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# Association of objective and subjective far vision impairment with perceived stress among older adults in six low- and middle-income countries

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**OBJECTIVES:** To assess the association between far vision impairment (objective and subjective) and perceived stress among older adults from six low- and middle-income countries (LMICs, i.e., China, Ghana, India, Mexico, Russia, and South Africa).
**METHODS:** Data from the WHO Study on global AGEing and adult health were analyzed. Objective visual acuity was measured using the tumbling E LogMAR chart and was used as a four-category variable (no, mild, moderate, and severe visual impairment). Subjective visual impairment referred to difficulty in seeing and recognizing an object or a person across the road. Using two questions from the Perceived Stress Scale, a perceived stress variable was computed, and ranged from 0 (lowest stress) to 100 (highest stress). Multivariable linear regression with perceived stress as the outcome was conducted.
**RESULTS:** Data on 14,585 adults aged ≥65 years [mean (SD) age 72.6 (11.5) years; 55.0% females] were analyzed. Only severe objective visual impairment (versus no visual impairment) was significantly associated with higher levels of stress ($b = 6.91$; 95% CI = 0.94–12.89). In terms of subjective visual impairment, compared with no visual impairment, mild ($b = 2.67$; 95% CI = 0.56–4.78), moderate ($b = 8.18$; 95% CI = 5.84–10.52), and severe ($b = 11.86$; 95% CI = 9.11–14.61) visual impairment were associated with significantly higher levels of perceived stress.
**CONCLUSIONS:** This large study showed that far vision impairment was associated with increased perceived stress levels among older adults in LMICs. Increased availability of eye care services may reduce stress among those with visual impairment in LMICs, while more research is needed to better characterize the directionality of the far vision impairment–perceived stress relationship.

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## INTRODUCTION

The world population is ageing at an unprecedented pace. It is estimated that 22% of the world's population will be aged >60 years by 2050 (versus 12% in 2015) [1]. Population ageing is more pronounced in low- and middle-income countries (LMICs) and 80% of older adults will be living in these countries by 2050. Along with this demographic shift, the prevalence of chronic conditions is likely to increase, including age-related eye diseases (e.g., diabetic retinopathy, cataract, age-related macular degeneration, and glaucoma) and consequent visual impairment. In 2020, globally, 295 million people were estimated to have moderate-to-severe visual impairment, of whom 207 million were aged ≥50 years, and this figure is projected to reach 474 million by 2050 [2]. The projected rise in the prevalence of eye diseases or visual impairment has major economic consequences, particularly in LMICs where health resources are limited [3] and where far visual impairment is more prevalent [4].

In this context, it is critical to understand the risk factors and exacerbating factors of eye diseases or visual impairment among older adults especially in LMICs. Recently, there has been increasing interest in the influence of stress on eye diseases or the consequent visual impairment [5]. Perceived stress refers to how individuals view or assess the levels of stress they experience over a given period of time, including experiences of irritating hassles and feelings about the uncontrollability or unpredictability of life [6]. Previous literature has shown that perceived stress and impaired well-being can be both a cause [7–9] and consequence of visual impairment [10–12]. It is possible for visual impairment to directly increase levels of perceived stress by limiting the individual's ability to engage in daily activities (e.g., recognizing people, mobility, reading, driving, and social interaction). Alternatively, given the chronic nature of many eye diseases, treatment and its costs may impose a heavy burden on the individual and lead to increased levels of perceived stress, especially in countries

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without a well-developed insurance scheme or a national health service, which is the case in many LMICs. Forgoing treatment due to high costs may further exacerbate the underlying eye condition and lead to worsening in visual impairment and perceived stress. In addition, some eye diseases have poor prognoses [13, 14], potentially inducing anxiety and fear of becoming blind. This may be particularly true in LMICs where treatment options may be limited. It is also possible that stress contributes to ophthalmological diseases such as glaucoma and optic neuropathy. Specifically, stress may be a risk factor for increased levels of cortisol, and this may have a negative impact on the brain and eye via autonomous nervous system imbalance and vascular dysregulation [5]. Furthermore, stress may lead to unhealthy behavior such as smoking, alcohol consumption, and poor diet leading to an increased risk for development or exacerbation of certain eye diseases [15–19]. Finally, there is also some research showing that stress may negatively impact vision restoration in patients with eye disorders [20], whereas meditation may lead to a decrease in intraocular pressure potentially via a lowering of stress biomarkers [21]. Hence, it is possible that there may be a vicious cycle where visual impairment may initially lead to increased levels of stress, and this in turn, may aggravate visual impairment, leading to further increase in levels of stress.

However, to the best of our knowledge, there are no studies specifically on visual impairment and perceived stress in the general population, particularly among older adults, and from LMICs. Therefore, the goal of this study was to investigate the association of objective and subjective far visual impairment with perceived stress in nationally representative samples of older adults living in six LMICs (i.e., China, Ghana, India, Mexico, Russia, and South Africa). Both subjective and objective measures of visual impairment were included in our study, as subjective and objective measures of visual impairment have been differentially associated with mental health outcomes [22], and the association between visual impairment and perceived stress may be influenced by the individual's perception of visual impairment.

## MATERIALS AND METHODS

### The survey

This study used data from the Study on global AGEing and adult health (SAGE). SAGE data can be downloaded at http://www.who.int/healthinfo/sage/en/. Six countries (i.e., China, Ghana, India, Mexico, Russia, and South Africa) participated in the survey in 2007–2010 and, at the time of the survey, all countries were LMICs. More details on the SAGE methodology have been previously published [23]. To summarize, nationally representative samples were obtained using a multistage clustered sampling of households. Samples included individuals aged ≥18 years with an oversampling of the age group ≥50 years. Face-to-face interviews were conducted by trained staff, and questionnaires were translated following standard procedures to allow comparability between countries. The survey response rate ranged from 53% in Mexico to 93% in China. Using United Nations statistics, sampling weights were constructed to adjust for the structure of the populations. The analytical sample included 14,585 adults aged ≥65 years (China 5360; Ghana 1975; India 2441; Mexico 1375; Russia 1950; and South Africa 1484). Finally, the WHO Ethical Review Committee and local ethics research review boards provided ethical approval, while each participant gave written informed consent.

### Perceived stress (dependent variable)

In line with previous publications [24–27], the assessment of last-month perceived stress relied on two questions from the Perceived Stress Scale [28]. The Perceived Stress Scale is a validated scale that has been extensively used to assess perceived stress in recent years. The two questions of interest were: "How often have you felt that you were unable to control the important things in your life?"; and "How often have you found that you could not cope with all the things that you had to do?". There were five answer options: never (scored as 1), almost never (scored as 2), sometimes (scored as 3), fairly often (scored as 4), and very often (scored as 5). In line with previous publications using the same perceived stress variable [26, 27], factor analysis with polychoric correlations was conducted to incorporate the covariance structure of the answers provided for these two questions measuring a similar construct. Factor extraction relied on the principal component method, while factor scores were obtained using the regression scoring method. These factor scores were later converted to scores ranging from 0 to 100 with higher values indicating higher levels of perceived stress [26].

### Objective visual impairment

The tumbling E LogMAR chart for distance vision acuity was used to measure the visual acuity of each eye [29]. Participants were seated on a chair 4 m away from the chart, and the chart was positioned and well lit to avoid any reflection. Participants usually wearing glasses or contact lenses were allowed to use them. Far vision was analyzed as a categorical variable with five different categories: no visual impairment (≥6/12); mild visual impairment (6/18–<6/12); moderate visual impairment (6/60–<6/18); and severe visual impairment (<6/60) [4].

### Subjective visual impairment

Subjective visual impairment was assessed with the question "In the last 30 days, how much difficulty did you have in seeing and recognizing an object or a person you know across the road (from a distance of about 20 meters)?" with answer options "none", "mild", "moderate", "severe", and "extreme/cannot do". Respondents were instructed to answer as when wearing glasses/contact lenses if used. Individuals who answered "extreme/cannot do" were included in the "severe" category as there were very few respondents in the "extreme/cannot do" category.

### Control variables

The control variables were selected based on their theoretical links with visual impairment and perceived stress, and included age, sex, wealth quintiles based on country-specific income, highest level of education achieved (primary, secondary, or tertiary), living arrangement (alone or not), setting (rural or urban), smoking (never, past, or current), and the number of chronic physical conditions [18, 26, 30]. The chronic physical conditions assessed in the study included angina, arthritis, asthma, chronic back pain, chronic lung disease, diabetes, edentulism, hearing problems, hypertension, and stroke. Arthritis, asthma, chronic lung disease, diabetes, and stroke were based solely on self-reported lifetime diagnosis. An angina diagnosis referred to self-reported diagnosis or diagnosis based on the validated Rose questionnaire [31]. Chronic back pain was defined as having had back pain every day during the last 30 days. Edentulism corresponded to a positive answer to the question "Have you lost all of your natural teeth?". Hypertension was defined as having at least one of: systolic blood pressure ≥140 mmHg; diastolic blood pressure ≥90 mmHg; or self-reported diagnosis. Finally, the participant was considered to have hearing problems if the interviewer observed this condition during the survey. The number of chronic physical conditions was used as a categorical variable (i.e., 0, 1, and ≥2 chronic physical conditions).

### Statistical analysis

The statistical analysis was performed with Stata 14.1 (Stata Corp LP, College station, Texas). The analysis was restricted to those aged ≥65 years as the focus of this study was on older adults. Multivariable linear regression was done to analyze the association between objective or subjective visual impairment (independent variables) and perceived stress (dependent variable). The model was adjusted for age, sex, wealth, education, living arrangement, setting, smoking, the number of chronic physical conditions, and country. We also conducted interaction analysis to assess whether age or sex is an effect modifier in the association between visual impairment and perceived stress by including the interaction terms visual impairment X sex or visual impairment X age (i.e., 65–80 or ≥80 years) in the model. Finally, in order to assess the influence of each covariate in the association between visual impairment and perceived stress, seven models were constructed. Specifically, a base model that only adjusted for age, sex, and country was constructed. Subsequently, we added wealth, education, living arrangement, setting, smoking, and the number of chronic conditions individually in the base model. In line with previous SAGE studies [32, 33], dummy variables for each country were included in the models to adjust for country. All variables were included in the models as categorical variables with the exception of perceived stress (continuous variable). The sample weighting and the complex study design were taken into account in the analyses. Results from the regression

**Table 1.** Sample characteristics.

| Characteristic | Category | % |
|---|---|---|
| Age (years) | 65–69 | 37.6 |
| | 70–74 | 28.5 |
| | 75–79 | 19.5 |
| | ≥80 | 14.4 |
| Sex | Male | 45.0 |
| | Female | 55.0 |
| Wealth | Poorest | 21.7 |
| | Poorer | 21.0 |
| | Middle | 20.4 |
| | Richer | 17.5 |
| | Richest | 19.4 |
| Education | Primary | 63.7 |
| | Secondary | 29.9 |
| | Tertiary | 6.4 |
| Living arrangement | Not alone | 83.6 |
| | Alone | 16.4 |
| Setting | Urban | 50.6 |
| | Rural | 49.4 |
| Smoking | Never | 62.2 |
| | Past | 8.5 |
| | Current | 29.3 |
| Number of chronic conditions | 0 | 16.2 |
| | 1 | 28.8 |
| | ≥2 | 55.0 |

analyses are presented as *b* coefficients with 95% confidence intervals (CIs). The level of statistical significance was set at $P < 0.05$.

## RESULTS

The sample characteristics are provided in Table 1. Mean (standard deviation) age was 72.6 (11.5) years, and 55.0% were women. Overall, 23.1%, 24.3%, and 0.8% of the sample had mild, moderate, and severe objective visual impairment, respectively. The corresponding figures for subjective visual impairment were 28.7%, 20.3%, and 12.9%, respectively. There was a large discrepancy between subjective and objective visual impairment (Table 2). For example, among those with no objective visual impairment (≥6/12), 15.9% and 8.1% perceived their levels of visual impairment as moderate and severe, respectively, while there were 13.8% of individuals with severe objective visual impairment (<6/60) reporting to have no problems in seeing and recognizing an object or a person across the road. The mean perceived stress score increased with increasing severity of visual impairment as assessed by objective and subjective measures, but the increase was more pronounced for subjective visual impairment (Fig. 1). The association between visual impairment and perceived stress assessed by multivariable linear regression is shown in Table 3. In terms of objective visual impairment, only severe visual impairment (versus no visual impairment) was significantly associated with higher levels of stress ($b = 6.91$; 95% CI = 0.94–12.89). In terms of subjective visual impairment, compared to no visual impairment, mild ($b = 2.67$; 95% CI = 0.56–4.78), moderate ($b = 8.18$; 95% CI = 5.84–10.52), and severe ($b = 11.86$; 95% CI = 9.11–14.61) visual impairment were associated with significantly higher levels of perceived stress. There was no significant interaction by sex or age in the association between visual impairment and perceived stress. Finally, covariates such as wealth, setting, and chronic conditions had some influence in the association between visual impairment and perceived stress (Supplementary Table S1).

**Table 2.** Correlation between subjective and objective visual impairment.

| | | Subjective visual impairment[a] | | | | |
|---|---|---|---|---|---|---|
| | | None | Mild | Moderate | Severe | Total |
| Objective visual impairment[b] | None | 46.6 | 29.3 | 15.9 | 8.1 | 100 |
| | Mild | 35.1 | 32.8 | 21.0 | 11.1 | 100 |
| | Moderate | 23.7 | 28.4 | 27.9 | 20.1 | 100 |
| | Severe | 13.8 | 14.1 | 35.0 | 37.0 | 100 |

Data are row percentage (%).
[a]Subjective visual impairment referred to the answer to the question "In the last 30 days, how much difficulty did you have in seeing and recognizing an object or a person you know across the road (from a distance of about 20 meters)?"
[b]Categories of objective visual impairment referred to the following: no visual impairment (≥6/12); mild visual impairment (6/18–<6/12); moderate visual impairment (6/60–<6/18); and severe visual impairment (<6/60).

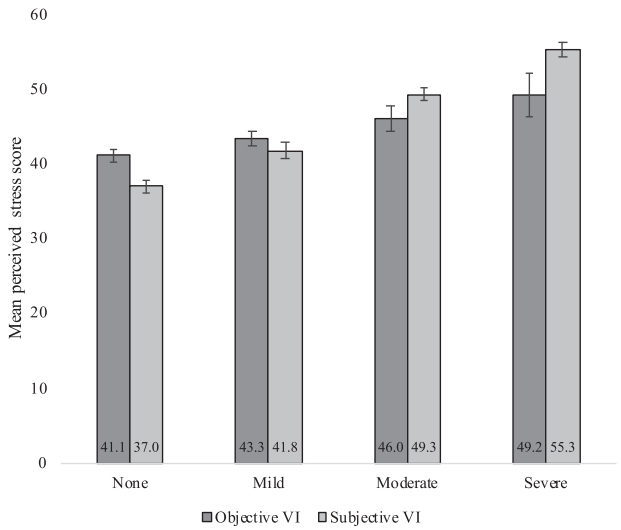


**Fig. 1 Mean perceived stress score by severity of objective and subjective visual impairment.** Perceived stress (dependent variable) was based on a score ranging from 0 to 100 with higher scores representing higher levels of perceived stress. Categories of objective visual impairment referred to the following: no visual impairment (≥6/12); mild visual impairment (6/18–<6/12); moderate visual impairment (6/60–<6/18); and severe visual impairment (<6/60). Subjective visual impairment referred to the answer to the question "In the last 30 days, how much difficulty did you have in seeing and recognizing an object or a person you know across the road (from a distance of about 20 meters)?". *VI* visual impairment. Bars denote standard error.

## DISCUSSION

### Main findings

This study including more than 14,500 older adults from six LMICs revealed that 25.1% and 33.2% had moderate-to-severe objective and subjective far vision impairment, respectively. An increase in the mean perceived stress score was observed with increasing severity of objective and subjective visual impairment. These findings were corroborated in the multivariable linear regression analyses where severe objective visual impairment and mild-to-severe subjective visual impairment were significantly associated

**Table 3.** Association of objective/subjective visual impairment and covariates with perceived stress estimated by multivariable linear regression.

| | | Objective visual impairment[a] | | Subjective visual impairment[b] | |
|---|---|---|---|---|---|
| **Characteristic** | **Category** | ***b*** | **95% CI** | ***b*** | **95% CI** |
| Visual impairment severity | None | Ref. | | Ref. | |
| | Mild | 0.18 | [−1.73, 2.08] | 2.67* | [0.56, 4.78] |
| | Moderate | −0.05 | [−3.34, 3.24] | 8.18*** | [5.84, 10.52] |
| | Severe | 6.91* | [0.94, 12.89] | 11.86*** | [9.11, 14.61] |
| Age (years) | 65–69 | Ref. | | Ref. | |
| | 70–74 | 0.11 | [−1.79, 2.01] | 0.72 | [−1.08, 2.52] |
| | 75–79 | 2.41** | [0.62, 4.20] | 1.73 | [−0.04, 3.51] |
| | ≥80 | 3.72** | [1.14, 6.29] | 2.17 | [−0.08, 4.41] |
| Sex | Female vs. Male | 3.04** | [0.93, 5.15] | 1.63 | [−0.32, 3.58] |
| Wealth | Poorest | Ref. | | Ref. | |
| | Poorer | −4.93* | [−8.87, −1.00] | −4.19* | [−7.60, −0.77] |
| | Middle | −2.97* | [−5.48, −0.46] | −2.71* | [−5.06, −0.37] |
| | Richer | −7.05*** | [−9.68, −4.41] | −6.02*** | [−8.50, −3.54] |
| | Richest | −11.46*** | [−14.62, −8.30] | −9.30*** | [−12.38, −6.21] |
| Education | Primary | Ref. | | Ref. | |
| | Secondary | −2.56* | [−4.66, −0.45] | −1.65 | [−3.79, 0.48] |
| | Tertiary | −3.63 | [−7.58, 0.31] | −2.74 | [−6.48, 0.99] |
| Living arrangement | Alone vs. Not alone | −2.05 | [−4.19, 0.08] | −2.60* | [−4.65, −0.55] |
| Setting | Rural vs. Urban | 4.24** | [1.64, 6.84] | 4.31*** | [1.88, 6.74] |
| Smoking | Never | Ref. | | Ref. | |
| | Past | 3.10* | [0.34, 5.87] | 2.29 | [−0.16, 4.74] |
| | Current | 0.36 | [−2.38, 3.10] | −0.28 | [−2.71, 2.16] |
| Number of chronic conditions | 0 | Ref. | | Ref. | |
| | 1 | 3.46** | [1.21, 5.71] | 2.83** | [0.72, 4.94] |
| | ≥2 | 7.46*** | [5.36, 9.56] | 5.43*** | [3.42, 7.44] |

*CI* confidence interval, *Ref.* reference category.
Perceived stress (dependent variable) was based on a score ranging from 0 to 100 with higher scores representing higher levels of perceived stress.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
[a]Categories of objective visual impairment referred to the following: no visual impairment (≥6/12); mild visual impairment (6/18–<6/12); moderate visual impairment (6/60–<6/18); and severe visual impairment (<6/60).
[b]Subjective visual impairment referred to the answer to the question "In the last 30 days, how much difficulty did you have in seeing and recognizing an object or a person you know across the road (from a distance of about 20 meters)?"
Models are adjusted for all variables in the table and country.

with higher levels of perceived stress. To the best of our knowledge, this is the first study to investigate the association between visual impairment and perceived stress in the general population, while it is also one of the largest studies focusing on the visual impairment-mental health relationship in LMICs.

### Interpretation of the findings

A positive and significant relationship was found between subjective or objective far visual impairment and perceived stress. There are several hypotheses to explain this association. First, visual impairment may limit an individual's ability to engage in activities due to factors such as reduced mobility (e.g., driving), inability to read, and difficulty recognizing people, and this would increase levels of stress. In particular, these limitations may reduce social interactions and lead to loneliness [34], which is often perceived as being stressful [35]. Second, it is possible that the high costs of treatment, especially in countries with limited universal health coverage, can lead to high levels of stress. For example, a study of 298 patients with moderate-to-severe visual impairment from China revealed that the annual direct costs related to visual impairment averaged $6989 per patient, with only a small proportion of these costs being covered by medical insurance [36]. Third, anxiety or fear of becoming blind may also lead to high levels of stress. In LMICs, where treatment options are limited, this can be a particularly important factor. For instance, a study including 1183 adults aged ≥50 years living in Nigeria found a relatively low cataract surgical coverage in those with visual impairment (9.5–29.4%) [37].

On the other hand, it is also possible that high levels of perceived stress increase the occurrence of visual impairment via inflammation, increased intraocular pressure, chronic physical disorders, and unhealthy behaviors [5]. For instance, basal release of several inflammatory mediators (e.g., interleukin 6 and tumor necrosis factor-α) have been noted to be elevated in those with high levels of stress [38], and these inflammatory markers have been found to be associated with the onset of early age-related macular degeneration [39]. Furthermore, one study showed that increased intraocular pressure and visual field changes were common (73%) among patients with primary open-angle glaucoma undergoing mental stress [9]. Previous research has also indicated that fluctuation of intraocular pressure is a risk factor for blindness in individuals diagnosed with open-angle glaucoma [40]. Research has further shown that perceived stress is significantly associated with a higher risk for type 2 diabetes onset (hazard ratio = 1.45) [41] and

psychological stress experienced in the postprandial period to be a risk factor for poor glucose control in patients with type 2 diabetes [42]. Uncontrolled diabetes is a well-known risk factor for sight threatening complications such as proliferative diabetic retinopathy and cataracts [43]. Finally, perceived stress may favor unhealthy behaviors such as smoking, poor diets, and insufficient physical activity or sedentary behavior [16, 18], while these unhealthy behaviors are significantly associated with cataracts [19], diabetic retinopathy [44], age-related macular degeneration [15, 17], and glaucoma [45, 46].

Interestingly, we found that even mild levels of subjective visual impairment were associated with higher levels of perceived stress but that only the severest form of objective visual impairment was associated with higher levels of perceived stress when objective measures were used. The reasons why the association between subjective visual impairment and perceived stress was more pronounced is unknown. However, it is possible that people with heightened stress sensitivity or lower levels of resilience may be more likely to claim to have more visual difficulties even when their vision is normal or almost normal based on objective measurement. In the present study, there was a low level of correlation between objective and subjective visual impairment, which concurs with previous studies [47, 48], and factors such as personality traits or levels of expectation may be important in the perception of visual impairment. These findings suggest that subjectively reported visual impairment may be more important than objectively reported visual impairment when identifying individuals with high levels of stress in the general population. However, further qualitative research is needed to understand these observed discrepancies, and also to understand whether perceived stress in visual impairment, measured subjectively or objectively, leads to different clinical outcomes.

### Clinical implications and directions for future research

Based on the fact that visual impairment was positively and significantly associated with perceived stress in older adults living in LMICs, interventions aiming at lowering the levels of perceived stress in this population should be developed. First, especially in the context of LMICs, it is possible that visual impairment may be corrected by spectacles, and this may lead to a decrease in stress levels. For example, although the assessment of visual impairment was based on conditions where participants wear the glasses or contact lenses that they normally use, it is possible that many people with refractive error in LMICs do not use corrective lenses or use those that are not up to date due to lack of resources. Furthermore, in cases where cataract is the cause of visual impairment, it is possible to improve vision through surgery. There are initiatives in place to provide surgery for people in LMICs [49]. Next, the utility of stress reduction and relaxation techniques in improving visual health in LMICs should also be assessed. Previous studies have shown that relaxation and visual imagery may lead to reduced intraocular pressure [50], while biofeedback is known to induce relaxation [5] and to improve visual functions in patients with visual impairment [51].

### Strengths and limitations

The strengths of this study are the large sample size and the use of nationally representative data from six LMICs. However, the study results should be interpreted in light of the limitations. First, perceived stress was assessed using two questions only, and a more complex measure may have allowed more detailed statistical analyses. Second, this was a cross-sectional study, and it was thus not possible to determine the causality or the temporality of the association between far visual impairment and perceived stress. Finally, we only had information on visual impairment and not individual eye diseases that led to visual impairment. Future studies should assess how different eye diseases are associated with perceived stress.

## CONCLUSION

This cross-sectional study including more than 14,500 older adults from six LMICs showed that far visual impairment was positively and significantly associated with perceived stress. Although causality could not be assessed in our study due to the cross-sectional design, it is worth mentioning that the mere co-existence of visual impairment and perceived stress is an issue in itself as it is possible that perceived stress may aggravate the impact of certain eye diseases [5], whilst also increasing risk for other adverse health outcomes including premature mortality [52]. Finally, future studies should assess the utility of interventions to reduce the co-existence of visual impairment and perceived stress. These interventions include the use of glasses/contact lenses or surgery in the scenario where visual impairment leads to perceived stress, and relaxation and meditation techniques in the scenario where perceived stress is a risk factor for visual impairment.

### Summary

What was known before

- There may be a bidirectional association between visual impairment and perceived stress.
- However, no study has specifically investigated this association in the general population.

What this study adds

- There was a positive association between far vision impairment and perceived stress in older adults in low- and middle-income countries (LMICs).
- Interventions are needed to reduce perceived stress in people with visual impairment living in LMICs.

## DATA AVAILABILITY

The datasets generated during and/or analyzed during the current study are available in the Global Ageing and Adult Health Survey repository, available at http://www.who.int/healthinfo/sage/en.

## REFERENCES

1. World Health Organization. Ageing and health. 2018. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. Accessed 9 Apr 2021.
2. GBD 2019 Blindness and Vision Impairment Collaborators, Vision Loss Expert Group of the Global Burden of Disease Study. Trends in prevalence of blindness and distance and near vision impairment over 30 years: an analysis for the Global Burden of Disease Study. Lancet Glob Health. 2021;9:e130–43.
3. Franzen SRP, Chandler C, Lang T. Health research capacity development in low and middle income countries: reality or rhetoric? A systematic meta-narrative review of the qualitative literature. BMJ Open. 2017;7:e012332.
4. World Health Organization. Blindness and vision impairment. 2020. https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. Accessed 26 Nov 2020.
5. Sabel BA, Wang J, Cárdenas-Morales L, Faiq M, Heim C. Mental stress as consequence and cause of vision loss: the dawn of psychosomatic ophthalmology for preventive and personalized medicine. EPMA J 2018;9:133–60.
6. Gellman MD, Turner JR. Encyclopedia of behavioral medicine. New York: Springer-Verlag New York; 2013. p. 2116. https://www.springer.com/fr/book/9781441910059#otherversion=9781441910042.
7. Grignolo FM, Bongioanni C, Carenini BB. [Variations of intraocular pressure induced by psychological stress (author's transl)]. Klin Monbl Augenheilkd. 1977;170:562–9.
8. Gelber GS, Schatz H. Loss of vision due to central serous chorioretinopathy following psychological stress. Am J Psychiatry. 1987;144:46–50.
9. Marc A, Stan C. [Effect of physical and psychological stress on the course of primary open angle glaucoma]. Oftalmologia 2013;57:60–6.
10. Williams RA, Brody BL, Thomas RG, Kaplan RM, Brown SI. The psychosocial impact of macular degeneration. Arch Ophthalmol. 1998;116:514–20.

11. Pinquart M, Pfeiffer JP. Psychological well-being in visually impaired and unimpaired individuals: a meta-analysis. Br J Vis Impairment. 2011;29:27–45.
12. Lehane CM, Dammeyer J, Wittich W. Intra- and interpersonal effects of coping on the psychological well-being of adults with sensory loss and their spouses. Disabil Rehabilitation. 2019;41:796–807.
13. Khairallah M, Kahloun R, Bourne R, Limburg H, Flaxman SR, Jonas JB, et al. Number of people blind or visually impaired by cataract worldwide and in world regions, 1990 to 2010. Invest Ophthalmol Vis Sci. 2015;56:6762–9.
14. Jonas JB, Cheung CMG, Panda-Jonas S. Updates on the epidemiology of age-related macular degeneration. Asia Pac J Ophthalmol (Philos). 2017;6:493–7.
15. Cong R, Zhou B, Sun Q, Gu H, Tang N, Wang B. Smoking and the risk of age-related macular degeneration: a meta-analysis. Ann Epidemiol. 2008;18:647–56.
16. Laugero KD, Falcon LM, Tucker KL. Relationship between perceived stress and dietary and activity patterns in older adults participating in the Boston Puerto Rican Health Study. Appetite 2011;56:194–204.
17. Islam FMA, Chong EW, Hodge AM, Guymer RH, Aung KZ, Makeyeva GA, et al. Dietary patterns and their associations with age-related macular degeneration: The Melbourne Collaborative Cohort Study. Ophthalmology 2014;121:1428.e2.
18. Stubbs B, Veronese N, Vancampfort D, Prina AM, Lin P-Y, Tseng P-T, et al. Perceived stress and smoking across 41 countries: a global perspective across Europe, Africa, Asia and the Americas. Sci Rep. 2017;7:7597.
19. Jiang H, Wang L-N, Liu Y, Li M, Wu M, Yin Y, et al. Physical activity and risk of age-related cataract. Int J Ophthalmol. 2020;13:643–9.
20. Sabel BA, Wang J, Fähse S, Cárdenas-Morales L, Antal A. Personality and stress influence vision restoration and recovery in glaucoma and optic neuropathy following alternating current stimulation: implications for personalized neuromodulation and rehabilitation. EPMA J 2020;11:177–96.
21. Dada T, Mittal D, Mohanty K, Faiq MA, Bhat MA, Yadav RK, et al. Mindfulness meditation reduces intraocular pressure, lowers stress biomarkers and modulates gene expression in glaucoma: a randomized controlled trial. J Glaucoma. 2018;27:1061–7.
22. Zhang X, Bullard KM, Cotch MF, Wilson MR, Rovner BW, McGwin G, et al. Association between depression and functional vision loss in persons 20 years of age or older in the United States, NHANES 2005–2008. JAMA Ophthalmol. 2013;131:573–81.
23. Kowal P, Chatterji S, Naidoo N, Biritwum R, Fan W, Ridaura RL, et al. Data resource profile: the World Health Organization Study on Global Ageing and Adult Health (SAGE). Int J Epidemiol. 2012;41:1639–49.
24. DeVylder JE, Koyanagi A, Unick J, Oh H, Nam B, Stickley A. Stress sensitivity and psychotic experiences in 39 low- and middle-income countries. Schizophr Bull. 2016;42:1353–62.
25. Stubbs B, Koyanagi A, Thompson T, Veronese N, Carvalho AF, Solomi M, et al. The epidemiology of back pain and its relationship with depression, psychosis, anxiety, sleep disturbances, and stress sensitivity: data from 43 low- and middle-income countries. Gen Hosp Psychiatry. 2016;43:63–70.
26. Vancampfort D, Koyanagi A, Ward PB, Veronese N, Carvalho AF, Solmi M, et al. Perceived stress and its relationship with chronic medical conditions and multimorbidity among 229,293 community-dwelling adults in 44 low- and middle-income countries. Am J Epidemiol. 2017;186:979–89.
27. Koyanagi A, Oh H, Vancampfort D, Carvalho AF, Veronese N, Stubbs B, et al. Perceived stress and mild cognitive impairment among 32,715 community-dwelling older adults across six low- and middle-income countries. Gerontology 2019;65:155–63.
28. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav. 1983;24:385–96.
29. Smith L, Shin JI, Jacob L, López-Sánchez GF, Oh H, Barnett Y, et al. The association between objective vision impairment and mild cognitive impairment among older adults in low- and middle-income countries. Aging Clin Exp Res. 2021.
30. Ehrlich JR, Stagg BC, Andrews C, Kumagai A, Musch DC. Vision impairment and receipt of eye care among older adults in low- and middle-income countries. JAMA Ophthalmol 2019;137:146–58.
31. Rose GA. The diagnosis of ischaemic heart pain and intermittent claudication in field surveys. Bull World Health Organ. 1962;27:645–58.
32. Koyanagi A, Garin N, Olaya B, Ayuso-Mateos JL, Chatterji S, Leonardi M, et al. Chronic conditions and sleep problems among adults aged 50 years or over in nine countries: a multi-country study. PLoS One. 2014;9:e114742.
33. Koyanagi A, Lara E, Stubbs B, Carvalho AF, Oh H, Stickley A, et al. Chronic physical conditions, multimorbidity, and mild cognitive impairment in low- and middle-income countries. J Am Geriatr Soc. 2018;66:721–7.
34. Verstraten PFJ, Brinkmann WLJH, Stevens NL, Schouten JSAG. Loneliness, adaptation to vision impairment, social support and depression among visually impaired elderly. Int Congr Ser. 2005;1282:317–21.
35. Huang L-J, Du W-T, Liu Y-C, Guo L-N, Zhang J-J, Qin M-M, et al. Loneliness, stress, and depressive symptoms among the Chinese rural empty nest elderly: a moderated mediation analysis. Issues Ment Health Nurs. 2019;40:73–8.
36. Guan X, Fu M, Lin F, Zhu D, Vuillermin D, Shi L. Burden of visual impairment associated with eye diseases: exploratory survey of 298 Chinese patients. BMJ Open. 2019;9:e030561.
37. Kolawole OU, Ashaye AO, Mahmoud AO, Adeoti CO. Cataract blindness in Osun State, Nigeria: results of a survey. Middle East Afr J Ophthalmol. 2012;19:364–71.
38. Martínez de Toda I, Miguélez L, Siboni L, Vida C, De la Fuente M. High perceived stress in women is linked to oxidation, inflammation and immunosenescence. Biogerontology 2019;20:823–35.
39. Klein R, Myers CE, Cruickshanks KJ, Gangnon RE, Danforth LG, Sivakumaran TA, et al. Markers of inflammation, oxidative stress, and endothelial dysfunction and the 20-year cumulative incidence of early age-related macular degeneration: The Beaver Dam Eye Study. JAMA Ophthalmol. 2014;132:446–55.
40. Forsman E, Kivelä T, Vesti E. Lifetime visual disability in open-angle glaucoma and ocular hypertension. J Glaucoma. 2007;16:313–9.
41. Novak M, Björck L, Giang KW, Heden-Ståhl C, Wilhelmsen L, Rosengren A. Perceived stress and incidence of Type 2 diabetes: a 35-year follow-up study of middle-aged Swedish men. Diabet Med. 2013;30:e8–16.
42. Faulenbach M, Uthoff H, Schwegler K, Spinas GA, Schmid C, Wiesli P. Effect of psychological stress on glucose control in patients with Type 2 diabetes. Diabet Med. 2012;29:128–31.
43. Onakpoya OH, Kolawole BA, Adeoye AO, Adegbehingbe BO, Laoye O. Visual impairment and blindness in type 2 diabetics: Ife-Ijesa diabetic retinopathy study. Int Ophthalmol. 2016;36:477–85.
44. Ren C, Liu W, Li J, Cao Y, Xu J, Lu P. Physical activity and risk of diabetic retinopathy: a systematic review and meta-analysis. Acta Diabetol. 2019;56:823–37.
45. Bonovas S, Filioussi K, Tsantes A, Peponis V. Epidemiological association between cigarette smoking and primary open-angle glaucoma: a meta-analysis. Public Health. 2004;118:256–61.
46. Lee MJ, Wang J, Friedman DS, Boland MV, De Moraes CG, Ramulu PY. Greater physical activity is associated with slower visual field loss in glaucoma. Ophthalmology 2019;126:958–64.
47. El-Gasim M, Munoz B, West SK, Scott AW. Discrepancies in the concordance of self-reported vision status and visual acuity in the Salisbury Eye Evaluation Study. Ophthalmology 2012;119:106–11.
48. Yip JLY, Khawaja AP, Broadway D, Luben R, Hayat S, Dalzell N, et al. Visual acuity, self-reported vision and falls in the EPIC-Norfolk Eye study. Br J Ophthalmol. 2014;98:377–82.
49. Ramke J, Petkovic J, Welch V, Blignault I, Gilbert C, Blanchet K, et al. Interventions to improve access to cataract surgical services and their impact on equity in low- and middle-income countries. Cochrane Database Syst Rev. 2017;11:CD011307.
50. Kaluza G, Strempel I. Training in relaxation and visual imagery with patients who have open-angle glaucoma. Int J Rehab Health. 1995;1:261–73.
51. Amore FM, Paliotta S, Silvestri V, Piscopo P, Turco S, Reibaldi A. Biofeedback stimulation in patients with age-related macular degeneration: comparison between 2 different methods. Can J Ophthalmol. 2013;48:431–7.
52. Prior A, Fenger-Grøn M, Larsen KK, Larsen FB, Robinson KM, Nielsen MG, et al. The association between perceived stress and mortality among people with multimorbidity: a prospective population-based cohort study. Am J Epidemiol. 2016;184:199–210.

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## AUTHOR CONTRIBUTIONS

LJ contributed to the design of the study, managed the literature searches, wrote the first draft of the manuscript, and corrected the manuscript. KK, LS, GFL-S, SP, HO, JIS, ASA, and JMH contributed to the design of the study and corrected the manuscript. AK contributed to the design of the study, performed the statistical analyses, and corrected the manuscript. All authors contributed to and have approved the final manuscript.

## COMPETING INTERESTS

The authors declare no competing interests.

## ADDITIONAL INFORMATION

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