# Gender Inequality in Global Burden of Near Vision Loss: An Analysis of Trends from 1990 to 2017

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# Abstract

Backgrounds

Eye disease burden is essential to life quality and crucial when making universal health policy with aging of population. Gender difference is a major factor of reducing burden caused by near vision loss (NVL). The research aimed to evaluate the trends and gender inequality in global health burden of NVL by year, age, and socioeconomic status using the disability-adjusted life years (DALY) from the Global Burden of Diseases (GBD) 2017 study.

Methods

The related DALY measurements were extracted from the GBD Study 2017. Human development index (HDI) in 2017 was obtained from the Human Development Report. The difference in age-standardized DALY rates (ASR) among four subgroups classified by HDI was compared by Mann-Whitney U tests. The effect of HDI on gender difference in ASR was investigated by Pearson correlation analyses and regression analyses.

Results

Gender difference has grown slightly since 1990, with ASR being 110 among males vs. 129 among females in 1990 and 108 vs. 134 in 2017. Gender inequality have existed in most WHO regions except European region. Females had higher burden of than males the same age and the inequality peaked around 50 years old, but men over 80 years old suffered greater burden. Female-minus-male difference in ASR ($r = -0.428$, $P<0.001$; standardized $\beta = -0.428$, $P<0.001$) and female-to-male ASR ratios ($r = -0.410$, $P<0.001$; standardized $\beta = -0.410$, $P<0.001$) were negatively related to HDI.

Conclusion

Gender inequality had persisted since 1990 and grown slightly these decades. The burden was heavier in women, especially in those elderly and from less developed countries. Gender inequality caused by NVL must be taken into consideration when making health care policy, reforming universal health and education coverage.


# Background

Visual impairment is credential for quality of life and for the socioeconomics and public health of societies and countries. Near vision impairment (NVI), as an important part of visual impairment, has already been acknowledged by World Health Organization as a vital aspect of visual function.[1] In Global Burden of Diseases (GBD) 2017 Study, Near vision loss (NVL) , which is one of the newly added causes, is defined as difficulty in seeing things that are nearer than 3 feet, but not with seeing things at a distance.[2,3]. One estimate revealed that nearly 108 million people worldwide suffered from impaired distance vision, whereas an even larger 517 million suffered from NVI. NVI significantly affects life quality and

burdens economy with global productivity loss of over $25 billion. [4-7] Most NVI in adults is attribute to presbyopia, which begins at around 30 years of age, with almost everyone developing and being completely incapable of accommodation by the age of 50 to 55 years.[8-10] With the aging of population, the risk and course of suffering from presbyopia increases. It was estimated to affect 1.8 billion people in 2015 and the number was predicted to reach approximately 2.1 billion in 2030.[11] However, nearly half of people were unable to access the necessary refractive correction to overcome the associated vision impairment.[11,12]

Disability-adjusted life-years (DALYs) was presented in GBD Study 2017 to estimate the burden of NVL by quantifying health loss. It was reported that NVL caused 9,800,000 DALYs in 2017 worldwide, with 5,540,000 DALYs among women and 4,260,000 DALYs among men. [3] According to the research did at seven sites, women tended to have greater burden in uncorrected near vision impairment, which was the same with GBD Study 2017.[13] In studies performed in Brazil[14], India[15] and Tanzania[16], it was also discovered female individuals had higher prevalence rates than that of male individuals. Therefore, the gender inequality in NVL burden is grabbing more and more attention to improve the quality of life and increase productivity. A global long-term analysis of gender-specific burden of NVL with available, credible data remains urgent need. Unfortunately, before the study, very few researches had estimated the prevalence of NVI as most countries largely focus on distance vision and had limited data about NVI. As far as we know, studies with high-quality data was mainly conducted in 4 areas: Brazil, India, Timor-Leste and Tanzania, where the data were from recent years.[11] Meanwhile, the relationship between gender and region-specific burden caused by NVL was still unclear. Consequently the aim of the study was to evaluate the trends in global health burden of NVL and assess multiple aspects of gender inequality in it since 1990 by year, age, and socioeconomic status using the recent DALY data from the GBD 2017 study.

# Methods

### Design

This is an international, comparative burden-of-disease study.

### Gender-Specific Burden of Near Vison Loss

NVL referred to individuals have difficulty with seeing things that are nearer than 3 feet, but not with seeing things at a distance, as described in the GBD 2017 study.[2] DALYs, presented in the GBD Study 2017 report, were used to quantify the health loss due to specific diseases and injuries.[3] The methodology has been described in GBD Study 2017 before.[3] The data for statistical analysis were extracted from the Global Health Data Exchange[17], including: (1)national gender-specific DALY numbers, DALYs per 100,000 population (crude rates), and age-standardized DALY rates (ASR) from 1990 to 2017, (2)WHO regional gender-specific ASR from 1990 to 2017; (3)national gender-age-specific DALY numbers and crude rates in 2017. Ethics approval and informed consent were not required since the data is from an open access database.

### Gender Inequality By National Socioeconomic Status

The human development index (HDI) is a composite index focusing on people's health, education and income, indicating national socioeconomic status. The national HDI in 2017 were extracted from the Human Development Indices and Indicators 2018 [18] and divided into 4 subgroups: very high (HDI ≥ 0.800), high (0.700 ≤ HDI < 0.799), medium 104 (0.550 ≤ HDI < 0.699), and low HDI countries (HDI < 0.550). Countries with higher HDI values indicated they had better socioeconomic development.

### Statistical Analysis

The difference in ASR among four subgroups classified by HDI was compared by Mann-Whitney U tests. The effect of HDI on female-minus-male difference in ASR and female-to-male ASR ratios was investigated by Pearson correlation analyses and regression analyses. All data analyses were performed by SPSS 23 (IBM, Chicago, Illinois, USA). A $p<0.05$ was considered statistically significant.

## Results

### Global Trends of Inequality in the Burden of Near Vison Loss by Sex

As is shown in Figure 1, gender difference has persisted since 1990 and maintained small growth in recent decades. The DALY numbers increased from 2,380,000 among male subjects vs 2,993,000 among female subjects in 1900 to 4,260,000 vs. 5,542,000 in 2017 (Figure 1a). After removing the influence of population size, gender difference in crude DALY rates also persisted from 1990 (88 among male subjects vs. 112 among female subjects) to 2017 (111 vs. 146) (Figure 1b). After controlling of population size and age structure, ASR decreased from 110 in 1990 to 108 in 2017 among men, but increased among women, from 129 in 1990 to 134 in 2017. However, it showed less inequality in gender inequality from 1990 (Figure 1c).

Regional trend plots showed that gender inequality have existed in most World Health Organization regions since 1990, except for European region (Figure 2). South-East Asia region, Eastern Mediterranean region and African region had greater gender inequality than that of global level. Among all the regions, the largest gap was observed in South-East Asia region, with 157 in men vs 222 in women in 1990 and 147 in men and 208 in women in 2017. However, the differences in ASR by sex changed little from 1990 to 2017 in all regions.

### Global Gender-Specific Near Vision Loss Burden by Age

GBD study 2017 evaluates global gender-specific DALYs for all ages. The gender inequality in DALY numbers increased and peaked around the age range of 50 to 55 years, with 642,539 among female individuals and 521,174 among male individuals (Figure 3a). After controlling of population size, the greatest gender inequality was found around the age range of 50 to 55 years and vanished in the age

range of 80 to 85 years. For people above 85 years old, the burden was heavier in men than women and the difference was greater with the age growth (Figure 3b).

### Global Gender-Specific Near Vision Loss Burden by National Socioeconomic Status

For 195 countries included in the GBD 2017 study, Mann-Whitney U test demonstrated that ASR were higher in women than that in men (Z=-3.417, p<0.001), with medians (interquartile range) being 124.89 (80.04 – 166.00) vs. 106.04 (72.79 – 138.60). Gender-difference (female-minus-male) in ASR map (Figure 4a) showed difference was greatest in India, followed by Morocco and Haiti. From the distribution map of gender-ratio (female-to-male) (Figure 4b), Bangladesh had the greatest inequality, then Croatia and Dominican Republic. HDI date were available for 185 countries in 2017, including 38 low, 38 medium, 52 high and 56 very-high HDI countries. Multiple comparisons by Mann-Whitney U test indicated that ASR were greater among female individuals than male individuals for low (175.95 [156.77-187.33] vs. 146.06 [122.57-158.63]), medium (158.30 [116.50-184.70] vs. 134.75 [101.98-160.38]), and high (136.76 [106.41-163.67] vs. 112.36 [95.82-135.65]) HDI countries. However, ASR showed no difference in sex in very-high countries, with 54.53 (28.15-79.47) among women vs. 56.55 (21.78-82.12) among men (Figure 5a). Generally, ASR were observed to be lower in countries with higher HDI in both sexes. Pearson correlation analyses and linear regression showed that female-minus-male difference in ASR were negatively related to HDI, with Pearson r = -0.428, P<0.001 and standardized β = -0.428, P<0.001. Female to male ASR ratios were also inversely associated with HDI in Pearson correlations (Pearson r = -0.410, P<0.001) and linear regression analyses (standardized β = -0.410, P<0.001) (Figure 5b and 5c).

## Discussion

In this study, it was found that gender differences caused by NVL have persisted since 1990 and had slight growth through 2017, with women suffering higher burden than men. Globally, the sexual differences increased with age and then decreased above 50-55 years of age along with the age growth. Besides, it was revealed that the gender inequality was heavier in countries with lower socioeconomic status.

According to GBD study 2017, NVL is one of the leading causes of blindness and vision impairment [3]. Several reasons might lead to near vision impairment, including presbyopia-the most common cause, uncorrected refractive error, cataract and retina diseases. [14] From 1990 to 2017, the sexual difference increased by 104.49% and 33.75% of global DALY numbers and ASR respectively. The population growth, lifespans extension and change of age structure might partially contribute to the increase of the sexual difference. It was reported that the global population increased by 197.2%, from 2.6 billion people in 1950 to 7.6 billion people in 2017. [19] And the global mean age of a person increased from 26.6 years in 1950 to 32.1 years in 2017, which indicates the transition of aging populations. [19] After controlling of population size and age structure, the sextual difference still existed, which was consistent with previous study .[14,15,16,20] One of the reasons that why female individuals were more likely to suffer from NVL might be that women tended to outlive men in most countries[21], which means higher life expectancy is

correlated with higher rates of poor health in women compared to men. And women were easier to lack awareness to get near-vision spectacles than men due to less educational resources, taking care of family and hidden of self-feelings.[22,23] Meanwhile, it has been indicated that women were more easily to have presbyopia. [15] In several studies, it was proposed that lens changes was associated with presbyopia, with the sclerosis of the nucleus and denaturation of lens proteins as people age. And it was more likely to happen in women than male, as elucidated in previous study. [24-27] A meta-analysis conducted in 2012 also indicated that female might have a higher risk for presbyopia than males of equivalent age. [28]

Apart from the gender difference since 1990, it was also observed that DALY numbers were greatest around 50-55 years old. It was in accordance with the findings in several studies that the onset of presbyopia was around 40-50 years old.[14,15] It was probably due to lack of awareness of the disease they had in initial episode and not getting the correction immediately, resulting in the heaviest burden around age 50-55, but not in 40-50. After controlling of population size and age structure，we found that the burden was increasing with the age growth，which was consistence with other studies in Brazil, China, Tanzania, India and Australia.[14,15,16,,20,29] Interestingly, in this study, we found that above 85 years old, ASR decreased for female individuals, smaller than that of male individuals. This might attribute to longer life expectancy of women than that of men, which meant elder men are more easily to have poor health and have greater burden than elder women.

Although global gender differences found in this study were the same with previous studies[14,15,16,30,31], there were other studies suggested that gender differences were not observed in Australia, Nepal and China.[20,32,33] The discrepancy might related to the area, sample size and statistical analysis methods. Using the credible data from GBD 2017, we found South East Asia region had the greatest gender difference among all global regions, with Bangladesh showing greatest difference among 195 countries (Figure 4b). On the contrary, there was little sexual difference in European region. The difference might relate to some socioeconomic indicators, which we performed further analysis. We observed that global burden of NVL was greater in lower socioeconomic countries, similar to previous study revealing higher burden of uncorrected refractive error in those countries. [24] In less developed countries, lower income, lower education and less availability to health care are the dominant reasons for the greater burden in women. According to The Global Gender Gap Report 2017, Middle East and South Asia had the widest gender gap, followed by South Asia and Western European was the best gender-equal region.[34] There are evidences that the gender gap in adolescent education was 8.4% in low-income countries, 3.6% in lower-middle–income countries, and 2.0% in upper-middle–income countries.[35] The defect in less developed countries could lead to inadequate of education among women and consequently, lack of awareness to receive health service. This could also lead to the limited financial decision-making authority and accessible social support for women in some areas.[22] In developing countries, women might often be likewise underserved in receiving near-vision spectacles.[36] Besides, it was demonstrated that in less developed countries, Optometry and Glasses Center were often located in urban areas, with some rural

communities more than 30 km from the nearest center. [37] Women were frequently busy with taking care of family and kids, which prevented them from getting health care in time, especially when it was inconvenient. Meanwhile, lack of ophthalmologists also deserved attention, with 1 doctor per 110,000 people in developing countries vs 1 doctor per 13,000 in developed countries. [38] Therefore, as the majority of NVI is treatable with optical correction with relatively ease and low cost, the improvement of economic capability, education equality, availability and affordability of medical services among female persons in developing countries should be taken into consideration when governments make health policy, including efficient resource allocation, popularization of low-cost spectacles with good quality and so on.

# Limitations

There were several limitations in our study that can't be ignored. First of all, our research was subject to the restrictions of data sources and statistical assumption in GBD Study 2017 since the data were extracted from the database which used representative population-based studies to calculate estimates through hierarchical models.[3,39] Secondly, our study provided a national view of gender inequality caused by NVL but were not appropriate to particular region since the statistical analyses were based on country level. Thirdly, the variation in the definition of NVL must be taken into consideration on account of lack of a unified definition. Fourthly, some potential confounders such as culture, lifestyle and genetic heterogeneity that might influence the sexual differences in global burden were not included in our study. Socioeconomic status could only explain part of gender inequality, as showed in Figure 5. Further studies based on individual research are needed to obtain more accurate results. Since the GBD database updated annually, a continued observation of gender inequality in NVL could be expected.

# Conclusions

In conclusion, this study discovered that gender inequality had persisted since 1990 and grown slightly these years. It was observed that the burden was heavier in females, especially in those elderly and from less developed countries. Since some factors causing NVL was easily treatable like presbyopia with low cost, government should pay more attention to formulate sexual-specific health policy and allocate medical resources appropriate to country's resources and needs. Gender inequality caused by NVL must be taken into consideration when reforming universal health and education coverage.

# Abbreviations

NVI: Near vision impairment

GBD: Global Burden of Diseases

NVL: Near vision loss

DALY: Disability-adjusted life-years

ASR: age-standardized DALY rates

HDI: The human development index

# Declarations


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### Availability of data and materials

All data extracted or analysed during this study are included in this article.

### Authors' contributions

All authors have made substantive intellectual contributions to this study. Jing Cao and Yufeng Xu contributed to conceptualization of the article. Jing Cao conducted statistical analysis and prepared daft manuscript. Yufeng Xu reviewed and edited the draft. Lixia Lou contributed to the design of this work. Yijie Wang and Xiling Lin extracted the data from databases. Discrepancy were finally resolved by Juan Ye. All authors reviewed and approved the final version of the manuscript.

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Conflict of Interest

The authors declare that they have no conflict of interest.

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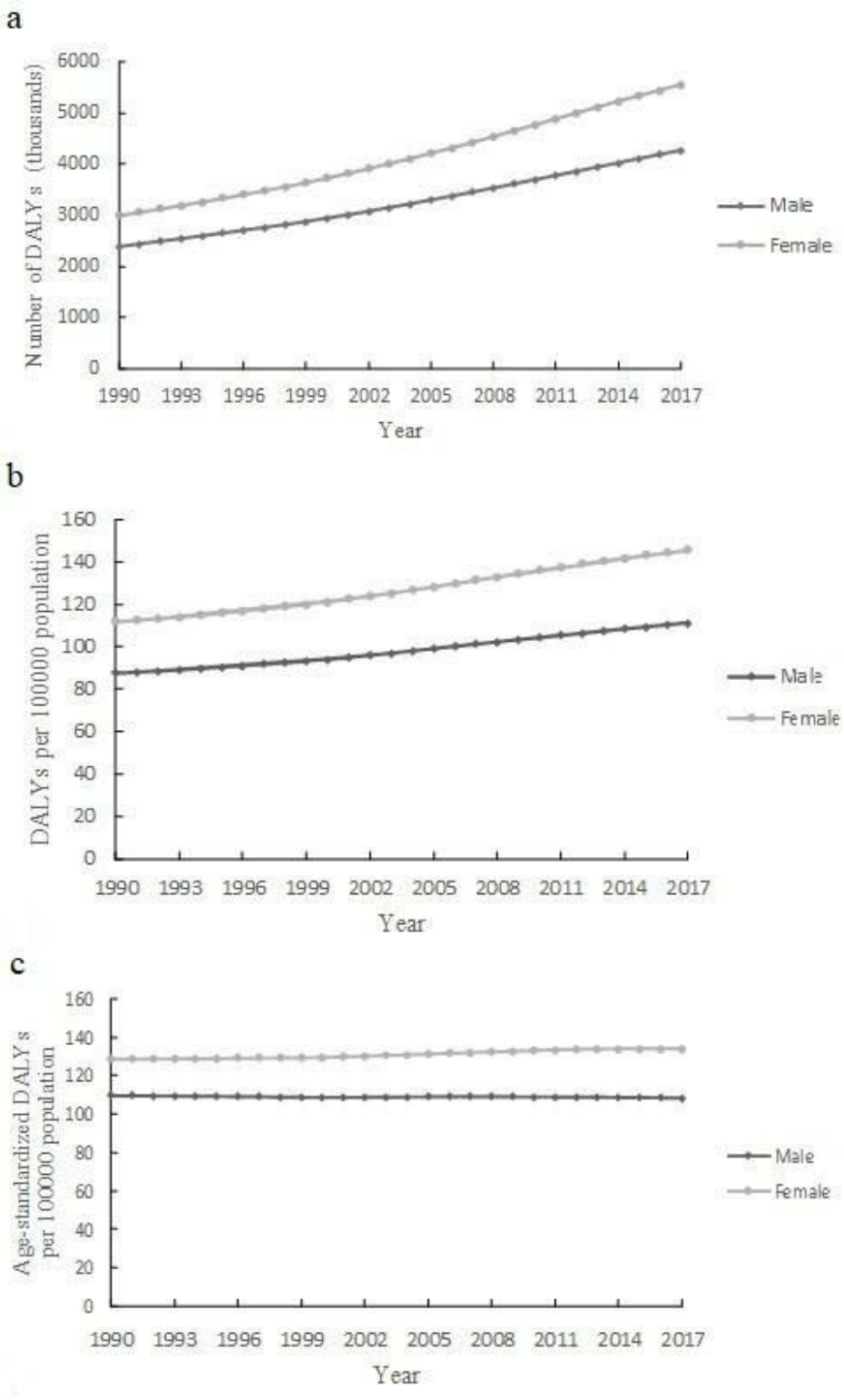
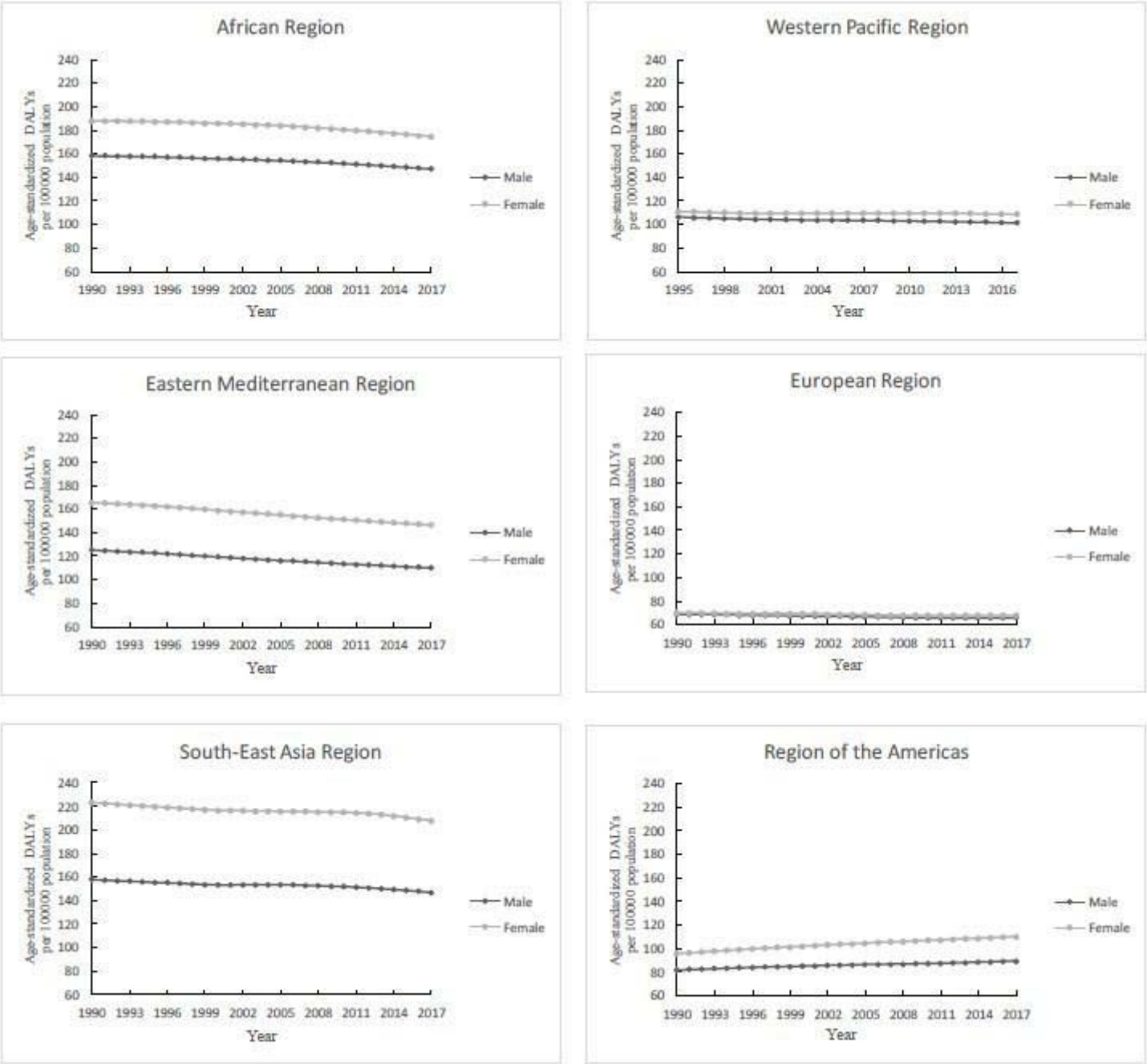
# Figures



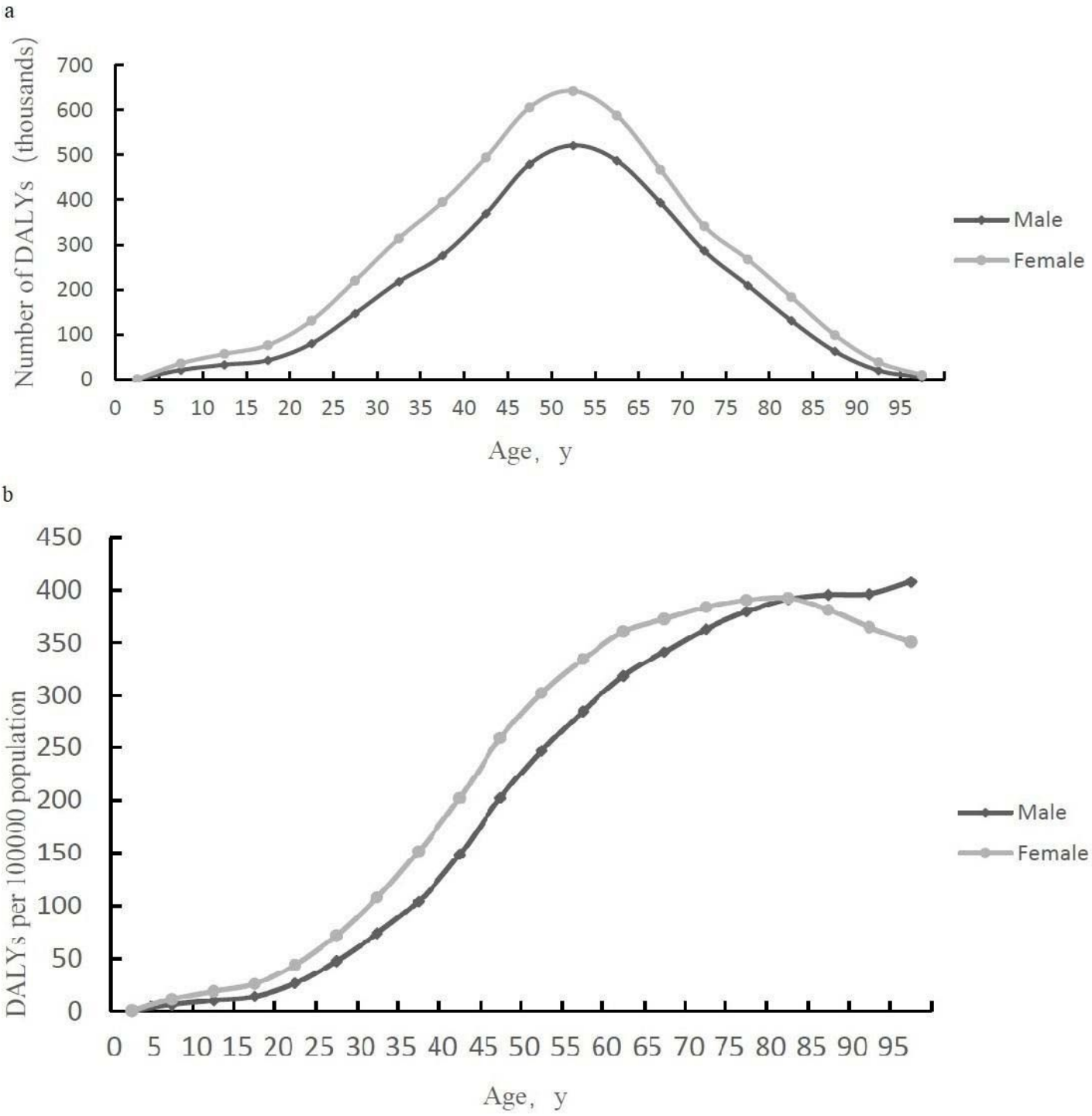

## Figure 1

Gender Inequality in Global Burden of Near Vision Loss from 1990 to 2017 a: Disability-adjusted life year (DALY) numbers, b: Crude DALY rates, c: Age-standardized DALY rates.



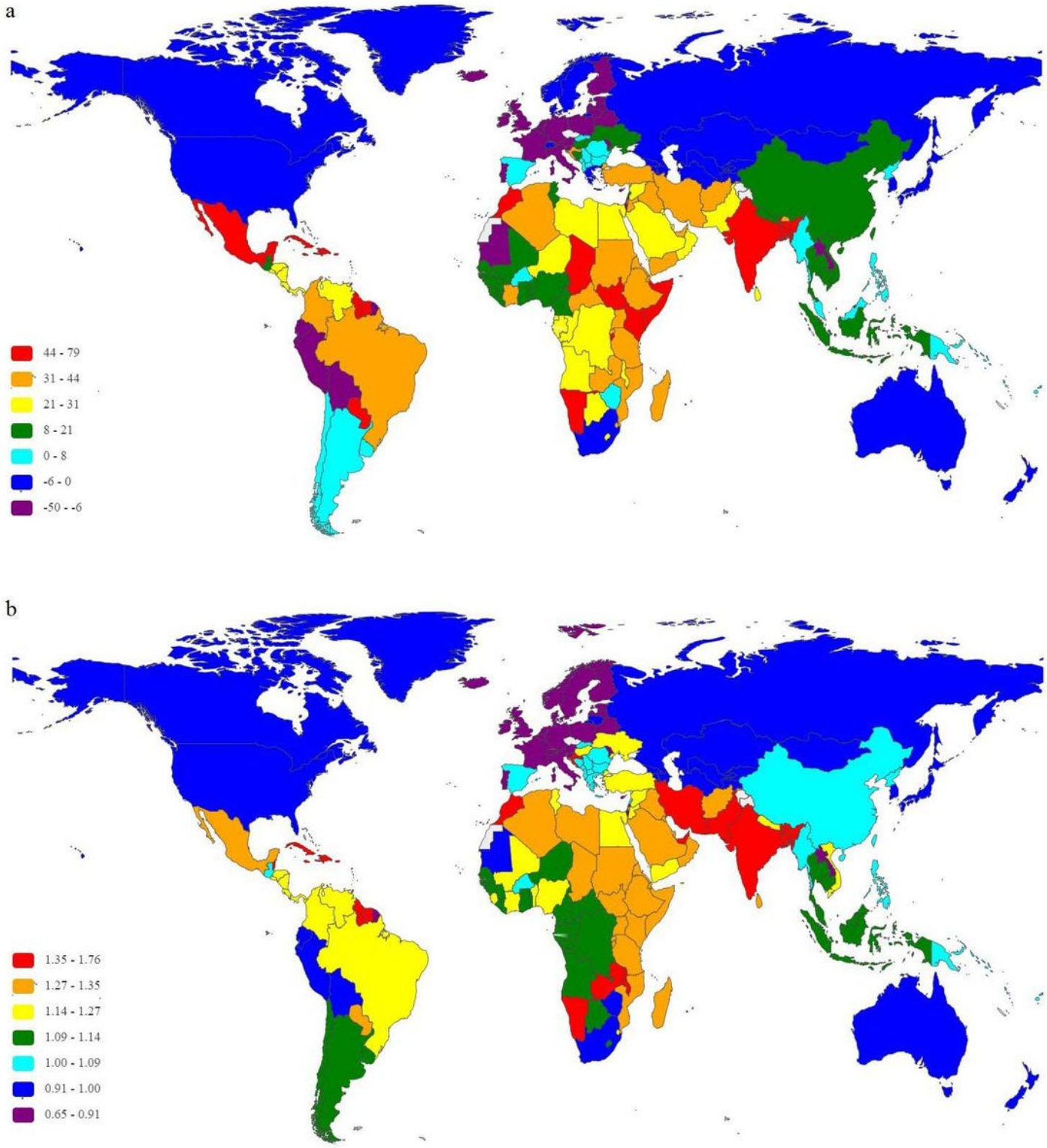

## Figure 2

Gender Inequality of World Health Organization Regional Burden due to Near Vision Loss



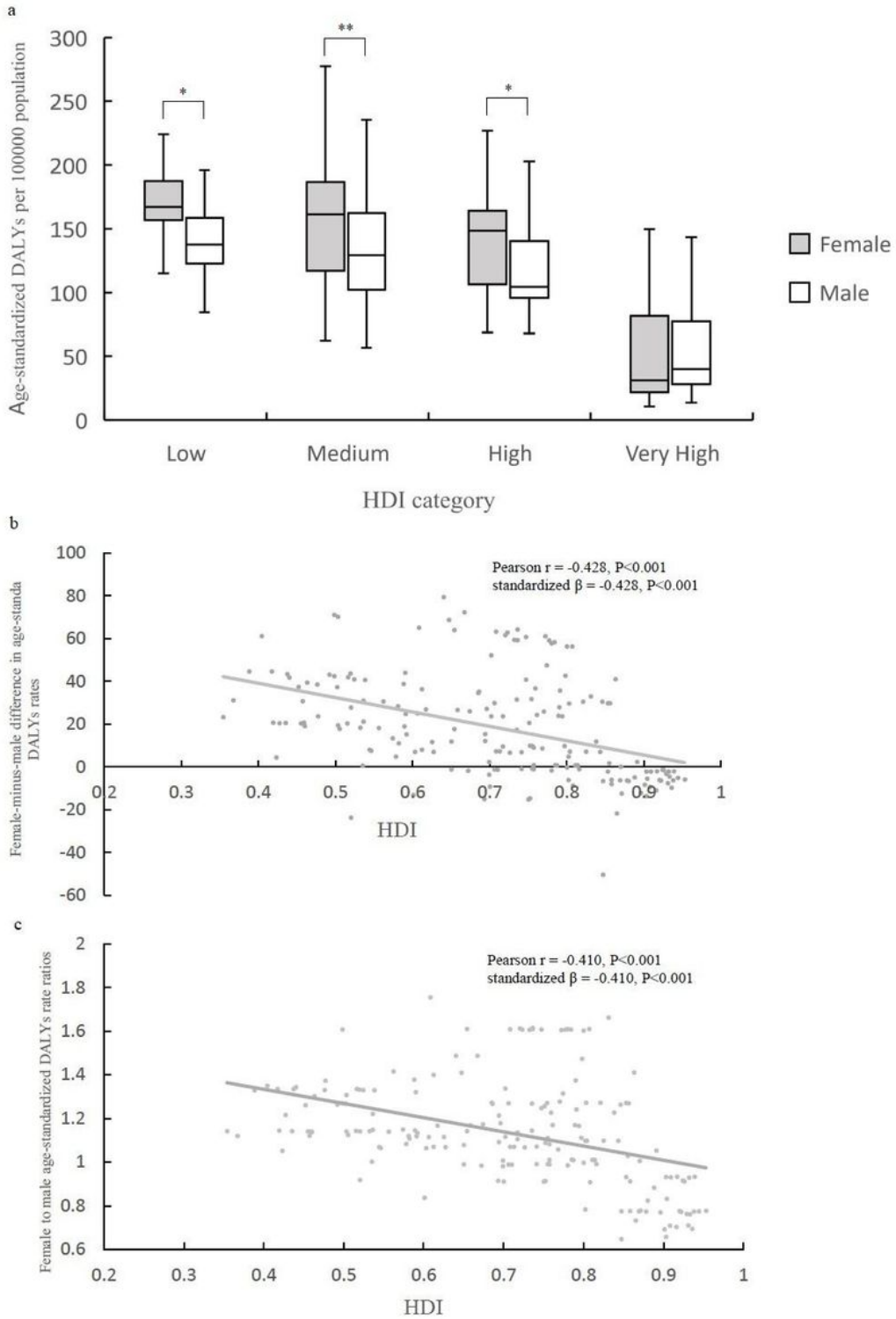

## Figure 3

Global Gender-age-specific Burden of Near Vision Loss in 2017 a: Disability-adjusted life year (DALY) numbers; b: Crude DALY rates.




## Figure 4

Gender-inequality Map in Age-standardized Disability-Adjusted Lifeyear (DALY) Rates of Near Vision Loss in 2017. a: female-minus-male; b: female-to-male




## Figure 5

The Relationship of Gender Inequality in Age-Standardized Disability-Adjusted Lifeyear (DALY) Rates and Socioeconomic Status in 2017 (a) Gender difference in age-standardized DLAYs in human development index (HDI)-based subgroup. Females had higher age-standardized DALY rates than males in each subgroup. * indicates P<.001, and ** P<.05. (b) Female-minus-male difference in age-standardized DALY

Rates. (c) Female-to-male age-standardized DALY ratios. Both female-minus-male difference and female-to-male ratios were negatively related to the level of national socioeconomic development.