of Higher Education, Sari, Iran. [248]Universal Scientific Education and Research Network (USERN), Kermanshah University of Medical Sciences, Kermanshah, Iran. [249]Department of Epidemiology and Biostatistics, Anhui Medicla University, Hefei, China. [250]Toxicology Department, Shriram Institute for Industrial Research, Delhi, India. [251]Faculty of Medicine Health and Human Sciences, Macquarie University, Sydney, NSW, Australia. [252]Department of Pharmacology and Toxicology, Hamadan University of Medical Sciences, Hamadan, Iran. [253]Brain and Behavioral Sciences Program, University of Georgia, Athens, GA, USA. [254]Department of Nursing, Arak University of Medical Sciences, Arak, Iran. [255]Department of Zoology and Entomology, Al Azhar University, Cairo, Egypt. [256]Department of Pharmaceutical Technology, University of Dhaka, Dhaka, Bangladesh. [257]Department of Ophthalmology, Iran University of Medical Sciences, Karaj, Iran. [258]Social Determinants of Health Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [259]Chapter of Addiction Medicine, University of Sydney, Sydney, NSW, Australia. [260]Independent Consultant, Santa Clara, CA, USA. [261]Department of Public Health, Madda Walabu University, Robe, Ethiopia. [262]Kasturba Medical College, Mangalore, Manipal Academy of Higher Education, Manipal, India. [263]Institute of Research and Development, Duy Tan University, Da Nang, Vietnam. [264]Department of Computer Science, University of Human Development, Sulaymaniyah, Iraq. [265]Department of Psychology, Tsinghua University, Beijing, China. [266]School of Biotechnology, Tan Tao University, Long An, Vietnam. [267]Department of Occupational Safety and Health, China Medical University, Taichung, Taiwan. [268]Department of Occupational Therapy, Asia University, Taiwan, Taichung, Taiwan. [269]Department of Public Health, University of Naples Federico II, Naples, Italy. [270]Faculty of Medicine, University of Belgrade, Belgrade, Serbia. [271]Institute for Physical Activity and Nutrition, Deakin University, Burwood, VIC, Australia. [272]Sydney Medical School, University of Sydney, Sydney, NSW, Australia. [273]Research and Development Unit, Biomedical Research Networking Center for Mental Health Network (CiberSAM), Sant Boi de Llobregat, Spain. [274]Faculty of Medicine, University of Versailles Saint-Quentin-en-Yvelines, Montigny-le-Bretonneux, France. [275]Department of Immunology, Kerman University of Medical Sciences, Kerman, Iran. [276]Department of Immunology, Rafsanjan University of Medical Sciences, Rafsanjan, Iran. [277]Institute of Advanced Manufacturing Technologies, Peter the Great St. Petersburg Polytechnic University, St, Petersburg, Russia. [278]Institute of Comparative Economic Studies, Hosei University, Tokyo, Japan. [279]Manipal College of Pharmaceutical Sciences, Manipal Academy of Higher Education, Manipal, India. [280]Centre of Studies and Research, Ministry of Health, Muscat, Oman. [281]Department of Biochemistry, Government Medical College, Mysuru, India. [282]Institute of Molecular and Clinical Ophthalmology Basel, Basel, Switzerland. [283]Department of Ophthalmology, Heidelberg University, Mannheim, Germany. [284]Department of Community Medicine, Manipal Academy of Higher Education, Mangalore, India. [285]Department of Economics, National Open University, Benin City, Nigeria. [286]Manipal Institute of Management, Manipal Academy of Higher Education, Manipal, India. [287]Save Sight Institute, University of Sydney, Sydney, NSW, Australia. [288]Sydney Eye Hospital, South Eastern Sydney Local Health District, Sydney, NSW, Australia. [289]School of Health Professions and Human Services, Hofstra University, Hempstead, NY, USA. [290]Department of Anesthesiology, Montefiore Medical Center, Bronx, NY, USA. [291]Health Policy Research Center, Shiraz University of Medical Sciences, Shiraz, Iran. [292]Department of Ophthalmology, Yenepoya Medical College, Mangalore, India. [293]Public Health Foundation of India, New Delhi, India. [294]Department of ENT, Dr. B. R. Ambedkar State Institute of Medical Sciences (AIMS), Mohali, India. [295]International Research Center of Excellence, Institute of Human Virology Nigeria, Abuja, Nigeria. [296]Julius Centre for Health Sciences and Primary Care, Utrecht University, Utrecht, Netherlands. [297]Department of Public Health, Jordan University of Science and Technology, Irbid, Jordan. [298]Amity Institute of Forensic Sciences, Amity University, Noida, India. [299]Department of Biophysics and Biochemistry, Baku State University, Baku, Azerbaijan. [300]Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan. [301]Natural and Medical Sciences Research Center, University of Nizwa, Oman, Nizwa, Oman. [302]Department of Basic Medical Sciences, Yarmouk University, Irbid, Jordan. [303]Global Consortium for Public Health Research, Datta Meghe Institute of Higher Education and Research, Wardha, India. [304]Department of Medical Physiology, Bahir Dar University, Bahir Dar, Ethiopia. [305]School of Traditional Chinese Medicine, Xiamen University Malaysia, Sepang, Malaysia. [306]School of Health Sciences, Kristiania University College, Oslo, Norway. [307]Department of International Health and Sustainable Development, Tulane University, New Orleans, LA, USA. [308]Department of Nursing and Health Promotion, Oslo Metropolitan University, Oslo, Norway. [309]Independent Consultant, Jakarta, Indonesia. [310]San Juan de Dios Sanitary Park, Barcelona, Spain. [311]Department of Anthropology, Panjab University, Chandigarh, India. [312]Faculty of Medicine, Gazi University, Ankara, Türkiye. [313]Department of

General Surgery, Dr NTR University of Health Sciences, Vijayawada, India. [314]Department of Health Policy and Strategy, Foundation for People-centric Health Systems, New Delhi, India. [315]SD Gupta School of Public Health, Indian Institute of Health Management Research University, Jaipur, India. [316]Department of Physiotherapy, Universitas Aisyiyah Yogyakarta, Yogyakarta, Indonesia. [317]Institute of Allied Health Sciences, National Cheng Kung University, Tainan, Taiwan. [318]Chief Medical Office, HelpMeSee, New York, NY, USA. [319]Mexican Institute of Ophthalmology, Queretaro, Mexico. [320]Department of Medical Science, Ajou University School of Medicine, Suwon, South Korea. [321]Department of Precision Medicine, Sungkyunkwan University, Suwon, South Korea. [322]Department of Internal Medicine, University of Texas, Galveston, TX, USA. [323]Lerner Research Institute, Cleveland Clinic, Cleveland, OH, USA. [324]Department of Quantitative Health Science, Case Western Reserve University, Cleveland, OH, USA. [325]School of Pharmacy, University of the West Indies, St. Augustine, Trinidad and Tobago. [326]Fellow, Planetary Health Alliance, Boston, MA, USA. [327]Department of Ophthalmology, Tehran University of Medical Sciences, Tehran, Iran. [328]Department of Internal Medicine, Dayanand Medical College and Hospital, Ludhiana, India. [329]Rabigh Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia. [330]Electrical Engineering Department, Prince Sattam bin Abdulaziz University, Al Kharj, Saudi Arabia. [331]Department of Clinical Pharmacy, Jouf University, Sakaka, Saudi Arabia. [332]Digestive Diseases Research Institute, Tehran University of Medical Sciences, Tehran, Iran. [333]Department of Public Health, Management and Science University, Shah Alam, Malaysia. [334]Jeffrey Cheah School of Medicine and Health Sciences, Monash University, Subang Jaya, Malaysia. [335]School of Public Health, Mekelle University, Mekelle, Ethiopia. [336]Department of Nursing, Arba Minch University, Arba Minch, Ethiopia. [337]University Centre Varazdin, University North, Varazdin, Croatia. [338]Pacific Institute for Research & Evaluation, Calverton, MD, USA. [339]School of Public Health, Curtin University, Perth, WA, Australia. [340]Macquarie Medical School, Macquarie University, Sydney, NSW, Australia. [341]National Data Management Center for Health, Ethiopian Public Health Institute, Addis Ababa, Ethiopia. [342]Department of Surgical Oncology, All India Institute of Medical Sciences, Jodhpur, India. [343]Department of Epidemiology and Biostatistics, Shahrekord University of Medical Sciences, Shahrekord, Iran. [344]Translational Ophthalmology Research Center, Tehran University of Medical Sciences, Tehran, Iran. [345]Department of Pharmacology, Abadan School of Medical Sciences, Abadan, Iran. [346]Department of Optometry and Vision Sciences, Zahedan University of Medical Sciences, Zahedan, Iran. [347]Eye Research Center, Mashhad University of Medical Sciences, Mashhad, Iran. [348]Non-Communicable Diseases Research Center, Tehran University of Medical Sciences, Tehran, Iran. [349]School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [350]Iran University of Medical Sciences, Tehran, Iran. [351]College of Medicine and Public Health, Flinders University, Adelaide, Australia. [352]Department of Engineering, Western Sydney University, Sydney, NSW, Australia. [353]Comprehensive Cancer Center, University of Alabama at Birmingham, Birmingham, AL, USA. [354]Department of Dental Public Health, King Abdulaziz University, Jeddah, Saudi Arabia. [355]Department of Health Policy and Oral Epidemiology, Harvard University, Boston, MA, USA. [356]Department of Biotechnology, University of Central Punjab, Lahore, Pakistan. [357]Department of Medical Laboratory Sciences, Adigrat University, Adigrat, Ethiopia. [358]Department of Epidemiology, Non-Communicable Diseases Research Center, Tehran, Iran. [359]Division of Cardiology, Massachusetts General Hospital, Boston, MA, USA. [360]Department of Medical Engineering, University of South Florida, Tampa, FL, USA. [361]Cardiovascular Laboratory, Methodist Hospital, Merrillville, Merrillville, IN, USA. [362]Department of Allergy, Immunology and Dermatology, Hanoi Medical University, Hanoi, Vietnam. [363]Cardiovascular Research Department, Methodist Hospital, Merrillville, IL, USA. [364]Department of Surgery, Danang Family Hospital, Danang, Vietnam. [365]Department of General Medicine, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam. [366]International Islamic University Islamabad, Islamabad, Pakistan. [367]Department of Applied Microbiology, Oslo University Hospital, Taiz, Yemen. [368]Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia. [369]Department of Applied Economics and Quantitative Analysis, University of Bucharest, Bucharest, Romania. [370]School of Pharmacy, University of the Western Cape, Cape Town, South Africa. [371]Department of Psychiatry and Behavioural Neurosciences, McMaster University, Hamilton, ON, Canada. [372]Department of Psychiatry, University of Lagos, Lagos, Nigeria. [373]Slum and Rural Health Initiative Research Academy, Slum and Rural Health Initiative, Ibadan, Nigeria. [374]Department of Pharmacology and Therapeutics, University of Nigeria Nsukka, Enugu, Nigeria. [375]Geography Department, East Carolina University, Greenville, NC, USA. [376]Department of Pharmacotherapy and Pharmaceutical Care, Medical University of Warsaw, Warsaw, Poland. [377]School of Medicine, Western Sydney University, Campbelltown, NSW, Australia. [378]Department of Optometry and Vision Science, University of KwaZulu-Natal, KwaZulu-Natal, South Africa. [379]Laboratory of Public Health Indicators Analysis and Health Digitalization, Moscow Institute of Physics and Technology, Dolgoprudny, Russia. [380]Department of Medicine, University of Ibadan, Ibadan, Nigeria. [381]Department of Medicine, University College Hospital, Ibadan, Nigeria. [382]Department of Forensic Medicine and Toxicology, Kasturba Medical College, Mangalore, Mangalore, India. [383]Privatpraxis, Heidelberg, Germany. [384]Global Health Governance Programme, University of Edinburgh, Edinburgh, UK. [385]School of Dentistry, University of Leeds, Leeds, UK. [386]Department of Genetics, Yale University, New Haven, CT, USA. [387]Department of Development Studies, International Institute for Population Sciences, Mumbai, India. [388]Department of Zoology, Yadava College, Madurai, India. [389]Department of Zoology, Annai Fathima College, Madurai, India. [390]Department of Statistics and Econometrics, Bucharest University of Economic Studies, Bucharest, Romania. [391]Medical School, Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam. [392]Department of Maternal and Child Nursing and Public Health, Federal University of Minas Gerais, Belo Horizonte, Brazil. [393]Department of Neonatology, Case Western Reserve University, Cleveland, OH, USA. [394]Manipal TATA Medical College, Manipal Academy of Higher Education, Manipal, India. [395]Department of Population Science and Human Resource Development, University of Rajshahi, Rajshahi, Bangladesh. [396]Department of Radiology, Stanford University School of Medicine, Stanford, CA, USA. [397]Department of Community Medicine, Mahatma Gandhi Medical College and Research Institute, Puducherry, India. [398]Department Biological Sciences, King Abdulaziz University, Jeddah, Egypt. [399]Department of Protein Research, Research and Academic Institution, Alexandria, Egypt. [400]Health Economics Research Centre, University of Oxford, Oxford, UK. [401]Department of Pharmacology and Toxicology, University of Antioquia, Medellin, Colombia. [402]Faculty of Medicine, Gonabad University of Medical Sciences, Gonabad, Iran. [403]Infectious Diseases Research Center, Gonabad University of Medical Sciences, Gonabad, Iran. [404]Department of Epidemiology, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [405]Sharjah Institute for Medical Research, University of Sharjah, Sharjah, United Arab Emirates. [406]Multidisciplinary Laboratory Foundation University School of Health Sciences (FUSH), Foundation University, Islamabad, Pakistan. [407]International Center of Medical Sciences Research (ICMSR), Islamabad, Pakistan. [408]Ophthalmic Epidemiology Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [409]Ophthalmic Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [410]Research Center for Immunodeficiencies, Tehran University of Medical Sciences, Tehran, Iran. [411]Sharjah Institute of Medical Sciences, University of Sharjah, Sharjah, United Arab Emirates. [412]Clinical Sciences Department, Sharjah, United Arab Emirates. [413]Applied Biomedical Research Center, Mashhad University of Medical Sciences, Mashhad, Iran. [414]Biotechnology Research Center, Mashhad University of Medical Sciences, Mashhad, Iran. [415]Multiple Sclerosis Research Center, Tehran University of Medical Sciences, Tehran, Iran. [416]Ludwig Maximilian University of Munich, Munich, Germany. [417]Institute for Employment Research, Nuremberg, Germany. [418]College of Medicine, University of Sharjah, Sharjah, United Arab Emirates. [419]Faculty of Pharmacy, Mansoura University, Mansoura, Egypt. [420]Department of Neurology, Charité University Medical Center Berlin, Berlin, Germany. [421]Department of Neurology, University of Southern Denmark, Odense, Denmark. [422]School of Public Health, Taipei Medical University, Taipei, Taiwan. [423]Department of Entomology, Ain Shams University, Cairo, Egypt. [424]Medical Ain Shams Research Institute (MASRI), Ain Shams University, Cairo, Egypt. [425]Market Access, Bayer, Istanbul, Türkiye. [426]Faculty of Dentistry, AIMST University, Bedong, Malaysia. [427]Department of Medicine and Surgery, Government Doon Medical College, Dehradun, India. [428]National Heart, Lung, and Blood Institute, National Institute of Health, Rockville, MD, USA. [429]Department of Clinical Sciences, Al-Quds University, Ajman, United Arab Emirates. [430]Independent Consultant, Karachi, Pakistan. [431]Department of Nursing, Debre Berhan University, Debre Berhan, Ethiopia. [432]National Institute of Infectious Diseases, Tokyo, Japan. [433]Department of Veterinary Public Health and Preventive Medicine, Usmanu Danfodiyo University, Sokoto, Sokoto, Nigeria. [434]Department of International Studies, Non-Communicable Diseases Research Center, Tehran, Iran. [435]Faculty of Medicine, Tehran University of Medical Sciences, Tehran, Iran. [436]Department of Medical-Surgical Nursing, Mazandaran University of Medical Sciences, Sari, Iran. [437]Department of Nursing and Health Sciences, Flinders University, Adelaide, Australia. [438]Department of Pediatrics and Child Health Nursing, Dilla University, Dilla, Ethiopia. [439]Unit of Basic Medical Sciences, University of Khartoum, Khartoum, Sudan. [440]Department of Medical Microbiology and Infectious Diseases, Erasmus University, Rotterdam, Netherlands. [441]Family, Health Promotion, and Life Course Department, Pan American Health Organization, Bogota, Colombia. [442]School of Medicine, University of Alabama at Birmingham, Birmingham, AL, USA. [443]Department of Medicine Service, US Department of Veterans Affairs (VA), Birmingham, AL, USA. [444]Department of Radiodiagnosis, All India Institute of Medical Sciences, Bathinda, India. [445]Department of Radiology, University of Alabama at Birmingham, Birmingham, AL, USA. [446]Directive Board, Association of Licensed Optometry Professionals, Linda-a-Velha, Portugal. [447]Division of Community Medicine, International Medical University, Kuala Lumpur, Malaysia. [448]Department of Pharmacology, Shaqra University, Shaqra, Saudi Arabia. [449]Trauma and Injury Research Center, Iran University of Medical Sciences, Tehran, Iran. [450]Medical Ethics and Law Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [451]Aier Eye Hospital, Jinan University, Guangzhou, China. [452]Pediatric Intensive Care Unit, King Saud University, Riyadh, Saudi Arabia. [453]Faculty of Public Health, Universitas Sam Ratulangi, Manado, Indonesia. [454]Nuffield Department of Primary Care Health Sciences, University of Oxford, Oxford, UK. [455]Department of Public Health, Woldia University, Woldia, Ethiopia. [456]Department of Medicine, University of Crete, Heraklion, Greece. [457]Medical School, University of Crete, Heraklion, Greece. [458]Department of Pharmacology, All India Institute of Medical Sciences, Deoghar, India. [459]Department of Public Health, East Carolina University, Greenville, NC, USA. [460]College of Public Health, Temple University, Philadelphia, PA, USA. [461]Medical Genomics Research Department, King Abdullah International Medical Research Center, Riyadh, Saudi Arabia. [462]Department of Life Sciences, University of Management and Technology, Lahore, Pakistan. [463]Clinical Cancer Research Center, Milad General Hospital, Tehran, Iran. [464]Department of Microbiology, Islamic Azad University, Tehran, Iran. [465]Urmia University of Medical Sciences, Urmia, Iran. [466]Division of Cardiology, Johns Hopkins University, Baltimore, MD, USA. [467]Department of Epidemiology and Biostatistics, Bahir Dar University, Bahir Dar, Ethiopia. [468]Department of Community Medicine, Rajarata University of Sri Lanka, Anuradhapura, Sri Lanka. [469]Department of Ophthalmology Research, Queen Mamohato Memorial Hospital, Maseru, Lesotho. [470]Ophthalmology Unit, Bahir Dar University, Bahir Dar, Ethiopia. [471]Department of Microbiology and Immunology, Zagazig University, Zagazig, Egypt. [472]Department of Cells and Tissues, Molecular Biology Institute of Barcelona, Barcelona, Spain. [473]Department of Cancer Epidemiology and Prevention Research, Alberta Health Services, Calgary, AB, Canada. [474]Department of Oncology, University of Calgary, Calgary, AB, Canada. [475]China Center for Health Development Studies, Peking University, Beijing, China. [476]Center for the Study of Aging and Human Development, Duke University, Durham, NC, USA. [477]Department of Health Management, Süleyman Demirel Üniversitesi (Süleyman Demirel University), Isparta, Türkiye. [478]Department of Pharmacology, Bahir Dar University, Bahir Dar, Ethiopia. [479]Pharmacy Department, Alkan Health Science Business and Technology College, Bahir Dar, Ethiopia. [480]Department of Neuropsychopharmacology, National Center of Neurology and Psychiatry, Kodaira, Japan. [481]Department of Public Health, Juntendo University, Tokyo, Japan. [482]Department of Bioengineering and Therapeutic Sciences, University of California San Francisco, San Francisco, CA, USA. [483]Addictology Department, Russian Medical Academy of Continuous Professional Education, Moscow, Russia. [484]Department of Public Health, Dilla University, Dilla, Ethiopia. [485]School of Medicine, Wuhan University, Wuhan, China. [486]College of Traditional Chinese Medicine, Hebei University, Baoding, China. [487]Department of Biochemistry and Pharmacogenomics, Medical University of Warsaw, Warsaw, Poland. [488]Department of Nursing, Yasuj University of Medical Sciences, Yasuj, Iran.