Gender Inequality in Global Burden of Uncorrected Refractive Error

LIXIA LOU, XI LIU, XIAJING TANG, LINYAN WANG, AND JUAN YE

• PURPOSE: To explore gender inequality in global burden of uncorrected refractive error (URE) by year, age, and socioeconomic status using disability-adjusted life years (DALYs).
• DESIGN: International, comparative burden-of-disease study.
• METHODS: Global, regional, and national gender-specific DALY numbers; crude DALY rates; and age-standardized DALY rates caused by URE, by year and age, were extracted from the Global Burden of Disease Study 2015. Human development index (HDI) in 2015 as an indicator of national socioeconomic status was extracted from the Human Development Report. Pearson correlation and linear regression analyses were conducted to investigate the association between socioeconomic status and gender inequality.
• RESULTS: Gender inequality in global URE burden has persisted since 1990, through 2015, with little improvement over the decades. Age-standardized DALY rates were 189.8 among male subjects vs 223.0 among female subjects in 1990 and 188.4 vs 225.2 in 2015. Female subjects had higher burden than male subjects of the same age, and gender inequality increased with age. Female-minus-male difference in age-standardized DALY rates ($r = -0.562$, $P < .001$; standardized $\beta = -0.562$, $P < .001$) and female-to-male age-standardized DALY rate ratios ($r = -0.258$, $P < .001$; standardized $\beta = -0.258$, $P < .001$) were negatively related to HDI.
• CONCLUSIONS: Gender inequality in global URE burden has persisted over the past few decades, with female individuals bearing more burden than male individuals. Older age and lower socioeconomic status are related to greater gender inequality. These findings highlight the importance of making gender-sensitive health policy to manage global vision loss caused by URE. (Am J Ophthalmol 2019;198:1–7. © 2018 Elsevier Inc. All rights reserved.)

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UNCORRECTED REFRACTIVE ERROR (URE) IS AMONG the most common ocular disorders worldwide.[1] The major types of URE are nearsightedness, farsightedness, astigmatism, and presbyopia.[2] Although most URE could be corrected with spectacles or contact lenses, they remain the leading causes of visual impairment, leading to 101.2 million cases of moderate and severe visual impairment (MSVI) and 6.8 million cases of blindness.[3] Globally, the prevalence of visual impairment caused by URE was 1.6% among female subjects vs 1.4% among male subjects in 2010.[3] Female individuals in low- and middle-income countries are less likely to seek spectacle correction than male individuals.[4] Considering the possible impact of URE on educational opportunity as well as labor productivity, quality of life of female persons might be more impaired owing to URE than that of male persons.[5–7]

In the Global Burden of Diseases Study (GBD study), the health burden of URE is evaluated by estimating disability-adjusted life years (DALYs).[8] DALY data from the GBD study have first been used to explore global health inequality in eye diseases by Ono and associates.[9] They found that URE is unequally distributed worldwide, especially in low- and middle-income countries. However, gender inequality in the health burden of URE has not yet been investigated. Since URE is the most easily treatable cause of visual loss,[10] gender inequality in URE burden becomes a major concern in reducing avoidable blindness. Identifying underlying contributors to gender inequality would be important for health policymaking. Thus, the aim of this study was to compare multiple aspects of gender inequality in global URE burden by year, age, and socioeconomic status using the recent DALY data from the GBD 2015 study.[8]

METHODS

• STUDY DESIGN: This is an international, comparative burden-of-disease study.

• GENDER-SPECIFIC BURDEN OF UNCORRECTED REFRACTIVE ERROR: International Classification of Diseases (10th edition) codes H49-H52 are mapped to URE in the GBD 2015 study.[11] Methods to estimate DALYs have been previously described.[8] DALYs caused by URE were extracted from the Global Health Data Exchange,[12]

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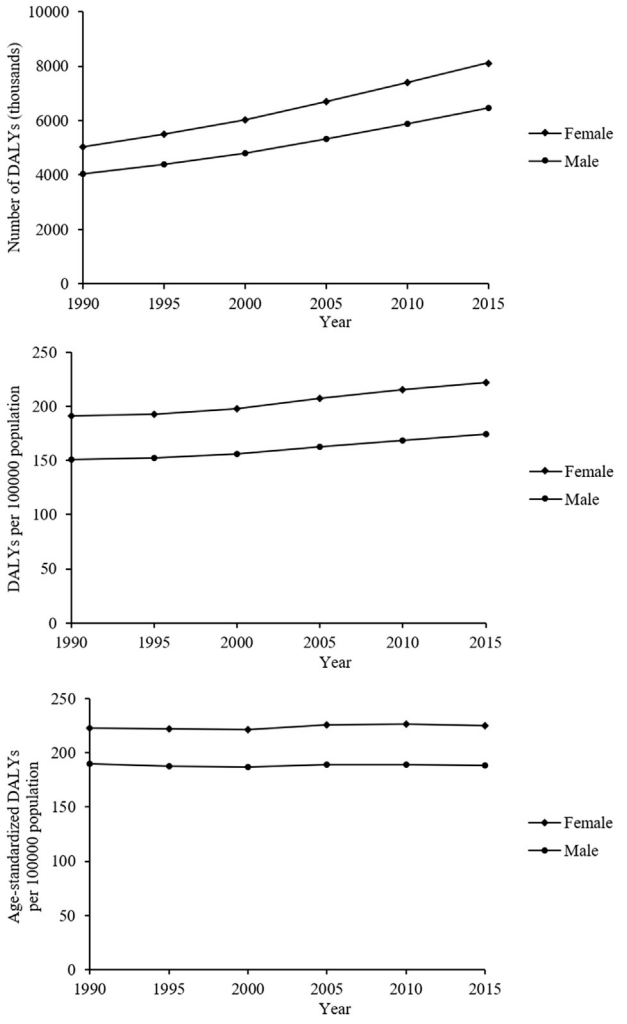

FIGURE 1. The persistence of gender inequality in global burden of uncorrected refractive error from 1990 to 2015, in terms of disability-adjusted life year (DALY) numbers (Top), crude rates (Middle), and age-standardized rates (Bottom).

including (1) global gender-specific DALY numbers, DALYs per 100 000 population (crude rates), and age-standardized DALYs per 100 000 population (age-standardized rates) from 1990 to 2015; (2) World Health Organization (WHO) regional gender-specific age-standardized DALY rates from 1990 to 2015; (3) global gender- and age-specific DALY numbers and crude rates in 2015; (4) national gender-specific age-standardized DALY rates in 2015.

• **NATIONAL SOCIOECONOMIC STATUS:** Human development index (HDI), a composite measure of health, education, and income, is considered an indicator of national socioeconomic status. HDI data in 2015 were extracted from the Human Development Report 2016.[13] A higher value of HDI ranging from 0 to 1 indicates a higher level of socioeconomic development. Countries were classified into 4 groups by HDI, including low-HDI countries ($0 < \text{HDI} < 0.550$), medium-HDI countries ($0.550 \leq \text{HDI} < 0.701$), high-HDI countries ($0.701 \leq \text{HDI} < 0.800$), and very-high-HDI countries ($0.800 \leq \text{HDI} < 1$).[13]

• **STATISTICAL ANALYSES:** Mann-Whitney *U* tests were conducted to compare global gender difference in age-standardized DALY rates caused by URE. Pearson correlation analyses and linear regression analyses were performed to explore the relationship of female-minus-male difference in age-standardized DALY rates and female-to-male age-standardized DALY rate ratios with HDI. SPSS 23 (IBM, Chicago, Illinois, USA) was used for all statistical analyses, with $P < .05$ being considered statistically significant.

RESULTS

• **TRENDS IN GLOBAL GENDER INEQUALITY:** Gender inequality in global burden of URE has persisted since 1990, through 2015, with little improvement over the decades. The DALY numbers were 4 028 442 among male subjects vs 5 039 309 among female subjects in 1990, and 6 472 480 vs 8 121 298 in 2015 (Figure 1, Top). After controlling for population size, gender inequality in crude DALY rates also persisted between 1990 (151.1 among male subjects vs 191.1 among female subjects) and 2015 (174.2 vs 222.2) (Figure 1, Middle). After controlling for both population size and age structure, gender inequality in age-standardized DALY rates showed no improvement over the decades, with 189.8 among male subjects vs 223.0 among female subjects in 1990 and 188.4 vs 225.2 in 2015 (Figure 1, Bottom). Regional trend plots revealed the persisting gender inequality in age-standardized DALY rates in all WHO regions from 1990 through 2015 (Figure 2). The gender inequality observed in the South-East Asia region, Eastern Mediterranean region, and African region was greater than that at the global level.

• **GLOBAL GENDER INEQUALITY BY AGE:** Globally, female individuals had higher burden of URE than male individuals of the same age in 2015. In general, gender inequality in global URE burden had an increasing trend with age. The gender inequality in DALY numbers was increasing with age among populations under 65 years of age (Figure 3, Top). The greatest inequality in DALY numbers was observed above 80 years of age, with 299 465 among male subjects vs 545 552 among female subjects. After controlling for population size, the greatest gender inequality in crude DALY rates was observed in the age range of 75-79 years, with 672.1 among male subjects vs 791.6 among female subjects (Figure 3, Bottom).

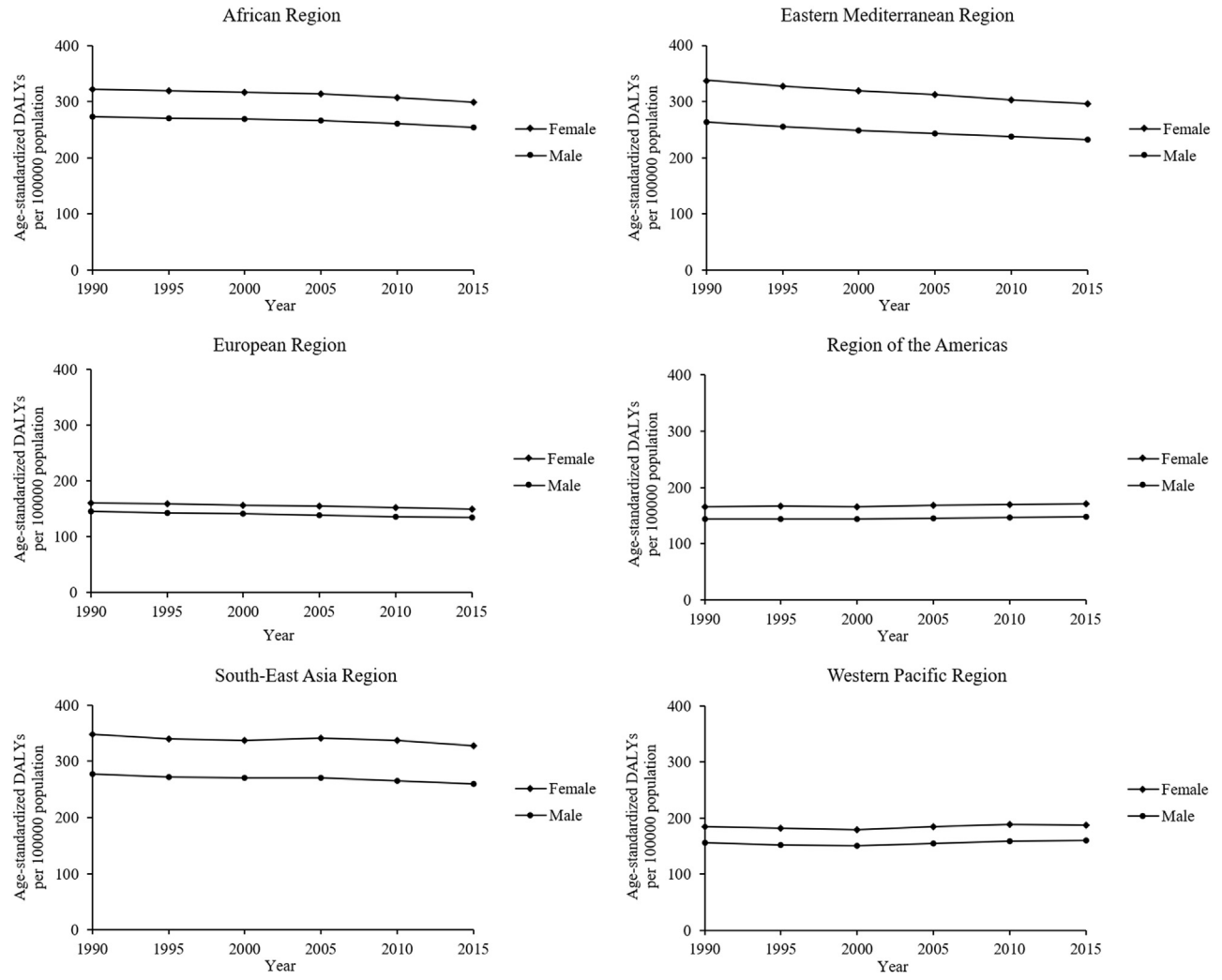

FIGURE 2. The persistence of gender inequality in World Health Organization regional burden of uncorrected refractive error in terms of age-standardized disability-adjusted life year (DALY) rates from 1990 to 2015: (Top left) African region, (Top right) Eastern Mediterranean region, (Middle left) European region, (Middle right)region of the Americas, (Bottom left) South-East Asia region, and (Bottom right) Western Pacific region.

• **GENDER INEQUALITY BY NATIONAL SOCIOECONOMIC STATUS:** Mann-Whitney *U* test demonstrated that for 195 countries included in the GBD 2015 study, age-standardized DALY rates caused by URE were greater among female than among male individuals ($Z = -4.315$, $P < .001$), with medians (interquartile ranges) being 214.0 (161.5-278.6) vs 188.4 (138.9-234.2). HDI data in 2015 were available for 184 countries, including 49 very-high-HDI countries, 53 high-HDI countries, 41 medium-HDI countries, and 41 low-HDI countries. Age-standardized DALY rates were higher among female than among male subjects for low- (297.5 [254.3-328.0] vs 253.4 [212.7-269.0]), median- (275.6 [223.9-291.9] vs 223.3 [191.4-249.6]), high- (202.1 [169.6-235.8] vs 163.6 [146.8-196.2]), and very-high-HDI countries (110.3 [100.7-159.0] vs 101.1 [89.1-149.3]) (Figure 4). Generally, age-standardized DALY rates were higher in lower-HDI countries for both genders. Further analyses revealed that female-minus-male difference in age-standardized DALY rates ($r = -0.562$, $P < .001$; standardized $\beta = -0.562$, $P < .001$) (Figure 5, Top) and female-to-male age-standardized DALY rate ratios ($r = -0.258$, $P < .001$; standardized $\beta = -0.258$, $P < .001$) (Figure 5, Bottom) were both negatively related to HDI, implying greater gender inequality in countries with lower HDI.

DISCUSSION

THIS STUDY REVEALED THAT GENDER INEQUALITY IN THE global burden of URE had persisted since 1990 and has

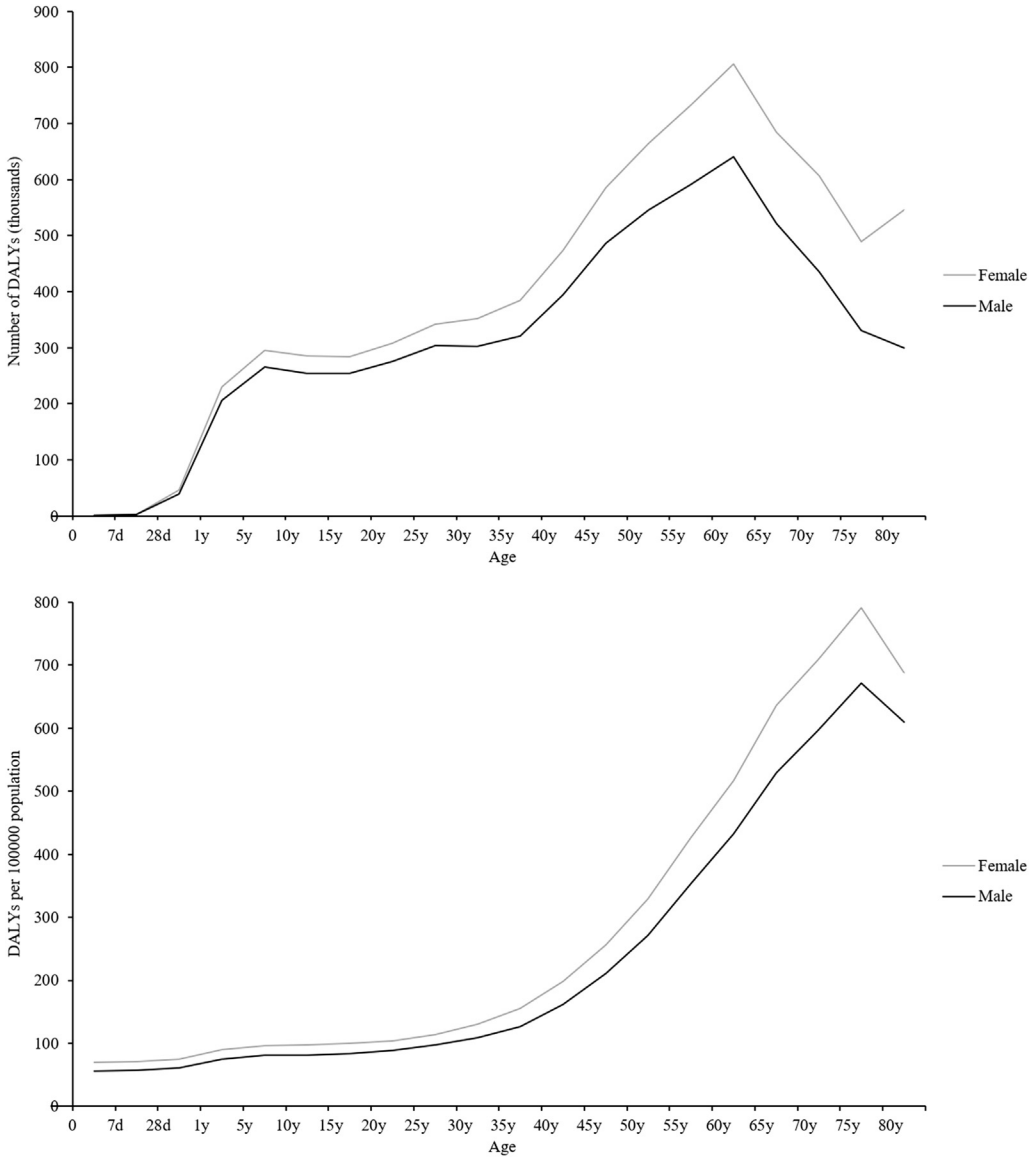

FIGURE 3. Global gender-specific burden of uncorrected refractive error by age in 2015, in terms of disability-adjusted life year (DALY) numbers (Top), and crude rates (Bottom).

shown little improvement over the past few decades, with those of female gender bearing higher burden of URE than those of male gender. Globally, gender inequality in URE burden increased with age and was greater in countries with lower levels of development.

According to a recent review, the prevalence of MSVI in all ages owing to URE decreased from 2.1% in 1990 to 1.5% in 2010, and the prevalence of blindness decreased from 0.2% in 1990 to 0.1% in 2010.[3] However, the global health improvement of URE does not mean fewer demands for refractive services or smaller gender inequality.[14,15] In 2010, the global age-standardized prevalence of visual impairment was higher among female individuals (1.6%) than that among male individuals (1.4%) and this gender disparity existed in all regions of the world.[3] The biological, social, cultural, and economic differences between male and female individuals would lead to the higher female burden of URE.[15] In all regions of the world and at all time periods, the longevity pattern that women live longer than men is the same.[16] Thus, more women are suffering from the eye diseases that occur late in life, such as presbyopia, the age-related loss of accommodation.[17] In addition, female individuals' child care responsibilities may make it difficult to leave home for eye care services. Besides, female family members' need for eye care may not be regarded as being as important as that of male family members, or female persons may have less income and less financial decision-making authority.[15] Furthermore, female subjects

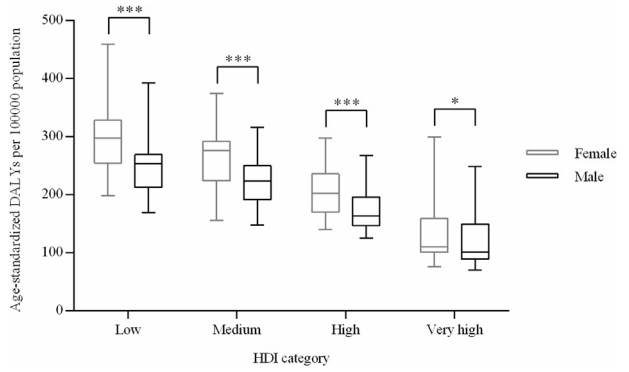

FIGURE 4. Age-standardized disability-adjusted life year (DALY) rates were higher among femalesubjects than among male subjects for each human development index (HDI)-based country group. Lines inside the boxes indicate the medians, boxes the 25th and 75th percentiles, and lines outside the boxes the minimum and the maximum. * indicates $P < .001$, and * $P < .05$.**

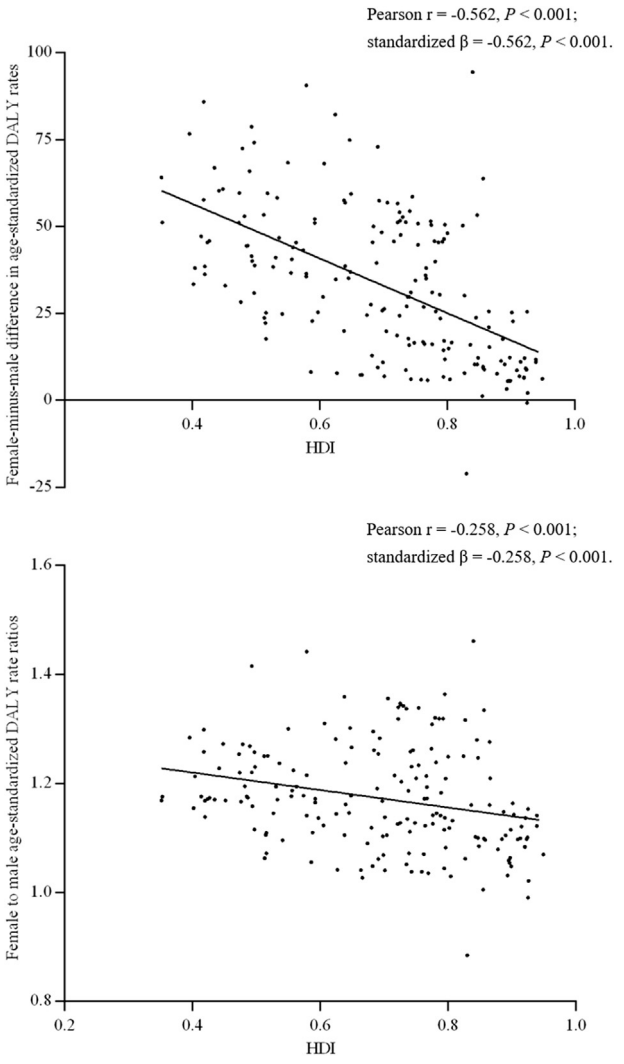

FIGURE 5. Female-minus-male difference in age-standardized disability-adjusted life year (DALY) rates (Top) and female-to-male age-standardized DALY rate ratios (Bottom) were negatively related to the level of national socioeconomic development. Lines represent the linear fits. HDI = human development index.

may feel ashamed of asking for families' support, while male subjects may have a strong desire for better vision.[18]

In general, the global burden of URE increased with age, as shown in Figure 3 (Bottom). However, the decline of the oldest age group might be an artifact, because of the small number of individuals in this group. According to the 2017 Revision of World Population Prospects released by the United Nations, the population aged above 80 years only accounts for 1.7% of the total world population in 2015.[19] Age is the most important demographic factor associated with different types of URE.[20] Myopia begins in early life and increases in both frequency and severity through childhood into adulthood. A population-based study in Tehran, Iran reported a significantly higher prevalence of myopia among female subjects than that among male subjects within each age group.[21] However, another population-based study conducted in Mashhad, Iran showed no relationship between gender and myopia based on both cycloplegic and noncycloplegic refraction.[22] Considerable regional difference in the prevalence of myopia exists from country to country even within the same geographic area.[20] Age-related increase in hyperopia has been reported in previous studies,[21,23] which may be owing to decreasing lens power with aging or increasing lens opacity making the lens more uniformly refractive. Similarly, no consensus has been reached regarding the association between gender and hyperopia, as implied by the results from different studies.[21,22,24] With an assumed onset age of 40-45 years, presbyopia is almost universal in individuals over 65 years old.[25] A systematic review suggested that increased association of presbyopia for female subjects is not because of a physiologic difference in accommodation but rather because of other gender differences, such as tasks performed and viewing distances.[17] Although inconsistent findings still exist in some epidemiologic studies on gender inequality in URE, this study has demonstrated the extent of gender differences within each age group from a global perspective, by using the most reliable data available.

Our previous study has found higher burden of URE in countries with lower socioeconomic status.[14] The present study confirms this finding and further reveals greater gender inequality in URE burden in those countries. Similarly, socioeconomic-associated gender inequality was also found in other eye diseases, such as cataract.[26] Female individuals in developing countries tend to have less income and less financial decision-making authority on their own health care. There is evidence that female persons in less

developed countries may often be underserved in receiving spectacles.[27] For instance, a population-based survey conducted in Timor-Leste reported that the refractive error correction coverage was 12.8% among female subjects vs 18.4% among male subjects, and the proportion of willingness to pay US $3 for spectacles was 15.2% vs 25.0%.[27] Moreover, the shortage of eye doctors in developing countries is well documented, with an average of 1 ophthalmologist per 110 000 people, which is significantly lower than the average 1 ophthalmologists per 13 000 people in developed countries.[28] Less availability to eye care service might lead to greater gender disparity in receiving refractive error correction in developing countries. However, it is worth mentioning that socioeconomic status only partly explains the gender inequality in URE, as shown by the scattered data points around the regression lines in Figure 5.

This study was subject to the limitations of the GBD 2015 study, such as statistical assumption and data sources, as noted in the GBD 2015 reports.[8,11] Because of the use of aggregate data at the national level instead of district data, bias might come from geographic variations in DALY estimates. Though a global view of gender inequality in URE burden has been provided in this study, the conclusions may not be applicable to a specific district. As annual updates of GBD data are available, a long-term view of gender inequality in URE burden could be expected.

In summary, this study revealed that gender inequality in global URE burden has persisted for decades and little improvement has been achieved. Female individuals, especially for the elderly and those from less developed countries, have a higher burden of URE than male individuals. These findings may raise public awareness of gender inequality in URE. Since URE is easily treatable, gender inequality is a major concern in reducing avoidable blindness. This study highlights the importance of making gender-sensitive health policy to manage global vision loss caused by URE.

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