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ORIGINAL RESEARCH

Changing Trends in the Disease Burden of Cataract and Forecasted Trends in China and Globally from 1990 to 2030

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Aim: To explore the trends in the prevalence and disease burden of cataract from 1990 to 2019, evaluate attributable risk factors, and predict trends over the next decade in China and globally.

Methods: Data was obtained from Global Burden of Disease Study 2019. We calculated the age-standardized prevalence rate (ASR) and annual percentage change (EAPC) to show the trends of cataract in China and different regions. We calculated and reported the proportion of disability adjusted life years (DALYs) attributable to risk factors by sex in China and different regions. Then, the Bayesian age-period-cohort (BAPC) analysis model was also used to predict the prevalence trends from 2020 to 2030 in China and globally.

Results: The ASR increased from 867.09 in 1990 to 991.56 in 2019 per 100,000 with an EAPC of 0.88 in China. The age-standardized DALY rate of females was higher than males. DALY rates were correlated to household air pollution from solid fuels, tobacco, high fasting plasma glucose and high body-mass index. The projective model indicates that the ASR for cataracts will rise to 1101.35×10^6 for male and 1616.63×10^6 for female by 2030.

Conclusion: The trends from 1990 to 2030 suggested that the burden of cataract remains high in China. Maintaining good lifestyle habits such as switching to clean energy, reducing cigar intake, controlling blood glucose and weight can reduce the risk of cataracts. As aging increases, China should pay more attention to cataract-induced low vision and blindness and develop public policies to reduce the disease burden.

Keywords: China, cataract, disease burden, risk factors

Introduction

A cataract is an ophthalmic condition that causes loss of visual quality due to changes in lens transparency and color,[1] and if left untreated, can eventually develop into severe visual impairment or even blindness. Although cataracts can be cured by surgery and then improve vision, as the population grows and ages, the need for cataract surgery and the associated increase in medical costs will place a growing burden on the health care systems and socioeconomic conditions, and the situation allows no delay.

In 1999, the World Health Organization (WHO) and the International Agency for the Prevention of Blindness (IAPB) launched the "Vision 2020: global initiative for the elimination of avoidable blindness the right to sight", focusing on avoidable blindness, including cataract.[2] China is the first country in the Western Pacific region to launch. It is one of the countries having the largest number of blind people in the world, with approximately 6.7 million blind people, representing 18% of the world's blind population at the time.[3] The study of epidemiological data on cataracts in China has significant implications for guiding blindness prevention and treatment efforts. Cataract surgery rate (CSR) is the number of cataract surgeries performed per million people per year, and is commonly used internationally as

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a measure of cataract blindness prevention and treatment and may also reflect demographic, geographic, or socio-economic differences. The number of cataract surgeries currently varies from country to country. By the end of 2020, the CSR has exceeded 3000, doubling compared to the end of 2015 in China, and the 14th Five-Year Plan for National Eye Health hopes that CSR will reach 3500 by the end of 2025. A study indicated that in 2020, cataracts still remained the main cause of blindness and visual impairment for people aged 50 and older worldwide, especially in developing countries.[4] Digging deeper into the epidemiological information related to cataract are urgently needed to learn the prevalence and trends of cataract and further help us to formulate policies.

The 2019 Global Burden of Disease (GBD) study assessed 369 causes of death or injuries and 87 risk factors in 204 countries and territories, and provided a shared database to assess the burden of blindness and vision loss due to cataracts and the differences in prevalence between countries and territories.[5] With the rapid socioeconomic development and aging, people's life expectancy has increased, many countries around the world have begun to pay more attention to the quality of life. As an organ for human beings that absorbs 80% of the external knowledge, vision has attracted increasing attention. The GBD tracked some main causes for blindness and vision loss, such as cataract,[6] age-related macular degeneration,[7,8] glaucoma[9] and refraction disorders. Several studies focused on many causes of blindness and vision loss, however none has used GBD data to estimate the disease burden of cataract in China. In the study, we collected the prevalence and disability-adjusted life years (DALY) of cataract by age, gender, SDI and income region and further calculated the ASR and EAPC. Then we also predicted the trends of cataract in the next ten years, which would give us a preliminary judgment on the future direction of healthcare policymaking. In addition, we analyzed the risk factors to find controllable risk factors for cataract. Cataract has become a global public health problem, and the study of global prevalence, disability adjusted life year (DALY) and risk factors has become a worldwide demand. The aim of the study was to use GBD 2019 to analyze the prevalence, trends, and risk factors of cataract from 1990 to 2019 in China and globally, and further predicts the prevalence in the next decade.

Materials and Methods

Data Sources

The data on prevalence, DALYs, and risk factors of cataract from 1990 to 2019 were obtained from the Global Health Data Exchange (GHDx) query tool (https://ghdx.healthdata.org/gbd-2019). Projected demographic data for the 2020–2030 came from a public web site (https://ghdx.healthdata.org/record/ihme-data/global-population-forecasts-2017-2100). The GBD world population age standard data came from an appendix table in Lancet.[10] The global maps were created with a data visualization tool provided by the GHDx which is supported by the Institute for Health Metrics and Evaluation (https://vizhub.healthdata.org/gbd-compare/). Socio-demographic index (SDI) varies between 0 and 1, with higher SDI implying better socioeconomic development: based on the SDI, regions are classified into five classes, including low (<0.46), low-middle (0.46–0.60), middle (0.61–0.69), high-middle (0.70–0.81) and high SDI (>0.81). Moreover, regions were also separated into four classes, including high income, upper middle income, lower middle income and low income in term of world bank income. Previous studies described the detailed methodology of GBD study.[11,12] The GBD study data followed the guidelines for Accurate and Transparent Health Estimation Reporting for Population Health Research (GATHER). This study was approved by the Ethics Committee of Tongji Hospital of Tongji University (K-W-2023-004).

Statistical Analysis

This study was a secondary analysis of GBD 2019, which is divided into four steps. Firstly, we calculated the age-standardized prevalence rate (ASR) and the estimated annual percentage change (EAPC) to show the trends of cataract in China and globally. The formula and methods for calculating ASR and EAPC were described in detail previously.[13,14] Secondly, we compared the ASR and burden of cataract between China and different SDI region, world bank income region and WHO region. Thirdly, we calculated and reported the proportion of DALYs attributable to risk factors, including household air pollution (HAP) from solid fuels, tobacco, high fasting plasma glucose and high body-mass index (BMI) by sex in China and different regions. Finally, the Bayesian age-period-cohort analysis (BAPC) model with integrated nested Laplace approximation (INLA) was also used to predict the cataract prevalence trend from 2020 to 2030 in China and globally.[15,16]

All data analyses were performed in Software R (version 4.2.2) and Rstudio, and the BAPC predictive model used the "nordpred (version 1.1)", "BAPC (version 0.0.36)" and "INLA (version 22.05.07)" package. GraphPad Prism (version 8.0.2) was used to input and display data.

Results

Global Burden of Cataract

We collated the prevalence numbers and ASR for different genders and SDI of cataract patients in 1990 and 2019, as well as calculated the EAPC, the results are shown in Table 1. Globally, the prevalence numbers of cataract increased

Table 1 The Prevalence Numbers and Age-Standardized Prevalence of Cataract in 1990 and 2019, and Its Temporal Trends from 1990 to 2019

Characteristic	1990		2019		1990–2019
	Numbers No.× 10^3 (95%UI)	ASR per 100,000 No.(95%UI)	Numbers No. ×10^3 (95%UI)	ASR per 100,000 No.(95%UI)	EAPC
Global	42,336.68 (37,728.56–47,615.12)	1,150.56 (1,027.31–1,287.4)	97,022.04 (85,370.88–109,696.64)	1,207.88 (1,361.26–1,065.04)	0.41 (0.33–0.5)
Sex					
Male	17,592.21 (15,618.06–19,827.46)	1,089.86 (972.55–1,218.79)	39,947.63 (34,974.83–45,332.55)	1,096.94 (965.34–1,237.51)	0.26 (0.17–0.34)
Female	24,744.46 (22,061.69–27,793.82)	1,203.35 (1,073.53–1,347.25)	57,074.41 (50,385.30–64,437.24)	1,302.54 (1,150.34–1,469.85)	0.52 (0.43–0.61)
China	5,607.60 (4,895.98–6,402.85)	867.09 (761.36–975.42)	18,142.57 (15,617.09–20,841.57)	991.56 (861.52–1,131.04)	0.88 (0.6–1.15)
Sex					
Male	2,218.03 (1,928.74–2,537.50)	752.74 (660.27–849.54)	6,982.58 (5,988.19–8,089.73)	833.8 (723.14–949.92)	0.79 (0.54–1.05)
Female	3,389.57 (2,949.97–3,847.25)	946.5 (832.76–1,064.33)	3,389.57 (2,949.97–3,847.25)	1,117.12 (967.62–1,268.37)	0.97 (0.68–1.26)
SDI					
Low	4,090.80 (3,662.47–4,570.88)	2,016.86 (1,810.94–2,241.28)	8,965.52 (7,936.26–10,105.44)	1,966.87 (1,753.94–2,205.73)	0.15 (0.06–0.24)
Low-middle	12,957.07 (11,530.66–14,545.10)	2,495.12 (2,234.99–2,780.44)	27,483.38 (24,295.55–31,144.03)	2,182.06 (1,937.04–2,455.86)	−0.1 (−0.2–0)
Middle	14,136.71 (12,629.95–15,813.74)	1,634.59 (1,464.8–1,816.28)	35,216.00 (31,190.20–39,729.95)	1,541.64 (1,373.65–1,723.02)	0 (−0.1–0.1)
High-middle	7,441.22 (6,485.46–8,455.91)	775.1 (678.01–876.07)	18,010.45 (15,528.82–20,513.99)	893.6 (774.42–1,013.51)	0.71 (0.62–0.81)
High	3,687.99 (3,146.94–4,258.64)	354.32 (305.76–407.33)	7,298.93 (6,237.67–8,428.45)	357.01 (306.85–409.46)	0.01 (−0.05–0.06)
World Bank Income Levels					
High Income	5,042.31 (4,305.83–5,805.32)	395.78 (341.7–454.24)	9,564.15 (8,195.42–11,021.46)	388.67 (334.16–446.25)	−0.08 (−0.12–0.04)
Upper Middle Income	11,514.91 (10,100.03–13,057.61)	914.82 (806.59–1,028.9)	31,486.09 (27,518.38–35,697.17)	995.19 (869.56–1,124.01)	0.55 (0.4–0.7)
Lower Middle Income	24,122.91 (21,549.45–27,024.60)	2,678.33 (2,404.16–2,982.65)	52,418.90 (46,537.67–59,211.04)	2,439.43 (2,172.71–2,734.94)	−0.03 (−0.12–0.07)
Low Income	1,633.38 (1,461.87–1,827.67)	1,289.53 (1,155.55–1,437.12)	3,504.67 (3,118.61–3,927.90)	1,274.6 (1,133.36–1,430.49)	−0.03 (−0.09–0.02)
WHO region					
Eastern Mediterranean Region	3,865.67 (3,441.34–4,348.39)	2,448.76 (2,189.62–2,739.14)	7,388.18 (6,526.63–8,375.53)	2,019.31 (1,780.67–2,284.56)	−0.73 (−0.81–0.65)
European Region	5,402.49 (4,596.31–6,225.07)	516.07 (443.83–593.46)	8,772.83 (7,446.10–10,143.89)	515.11 (439.14–591.61)	0 (−0.02–0.02)
Region of the Americas	3,465.44 (3,035.34–3,916.53)	578.72 (508.18–653.84)	7,804.41 (6,811.32–8,890.97)	606.06 (528.48–689.43)	0.31 (0.26–0.37)
South-East Asia Region	18,463.51 (16,519.59–20,739.04)	3,164.64 (2,845.24–3,516.04)	42,470.22 (37,804.18–47,934.33)	2,670.56 (2,392.28–2,983.25)	−0.21 (−0.32–0.1)
Western Pacific Region	7,823.88 (6,870.43–8,863.16)	812.11 (718.04–911.24)	23,372.09 (20,245.80–26,654.52)	886.79 (770.18–1,008.6)	0.58 (0.4–0.76)
African Region	3,192.68 (2,858.48–3,546.69)	1,633.24 (1,469.9–1,804.86)	6,849.73 (6,106.46–7,677.45)	1,585.09 (1,410.03–1,773.67)	−0.09 (−0.15–0.03)

129.17% from 42,336.68 $\times 10^3$ in 1990 to 97,022.04$\times 10^3$ in 2019. The ASR increased by an average 0.41% (95% CI 0.33%−0.5%) per year in the same period (from 1150.56 per 100,000 in 1990 to 1207.88 per 100,000 in 2019). While in China, the prevalence numbers of cataract increased 223.54% from 5607.60$\times 10^3$ in 1990 to 18,142.57$\times 10^3$ in 2019. The ASR increased by an average 0.88% (95% CI 0.6%−1.15%) per year in the same period (from 867.09 per 100,000 in 1990 to 991.56 per 100,000 in 2019).

As shown in Figure 1A and C, the age-standardized prevalence rate (ASR) of cataract in 2019 among females was higher than that among males in China and globally. The ASR increases with age in both men and women, from 20 years to 95+ years and the ASR increases more in women than in men as they aged. Similar to ASR, we found a higher burden of disease in women than in men, and a higher in aged (Figure 1B and D). The age-standardized DALYs rate of females was 89.82 (95% UI 63.97–120.60) while 74.91 (95% UI 53.35–101.18) for males in 2019 globally and 66.84 (95% UI 47.08–90.43) for female, 49.06 (95% UI 34.4–67.10) for male in China.

Global Prevalence and Disease Burden of Cataract by Regions

The global distribution of the prevalence and diseases burden of cataract are illustrated in Appendix Figures 1–4. The age-standardized prevalence rate (ASR) of the whole world peaked in 2017 at 1283.53 (95% CI 1134.46 to 1442.93) per 100,000, then there was a downward trend with 1207.88 (95% CI 1065.04 to 1361.26) per 100,000 in 2019. The ASR per 100,000 in 2019 was highest in Indonesia (3599.99, 95% CI 3279.94 to 3962.76) and lowest in Bulgaria (245.06, 95% CI 197.15 to 297.88) (Appendix Figure 1). The annual change from 1990 to 2019 is not significant globally. The greatest increase in the prevalence was in Côte d'Ivoire (1.18) per 100,000, while the greatest decrease was in Equatorial Guinea (−0.56) per 100,000 (Appendix Figure 2). India, China and Indonesia ranked top three in 2019 for the DALYs of all ages (Appendix Figures 3 and 4).

ASR of Cataract by Region, Income Level and SDI

Among the six WHO regions, the ASR of South-East Asia region between 1990 and 2019 was the highest, but we can see a clear downward trend in 2017–2019 (Figure 2A). By the contrast, the region of the Americas and

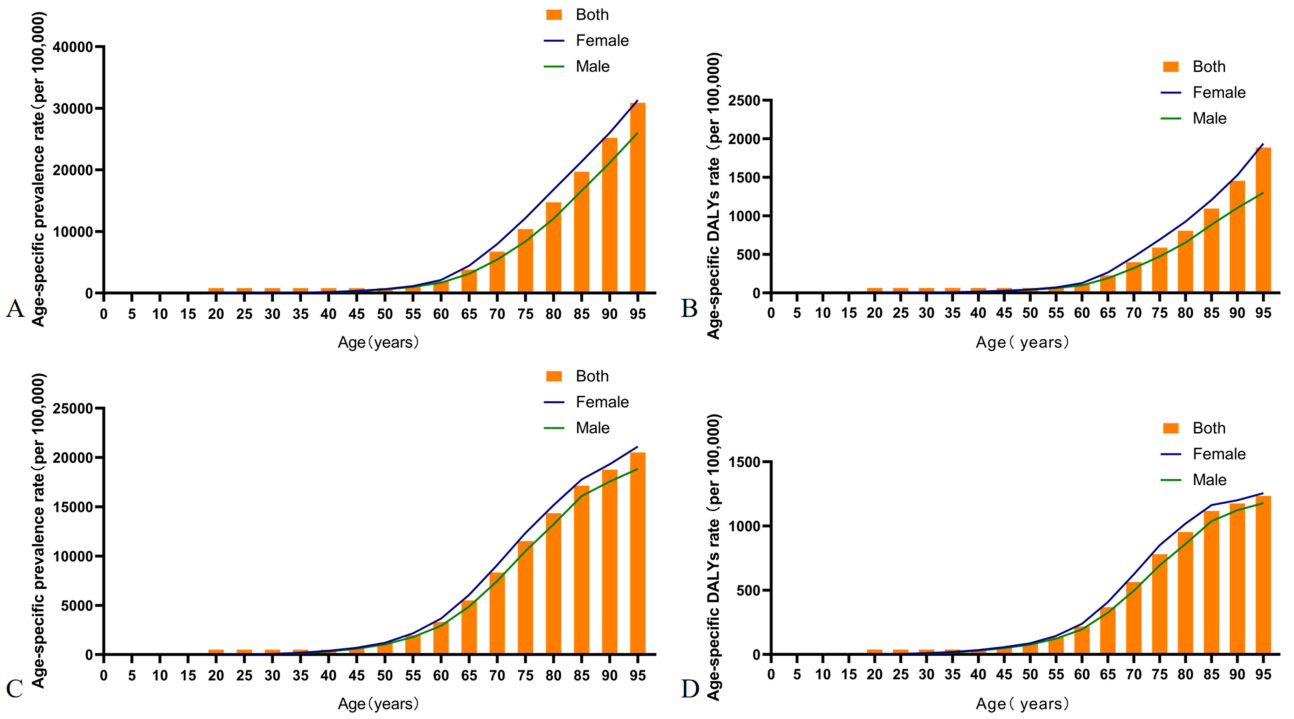

Figure 1 The age-specific prevalence rate and DALYs rate of cataract by age and gender in China (**A** and **B**) and globally (**C** and **D**) in 2019. DALYs, disability-adjusted life years.

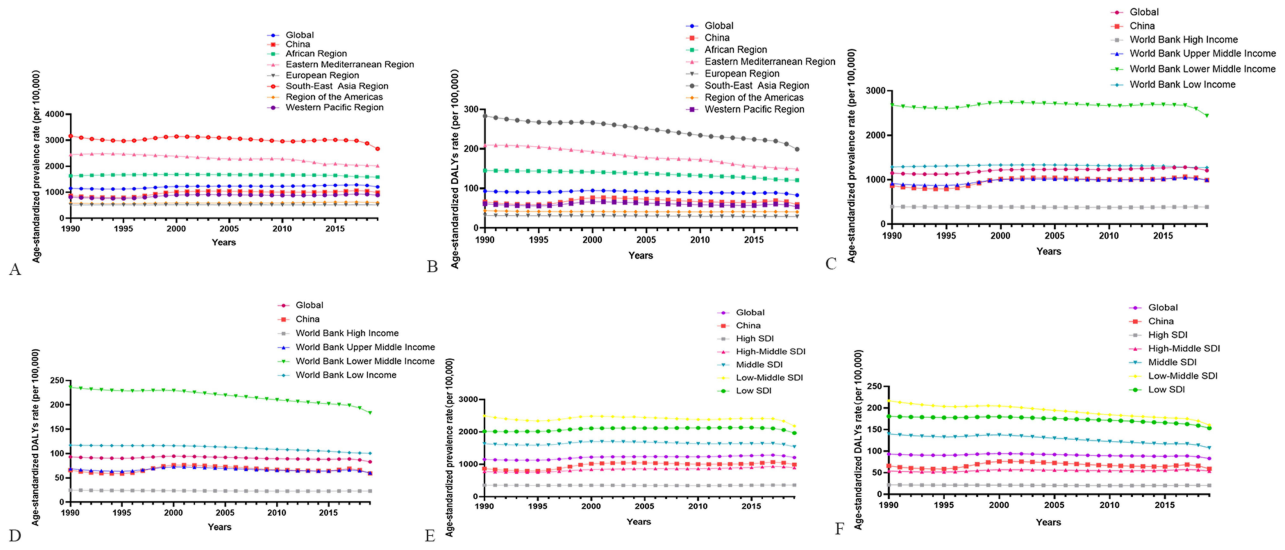

Figure 2 The age-standardized prevalence rate and burden of cataract in 1990–2019 by different regions (**A** and **B**), by different levels of income regions (**C** and **D**), by different levels of SDI regions (**E** and **F**). SDI, Socio-Demographic Index.

European region had the lowest prevalence in 1990–2019 (515.11 per 100,000 for European and 606.06 per 100,000 for Americas in 2019). China has a similar ASR with Western Pacific region. In terms of world bank income, lower-middle income regions have the highest prevalence rates (2439.43 per 100,000) compared to low income countries, while high income regions have the lowest prevalence rates (388.67 per 100,000) (Figure 2C). Similarly, lower-middle SDI regions has the highest prevalence rate (2182.06 per 100,000) and high SDI regions had the lowest (357.01 per 100,000) in 2019. China and upper middle region have similar ASR. As we can see in the Figure 2E, there is a clear downward trend from 2017 in global, low-middle, low and middle SDI regions. The ASR of China is between middle and high-middle regions.

Global Health Burden of Cataract by Region, Income Level and SDI

Among the six WHO regions, South-East Asia region suffered from the highest burden of cataract while European region suffered from the lowest (Figure 2B). China has a similar burden of cataract with Western Pacific region. In terms of world bank income, high income regions tend to suffer from a lower burden of cataract compared to others (Figure 2D). China and upper-middle income region have similar burden. In the subgroup of SDI levels, the disease burden of cataract is much heavier in low and low–middle SDI regions than three other regions (Figure 2F). China's disease burden is between middle and high-middle regions.

Risk Factors for Cataract

We included 86 risk factors from the website (GHDx) for analysis and finally filtered out 4 risk factors. At the global level, HAP from solid fuels, tobacco, high fasting plasma glucose and high body-mass index are associated with a heavier disease burden of cataract (Appendix Figure 5). While HAP from solid fuels was rated as the biggest risk factor in the global level (32.2% in 2019). At the same time, we analyzed the risk factors in different GBD regions. Interestingly, we find the impact of HAP from solid fuels was related with SDI, the higher SDI with the lower proportion. Likewise, high-income Asia Pacific and high-income North America had low proportion. While Eastern Sub-Saharan Africa ranked firstly in 2019 (56.9%, 34.0–72.8%). On the other hand, the proportion of DALYs attributable to HAP from solid fuels and tobacco in 2019 was much lower than in 1990, while the proportions resulting from high BMI and high fasting plasma glucose were instead higher in 2019 than in 1990. We also analyzed attributable risk factors by gender. It was evident that the proportion of tobacco was much higher in men than in women (Figure 3B), the proportion of high body-mass index was slightly higher in women than in

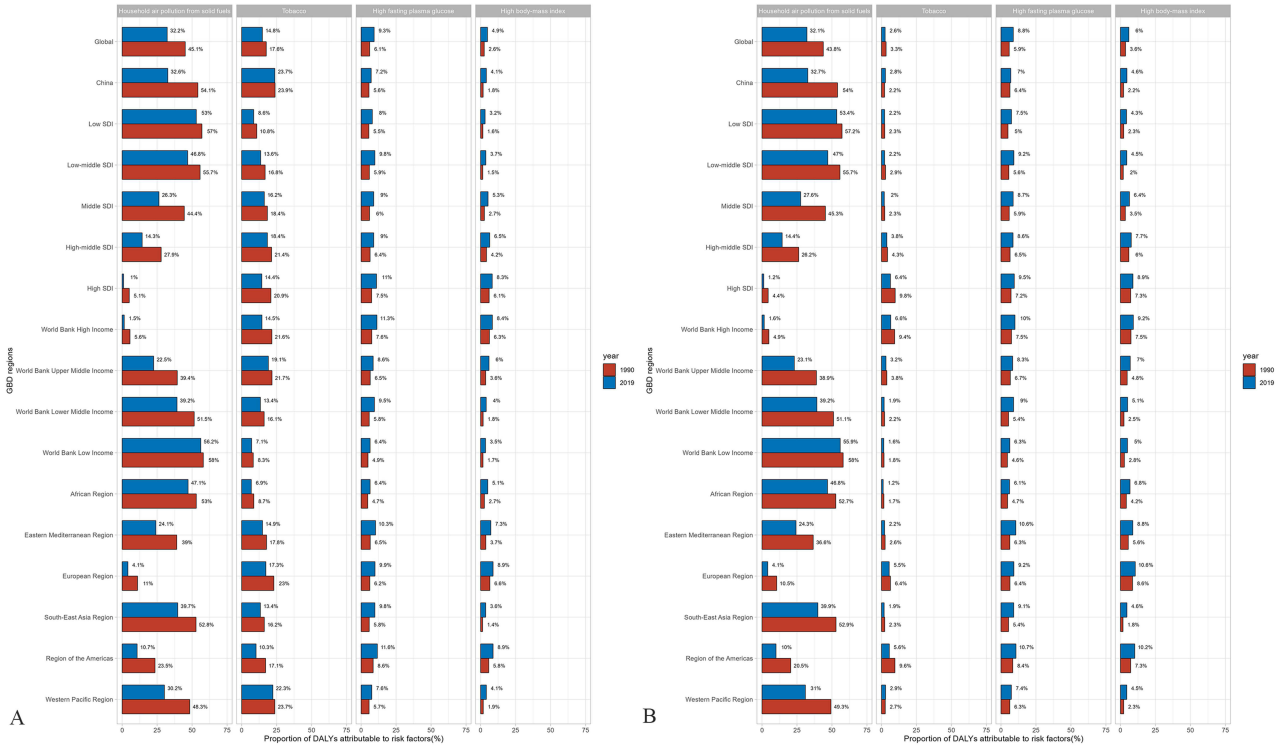

Figure 3 Proportion of cataract DALYs attributable to four risk factors, for global, China and 15 regions in 1990 and 2019 by sex: (**A**) Male, (**B**) Female. Injuries, and Risk Factors Study.
Abbreviation: GBD, Global Burden Diseases.

men (Figure 3A), and the proportion of HAP from solid fuels and fasting plasma glucose were similar in both. Moreover, the proportion of attributable to risk factors in China is closer to that of low, or middle-income regions than high-income regions.

Changes in Cataract Burden by Gender from 2020 to 2030

As shown in Appendix Figure 6A and B, the curve had a slow upward trend until 2017, and began to decline after peaking in 2017. Bayesian age-period-cohort (BAPC) models expect this trend to gradually decline from 2020 onwards. Males and females share a similar trend. On the contrary, ASR in China shows a growing trend after 2019 both in male and female (Figure 4A and B). The Projective model indicates that by 2030, the ASR for cataracts will rise to 1101.35×10^6 for male and 1616.63×10^6 for female. The growth trend from 1990 to 2019 was stable and slow.

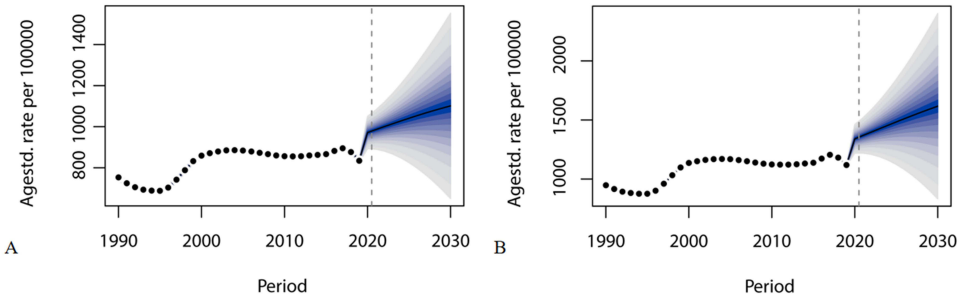

Figure 4 The change trends of the cataract-related disease burden by sex from 1990 to 2030 in China: (**A**) Male, (**B**) Female.

Discussion

The study reports on current trends in the prevalence and disease burden of cataract worldwide, with a focus on China. From 1990 to 2019, the global prevalence of cataract increased by 129.17%, and in China the increase was even as high as 223.54%. The DALY rate in China and globally peaked in 2017 and then began to decline, after adjusting for population growth and aging, the age-standardized DALYs rate fluctuated downward globally and fluctuates up and down in China. The age-specific disease burden of cataract increased with age. Age-standardized DALY rates and age-specific prevalence were higher in women than in men of the same age. Further studies suggest that HAP from solid fuels was the highest attributable factor. Identifying risk factors is important to develop public strategies to prevent cataracts and prevent their progression. In our results, it was found that the prevalence was greater in women compared to men, which is consistent with previous studies.[17–19] Another demographic variable that has been used as a risk factor in some epidemiological studies is age, with the older the age, the higher the prevalence.[20] In addition to this, the prevalence and disease burden of cataract varies by race. South-East Asian and African had higher ASR and age-standardized DALYs rate of cataract. Americans and European had lower ASR and age-standardized DALYs rate of cataract compared with global. A Singaporean study also showed that cataract was more common in Asians and earlier than in Europeans.[21]

Age, gender, and race are important non-modifiable risk factors for the development of cataract, modifiable risk factors should be the main areas of concern.[22] Interestingly, analysis of attributable risk factors in our study showed that HAP from solid fuels,[23–25] tobacco,[26] high fasting plasma glucose[27] and high BMI[28] are associated with a heavier disease burden of cataract. HAP is mainly derived from cooking and heating, and developing countries are the main users of solid fuels (biomass and coal).[29] HAP from the use of solid fuels and techniques is a major source of many eye diseases, such as cataract,[30] conjunctiva disorders[31] and disorders of sclera, cornea, iris, and ciliary body.[32] A population-based cohort study in China found that HAP from solid fuels has been linked to higher risks of cataracts.[31] Previous studies have concluded that the increased risk associated with solid fuels use is primarily associated with women.[24,31] However, there is no evidence in the present study to suggest that women have higher rates of cataract due to HAP from solid fuels, although women may be more frequently exposed to fuels in the home. Since particulate matter caused by solid fuels, persist in an unventilated environment, there is a risk of exposure for both men and women,[33] as well as the fact that men also cook, the above two points may be the reason why there is no difference in risk factors between men and women. In addition, our findings show a significant decrease proportion of DALYs attributable to HAP in 2019 compared to 1990, high income, high SDI regions have a lower risk compared to low-income, low-SDI regions, suggesting a possible association with the gradual spread of clean energy use. Further studies have found that switching to cleaner fuels appears to mitigate this risk, suggesting that promoting the widespread use of cleaner fuels is important for global health.[34] Tobacco and HAP have many similarities. Tobacco causes oxidative stress by reducing endogenous antioxidant levels, which plays a major role in the cataract formation.[35] Our study found that tobacco is the second most attributable risk factor, suggesting that smoking may cause an increased burden of cataract disease, which was consistent with previous studies.[36–38] Given the correlation between tobacco and cataract, we urge people to quit smoking to maintain healthy life. While there is nothing we can do to change the non-modifiable risk factors, there are modifiable factors that we should try to stay away from, such as switching to clean energy, reducing tobacco intake, controlling blood glucose and weight.

Our BAPC predictive model shows a downward trend in global prevalence trends after 2020, however, a concerning finding is that prevalence in China is still increasing. Future trends are consistent in both men and women. There are some possible reasons for it. Firstly, China has the largest elderly population and is accelerating into an ageing society,[39] which could lead to an increase in prevalence over the next decade. Secondly, risk factors for cataracts include myopia, hypertension, obesity, diabetes mellitus and environmental pollution, which are now common in China and may be responsible for the increased prevalence of cataract. Considering the continued growth, the burden of disease caused by cataracts will become one of the major public health problems in China. Therefore, we should strengthen the prevention and management of modifiable risk factors for cataract, and in the meantime, develop public strategies for widespread screening of cataract and operate on cataract patients who need surgery to restore

vision. Our results provide guiding direction for curbing the increasing trend of cataract-related disease burden, and reducing the burden of cataract.

However, this study has some limitations. Firstly, our study relied on the results of secondary analysis of the GBD database, which has shortcomings such as data quality assurance. Secondly, due to the lack of relevant data, cataracts referred to in this study do not include congenital cataracts, etc. Further classification of cataracts is needed to analyze epidemiological trends. Third, based on GBD 2019, it is insufficient for cataract to focus only on prevalence, incidence should also be considered. Beyond that, we need to translate the results of our study into action develop public policy, as well as to inform subsequent research.

Conclusions

In summary, the disease burden and the ASR of cataract from 1990 to 2019 in China had increased, while female had more than male. Predictive models suggest the age-standardized prevalence rate will remain elevated in the next decade years, which means the burden of cataract in China is still very high. In addition, older age and being female were associated with a higher burden of cataract. Maintaining good lifestyle habits such as switching to clean energy, reducing cigar intake and controlling blood glucose and weight can also reduce the risk of cataracts. Therefore, as aging increases, China should pay more attention to cataract-induced low vision and blindness and develop public policies to reduce the disease burden.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declared no conflict of interest.

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