

Time trends and gender disparities of Chinese cataract burden and their predictions

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Abstract

• **AIM:** To evaluate the trends and changes in the number and rates of disability-adjusted life years (DALYs) and prevalence of cataract in China between 1990 and 2019, and to predict the trends of cataract burden from 2020 to 2030.

• **METHODS:** The Global Burden of Diseases (GBD) database was employed to collect the data on DALYs and the prevalence of cataract in China, which was distinguished by age and sex during the past three decades from 1990 to 2019, and then changes in the number and rates of cataract from 2020 to 2030 were predicted. All data were analyzed by the R program (version 4.2.2) and GraphPad Prism 9.0 statistics software.

• **RESULTS:** The number of DALYs of cataract increased from 449 322.84 in 1990 to 1 087 987.61 in 2019, number of cataract cases increased from 5 607 600.94 in 1990 to 18 142 568.96 in 2019. The age-standardized DALY rates (ASDR) generally increased slightly [estimated annual percentage change (EAPC)=0.1; 95%CI: -0.24 to 0.45), age-standardized prevalence rates (ASPR) also increased (EAPC=0.88; 95%CI: 0.6 to 1.15). Cataract burden increased with age and female gender. Among the causes of cataract, air pollution was the most important, followed by smoking, high fasting plasma glucose, and high body mass index (BMI). The burden of cataract is predicted to grow persistently from 2020 to 2030, the number of DALYs and prevalence for cataract will rise to 2 336 431 and 43 698 620 respectively by 2030, the ASDR is predicted to be 85/100 000 and ASPR will be 1586/100 000 in 2030, females will still be at greater risk of suffering from cataract than males.

• **CONCLUSION:** The burden of cataract in China kept rising from 1990 to 2019. Increasing age and female gender are risk factors for cataract. Air pollution, smoking, high fasting plasma glucose, and high BMI are associated with cataract. The burden of cataract in China will gradually increase from 2020 to 2030, the elderly women in particular need attention. Our results may be of help for providing reference strategies to reduce cataract burden in the near future.

• **KEYWORDS:** cataract; disease burden; tendency; prediction

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INTRODUCTION

Visual impairment caused by ocular diseases is a crucial factor which affects the quality of life and even increases the risk of death^[1-2]. Cataract is one of the leading causes of visual impairment, especially in the developing world, it accounts for almost half of all blindness^[3-4]. Cataract develops due to reduced lens transparency, resulting in loss of vision if left untreated^[5]. With correct intervention, cataract could be cured. Nowadays, surgery is the only effective way for cataract treatment^[6]. However, cataract surgery is not widely available in many remote and backward regions due to the underdeveloped economy, lagging medical technology, and poor education^[7-8].

As the living standards of the Chinese population increase, citizens are becoming more concerned about the quality of life and health issues^[1]. In China, cataract is the main cause of visual impairment and blindness^[9], and has become the second leading cause of disabilities for the seniors^[10]. Cataract is even correlated with the depressive symptom of the old^[11]. Chinese researchers have started to investigate cataract incidence since the 1990s^[12]. With ageing problems getting more serious, the incidence of cataract is on the rise^[13-14], causing a heavier burden on individuals, national health problems^[11], as well as the social economy^[12].

As far as we know, in the past few decades, studies for cataract in China were usually regional and targeted at the elderly, few studies have made the predictions of cataract burden, nor have the Global Burden of Diseases (GBD) database been employed to evaluate the incidence of cataract, which also limited the extensive cataract screening and popularization of cataract surgery^[10]. This study focuses on assessing the trends in the number and rates of cataract disability-adjusted life years (DALYs) and prevalence in China between 1990 and 2019, and makes predictions of cataract burden from 2020 to 2030. Furthermore, some of the risk factors associated with cataract are also analyzed. It is necessary to provide helpful information on the future trends and treatments of cataract in China.

MATERIALS AND METHODS

Data Sources GBD 2019 study provides the incidence, prevalence, mortality, years of life lost (YLLs), years lived with disability (YLDs), and DALYs due to 369 diseases and injuries, in 204 countries and territories from 1990 to 2019. We collected the DALYs and prevalence of cataract in China from the GBD study database (<http://ghdx.healthdata.org/gbd-results-tool>). The estimated population of China was taken from the United Nations World Population Prospects 2019 Revision, by year (up to 2100), age, and sex (<https://population.un.org/wpp/Download/Standard/Population/>). No informed consent or ethical approval was required as these data are freely available.

Study Variables All the results were presented by the number of DALYs and cases, age-standardized DALY rates (ASDRs) and age-standardized prevalence rates (ASPRs), crude DALY rates and prevalence rates, and estimated annual percentage change (EAPC) through year and sex between 1990 and 2019 using 95% uncertainty intervals (UI) and 95% confidence intervals (CI). The epidemiological outcomes of blindness and vision impairment were modelled by using the Disease Modeling-Meta Regression (DisMod-MR) version 2.1, a Bayesian Meta-regression framework widely used for GBD epidemiological modelling. Moreover, we predicted the DALYs and prevalence of cataract in China from 2020 to 2030 by running the Bayesian age-period-cohort (BAPC) models and integrated nested laplace approximations (INLA) packages in R by sex.

Statistical Analysis When considering variations in the age structure, it was necessary to standardize the age-standardized rate (ASR) calculation. The ASR was obtained by the formula:

$$ASR \text{ (per 100000 population)} = \frac{\sum_{i=1}^A a_i w_i}{\sum_{i=1}^A w_i} \times 100000$$

The ASR (per 100 000 population) in accordance with the direct method is calculated by summing up the products of the age-specific rates (a_i , where i denotes the i^{th} age class) and the

number of persons (or weight; w_i) in the same age subgroup i of the chosen reference standard population, then dividing the sum of standard population weights. The EAPC was calculated as $100 \times [\exp(\beta) - 1]$. The linear regression model was used to obtain the EAPC's 95%CI. We used the BAPC models and INLA packages to predict the number and rate of cataract DALYs and prevalence in the next 11y. All data visualization and analyses were completed using the R program (version 4.2.2) and GraphPad Prism 9.0 statistics software.

RESULTS

Time Trends of Disease Burden due to Cataract in China From 1990 to 2019

The number of DALYs [449 322.84 (95%UI: 317 651.79-618 751.82) in 1990 vs 1 087 987.61 (95%UI: 761 917.08-1 487 672.38) in 2019] and prevalence [5 607 600.94 (95%UI: 4 895 979.54-6 402 853.51) in 1990 vs 18 142 568.96 (95%UI: 15 617 088.67-20 841 571.94) in 2019] of cataract in China had a noticeable increase, 2.42 and 3.24 times more in 2019 than in 1990 respectively, the increase in number for males and females was approximately equal multiples. Globally, the trend was the same in general, but the increase was not as pronounced as in China (Table 1).

The ASDR of cataract in China was 65.85/100 000 (95%UI: 46.39-89.41) in 1990, and 59.16/100 000 (95%UI: 41.7-80.15) in 2019, but overall, the ASDR increased over the 30-year period, with the EAPC of 0.1 (95%CI: -0.24 to 0.45). The ASDR generally increased for women [EAPC=0.22 (95%CI: -0.14 to 0.57)] and decreased for men [EAPC=-0.04 (95%CI: -0.35 to 0.28)]. The ASDR of global cataract decreased both in males and females from 1990 to 2019 (Table 1).

The ASPR of cataract in China was 867.09/100 000 (95%UI: 761.36-975.42) in 1990 and 991.56/100 000 (95%UI: 861.52-1131.04) in 2019 respectively, the EAPC was 0.88 (95%CI: 0.6-1.15). Both men [EAPC=0.97 (95%CI: 0.68-1.26)] and women [EAPC=0.79 (95%CI: 0.54-1.05)] showed an upward trend in ASPR. It was the same situation with the ASPR of global cataract (Table 1).

Age-specific and Gender-specific Disease Burden due to Cataract in China in 2019

The number of DALYs and cases of cataracts increased with increasing age, peaking in the 70-74y age group and then decreasing with age. Both crude DALY and prevalence rates rose slowly with increasing age until 64 years old and more steeply after age 65y. When younger than 45y, the difference in the number of DALYs and cases of cataract due to gender is insignificant. The disparities in rates caused by gender were presented after age 59y (Figure 1).

Gender disparities are reflected in cataracts. The number of cataract DALYs and cases was notably higher for females than males in each year from 1990 to 2019, it was the same with ASDR and ASPR (Figure 2). In 2019, the ASDR for females [66.84/100 000 (95%UI: 47.08-90.43)] was higher than that

Table 1 DALYs and prevalence of cataract in 1990 and 2019, and percentage change of age-standardized rates

Characteristics	1990		2019		1990-2019	
	Number (95%UI)	ASR (95%UI)	Number (95%UI)	ASR (95%UI)	ASR (95%UI)	EAPC (95%CI)
DALYs						
Global						
Both	3492604.65 (2481846.35-4719629.21)	93.17 (66.14-125.32)	6676281.11 (4761210.7-9006193.63)	82.94 (59.06-111.75)	-0.23 (-0.31 to -0.14)	
Female	2025405.33 (1442842.4-2729747.95)	97.44 (69.34-130.79)	3928327.32 (2798531.24-5275330.18)	89.82 (63.97-120.6)	-0.1 (-0.19 to -0.01)	
Male	1467199.32 (1038552.56-1989939.06)	88.46 (62.56-118.7)	2747953.79 (1954020.15-3725738.19)	74.91 (53.35-101.18)	-0.41 (-0.49 to -0.33)	
China						
Both	449322.84 (317651.79-618751.82)	65.85 (46.39-89.41)	1087987.61 (761917.08-1487672.38)	59.16 (41.7-80.15)	0.1 (-0.24 to 0.45)	
Female	268605.12 (191239.94-368524.29)	72.39 (51.22-98.45)	667683.36 (470817.2-905386.26)	66.84 (47.08-90.43)	0.22 (-0.14 to 0.57)	
Male	180717.72 (126384.78-250235.49)	56.4 (39.54-76.37)	420304.26 (294944.25-582247.37)	49.06 (34.4-67.1)	-0.04 (-0.35 to 0.28)	
Prevalence						
Global						
Both	42336679.03 (37728563.83-47615115.01)	1150.56 (1027.31-1287.4)	97022038.9 (85370876.66-109696643.7)	1207.88 (1065.04-1361.26)	0.41 (0.33-0.5)	
Female	24744464.93 (22061694.18-27793816.88)	1203.35 (1073.53-1347.25)	57074405.2 (50385295.11-64437237.81)	1302.54 (1150.34-1469.85)	0.52 (0.43-0.61)	
Male	17592214.1 (15618056.05-19827463.12)	1089.86 (972.55-1218.79)	39947633.7 (34974826.81-45332548.63)	1096.94 (965.34-1237.51)	0.26 (0.17-0.34)	
China						
Both	5607600.94 (4895979.54-6402853.51)	867.09 (761.36-975.42)	18142568.96 (15617088.67-20841571.94)	991.56 (861.52-1131.04)	0.88 (0.6-1.15)	
Female	3389569.02 (2949971.85-3847246.48)	946.5 (832.76-1064.33)	11159984.56 (9618369.08-12767304.08)	1117.12 (967.62-1268.37)	0.97 (0.68-1.26)	
Male	2218031.92 (1928740.42-2537501.91)	752.74 (660.27-849.54)	6982584.4 (5988188.77-8089726.5)	833.8 (723.14-949.92)	0.79 (0.54-1.05)	

DALYs: Disability adjusted life years; ASR: Age-standardized rate; EAPC: Estimated annual percentage change; UI: Uncertainty interval; CI: Confidence interval.

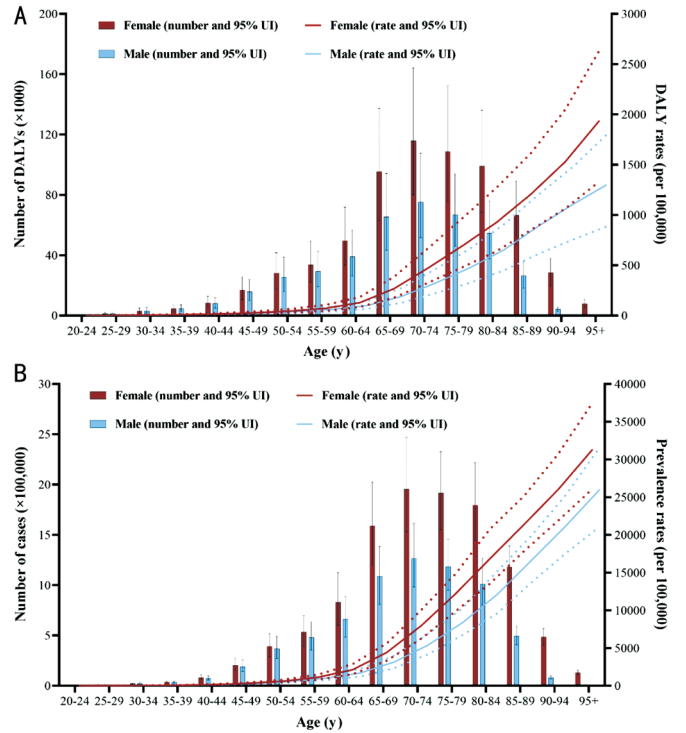


Figure 1 Disease burden due to cataract for females and males by age in China in 2019 A: Number of DALYs and crude DALY rates; B: Number of cases and crude prevalence rates. Red and blue dashed line indicates the upper and lower limits of the 95%UI for females and males respectively. DALY: Disability adjusted life year; UI: Uncertainty interval.

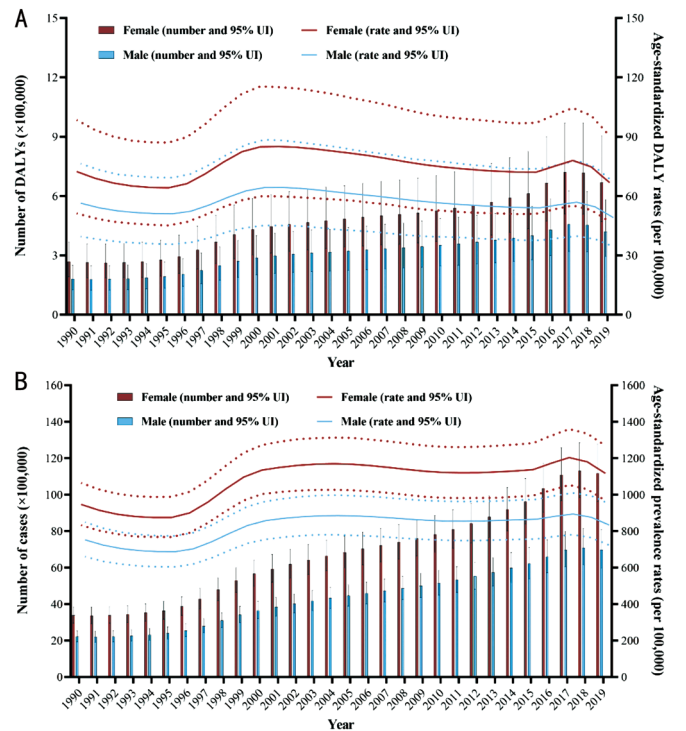


Figure 2 Time trends of cataract burden in China for females and males from 1990 to 2019 A: Number of DALYs and age-standardized DALY rates; B: Number of cases and age-standardized prevalence rates. Red and blue dashed line indicates the upper and lower limits of the 95%UI for females and males respectively. DALY: Disability adjusted life year; UI: Uncertainty interval.

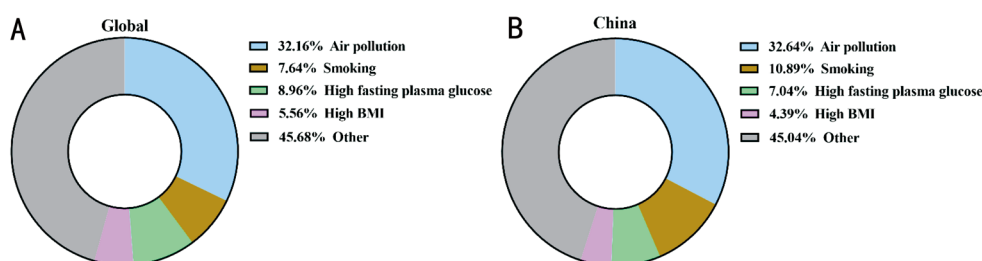


Figure 3 Proportion of cataract DALYs attributable to air pollution, smoking, high fasting plasma glucose, and high BMI for global (A) and China (B) in 2019 DALY: Disability adjusted life year; BMI: Body mass index.

for males [49.06/100 000 (95%UI: 34.4-67.1)], the number of DALYs for women [667 683.36 (95%UI: 470 817.2-905 386.26)] was 1.59 times of that for men [420 304.26 (95%UI: 294 944.25-582 247.37)]. ASPR was 1117.12/100 000 (95%UI: 967.62-1268.37) for females, and 833.8/100 000 (95%UI: 723.14-949.92) for males. The number of females' cases [11 159 984.56 (95%UI: 9 618 369.08-12 767 304.08)] was 1.6 times of male's [6 982 584.4 (95%UI: 5 988 188.77-8 089 726.5; Table 1)].

Characteristics of the Cataract Burden in China Attributed to Risk Factors For risk factors of cataract DALYs in China in 2019, air pollution accounted for the most significant proportion (32.64%), followed by smoking (10.89%), high fasting plasma glucose (7.04%) and high body mass index (BMI; 4.39%). This is the same order as the global ones. Smoking and air pollution have a more significant impact on cataracts in China than in the world, but the difference in air pollution is not as pronounced as in smoking. High fasting plasma glucose, high BMI and other factors were less impactful on cataract burden in China than globally (Figure 3).

Predictions of DALYs and Prevalence due to Cataract in China From 2020 to 2030 Our predictions suggest that the number of DALYs and prevalence due to cataract will continue to rise after 2020. The number of DALYs will increase from 1 415 881 in 2020 to 2 336 431 in 2030, the number of cataract cases will also increase from 23 316 549 in 2020 to 43 698 620 in 2030, and unsurprisingly, women will have a higher risk of developing cataract than men, the number of DALYs and prevalence of cataract for females are 1.9 and 1.8 times higher for males respectively by 2030.

Similarly, ASDR and ASPR will rise persistently, especially in females. ASDR will increase from 74/100 000 in 2020 to 85/100 000 in 2030, it is predicted to be 97/100 000 for females and 64/100 000 for males by 2030. ASPR will also increase from 1222/100 000 in 2020 to 1568/100 000 in 2030, it will be 1807/100 000 and 1227/100 000 for females and males respectively by 2030. Additionally, prevalence rates will grow faster than DALY rates. The rise will be greater for females than for males, this is more evident in DALY rates (Figure 4).

DISCUSSION

By evaluating the trends and changes in the number and rates of DALYs and prevalence of cataract in China between 1990 and 2019, we found that the burden of cataract showed an upward trend over the 30-year period. Increasing age and female gender were risk factors for cataract. Additionally, air pollution was the leading cause of cataract, and the proportion of cataract caused by smoking was more remarkable in China than in the world. From 2020 to 2030, the number and rates of DALYs and prevalence due to cataract are predicted to increase annually.

Cataract is the second leading cause of visual impairment in China^[1]. One study predicted that the incidence of visual impairment would gradually increase in the coming years in China^[2]. According to our predictions, the Chinese burden of cataract will continue to rise from 2020 to 2030. When cataract has progressed to a stage where it affects the vision, it will not only impact the patient's quality of life, but also cause psychological disorders^[10,15]. Cataract can also lead to a decline in the country's productivity and affect national economic development^[16]. Fortunately, unlike some irreversible vision-impairing diseases, most cataract patients experience significant improvement in their vision after surgical treatment^[6,17]. What's noteworthy is that cataract surgery coverage needs to be improved, especially in rural and remote regions^[13-14]. Prompting efforts in all aspects of cataract prevention, diagnosis and treatment is urgent.

Increasing age is a major cause of cataract^[10,18-19]. Age-related cataract is the most common^[20], and there exist a series of complex molecular mechanisms, including the decreasing of one kind of heat shock protein, reduction of glutathione activity^[21], and oxidative stress accumulation of lens proteins^[22]. Cataract ranks second in the top five causes of disability burden for older Chinese, causes depressive symptoms in the elderly^[10], and may have a relationship with Alzheimer's disease^[15]. After cataract surgery, anxiety and depression levels drop^[23]. From 1990 to 2019, the burden of cataract kept growing, this was mainly due to the continued growth of Chinese population during this period and increasingly serious ageing problems^[24-26]. The crude

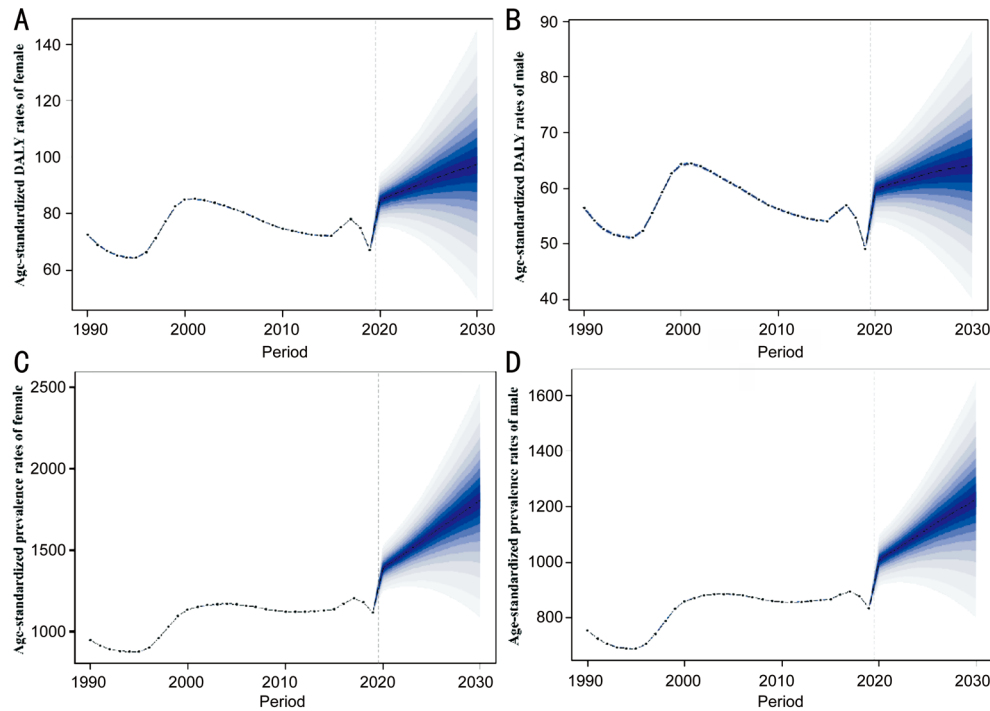


Figure 4 Predictions of age-standardized DALY rates (per 100 000) and age-standardized prevalence rates (per 100 000) of cataract in China from 2020 to 2030 A: Age-standardized DALY rates (per 100 000) of female; B: Age-standardized DALY rates (per 100 000) of male; C: Age-standardized prevalence rates (per 100 000) of female; D: Age-standardized prevalence rates (per 100 000) of male. DALY: Disability adjusted life year.

prevalence and DALY rates of cataract increased with age, but after 74 years old, the number of DALYs and cases decreased, possible cause was that the mortality rates of the older adults rose after 74y and the population decreased.

Previous studies have proven that the female gender is one of the risk factors in cataract development^[22]. Estrogen protects the lens from being opaque^[27]. After menopause, cataract occurs more severely in women than in men of the same age due to the lack of protective effect of estrogen and its withdrawal effect^[28]. Cataract is more likely to cause other diseases in females than in males, one study showed that cataract was a risk factor for depression and anxiety in women with diabetes, but not in men^[29]. In China, a traditional social country, women are more inclined to do housework, and burning biomass used in cooking, especially in rural areas, is proven to be related to cataract formation^[30]. Poor ventilation in the kitchen may also contribute to the development of cataract^[31]. Moreover, the waiting time for cataract surgery is longer for females than males^[32]. Therefore, postmenopausal women should be more aware of cataract prevention.

Air pollution is strongly associated with cataract^[33], especially the household air pollution (HAP) from solid cookfuel use^[34-36], this is more serious in economically disadvantaged areas^[37], HAP could also cause many other ocular diseases such as conjunctivitis, glaucoma, and age-related macular degeneration (AMD)^[34]. Small particulate matter from solid

fuels including particulate matter less than 2.5 μm in diameter (PM_{2.5}) is the crucial cause of cataract among the various factors of air pollution^[38-39]. The exact mechanism is not very clear, but it may have something to do with the damaged membrane luminal and secretory proteins^[40-41]. Additionally, solar ultraviolet radiation is the cause of cataract^[42-44], higher O₃ concentrations are protective against cataract^[45]. However, there is no consensus on whether some other air pollution components such as SO₂, NO₂, and CO are associated with cataract^[46], further researches are required in this direction. Smoking is cataract related^[5,47]. Tobacco contains a large amount of toxic heavy metal substances^[48], which promote the production of reactive oxygen species (ROS) and then accelerate the development of cataract^[5], but China lacks a tobacco promotion restriction policy^[49-50], so the impact of smoking on cataract is greater in China than in the world. Hyperglycemia is one of the risk factors for cataract, it leads to non-enzymatic glycosylation of lens proteins or changes in osmotic pressure^[51-53]. The prevalence of cataract, especially posterior sub-capsular cataract, is associated with high BMI. Obesity is related to insulin resistance, this can accelerate the formation of cataract^[54-55], and abdominal obesity is more relevant^[56]. In developed countries, the risk of suffering from hyperglycemia and obesity is higher^[57-58].

Our predictions show that the burden of cataract will persistently increase from 2020 to 2030. It is predicted by

some researchers that the Chinese population will continue to rise in the next few decades^[24,59]. By 2035, people over 60y will make up the majority of the population, and the problem of ageing has further aggravated^[24,59]. Moreover, due to the rising pressure of life and changes in eating habits among the Chinese, the incidence of diabetes and obesity in China is increasing, they are two significant risk factors for cataract^[60-62]. With the increase in daily use of electronic devices, the prevalence of myopia in China has soared in recent years. Myopia, especially high myopia, accelerates the development of cataract^[63-64]. These are all likely to be responsible for the rising burden of cataract in China over the next several years. Our study still has the following limitations, which require attention and subsequent improvement. First, the data was only analyzed up to 2019, the end of 2019 was when the COVID-19 pandemic began, and it affects the occurrence, development, and treatment of cataract^[65-67]. Second, this study only analyzes for the whole country and does not include geographical conditions, economic conditions, provinces, cities, rural areas and other factors, but the prevalence of cataract in China varies considerably among regions^[12,18,68-71]. Third, cataract is multifactorial, but the database does not provide some of the risk factors such as nutrition^[72], drugs^[73], other eye diseases and systemic diseases^[74] and thus these factors were not covered in this study.

Over the three decades from 1990 to 2019, the burden of cataract in China presented an upward tendency, with a higher burden in females. In the decade after 2020, the burden of cataract in China will gradually increase, it is necessary to focus on age-related ocular diseases, and pay particular attention to cataract in elderly women. In the meanwhile, prompt diagnosis and appropriate treatment methods are also vital components of fighting against cataract. Ophthalmologists are supposed to improve their professional knowledge and skills and explore better approaches to prevent and treat cataract.

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