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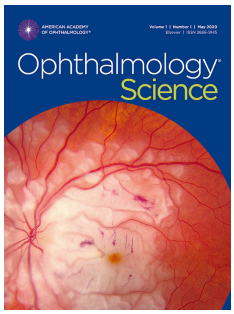

Global Patterns of Myopia, Age, Sex and Vision Loss: A Comparative Analysis of U.S. and South Korean National Surveys

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Patient Consent: Patient consent was obtained at the time of data collection after receiving a description of the study.

Conflict of Interest

All authors have completed and submitted the ICMJE disclosures form.

Key Words

Myopia, visual impairment, refractive error, NHANES, KNHANES

37 **Abbreviations**

38 BCVA (Best Corrected Distance Visual Acuity), CI (Confidence Interval), KNHANES (Korean
39 National Health and Nutrition Survey), NHANES (National Health and Nutrition Survey), SE
40 (Standard Error), SER (Spherical Equivalent Refraction)

41

Abstract

Objective

Myopia prevalence is rising globally and has reached critical levels in some regions. Beyond refractive correction needs, myopia is a major risk factor for irreversible, vision-threatening ocular disease. This study investigated the relationship between myopia, age, sex, and visual impairment in two nationally representative populations in the United States and South Korea.

Design

Cross-sectional analysis using data from the U.S. National Health and Nutrition Examination Survey (NHANES) and the Korean National Health and Nutrition Examination Survey (KNHANES).

Participants

Participants in the NHANES and KNHANES.

Methods

Best-corrected visual acuity and non-cycloplegic refractive error were analyzed from NHANES (1999–2008) and KNHANES (2008–2022), excluding those with cataract or

refractive surgery. Visual impairment was defined as best-corrected visual acuity ≥0.30 LogMAR. Logistic regression and Kaplan–Meier analyses were used to evaluate and visualize the cumulative risk of visual impairment by refractive error age and sex.

Main Outcome Measure

Visual impairment probability and the Odds Ratios for visual impairment by region, age and degree of myopia.

Results

Visual impairment rates increased with both myopia severity and age in both populations. Among younger non-myopes, impairment affected 1%, rising to 50% in high myopes by age 75. High myopes had up to 13-fold higher odds of visual impairment than non-myopes. Age-related risks were similar across regions, but myopia had a stronger effect in South Korea: each 1 D increase in myopia raised the odds of impairment by 41% versus 27% in the USA. Sex was not a significant factor in the U.S. ($p = 0.207$) but was significant in South Korea (OR: 1.69, 95% CI: 1.33–2.14, $p < 0.01$).

Conclusions

Myopia substantially increases the risk of visual impairment in both the United States and South Korea, with risk rising proportionally with myopia severity. Age-related effects were

similar across cohorts, though myopia exerted a greater influence in South Korea. Females demonstrated higher rates of visual impairment independently of refractive error. These findings highlight myopia as a global health concern, reinforcing the need for prevention and early intervention to reduce lifetime risk across all severities.

Introduction

In the past several decades the global prevalence of myopia has seen dramatic increases, with projections indicating almost half the global population will be myopic by 2050.[1] Myopia prevalence in some young adult cohorts has already exceeded this level, with epidemiological studies documenting rates in excess of 90%.[2–4] The accelerating prevalence of myopia raises serious concern given its established association with increased risk of vision-threatening complications. Myopia can result in both reversible and irreversible visual impairment. As a highly symptomatic refractive error, it may cause functional vision loss in individuals without access to appropriate refractive correction—a challenge that continues to affect visual outcomes in underserved populations.[5] Beyond the need for optical or surgical correction, myopia is associated with an increased risk of sight-threatening ocular complications including cataract,[6] glaucoma,[7] retinal detachment[8,9] and myopic maculopathy.[10] The latter is of particular concern, as it remains untreatable,[11] and progression to advanced myopic maculopathy often leads to permanent visual impairment or blindness.[12,13]

While myopia usually develops during childhood,[14,15] its vision-threatening complications often do not manifest until much later in life.[16] Consequently, the only opportunity to reduce the lifetime risk of myopia-associated pathology occurs during these early formative years —long before an individual is likely to develop its associated complications. This temporal disconnect may lead children and their parents to underestimate the long-term risks of myopia,[17] a misconception that is also reflected more broadly across society.[18,19] Several interventions are now available to slow myopia progression during childhood,[20–22] with the theoretical potential to reduce the incidence of visual impairment in adulthood.[19]

To inform clinical decision-making and public health strategies, it is important to quantify the population-level risk of visual impairment attributable to myopia.

To date, few studies have assessed the risk of visual impairment due to myopia in representative population sample or explored the impact of sex, and none have established whether this risk is consistent across diverse populations. Most existing estimates of the population burden of visual impairment attributable to myopia rely on a single study from the Netherlands.[16] While this study included a large sample size and applied robust analytical methods, its non-representative nature limits the generalizability of its findings to other populations. This limitation is particularly relevant in East Asian populations, where the underlying prevalence of myopia is substantially higher than in Europe[23,24] potentially altering both individual and population-level risk profiles.

The study hypothesis was therefore to evaluate whether the relationship between spherical equivalent refraction (SER) and visual impairment reported in a Netherlands-based study is generalizable to other populations using population-representative surveys, one from a Western population and one from an East Asian population. Accordingly, the analyses are comparative in nature and intended to assess cross-population consistency and quantify rates of myopia-associated visual impairment, rather than to establish causal relationships.

Methods

The National Health and Nutrition Survey (NHANES) and Korean National Health and Nutrition Survey (KNHANES) are ongoing health surveys that examine a nationally representative sample of individuals in the United States and South Korea respectively. Both

surveys use a stratified multi-stage clustered sampling method based on census data for the respective country. As a result of this sampling strategy, the results of each survey are representative of the entire population for each country. The NHANES takes place on a two-year cycle while the KNHANES is repeated annually. Each survey comprises a variety of demographic surveys, lab tests and in person examinations. Best corrected distance visual acuity (BCVA) and non-cycloplegic refractive error were assessed over 5 separate 2-year cycles in the NHANES from 1999-2008 and over 15 separate 1-year cycles in the KNHANES from 2008-2022. To maximize statistical power, data from each individual survey cycle were pooled separately for NHANES (n = 30,639) and KNHANES (n = 53,918). For each study, sample weights were then adjusted based on their stratified sampling designs to yield population-representative cross-sectional datasets. All analysis was performed with the R programming language (R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/) using the survey and srvyr packages to account for the stratification, clustering and weighting used in both the NHANES and KNHANES.[1] The National Health and Nutrition Examination Survey protocol was approved by the National Center for Health Statistics Research Ethics Review Board. The Korea National Health and Nutrition Examination Survey protocol was approved by the Korea Disease Control and Prevention Agency Institutional Review Board.

For the NHANES, visual acuity and refractive error were assessed with the NIDEK ARK-760 (Nidek Co Ltd, Tokyo, Japan) an auto-refractor with a built in Snellen visual acuity chart. Participants had their presenting visual acuity assessed with their current spectacles if worn. In the case that presenting visual acuity was worse than 0.18 LogMAR (Snellen 20/30), visual

acuity was reassessed with the objective refraction found by auto-refraction in place. The BCVA was taken to be whichever measurement gave the best visual acuity. For KNHANES, visual acuity was measured using Jin's vision chart using number optotypes (JV Institute, Seoul, Korea) and refractive error was assessed using a Topcon KR8800 auto-refractor (Topcon, Tokyo, Japan). For those who had presenting visual acuity worse than 0.1 LogMAR (0.8 decimal), visual acuity was reassessed with the objective refraction in place. The BCVA was taken to be whichever measurement gave the best visual acuity.

Participant sex was recorded in both NHANES and KNHANES as part of their respective national health examination surveys. In both datasets, a binary variable (male or female) is collected at the time of interview and which we have interpreted as corresponding to the participant's sex as registered or reported at birth. Neither NHANES nor KNHANES includes a separate measure of gender identity, we therefore use the term sex throughout and acknowledge that our findings may not capture gender-related influences on myopia or vision outcomes.

For the purposes of this study, all visual acuity measurements were converted to LogMAR, with visual impairment being defined as a BCVA of 0.30 LogMAR (corresponding to 20/40 Snellen acuity) or worse.[25] Spherical equivalent refraction (SER) was calculated by adding the sphere to half the cylinder value. Each participants SER was categorized as emmetropia (> -0.50 D & ≤ +0.75 D),[26] low myopia (≤ -0.50 & > -6.00 D) and high myopia (≤ -6.00 D). Any participant that had cataract or refractive surgery was excluded from the analysis. To understand the relationship between myopia and visual impairment on a per eye basis rather than per person, analysis was confined to right eyes only. Due to the low prevalence of visual impairment in those aged 18-39 years, further analysis of visual impairment was

177 confined to those aged 40 years and over. A Kaplan-Meier survival analysis was performed
178 to estimate the probability of visual impairment for each SER category with age from 40 to
179 79 years of age. Survey-weighted Kaplan–Meier analysis was used to account for
180 NHANES/KNHANES sampling design. Kaplan–Meier curves in the present study should be
181 understood as estimates of age-specific cumulative probability (prevalence) rather than
182 incidence due to the cross-sectional nature of the data sources. Logistic regression was used
183 to determine the odds ratio of visual impairment based on these SER and age categories.
184 Both surveys were combined, and logistic regression models refit to determine if each
185 survey influenced the risk of visual impairment. The models derived from both the NHANES
186 and KNHANES were compared to work previously published by Bullimore et al[19] on the risk
187 of visual impairment due to myopia. For this comparison, the definition of visual impairment
188 of worse than 0.3 logMAR was used to match the threshold used by Bullimore et al.[19]

189

190 **Results**

191 Cross sectional data for those aged 40 and older was available for 12,661 (51.4% female)
192 participants of the NHANES and 30,873 (50.7% female) participants of the KNHANES. The
193 mean age of participants included was 55.0 ± 0.20 (SE) years in the NHANES and 54.3 ± 0.11
194 (SE) years in the KNHANES. In this older age group (40–79-year-olds), the prevalence of
195 myopia was similar in the two populations, with 38.4% classified as myopic in the NHANES
196 survey and 40.8% in the KNHANES survey after adjusting for survey weights. In the younger
197 18–39-year-old cohort, the prevalence of myopia was 45.6% in the United States (n =
198 10,302), slightly higher than in the older age group, whereas in South Korea (n = 13,980) it

199 was 75.8%, substantially greater than in the older South Korean cohort. The distributions of
200 myopia in each age group and region are shown in Figure 1.

201 The overall prevalence of visual impairment was 4.4% (95% CI: 4.0%, 4.8%) in the NHANES
202 and 4.4% (95% CI: 4.1%, 4.7%) in the KNHANES. In both surveys the prevalence of visual
203 impairment was higher in females than in males. In the NHANES, prevalence was 4.8% (95%
204 CI: 4.2%, 5.5%) for females and 3.9% (95% CI: 3.4%, 4.5%) for males; in the KNHANES,
205 prevalence was 5.6% (95% CI: 5.2%, 6.0%) for females and 3.1% (95% CI: 2.8%, 3.5%) for
206 males. The prevalence of visual impairment across spherical equivalent refraction (SER)
207 categories is presented in Table 1. Visual impairment rates increased with age and greater
208 degrees of myopia. The relationship between visual impairment and myopia was most
209 apparent in older (60–79-year-olds) participants. Small regional differences were observed
210 in the visual impairment rates in the youngest age group (18-39 years), with South Korea
211 having lower rates than the US in emmetropes, low myopes and moderate myopes. This
212 pattern was not observed in the two age groups that are the primary focus of this paper (40-
213 59 years and 60-79 years).

214 The odds of visual impairment, calculated with survey-weighted logistic regression (see
215 Supplementary Appendix), were significantly higher among myopes compared to age-
216 matched emmetropes in both regions (Table 2 and Supplementary Appendix Tables S1 to
217 S4). This association was evident across different levels of myopia severity, and
218 demonstrated a clear dose–response relationship, with the odds of visual impairment rising
219 progressively with increasing myopia severity. In this table the odds ratios are calculated
220 based on the emmetropic visual impairment for each age group and survey. This shows the
221 impact of myopia level on visual impairment risk in the two age groups without the

222 confounding effect of the higher rate of visual impairment in 60–79-year-olds. Although the
223 odds ratios in high myopia were higher in KNHANES than NHANES, the confidence intervals
224 in this analysis overlapped across all strata, indicating reasonable consistency of the
225 association between visual impairment and degree of myopia in the two regions.

226 Age-related cumulative probability curves (using age at examination as the time scale)
227 demonstrated a progressive increase in the risk of visual impairment with increasing age
228 and greater myopia severity, a pattern consistent across both surveys (Figure 2). For all SER
229 categories, the risk of visual impairment increased with age; however, significantly higher
230 risks were observed among individuals with higher levels of myopia.

231 In both NHANES and KNHANES, survey-weighted prevalence of visual impairment increased
232 monotonically with both age and increasing severity of myopia (see Table 1). In NHANES,
233 weighted prevalence among adults aged 40–59 years ranged from 1.1% (95% CI 0.6–1.6) in
234 emmetropia to 5.2% (95% CI 1.7–8.6) in high myopia, increasing in the 60–79-year-old group
235 to 6.1% (95% CI 4.5–7.7) and 25.3% (95% CI 7.1–43.5), respectively. In KNHANES, the
236 weighted prevalence of visual impairment among younger adults was modestly lower than
237 in NHANES across emmetropia to moderate myopia, but these between-population
238 differences were not statistically significant (model-based Wald tests comparing estimated
239 marginal prevalences within refractive categories, $p = 0.07–0.17$). Weighted prevalence was
240 generally higher in KNHANES than NHANES in older adults, with significant differences
241 present in the moderate and high myopia groups ($p = 0.01$ and 0.001 respectively).

242 Refractive categories were well matched between NHANES and KNHANES, with mean SER
243 differences ≤ 0.2 D in 7 of 8 category–age strata (see Table 1). An exception was observed in
244 the high myopia group among adults aged 60–79 years, where KNHANES participants had a

significantly more myopic mean SER (difference −1.79 D; 95% CI −3.14 to −0.43). This imbalance may contribute to the higher prevalence of visual impairment in Korea vs the USA in this sub-group. In older moderate myopes there was a significant difference in prevalence but an almost identical mean refractive error, indicating that between-country differences are not explained by differences in refractive error severity alone. To minimize bias arising from categorical classification, particularly among older individuals with high myopia, subsequent analyses model spherical equivalent refraction (SER) as a continuous variable in logistic regression.

Survey-weighted logistic regression, treating refractive error and age as continuous variables, revealed that older age and more myopic SER each contributed to higher risk of visual impairment in both surveys (Figure 3 and Supplementary Appendix Tables S5 and S6). A strong dose–response relationship between SER and visual impairment was evident, showing a relatively consistent pattern across the two populations. In NHANES, each 1-diopter increase in myopia (modeled as −SER) was associated with a 26.6% increase in the odds of visual impairment (OR = 1.27; 95% CI 1.19–1.35). In KNHANES, the corresponding increase was 41.2% per diopter (OR = 1.41; 95% CI 1.35–1.48). While the direction of association was consistent across surveys, the magnitude of the association was substantially stronger in KNHANES, suggesting a steeper myopia–visual impairment relationship in the Korean population. Age showed a highly consistent association with visual impairment in both surveys. Each additional year of age was associated with a 13% increase in odds in NHANES (OR = 1.13; 95% CI 1.12–1.15) and a 15% increase in odds in KNHANES (OR = 1.15; 95% CI 1.14–1.16). The similarity of these age effects supports the robustness of age as a predictor of visual impairment across populations. Full model details

268 are included in the Supplementary Appendix. To investigate regional differences, NHANES
269 and KNHANES data were jointly analyzed, with the source dataset modelled as a categorical
270 variable in a logistic regression model (see Supplementary Appendix Table S9). There was
271 no significant difference in baseline odds of visual impairment between KNHANES and
272 NHANES after adjustment for age and refraction (OR = 0.35, 95% CI 0.08–1.48; p = 0.15). The
273 effect of age on visual impairment risk was similar in both populations (OR = 1.01, 95% CI,
274 0.99–1.03; p=0.19). However, the association between myopia and visual impairment was
275 significantly stronger in KNHANES than in NHANES, as indicated by a significant SER ×
276 dataset interaction (OR = 1.12, 95% CI 1.03–1.21; p = 0.008). This suggests that for a given
277 increase in myopia, the corresponding increase in odds of visual impairment is greater in the
278 Korean population compared with the US population. This relationship is demonstrated in
279 Figure 4 where the probability of visual impairment is plotted on a logit scale. The parallel
280 slopes of the lines indicate consistent age-related effects across the two populations, while
281 the increased separation between the lines in the KNHANES graph reflects the higher
282 myopia-related risk in the South Korean cohort.

283 A further regional difference was observed when considering the interaction between sex
284 and SER and the risk of visual impairment (Figure 5, and Supplementary Appendix Tables S7
285 and S8). Female sex was not significant for the risk of visual impairment in the NHANES
286 dataset (OR: 1.195, 95% CI: 0.90–1.58, p = 0.21), however it was a significant, independent
287 risk factor for visual impairment in the KNHANES dataset (OR: 1.69, 95% CI: 1.33–2.14, p <
288 0.001), indicating a marked sex difference between populations.

289 The observed risk of visual impairment in this study aligned with the model of Bullimore et
290 al[19], when recalculated using the definition of visual impairment used in that study (VA <

20/40, see Figure 6). The NHANES results showed a slightly greater risk at lower levels of myopia but corresponded reasonably well at higher levels of myopia. Their model appeared to markedly underestimate risk in the KNHANES cohort, which is consistent with the fact that their model was based on European data.

Discussion

This analysis of two nationally representative population surveys demonstrates a clear association between myopia and increased risk of visual impairment, particularly in older adults. The relationship is non-linear, with risk increasing exponentially as a function of the degree of myopia present. Individuals with high myopia face a considerable lifetime risk of developing visual impairment. These findings are particularly concerning in the context of the global rise in myopia prevalence[1,27] and the age-dependent nature of its complications. The highest reported prevalence rates of myopia are now seen in older children and young adults,[2,3] groups not yet affected by pathology but already at elevated lifetime risk. This is particularly the case in East Asia where myopia prevalence in recent generations has reached extraordinarily high levels.[28] This recent increase in myopia prevalence in East Asia can be seen in Figure 1 in the 18–39-year age group, most notably in the KNHANES and has previously been reported.[23,29] This emerging cohort of highly myopic individuals may place a substantial future burden on healthcare systems. In South Korea, for example, a 10-year analysis of retinal detachment has already shown a secondary incidence peak among young myopic adults aged 20–24-years, underscoring the early clinical impact of high myopia.[30]

It is noteworthy that similar patterns of myopia-associated visual impairment emerged across two demographically distinct, nationally representative populations. In both NHANES and KNHANES, the risk of visual impairment increased progressively with higher myopia and

older age. Survival analysis demonstrated comparable ages at which visual impairment is likely to occur across refractive error categories, while logistic regression (Figure 3) showed a clear and consistent dose–response relationship across both populations. The odds of visual impairment were significantly higher in individuals with myopia than in those with emmetropia (Table 2), with the most pronounced risk observed in those with high myopia (≤−6.00 D). This pattern was evident in both surveys and overlapping confidence intervals of the odds ratios at each refractive error level for the two regions (Table 2) indicated generalizability of the association across populations. These findings align with the only other large cross sectional analysis of myopia-related visual impairment,[16] and reinforce the growing recognition of myopia as a major non-communicable eye health burden. The consistency of association across regions strengthens the case for earlier intervention, particularly as the highest prevalence of myopia is now seen in children and young adults who remain pathology-free but face elevated long-term risk.[2–4] This has direct implications for global eye care planning and health policy, since the costs of managing advanced visual impairment may ultimately exceed the investments required for early myopia control.[31]

One area of divergence between the two surveys was the steeper increase in visual impairment risk with increasing myopia in KNHANES (Figure 4). This suggests that while myopia-related risk of visual impairment is present across all ethnicities, it may be greater in East Asian populations. Another regional difference was the lower rates of visual impairment among emmetropes and low-to-moderate myopes in South Korea within the 18–39-year age group. In younger adults, much of the visual impairment burden is attributable to amblyopia, whereas in older adults age-related ocular disease becomes dominant. Rates of amblyopia are reported to be significantly lower in Asia (1.04–1.27%)

337 than the USA (1.59-2.3%), which may at least partly account for this regional difference in
338 visual impairment. [32] Additionally, females were observed to have a higher risk of visual
339 impairment in KNHANES but not in NHANES. Given that women in South Korea are currently
340 projected to live 5.7 years longer than men, this sex difference in risk may amplify the
341 overall public health burden of myopia-related visual impairment.[33] A recent analysis of
342 myopia prevalence in South Korea has also demonstrated that sex-differences in the
343 temporal trends in myopia with stable levels of myopia in boys over a decade (prevalence
344 rates in 2011: 53.7% and 2021: 52.8%) but increasing myopia prevalence myopia in girls
345 (prevalence rates 2011: 51.6% and2021: 73.7%).[34] Future public health models of the impact
346 of myopia should consider the interactions between sex, myopia prevalence, longevity and
347 visual impairment.

348

349 A key finding of this study is that the risk of visual impairment was elevated across all
350 categories of myopia, not only among those with high myopia. In both nationally
351 representative datasets, every level of myopia was associated with significantly increased
352 odds of visual impairment compared with emmetropia, as risk increased progressively with
353 higher degree of myopia. In the older cohort (60-79 years) these results support the view
354 that no degree of myopia can be considered entirely safe[35] and that each diopter
355 contributes meaningfully to lifetime ocular risk.[36] While pathological changes in highly
356 myopic eyes have received considerable clinical attention,[10,37] the broader public health
357 burden may lie with individuals with low to moderate myopia given their substantially
358 higher prevalence in the population,[38] and contribution to overall numbers of vision-
359 impaired individuals, even if individual risk is lower. These findings are consistent with a

recent systematic review demonstrating that sight-threatening complications are not limited to high myopia, but occur across a wider spectrum of refractive error.[39] In the absence of effective treatments for some myopia-related complications,[40] these data underscore the urgent need to prioritize myopia prevention and early management. From a population health perspective, the implications extend beyond clinical care to education, policy, and long-term planning. Addressing the future burden of myopia-related visual impairment will require coordinated action from a broad coalition of stakeholders, including public health agencies, policymakers, educators, patients, parents and eyecare providers. Spectacle correction in myopia induces retinal image minification that can modestly reduce measured visual acuity and could theoretically shift some individuals with high myopia across a visual impairment threshold. However, the magnitude of this effect is small (approximately 0.01 logMAR per diopter of increasing myopia) and is not expected to vary systematically by region, age or sex, making it unlikely to materially influence the impact of these factors on visual impairment rates. [41]

Strengths

This study leverages two of the largest, nationally representative health surveys in the world, providing over 40,000 participants over the age of 40. The large sample size allows for precise estimation of risk across a range of refractive errors and ages, including subgroups such as those with high myopia who are often underrepresented in smaller clinical studies. Furthermore, the standardized examination protocols and use of stratified sampling methodologies in both NHANES and KNHANES, provide robust, population-level estimates for the two countries. Finally, the parallel analysis of these two independent cohorts from different regions adds confidence to the generalizability of findings and

highlights consistent global patterns in the relationship between myopia, age, and visual impairment.

Limitations

This study has several limitations. Both NHANES and KNHANES used non-cycloplegic refraction. Although the lack of cycloplegia may introduce some misclassification of refractive error in younger participants, this is unlikely to materially affect the main findings. In the Beaver Dam Offspring Study, the mean difference between cycloplegic and non-cycloplegic refraction in 40-49 year-old myopes was 0.3 D and over 60 years of age was just 0.03 D.[42] Recent work in various populations has also demonstrated that the difference between non-cycloplegic and cycloplegic refraction is lowest among myopes and particularly older myopes with those aged 60 and over having a difference of 0.07 D.[43,44] The cross-sectional design precludes direct causal inference and limits assessment of longitudinal changes in visual impairment risk. As with the Kaplan–Meier curves presented in Tideman et al. (2016),[16] the Kaplan–Meier curves in Figure 2 should be interpreted as estimates of the cumulative probability of visual impairment at a given age, that is prevalence, rather than incidence because the underlying data are cross-sectional. In addition, the direct cause of visual impairment was not assessed, hence the results represent the associations between myopia, sex, age and visual impairment of all causes.

Axial length was not measured for either the NHANES or KNHANES and as such the relationship between axial length and vision impairment could not be determined. It has however been shown that most myopia is axial in nature and in this case, SER is likely a

reasonable surrogate for axial length.[16] Other unmeasured environmental, genetic or phenotypic factors that may modify susceptibility to visual impairment in the presence of myopia may have contributed to the observed regional differences. Choroidal thickness, which was not measured in the NHANES and KNHANES surveys, has been identified as an independent risk factor for myopia-related pathology,[45] but little data exists regarding regional differences in this parameter. Alternatively, methodological considerations may contribute, including differences in the distribution of high myopia between surveys. The greater representation of individuals with very high myopia in KNHANES may accentuate effects at the upper end of the refractive error spectrum. Despite this variation, the existence of a consistent, dose–response relationship between myopia and visual impairment in both surveys supports the conclusion that myopia-related risk of visual impairment is a robust and generalizable concept across populations.

Differences in survey methodology, examination protocols, and population characteristics between the two countries may have influenced comparisons. Visual acuity assessment differed between NHANES and KNHANES, which may influence absolute estimates of visual impairment and should be considered when interpreting inter-country comparisons. NHANES used a letter-based chart integrated into an autorefractor, whereas KNHANES employed a logMAR chart with numeric optotypes. Differences in optotype design, chart characteristics, and testing conditions are known to produce systematic variation in measured acuity. Such methodological differences could contribute to observed inter-country differences in vision impairment, particularly at higher levels of myopia. Accordingly, inter-country comparisons should be interpreted cautiously. However, these differences are unlikely to explain the consistent within-country patterns observed across

refractive error severity, age, or sex. Finally, unmeasured confounding factors such as socioeconomic status, access to eye care, or comorbid health conditions may also have contributed to observed differences.

Conclusion

This study provides robust, population-level evidence that myopia is a significant and quantifiable risk factor for visual impairment, with risk increasing progressively with both age and myopia severity. Confirmation of this association in two ethnically and demographically distinct national cohorts underscores its generalizability and global relevance. While age-related effects were consistent between the United States and South Korea, the steeper myopia-related risk and increased risk in females observed in South Korea underscores the potential for regional variation. These findings reinforce the need to prioritize myopia prevention and early intervention, not only at the level of individual clinical care, but also through coordinated strategies by health systems and policymakers to mitigate the growing global burden of myopia related vision loss.

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Figure 1: Distribution of right eye spherical equivalent for participants aged 18-39 and aged 40-79 in both the National Health and Nutrition Survey (NHANES) and Korean National Health and Nutrition Survey (KNHANES). The y axis for the top and bottom panels has a different scale due to the United States having almost 7 times the population of South Korea.

Figure 2: Kaplan-Meier survival curves showing the estimated, visual impairment probability for no myopia (> -0.50 D), low myopia (≤ -0.50 & > -3.00 D), moderate myopia (≤ -3.00 & > -6.00 D) and high myopia (≤ -6.00 D) estimated for the entire population aged 40 to 79 for the United States and South Korea.

Figure 3: Logistic regression for both the National Health and Nutrition Survey (NHANES) and Korean National Health and Nutrition Survey (KNHANES) showing the risk of visual impairment with worsening myopia.

Figure 4: Predicted risk of visual impairment (≥0.3 logMAR) by age and spherical equivalent refraction (SER) in the National Health and Nutrition Survey (NHANES) and Korean National Health and Nutrition Survey (KNHANES) on a logit scale. Parallel slopes indicate similar age-related effects across both populations, while the wider separation of the KNHANES curves demonstrates the steeper increase in risk associated with myopia in the South Korean cohort.

Figure 5: Predicted risk of visual impairment (≥0.3 logMAR) by sex and spherical equivalent refraction (SER) in the National Health and Nutrition Survey (NHANES) and Korean National Health and Nutrition Survey (KNHANES). For the NHANES, the risk of visual impairment was not significantly different between the two sexes whereas for the KNHANES the risk was significantly greater for female sex.

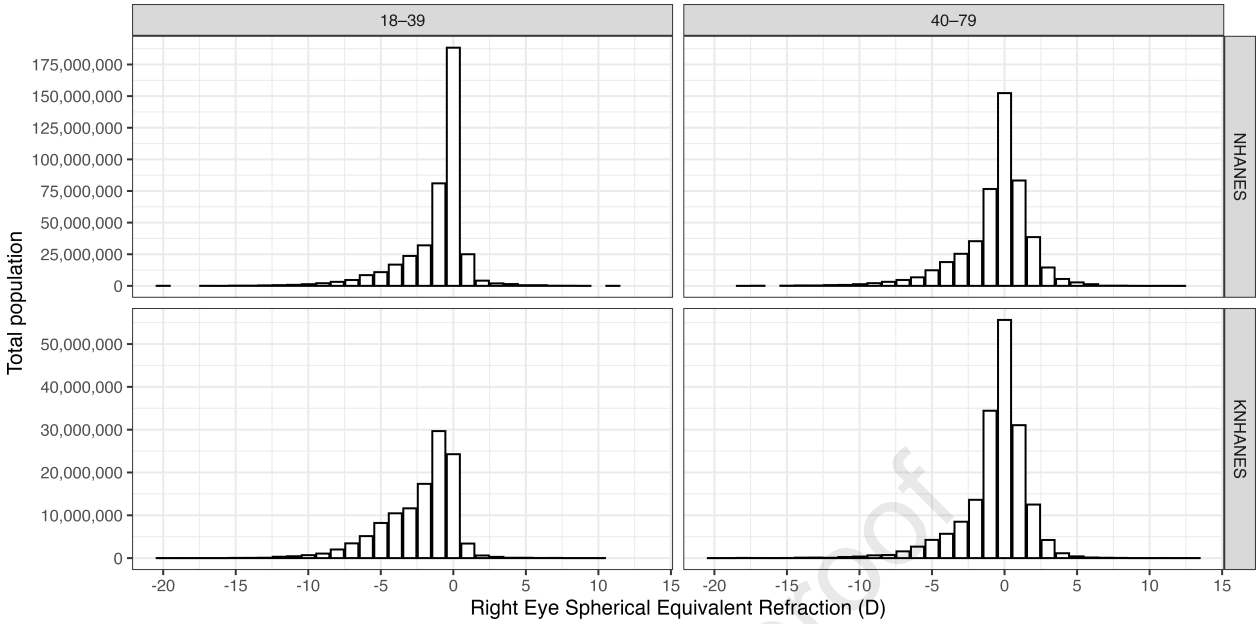
Figure 6: Comparison of NHANES and KNHANES model estimates of visual impairment rates with those of Bullimore et al.[19] using a visual impairment threshold of < 20/40. The NHANES results showed a slightly greater risk at lower levels of myopia but aligned reasonably well at higher levels of myopia. The Bullimore et al. model significantly underestimated risk of visual impairment compared to our model in the South Korean population.

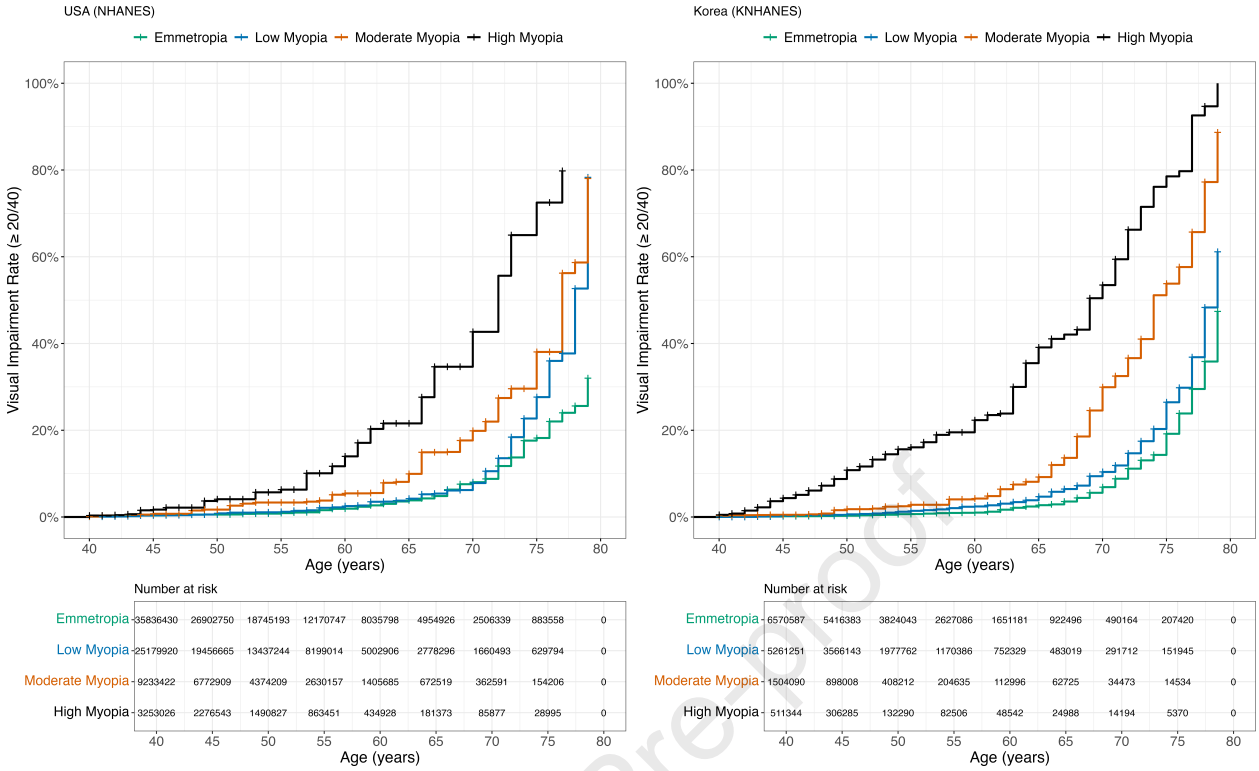
Table 2: Survey-weighted Odds Ratio of visual impairment in myopes compared to age-matched emmetropes for both the National Health and Nutrition Survey (NHANES) and Korean National Health and Nutrition Survey (KNHANES) across different spherical equivalent refraction (SER) categories and age groups. The emmetropic group acts as the reference for that age group and survey in each column.

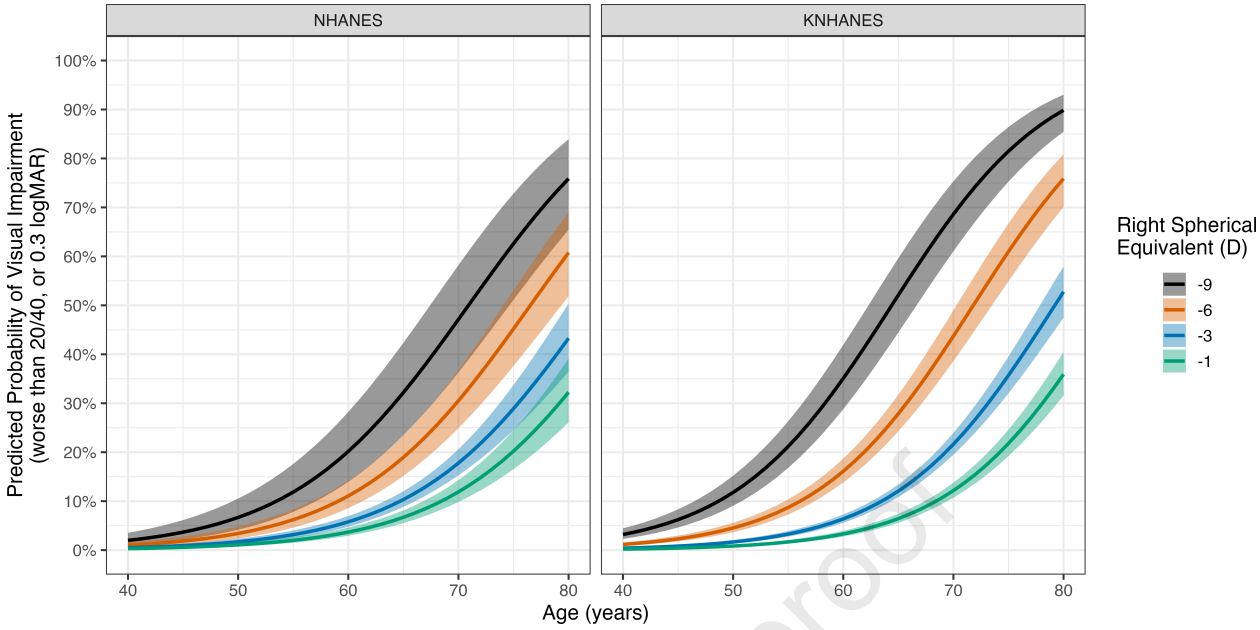
	Odds ratio vs emmetropia (95% CI)	
	40–59 years	60–79 years
USA (NHANES)		
Emmetropia	1.00 (Reference)	1.00 (Reference)
Low Myopia	1.14 (0.66–1.98)	1.84 (1.17–2.87)
Moderate Myopia	2.44 (1.29–4.62)	2.34 (1.40–3.90)
High Myopia	4.88 (2.08–11.43)	5.24 (2.53–10.88)
Korea (KNHANES)		
Emmetropia	1.00 (Reference)	1.00 (Reference)
Low Myopia	1.28 (0.79–2.07)	2.00 (1.61–2.48)
Moderate Myopia	1.91 (0.94–3.87)	4.98 (3.39–7.33)
High Myopia	13.28 (8.09–21.79)	13.29 (8.33–21.22)

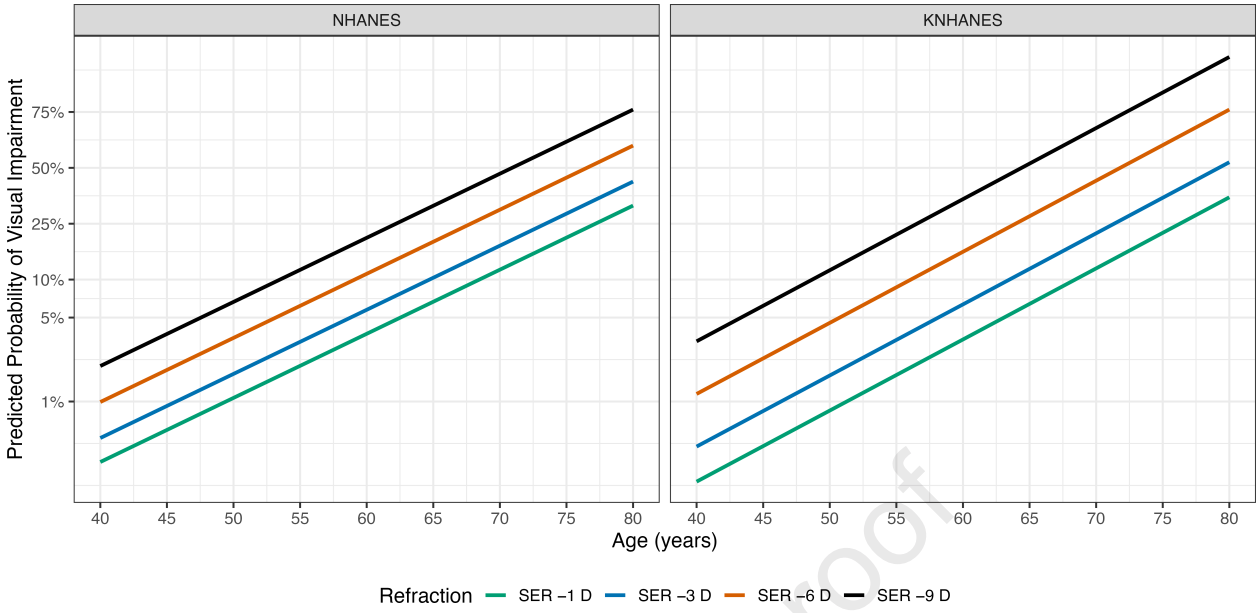
Table 1: Visual impairment prevalence for older and younger participants of the National Health and Nutrition Survey (NHANES) and Korean National Health and Nutrition Survey (KNHANES) for different categories of spherical equivalent refraction (SER). Counts [for Total and VI(n)] are the unweighted raw data. Visual impairment prevalence is presented as survey-weighted, population-representative estimates.

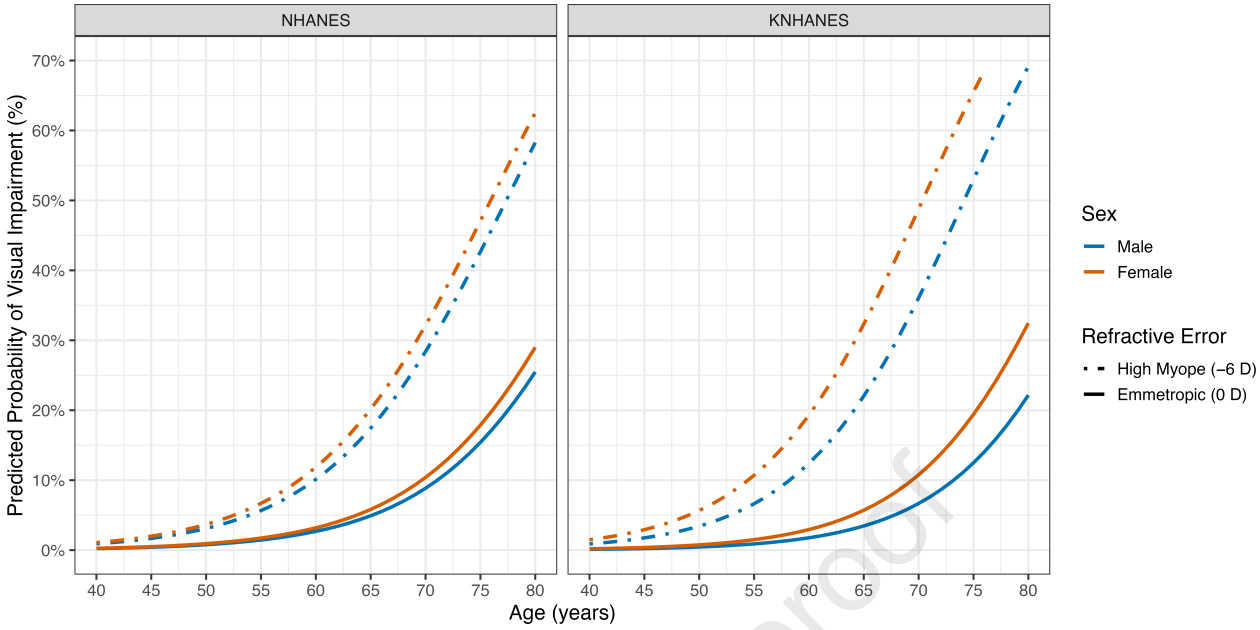
	Age 18–39				Age 40–59				Age 60–79			
	Total	VI (n)	VI (%weighted, 95% CI)	Mean SER (D)	Total	VI (n)	VI (%weighted, 95% CI)	Mean SER (D)	Total	VI (n)	VI (%weighted, 95% CI)	Mean SER (D)
USA (NHANES)												
Emmetropia	5240	89	1.2 (0.8, 1.6)	0.06	2899	39	1.1 (0.6, 1.6)	0.12	1447	101	6.1 (4.5, 7.7)	0.24
Low Myopia	3279	115	2.8 (2.1, 3.6)	−1.27	1890	37	1.3 (0.7, 1.8)	−1.29	831	120	10.6 (7.9, 13.3)	−1.37
Moderate Myopia	973	38	2.6 (1.5, 3.6)	−4.18	616	25	2.6 (1.4, 3.9)	−4.19	195	32	13.2 (7.4, 18.9)	−4.06
High Myopia	365	35	5.7 (3.0, 8.5)	−8.18	213	16	5.2 (1.7, 8.6)	−8.39	61	17	25.3 (7.1, 43.5)	−8.52
Korea (KNHANES)												
Emmetropia	3053	12	0.4 (0.1, 0.6)	0.00	7099	50	0.7 (0.4, 0.9)	0.11	3920	310	7.1 (6.1, 8.0)	0.26
Low Myopia	6194	35	0.7 (0.4, 1.0)	−1.40	6239	68	0.9 (0.6, 1.1)	−1.29	1742	266	13.2 (11.3, 15.1)	−1.19
Moderate Myopia	3178	25	0.8 (0.4, 1.1)	−4.23	1864	25	1.3 (0.5, 2.1)	−4.21	242	74	27.5 (20.2, 34.7)	−4.08
High Myopia	1215	40	3.2 (1.9, 4.5)	−7.82	619	57	8.5 (5.9, 11.0)	−8.11	119	63	50.3 (38.9, 61.6)	−9.80

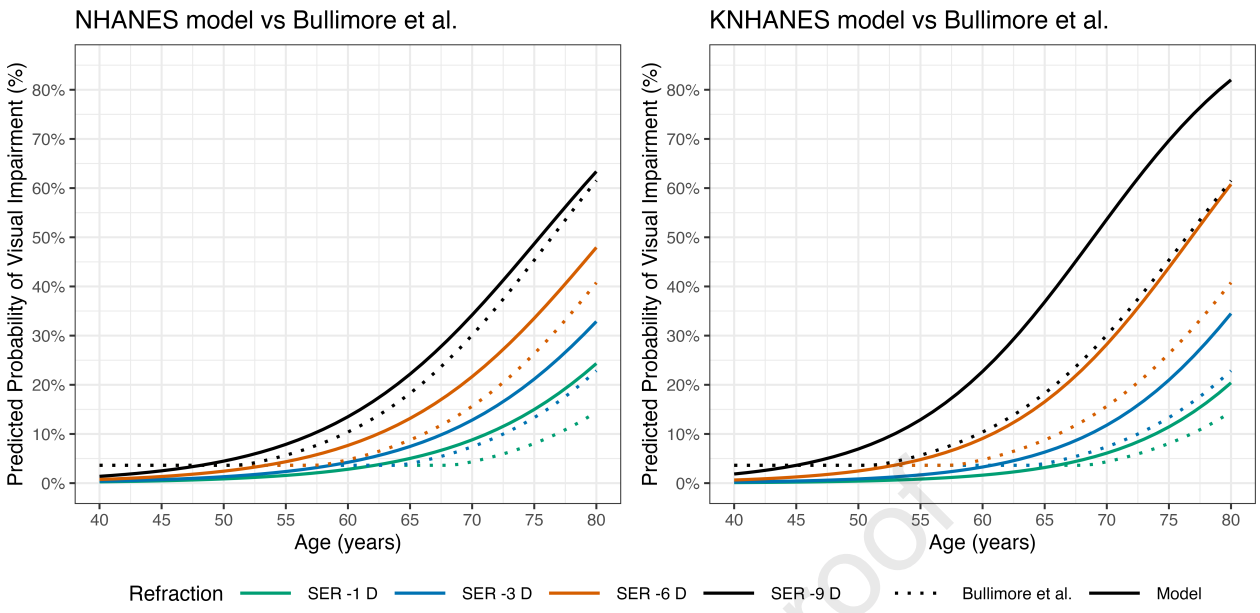












Myopia represents a significant risk for visual impairment in both the United States and South Korea, with risk increasing in a dose response manner across all levels of myopia.