


# Disease Burden of Glaucoma in China: Findings from the Global Burden of Disease 2019 Study

Yi Sun<sup>1,\*</sup>, Aiming Chen<sup>2,\*</sup>, Minjie Zou<sup>3,\*</sup>, Zhenzhen Liu<sup>3</sup>, Charlotte Aimee Young<sup>4</sup>, Danying Zheng<sup>3</sup>, Guangming Jin<sup>3</sup> 

<sup>1</sup>Department of Ophthalmology, Third Affiliated Hospital of Sun Yat-Sen University, Guangzhou, 510630, People's Republic of China; <sup>2</sup>The Fifth Affiliated Hospital of Sun Yat-sen University, Zhuhai, People's Republic of China; <sup>3</sup>State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangdong Provincial Key Laboratory of Ophthalmology and Visual Science, Guangdong Provincial Clinical Research Center for Ocular Diseases, Guangzhou, 510060, People's Republic of China; <sup>4</sup>Department of Ophthalmology, Third Affiliated Hospital, Nanchang University, Nanchang, Jiangxi Province, People's Republic of China

\*These authors contributed equally to this work

Correspondence: Guangming Jin; Danying Zheng, State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, #54 Xianlie South Road, Yuexiu District, Guangzhou, 510060, People's Republic of China, Email [jingm@mail2.sysu.edu.cn](mailto:jingm@mail2.sysu.edu.cn); [zhengdy@163.com](mailto:zhengdy@163.com)

**Purpose:** To provide evidence for future strategies in preventing glaucomatous blindness by investigating the disease burden in terms of age, year, and gender from 1990 to 2019 in China.

**Methods:** The prevalence and disability-adjusted life years (DALYs) of blindness and vision loss due to glaucoma in China were extracted from the Global Burden of Disease (GBD) 2019 study. Age-standardized data is presented in comparison to China's neighboring countries.

**Results:** From 1990 to 2019, the prevalent cases and DALYs number with glaucomatous blindness and vision loss increased by 129.53% and 67.29%, respectively. Overall, higher age-standardized prevalence and DALYs rate were detected in males than in females between 1990 and 2019, and people aged 60 to 89 years suffered from a higher DALY number than other age groups in 2019. Among the neighboring countries, China ranked from fourth in 1990 (88.52, 95% uncertainty interval [UI]: 74.62 to 103.24, per 100,000 population) to third in 2019 (71.14, 95% UI: 59.34 to 84.42, per 100,000 population) in age-standardized prevalence while from fourth in 1990 (10.13, 95% UI: 6.68 to 14.46, per 100,000 population) to sixth in 2019 (5.98, 95% UI: 4.14 to 8.42, per 100,000 population) in age-standardized DALYs. Compared with other GBD regions, the largest decrease in age-standardized DALY rate due to glaucoma was found in China (−40.87%, 95% UI: −43.97% to −37.82%). A higher percentage decrease in age-standardized prevalence was also found in China (−19.66%, 95% UI: −22.44% to −17.09%).

**Conclusion:** Substantial increases in the prevalence of visual impairment and DALYs number of glaucoma were observed from 1990 to 2019. Efforts targeting glaucoma prevention and treatment in China are urgently required, especially for the elderly population and men.

**Keywords:** glaucoma, epidemiology, disability-adjusted life years, health burden

## Introduction

Glaucoma is characterized by progressive atrophy of the optic nerve that may or may not be accompanied by elevated intraocular pressure.<sup>1</sup> The irreversible visual impairment caused by glaucoma can lead to other lifestyle concerns, such as an increased risk of falls and difficulty in driving.<sup>2,3</sup> These deficits reduce quality of life and cause an undue burden on the individual, both physically and economically, in lost productivity. Previous studies have shown that the odds of glaucoma are positively associated with aging<sup>4–6</sup> and negatively associated with income.<sup>7,8</sup>

China is the largest developing country with a population of 1.4 billion in 2019. Despite the government's nationwide efforts to improve quality of life, China suffers from a growing population as well as discrepancies across the population in income and access to healthcare services. Until now, the disease burden of vision loss due to glaucoma remains unclear. Therefore, a comprehensive analysis of data on the disease burden due to glaucoma is necessary in order to prevent glaucoma vision loss.

The 2019 Global Burden of Disease, Injuries, and Risk Factors Study (GBD) aims to quantify health loss across 369 diseases and injuries in 204 countries and territories. The current study investigates the variation in the prevalence of blindness and vision loss due to glaucoma and its disability-adjusted life years (DALYs) among the Chinese population, as well as their differences in age and gender. A comparison between China and its seven neighboring countries was also conducted. We hope that the findings of the study provide a basis for effective targeted group screening strategies which will greatly reduce the prevalence of blindness due to glaucoma.

## Materials and Methods

The study was approved by the ethics committees of the Zhongshan Ophthalmic Center (No.2020KYPJ074) and adhered to the tenets of the Declaration of Helsinki. The 2019 GBD data on the disease burden due to glaucoma were extracted from the Global Health Data Exchange (GHDx, <http://ghdx.healthdata.org/gbd-results-tool>). Details of the methodology have been described elsewhere.<sup>9</sup> In brief, population-based surveys of published and unpublished literature were systematically reviewed, and all available demographic and epidemiological data were collected. To evaluate the disease burden of glaucoma in China, 31 studies with 857 metadata rows were selected for the analysis. DALYs were defined as the years of life lost and the years lived with disability due to glaucoma by the following formula: DALY number = (Number of deaths × Standard life expectancy at age of death in years) + (Number of prevalent cases × Disability weight). Age and gender-specific numbers of DALYs ascribable to glaucoma were calculated for populations of all ages. Uncertainty was calculated in each phase of the analytical process by sampling 1000 draws in each computational step, and the uncertainty interval (UI) was defined as the 2.5th and 97.5th values of the ordered draw. The DALY rate was calculated as the number of cases per 100,000 population by adjusting for population size, while the age-standardized DALY rate was adjusted for age structure.

The following data were acquired for further analyses: (1) gender and age-specific numbers of cases with glaucomatous blindness and vision loss and DALYs due to glaucoma in China from 1990 to 2019; (2) gender and age-specific age-standardized prevalence of glaucomatous blindness and vision loss and DALYs (per 100,000 population) due to glaucoma in China and its seven neighboring countries (viz., India, Pakistan, Singapore, Russia, South Korea, Japan, and North Korea) in 1990 and 2019; (3) counts and age-standardized prevalence and DALYs rate of glaucomatous blindness and vision loss among other important GBD regions (global, high-income Asia Pacific, high-income North America, Western Europe, Australasia, Andean Latin America, and tropical Latin America) and World Bank income levels (World Bank high income, World Bank upper-middle income, World Bank lower-middle income, and World Bank low income) between 1990 and 2019.

## Statistical Analysis

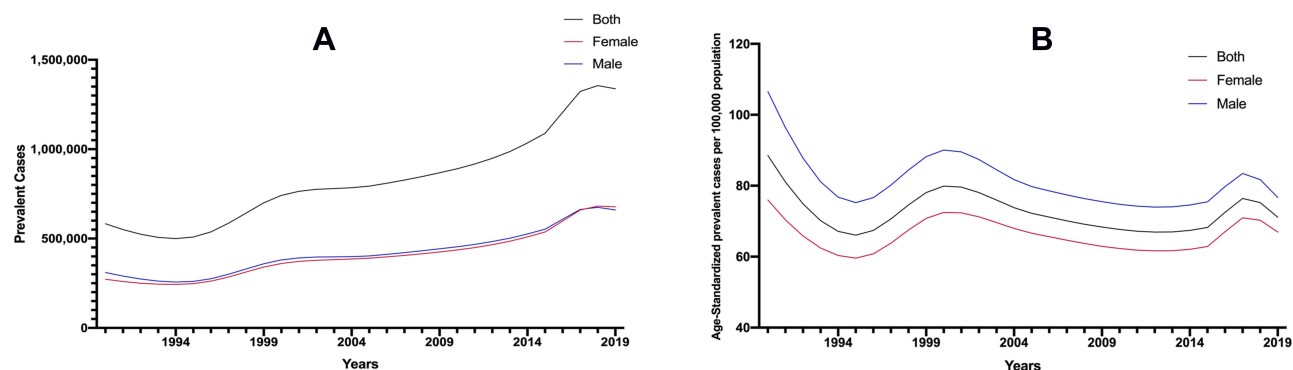
The two-sample proportion Z-test was used to identify the differences in the prevalence of blindness and vision loss and DALY rates due to glaucoma between gender groups, and the Mann-Kendall trend test was conducted to detect the changing trends for age- and gender-specific prevalence of blindness and vision loss and DALY rates due to glaucoma. A one-way analysis of variance was used to compare the age-standardized prevalence and DALYs between China and its seven neighboring countries in 1990 and 2019. The Bonferroni correction was used for multiple comparisons. Figures were drawn using GraphPad Prism software 5.01 (San Diego, CA, USA). All statistical analyses were conducted using Stata MP 15.1 (Stata Corp LP, College Station, Texas, USA).

## Results

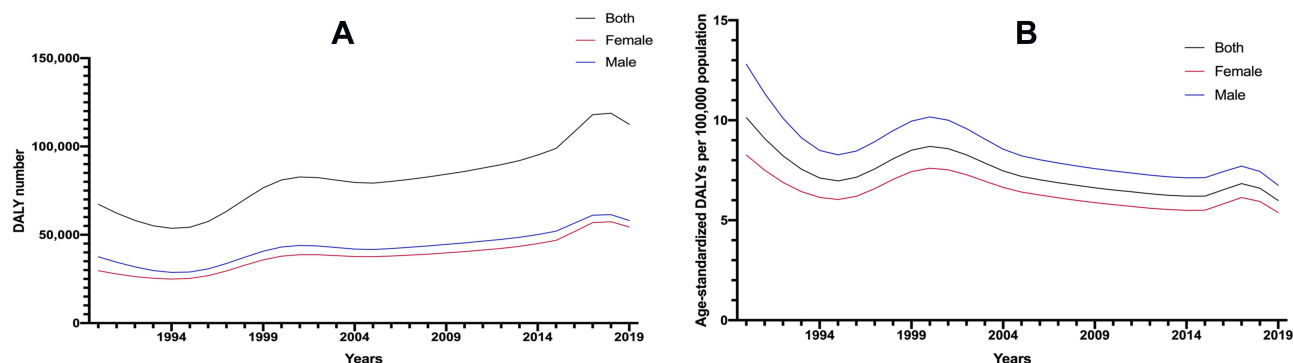
### Time Trends of DALYs and Prevalence of Blindness and Vision Loss Due to Glaucoma in China from 1990 to 2019

The prevalent cases with glaucomatous blindness and vision loss for both genders increased by 129.53%, from 583,026.05 (95% UI: 489,554.62 to 685,822.42) in 1990 to 1,338,209.52 (95% UI: 1,111,297.55 to 1,592,225.46) in 2019 in China (Figure 1A). After adjusting for population size and age structure, the age-standardized prevalence rate among men was higher than that among women (Figure 1B).

The DALYs number for both genders also showed an upward trend, rising by 67.29% from 67,266.71 (95% UI: 44,127.37 to 96,850.89) in 1990 to 112,528.29 (95% UI: 77,352.87 to 160,898.46) in 2019 (Figure 2A). However, after adjusting for population



**Figure 1** Prevalence of blindness and vision loss due to glaucoma in China from 1990 to 2019. Prevalent cases (A) and age-standardized prevalence rate (B).

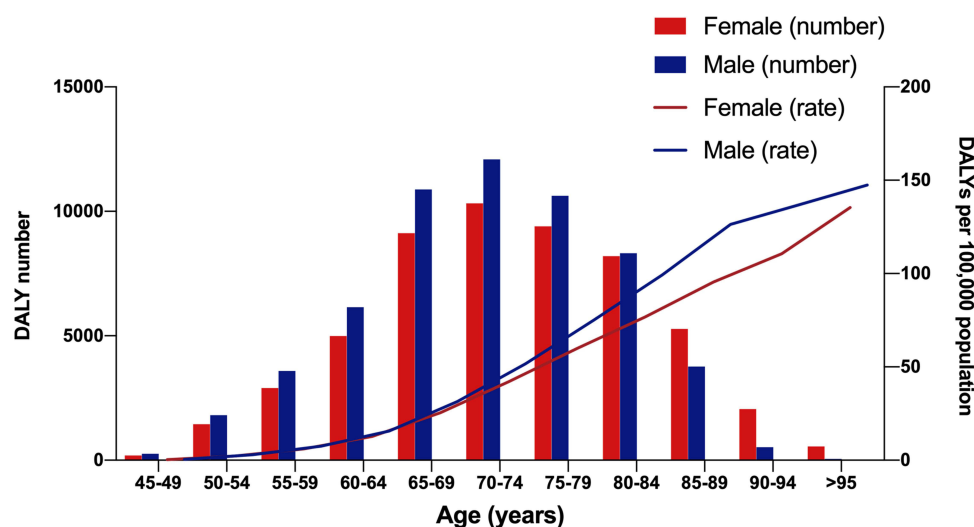


**Figure 2** DALYs of blindness and vision loss due to glaucoma in China from 1990 to 2019. DALYs number (A) and age-standardized DALYs rate (B).

size and age, the age-standardized DALYs rate for both genders dropped from 10.13 (95% UI: 6.68 to 14.46) per 100,000 population in 1990 to 5.99 (95% UI: 4.14 to 8.42) per 100,000 population in 2019 (Figure 2B). The DALYs due to glaucoma in males were consistently higher than those in females for DALYs number and age-standardized DALYs rate from 1990 to 2019.

## Age- and Gender-Specific Disease Burden Due to Glaucoma in 2019

Figure 3 illustrates the age-specific number and rate of DALYs per 100,000 population due to glaucoma by gender in 2019. The elderly population (aged 60 to 89 years) tended to have a higher disease burden, with 70 to 74 years



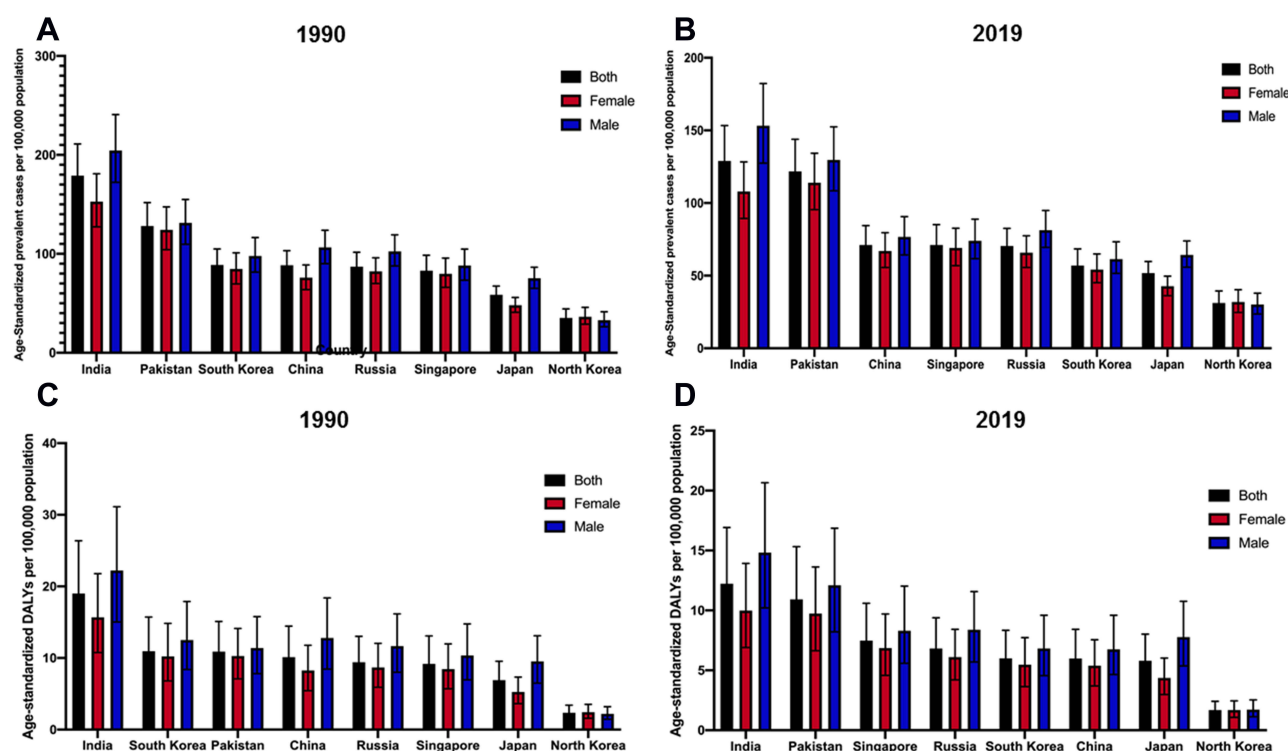
**Figure 3** Age-specific number and crude rate of DALYs due to glaucoma by sex in China in 2019.

being the most vulnerable. Among the population younger than 85 years, males had a higher DALYs number than females, while among people older than 85 years, females had a higher DALYs number than males. Males had a higher DALYs rate than females.

## Comparison of Disease Burden Between China and Its Neighboring Countries and Other GBD Regions

For the age-standardized prevalence of blindness and vision loss due to glaucoma in China and its seven neighboring countries, China ranked fourth highest in 1990 (88.52, 95% UI: 74.62 to 103.24 per 100,000 population), while ranking third highest in 2019 (71.14, 95% UI: 59.34 to 84.42 per 100,000 population) (Figure 4A and B). For the age-standardized DALY rate, China dropped from fourth (10.13, 95% UI: 6.68 to 14.46 per 100,000 population) to sixth place in 2019 (5.98, 95% UI: 4.14 to 8.42 per 100,000 population) (Figure 4C and D).

As shown in Table 1, the disease burden of glaucoma in China is at the average level among GBD regions in 2019. In terms of the percentage change of the age-standardized DALYs rates between 1990 and 2019, disease burden of glaucoma decreased the most in China (−40.87%, 95% UI: −43.97% to −37.82%) compared to other regions. For the percentage change of age-standardized prevalence of glaucomatous blindness and vision loss between 1990 and 2019, China had a higher decrease (−19.66%, 95% UI: −22.44% to −17.09%) than developed regions but the decrease among Andean Latin America (−27.08%, 95% UI: −33.95% to −20.94%) and the World Bank lower-middle-income region (−23.39%, 95% UI: −30.46% to −17.27%) surpassed that of China.



**Figure 4** Distribution of age-standardized prevalence rate of blindness and vision loss due to glaucoma and age-standardized DALYs rate in China and other neighboring countries in 1990 and 2019. Age-standardized prevalence of blindness and vision loss due to glaucoma in 1990 (A), age-standardized prevalence of blindness and vision loss due to glaucoma in 2019 (B), age-standardized DALYs rate in 1990 (C) and age-standardized DALYs rate in 2019 (D).

**Table I** Prevalence of Blindness and Vision Loss Due to Glaucoma and DALYs Caused by Glaucoma in 2019 and Percentage Change of Age-Standardized Rates by GBD Region

	Prevalent Cases (95% UI)			DALYs (95% UI)		
	Counts (2019)	Age-Standardized Rates (2019)	Percentage Change in Age-Standardized Rates Between 1990 and 2019 (%)	Counts (2019)	Age-Standardized Rates (2019)	Percentage Change in Age-Standardized Rates Between 1990 and 2019
China	1,338,210 (1,111,298, 1,592,225)	71.14 (59.34, 84.43)	-19.66 (-22.44, -17.09)	112,528 (77,533, 160,898)	5.99 (4.14, 8.42)	-40.87 (-43.97, -37.82)
Global	7,473,400 (6,347,183, 8,769,520)	94.68 (80.42, 110.87)	-15.37 (-17.62, -13.31)	748,308 (515,636, 1,044,667)	9.52 (6.58, 13.22)	-25.51 (-27.99, -23.14)
High-Income Asia	292,514 (249,497, 340,022)	52.92 (45.33, 61.29)	-14.92 (-15.83, -14.04)	31,811 (21,984, 43,721)	5.85 (4.01, 8.09)	-20.84 (-23.95, -17.96)
pacific						
High-Income	294,458 (249,498, 343,827)	42.17 (35.71, 49.24)	-2.86 (-3.40, -2.38)	30,561 (21,274, 41,693)	4.38 (3.05, 5.96)	-5.19 (-7.63, -3.36)
North America						
Western Europe	690,822 (570,690, 822,355)	63.73 (53.14, 75.27)	-17.27 (-18.13, -16.43)	81,583 (55,393, 113,969)	7.61 (5.18, 10.63)	-21.38 (-24.10, -18.84)
Australasia	28,496 (23,616, 34,370)	51.56 (42.90, 61.83)	-10.18 (-10.99, -9.41)	2863 (1937, 4008)	5.21 (3.541, 7.30)	-15.28 (-18.38, -12.53)
Andean Latin	75,131 (62,646, 90,013)	140.90 (117.27, 169.10)	-27.08 (-33.95, -20.94)	7851 (5270, 11,067)	14.76 (9.86, 20.79)	-36.08 (-38.07, -34.11)
America						
Tropical Latin	370,684 (313,202, 436,338)	161.37 (136.18, 189.81)	-17.86 (-23.95, -12.76)	33,436 (23,076, 46,432)	14.64 (10.06, 20.26)	-23.87 (-25.84, -21.98)
America						
World Bank High	1,439,389 (1,208,275, 1,691,625)	54.80 (46.17, 64.17)	-14.06 (-25.02, -6.64)	159,401 (109,688, 220,261)	6.10 (4.23, 8.43)	-19.63 (-22.64, -16.86)
Income						
World Bank Upper	2,902,887 (2,441,644, 3,436,657)	92.05 (77.70, 108.29)	-19.30 (-27.75, -12.51)	267,674 (185,410, 378,386)	8.56 (5.91, 11.99)	-34.05 (-36.70, -31.47)
Middle Income						
World Bank	2,634,852 (2,193,253, 3,124,538)	130.63 (109.67, 154.22)	-23.39 (-30.46, -17.27)	263,536 (180,140, 369,643)	13.29 (9.15, 18.63)	-30.05 (-32.17, -28.00)
Lower Middle						
Income						
World Bank Low	491,543 (412,300, 579,845)	201.62 (168.79, 237.63)	-14.41 (-19.55, -10.19)	57,172 (38,622, 81,709)	23.69 (16.06, 33.40)	-20.66 (-22.16, -19.22)
Income						

**Abbreviations:** DALYs, disability-adjusted life years; GBD, Global Burden of Disease; UI, uncertainty intervals.

## Discussion

Although a small number of studies have provided an estimation of the health burden of glaucoma globally,<sup>10,11</sup> little is known about the burden of glaucoma in China, which accounts for approximately 1/6 of the world population. Thus, the current study was conducted to investigate the disease burden due to glaucoma by age, year, and gender in China from 1990 to 2019. Results showed the burden of glaucoma increased significantly during the past three decades, especially among men. People aged 70 to 74 years suffered a higher disease burden than other age groups. Compared with its neighboring countries, the age-standardized prevalence of glaucomatous blindness and vision loss in China increased and the age-standardized DALYs rate reduced during the period. Compared with the GBD regions, the percentage change in age-standardized DALYs rate due to glaucoma decreased the most in China.

This study showed that blindness and vision loss due to glaucoma in China was more common among males than females (Figure 1B), which is consistent with previous studies.<sup>12–14</sup> Moreover, the current study revealed that males endured a heavier disease burden than females in terms of all-age DALYs number and age-standardized DALYs rate (Figure 2A and B). The types of glaucoma may be attributed to gender disparities. In China, it is more common for males to develop open-angle glaucoma (OAG), whereas females are vulnerable to angle-closure glaucoma (ACG).<sup>15</sup> Presenting like OAG, ACG presents in most Asians as asymptomatic. Approximately a third of ACG accompanies with acute angle closure, which prompts referral to ophthalmologists. In addition, with cataract surgery rate increased, the prevalence of ACG decreased markedly.<sup>16</sup> Therefore, compared to ACG, OAG is more difficult to detect at an early stage and is more seriously detrimental to visual function.

Males had higher DALY numbers than females among people younger than 84 years in 2019, but the opposite was observed among people older than 85 years. This may be due to the longer life expectancy of females. Males had higher DALYs rate of glaucoma than females which is consistent with the global analysis by Zhang<sup>11</sup> and Ye<sup>17</sup> but inconsistent with the analysis by Wang.<sup>10</sup> Above all, the rapidly increasing DALYs rate as shown in Figure 3 necessitates the development of new methods for glaucoma screening and diagnosis.

Although several studies on the global disease burden of glaucoma have been conducted, the agreement between the results is suboptimal. In an analysis of the global glaucoma burden, Wang showed that the age-standardized DALY rates continually increased from 1990 to 2015.<sup>10</sup> Wu reported that the age-standardized DALY rates for global glaucoma increased by 12.12% from 1990 to 2016.<sup>18</sup> On the contrary, Ye revealed that the age-standardized DALY rates decreased consistently from 10.7 in 1990 to 9.4 in 2017 among men and from 8.8 in 1990 to 8.0 in 2017 among women.<sup>17</sup> We give several potential reasons for the variation. First, the strategies for the prevention and control of glaucoma were different among regions. Second, a different database for different years was used. Nevertheless, the decreasing trend of the age-standardized DALY rate in China indicated positive progress in glaucoma prevention and treatment.

Our results show that the disease burden due to glaucoma in China has decreased in the past three decades. Although China's rank in age-standardized glaucoma prevalence increased from fourth in 1990 to third in 2019, its rank in age-standardized glaucoma DALY rates decreased from fourth in 1990 to sixth in 2019. Moreover, the age-standardized prevalence and age-standardized DALY rates showed a decreasing trend over the past three decades. These findings further reflect China's efforts in early detection of glaucoma and improvement of eye care, including but not limited to center-based opportunistic eye diseases screening, community-level screening,<sup>19</sup> combined screening of primary open-angle glaucoma and primary angle closure glaucoma,<sup>20</sup> and artificial intelligence assisted glaucoma screening.<sup>21</sup>

Another finding of this study is that the burden of glaucoma has decreased significantly in less developed regions during the past three decades. Glaucoma is generally believed to cause greater damage in developing countries, as indicated by the higher age-standardized DALY rates (2019) in the World Bank low-income region (23.69%), Andean Latin America (14.76%), tropical Latin America (14.64%), and the World Bank lower-middle-income region (13.29%) compared with developed regions such as high-income North America (4.38%) and World Bank high income (6.1%). Although the age-standardized DALY rate in China was higher than that in some developed areas in 2019, the percentage change of the age-standardized DALY rate (−40.87%) reduced the most in China than in other GBD regions. This implies that while the prevalence of glaucoma is high in China, great efforts have been made with positive outcomes to alleviate the disease burden.



Several limitations of this study should be emphasized. First, the subtypes of glaucoma are not separated specifically in the database. Therefore, the disease burden of different types of glaucoma could not be evaluated. Second, undetected glaucoma was not included in the database; thus, the disease burden of glaucoma could be underestimated. Notwithstanding the limitations mentioned above, the study uses the latest GBD database to evaluate the disease burden of glaucoma in China, and the findings of this study may offer healthcare policy-makers important evidence on the burden of glaucoma. We hope that this study can support advocacy for more preventive policies associated with glaucoma in China and beyond.

## Conclusion

In summary, between 1990 and 2019, although the age-standardized prevalent rate and DALYs rate of glaucoma were reduced in China, substantial increases in the prevalent cases with visual impairment and DALYs number of glaucoma were observed. Efforts targeting glaucoma prevention and treatment in China are urgently required, especially for the elderly population and men.

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## Disclosure

The authors have no conflicts of interest concerning this study.

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