Trends in the prevalence of vision impairment among the oldest-old Chinese population from 1998 to 2018

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Background Vision impairment has become a prominent public health issue worldwide. However, little is known about vision impairment prevalence trends among the oldest-old adults in China. This study aimed to examine 20-year trends in the prevalence of vision impairment among the oldest-old Chinese adults and explore the contributions of sociodemographic variables, health behaviours, and chronic conditions to the trends.

Methods This retrospective longitudinal study used data from the Chinese Longitudinal Healthy Longevity Survey during 1998-2018. A total of 45,849 participants aged ≥80 years at study entry were included. Vision impairment was assessed by an adapted Landolt-C chart at each wave. We examined unadjusted and adjusted nonlinear trends using generalized estimating equation models incorporating a natural cubic spline. We conducted linear regression models to estimate absolute annual prevalence changes and determine the contributions of sociodemographic variables, health behaviours, and chronic conditions to the trends.

Results The fully adjusted prevalence doubled from 5.5% (95% confidence interval (CI) = 5.1%-6.0%) in 1998 to 10.7% (95% CI = 9.9%-11.5%) in 2011 and slightly increased to 11.1% (95% CI = 10.3%-12.0%) in 2018 among the oldest-old Chinese population. Glaucoma, cataracts, cognitive impairment, hearing impairment, and urban residence were significant contributors to changes in vision impairment prevalence during 1998-2018. Differences in vision impairment prevalence associated with glaucoma and cataracts narrowed since 2005. Disparities in the trends among cognitively impaired and unimpaired older adults remained unchanged over time. Similar results were observed in older people with and without hearing impairment.

Conclusions Vision impairment prevalence among the oldest-old Chinese population increased from 1998 to 2011 and remained stable from 2011 to 2018. Future work is needed to improve the prevention and management of chronic diseases associated with vision impairment to reduce its prevalence.
Research has shown inconsistent trends in vision impairment prevalence [2,5-11]. With socio-economic development, improvements in the accessibility of medical services may play a role in the declining prevalence of vision impairment [6,7,11]. Multiple strategies, such as early detection, spectacle use, and treatment with drugs and surgery, have been applied to promote visual health since the WHO proposed VISION 2020 and Universal Eye Health [10,12]. However, population ageing and the rising burden of age-related diseases could negatively affect visual outcomes in the population [2,10]. Moreover, most studies estimated vision impairment prevalence at only two time points, and little research explicitly described the courses of changes over the years.

Evidence regarding trend analysis in vision impairment and factors influencing the trends is of great importance for evaluating the impacts of policies, estimating disease burdens, and planning for future eye care strategies for older adults. This study aimed to investigate long-term trends in vision impairment prevalence among a nationally representative sample of Chinese adults aged ≥80 years and explore the contributions of sociodemographic variables, health behaviours, and chronic conditions to the observed trends.

METHODS

Study design

Data came from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), an ongoing prospective cohort study aiming to examine determinants of health and longevity in China. The survey was initiated in 1998, and subsequent surveys were conducted every 2-3 years. The sample was randomly selected from half of the counties in 23 provinces throughout China [13]. For this study, a total of 46,285 participants aged ≥80 years at baseline were derived from the eight-wave panel data covering the 1998-2018 period. After excluding those with missing vision assessment data at all waves (n = 436), 45,849 participants with 74,804 observations were included. The sample size, characteristics of participants at each wave, and comparison of baseline characteristics between included and excluded participants are shown in Tables S1-S3 in the Online Supplementary Document.

Vision impairment

Visual function was measured by an adapted Landolt-C chart in the CLHLS, given that this visual screening test is intuitively clear for older populations and has excellent discrimination capacity (Figure S1 in the Online Supplementary Document) [14,15]. Participants were asked if they were able to see a break in the circle on the cardboard sheet without glasses and distinguish where the break was located. The testing distance was one meter. Visual function at this distance is considered as the intermediate vision, which plays an essential role in daily activities such as cooking and eating among older people [16]. Responses included the following: 1) able to see the break in the circle, 2) unable to see the break but able to see the circle, 3) unable to see the circle, and 4) medically blind. For this study, we classified participants as having vision impairment if they were unable to distinguish the break in the circle, unable to see the circle, or medically blind.

Covariates

Sociodemographic variables included age (80-89, 90-99, and ≥100 years), sex (male or female), residence (urban or rural areas), marital status, education levels (0 years or ≥1 year of schooling), and financial independence. Marital status was categorized into 1) married and living with a spouse and 2) unmarried, including separated, divorced, widowed, or never married. Participants who received retirement wages or employment income were considered financially independent. Health behaviours included smoking status (ever-smoker or non-smoker), alcohol consumption (ever-drinker or non-drinker), regular exercise in the past (yes or no), daily intake of fruit (yes or no), and daily intake of vegetables (yes or no). Glaucoma, cataracts, diabetes, heart disease, and cerebrovascular disease were defined by the self-report of physician diagnoses. Participants were considered to have hypertension if their systolic blood pressure was ≥140 mm Hg and/or diastolic blood pressure was ≥90 mm Hg, or if they self-reported diagnosed hypertension. Cognitive function was measured using the Chinese version of the Mini-Mental State Examination (MMSE). Given that the MMSE score is associated with education and a number of oldest-old Chinese adults are of low educated, an MMSE cutoff of ≤18 points was previously suggested for defining whether participants have cognitive impairment or not among this population [17]. Hearing impairment was identified if participants could not hear the interviewers clearly even using hearing aids or could not hear at all.
**Statistical analyses**

Characteristics were summarized using frequencies (percentages) for categorical variables and means (standard deviations (SD)) for continuous variables. Generalised estimating equation (GEE) models with survey year as the independent variable were used to assess the changes in sociodemographic variables, health behaviours, and chronic conditions over time. Categorical and continuous characteristics were modelled with logit and identity link functions.

We performed GEE models to assess temporal trends in the prevalence of vision impairment by examining higher-order terms of survey year [18]. The presence of vision impairment was modelled as a binomial outcome with a logit link in GEE models, with an exchangeable working correlation to account for repeated visual assessments of the same participant. Because the quadratic term of survey year was statistically significant (data not shown), a natural cubic spline with three knots at 2000, 2005, and 2011 was incorporated into all GEE models to examine nonlinear associations between survey years and vision impairment prevalence [19]. The predicted prevalence among the overall population was estimated based on the GEE models. To better compare the prevalence across studies [2,20], we also estimated unadjusted prevalence trends for people who were unable to distinguish the break in the circle, unable to see the circle, and medically blind, respectively.

We examined which factors were associated with the trends in two steps. We included age, sex, and the interaction term between survey year spline and each factor in GEE models (abbreviated hereafter as age- and sex-adjusted models). To quantitively describe the trends, we estimated the $\beta$ coefficient of the survey year from linear regression models using the predicted prevalence obtained from each of the models mentioned above as the dependent variable. The $\beta$s represented absolute annual prevalence changes (APCs) in the trends of vision impairment [21]. Since the rate of change (ie, the slope of a tangent line) in crude prevalence was minimal in 2011 (Table S4 in the Online Supplementary Document), we estimated APCs during 1998-2011 and 2011-2018 separately. To compare the factors’ contributions to the trends, we calculated the absolute difference in APCs from two categories (ie, “Yes” and “No” categories) defined by each factor. A larger absolute difference indicated more contributions of the factor to the trends.

To investigate the trends over 1998-2018 among groups stratified by factors that influenced the trends significantly, we estimated the predicted prevalence by subgroups based on the age- and sex-adjusted models, as well as the models further adjusted for sociodemographic variables, health behaviours, and chronic conditions (abbreviated hereafter as fully-adjusted models). The flow diagram of statistical analyses is shown in Figure S2 in the Online Supplementary Document.

Given that impaired cognitive function may affect vision assessment accuracy [22], we estimated the crude prevalence of vision impairment after excluding observations with cognitive impairment (n=23064). All statistical analyses were conducted using R software (version 4.1.1). A two-sided $P<0.05$ was considered statistically significant.

**RESULTS**

The characteristics of participants in 1998, 2011, and 2018, as well as changes in proportions or means over 1998–2018, are presented in Table 1. At baseline, the mean age was 92.1 (SD = 7.8) years and 61.0% of the participants were female (Table S3 in the Online Supplementary Document). The proportion of older adults who were married and living with a spouse, as well as those with ≥1 year of schooling declined between 1998 and 2018 ($P<0.001$). The proportion of participants living in urban areas, and those who were financially independent increased over time (all $P<0.001$). There were increases in the proportion of reports of daily intake of fruit or vegetables between 1998 and 2018 (all $P<0.001$), whereas the proportion of participants who ever smoked, ever drank, and had regular exercise decreased ($P<0.001$). The prevalence of cognitive impairment, hearing impairment, and self-reported diagnoses of hypertension, heart disease, cerebrovascular disease, diabetes, cataracts, and glaucoma increased over time (all $P<0.001$).

Figure 1 shows the trends in the predicted prevalence of vision impairment. Over the 20-year study period, the fully adjusted prevalence doubled from 5.5% (95% CI = 5.1%-6.0%) in 1998 to 10.7% (95% CI = 9.9%-11.5%) in 2011 and slightly increased to 11.1% (95% CI = 10.3%-12.0%) in 2018 among Chinese adults aged ≥80 years. The results of the unadjusted GEE model are shown in Table S7 in the Online Supplementary Document. Trends in the unadjusted prevalence by the severity of vision impairment are shown in Table S6 in the Online Supplementary Document. The prevalence among medically blind participants from 1998 (2.5%, 95% CI = 2.2%-2.9%) to 2018 (1.8%, 95% CI = 1.6%-2.1%) remained constant. Furthermore, we found no sig-
significant differences in the trends between participants with and without cognitive impairment (Table S5 in the Online Supplementary Document).

As shown in Figure 2, during 1998-2011, the factors that significantly moderated the trends in the prevalence predicted by the age- and sex-adjusted models included glaucoma, cataracts, cognitive impairment, residence, and hearing impairment, whose absolute differences in APCs were higher than 0.4%. Glaucoma, cataracts, regular exercise, hearing impairment, and daily vegetable intake were significantly associated with the trends between 2011 and 2018. Absolute differences in APCs of the above factors were greater than 0.8%.

The trends between 1998 and 2018 for vision impairment prevalence by subgroups are represented in Figure 3. The results of the GEE models are shown in Tables S8-S12 in the Online Supplementary Document. Adding all covariates to the age- and sex-adjusted models attenuated the slope of the trend line. The fully adjusted prevalence of vision impairment among older adults with glaucoma and cataracts increased during 1998-2005 and decreased during 2005-
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2018. The increasing trends among those without glaucoma and cataracts were similar from 1998 to 2018. Disparities in the prevalence of vision impairment associated with these two eye diseases narrowed over time. The fully adjusted prevalence of cognitive impairment, hearing impairment, and residence changed similarly between 1998 and 2018. Differences in the trends of vision impairment among cognitively impaired and unimpaired older adults remained unchanged over time. Similar results were observed in older people with and without hearing impairment.

DISCUSSION

This was the first study to report a long-term trend in vision impairment prevalence among Chinese adults aged ≥80 years over the past two decades. The prevalence increased from 1998 to 2011 and remained stable from 2011 to 2018. Glaucoma, cataracts, cognitive impairment, hearing impairment, and residence contributed to changes in the prevalence during 1998-2018. Narrowing differences in vision impairment prevalence associated with glaucoma and cataracts have been observed since 2005. In contrast, there were substantial disparities in vision impairment prevalence by subgroups, including cognitive impairment and hearing impairment.

Most surveys of visual health in China included a wide age range but only had small groups of oldest-old people, making it hard to reliably estimate vision impairment prevalence among this population [5,23,24]. Additionally, our findings on vision impairment prevalence might not be directly comparable with the results of previous studies on the oldest-old due to different assessments of vision impairment. A study of Russian adults aged ≥85 years found prevalences of mild vision impairment, moderate to severe vision impairment, and blindness during 2017-2020 determined by a physical examination of visual acuity of 9.9%, 48.9%, and 5.9%, respectively [20]. Another national study observed that the prevalences of self-reported vision impairment and blindness among American adults aged ≥85 years were 15.0% and 12.5%, respectively [25]. These findings showed that the self-reported prevalence of vision impairment seems to be lower than the prevalence...
reported based on eye examinations among the oldest-old people [25]. Disparities in the definitions for vision impairment using different measurements may also account for variations between the examination-based prevalences [26]. For ease of use in large-scale investigations and better comparisons across studies, a unified and precise screen test suitable for oldest-old populations is warranted in the future.

Previous studies on vision impairment trends were conducted among older adults younger than participants in our study, showing inconsistent results [2,5-11]. Several studies have documented a decline in vision impairment prevalence in older populations over recent decades [6-9,11], most of which were conducted in western countries [6-8,11]. These findings might reflect the change in prevalence due to improved eye care utilisation related to economic development and public health policy implementation [6-9]. Additionally, with improve-
mements in health care services in rural China, a study based on rural Chinese adults aged ≥50 years observed a declining trend in vision impairment prevalence from 2006 to 2014 [5]. In contrast, consistent with our findings, a global study found that the age-standardized prevalence of moderate and severe vision impairment increased by 10.7% between 1990 and 2020 among adults aged ≥50 years in East Asia [10]. Another study also reported that the prevalence of moderate and severe vision impairment in the overall Chinese population increased from 2.53% in 1990 to 2.82% in 2019 [2]. The rising burden of age-related eye diseases, as well as dili-
tory intervention due to unmet needs for eye care services and inadequate public awareness of visual health, may contribute to the increasing prevalence [2,10].

We found that sociodemographic variables, health behaviours, and chronic conditions, especially glaucoma, cataracts, cognitive impairment, hearing impairment, and residence, were associated with the trends between 1998 and 2018. Our results showed that the burden of glaucoma and cataracts, two main causes of vision impair-
ment, increased over time among the oldest-old population, which is in line with one previous study [2]. However, we found that differences in vision impairment prevalence associated with glaucoma and cataracts narrowed. These findings may be explained by multiple cataract surgery projects and population-based glau-
coma screening, which effectively reduce vision impairment prevalence among older patients [27,28]. Never-
theless, there might still be enormous unmet needs for eye care in the oldest-old Chinese adults, mainly due to a lack of awareness regarding preventable vision impairment and barriers to eye care services such as mo-
bility problems and travel inconvenience [29,30]. Given that the number of older people with glaucoma and cataracts might continue to increase, eye care education for both oldest-old individuals and their families, as well as targeted interventions including early detection and timely treatment, are crucial for slowing eye dis-
ases process to vision impairment [2,31-34].

Our study revealed that chronic conditions including cognitive impairment and hearing impairment in-
fluenced the trends of vision impairment during 1998-2018. Consistent with previous studies [35,36], we observed the increasing prevalence of functional impairment in China. Considerable literature has report-
ed that sensory impairment had effects on cognitive decline among older people [37-39]. Meanwhile, de-
mentia and hearing loss were associated with high risks of vision impairment [40,41]. Although the patho-
physiological mechanism for associations between vision, hearing, and cognition is still unclear, several hypothesizes, such as “cognitive load on perception” and “sensory deprivation,” have been presented [38]. Therefore, changes in cognitive impairment and hearing impairment may play a role in unfavourable trends of vision impairment among oldest-old Chinese populations. These findings suggest that, in the context of multimorbidity, proper management of other common chronic conditions might promote visual health among older people [40].

We observed urban-rural differences in the trends of vision impairment, although the discrepancy in the preval-
ence diminished after adjusting for all covariates. A plausible explanation is that rural older people in China bear higher financial burdens than urban residents when seeking eye care services before the New Cooper-
"tive Medical Scheme was established in 2003 [42]. Moreover, the shortage of eye care professionals in rural ar-
eas could limit access to ophthalmic services, therefore contributing to the high vision impairment prevalence among rural older adults [42]. Although the number of ophthalmologists and county-level hospitals has in-
creased since 2003, exceeding the goal of Vision 2020, these resources are distributed unequally across China, as most are allocated to urban areas [27,43,44]. Therefore, various methods, such as digital ophthalmology and telemedicine, have been suggested to improve the capability of country-level hospitals to provide high-quality and affordable eye care services to older adults [34,43,43].

Strengths and limitations

One strength of this study is that we used data from eight waves of a multi-provincial survey covering 20 years to describe the long-term trends of vision impairment. Moreover, we used an adapted Landolt-C chart to as-
"ess visual function. The Landolt-C chart can measure recognition acuity, which may be more relevant in daily living than resolution acuity [45]. It is also more comprehensible than other charts, such as the ETDRS chart with different optotypes, for oldest-old Chinese individuals given their relatively low education level.

Our study has several limitations. First, cataracts, glaucoma, and other chronic diseases in our study were self-reported; recall bias and measurement bias caused by changing diagnostic criteria likely exist. Second, data on other common eye diseases among older people (such as under-corrected refractive error, age-related macular degeneration, and diabetic retinopathy), spectacle use, cataracts surgery status, and barriers to health care (eg, transportation and distance to hospitals) were not available in the CLHLS, preventing us from further explaining the trends observed in this study.

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CONCLUSIONS

This study identified an upward trend followed by a plateau in vision impairment prevalence among the oldest-old Chinese population from 1998 to 2018. Although China has made significant progress in the prevention and treatment of eye diseases, especially cataracts, the burden of vision impairment remains heavy given the rapidly ageing population. Future work should enhance the prevention and management of chronic diseases associated with vision impairment. Additional studies are needed to elucidate the mechanisms of population-level changes in vision impairment among older adults.

Ethics approval: The CLHLS study was approved by the Research Ethics Committees of Duke University and Peking University. Written informed consent was obtained from participants or their proxies.

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Online Supplementary Document


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