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Global Prevalence of Presbyopia and Vision Impairment from Uncorrected Presbyopia

Systematic Review, Meta-analysis, and Modelling

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Topic: Presbyopia prevalence and spectacle-correction coverage were estimated by systematic review and meta-analysis of epidemiologic evidence, then modeled to expand to country, region, and global estimates.

Clinical Relevance: Understanding presbyopia epidemiologic factors and correction coverage is critical to overcoming the burden of vision impairment (VI) from uncorrected presbyopia.

Methods: We performed systematic reviews of presbyopia prevalence and spectacle-correction coverage. Accepted presbyopia prevalence data were gathered into 5-year age groups from 0 to 90 years or older and meta-analyzed within World Health Organization global burden of disease regions. We developed a model based on amplitude of accommodation adjusted for myopia rates to match the regionally meta-analyzed presbyopia prevalence. Presbyopia spectacle-correction coverage was analyzed against country-level variables from the year of data collection; variation in correction coverage was described best by a model based on the Human Development Index, Gini coefficient, and health expenditure, with adjustments for age and urbanization. We used the models to estimate presbyopia prevalence and spectacle-correction coverage in each age group in urban and rural areas of every country in the world, and combined with population data to estimate the number of people with near VI.

Results: We estimate there were 1.8 billion people (prevalence, 25%; 95% confidence interval [CI], 1.7–2.0 billion [23%–27%]) globally with presbyopia in 2015, 826 million (95% CI, 686–960 million) of whom had near VI because they had no, or inadequate, vision correction. Global unmet need for presbyopia correction in 2015 is estimated to be 45% (95% CI, 41%–49%). People with presbyopia are more likely to have adequate optical correction if they live in an urban area of a more developed country with higher health expenditure and lower inequality.

Conclusions: There is a significant burden of VI from uncorrected presbyopia, with the greatest burden in rural areas of low-resource countries. *Ophthalmology 2018;■:1–8 © 2018 by the American Academy of Ophthalmology. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).*

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Presbyopia was estimated to affect more than 1 billion people globally in 2005, with more than half unable to access the necessary refractive correction to overcome the associated vision impairment (VI).[1] When that estimate was made, high-quality prevalence data were available only for 4 countries—Tanzania,[2,3] Brazil,[4] India,[5] and Timor-Leste[6,7]—so the global presbyopia prevalence estimates involved extensive extrapolation and a high degree of uncertainty. Data for presbyopia correction rates similarly were limited, and correction estimates similarly uncertain. In addition to the paucity of evidence, the authors noted a need to increase consistency in presbyopia prevalence study methodology to enable comparability.[1]

Subsequently, the World Health Organization developed a standardized protocol for assessing prevalence of VI caused by uncorrected presbyopia.[8] Variations in font type, font size, and test distances previously had been a major cause of comparability issues and were addressed in the standardized protocol. The vast majority of near-vision research since then has used Times New Roman font, with ability to see either N6 or N8 (N = Times New Roman font and the number denotes the point size in print)[6] at either 40 cm or preferred distance as the threshold for impairment. N6 or N8 at 40 cm corresponds to 20/40 or 20/50, and there has been an assumption that the acuity variations caused by allowing preferred distance have been insignificant.

New prevalence and spectacle-correction data, together with improved modelling techniques based on newer demographic data, warrant updated global presbyopia estimates and projections. The objectives of this review were to update global and regional presbyopia prevalence and spectacle-correction coverage estimates based on new epidemiologic evidence and improved modelling.

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Methods

Presbyopia Epidemiology: Systematic Review, Meta-analysis, and Modelling

We performed a systematic search for prevalence of presbyopia evidence, summarized in Figure 1. Our inclusion criteria were (1) population-based studies quantifying presbyopia prevalence, (2) presbyopia defined as unaided near vision worse than N6 or N8 at 40 cm or customary working distance, (3) a mechanism to exclude people with eye disease causing reduced near vision, (4) sampling representative of entire communities, and (5) sample size of at least 400 participants, without date restrictions. We excluded articles that were not available in English, which did not specify the number of eligible participants or participation rate, that had unspecified or ambiguous definitions, that had a participation rate of less than 70%, or that were based on duplicate data used in other included studies. Seven additional articles were identified by key informants and reference lists of included studies.

From the 170 articles identified, we included 25 studies in our analysis of the prevalence of presbyopia, summarized in Table S1 (available at www.aaojournal.org).[2,5,9−27] Most article exclusions were the result of lack of presbyopia prevalence data, not being population based, not being representative of entire communities, or a combination thereof. Additionally, Duarte et al[4] was excluded because of data labelling ambiguities in the translated English version and use of an outlying definition (N4 at 37 cm), and Abdullah et al[28] was excluded for not specifying the presbyopia cutoff.

We gathered the prevalence data into 5-year age groups from 0 to 90 years or older. Published evidence covered all age groups 40 years or older in 11 of the 21 World Health Organization global burden of disease (GBD) regions, plus the 35- to 39-year-old age group in 6 of the same regions.[29] We meta-analyzed the prevalence of presbyopia within each age group within each of the 11 GBD regions using Comprehensive Meta-Analysis version 3 (Biostat, Englewood, NJ). A logit random effects model was used to combine studies within each age group and region. The logit prevalence was defined as $\log(p / (1 - p))$, where p is the prevalence within each age group. The study-to-study variance (τ^2) was not assumed to be the same for all age groups within the region, indicating that this value was computed within age groups and not pooled across age groups. Inverse of the variance was used to compute relative weights. The logit prevalence and its standard error were used to compute the 95% confidence interval (CI), which then were transformed to the estimated prevalence and its corresponding limits using the formula exp^(Logit prevalence) / (exp^(Logit prevalence) + 1).

Presbyopia was assumed to have 0 prevalence in people younger than 30 years of age. In the 6 regions with data from those 35 years of age or older and the 5 regions with data from those 40 years of age or older, we linearly decreased the prevalence from the last known evidence down through the relevant age groups to 0 at 30 years of age. In regions with data, but no data in 1 or more of the age groups 65 years of age or older, we extrapolated the prevalence as a constant from the last known evidence through to the 90 years or older age group.

We also estimated presbyopia prevalence in the same 11 GBD regions by developing a model based on published amplitude of accommodation versus age relationships,[30−33] modified by the age-specific prevalence of myopia (from section 5 of the online supplemental material for Holden et al[34]). Accommodation is the ability of the eye to change focus, and amplitude of accommodation is the maximum optical power an eye can achieve relative to rest. Evidence suggests that the average person can maintain two thirds of his or her amplitude of accommodation, meaning that an emmetropic person would need 3.75 diopters (D) or more of amplitude of accommodation to perform tasks at 40 cm for a prolonged period without optical assistance.[35] Because accommodative need is reduced in myopic people, estimates of the number of people in each country, in each 5-year age group from 0 to 90 years or older with myopia of −0.50 D or less, −0.75 D or less, −1.25 D or less, −1.75 D or less, or −2.25 D or less were made using the methods of Holden et al.[34] We found 4 articles describing the relationship between amplitude of accommodation and age of 30 years or older, 1 each from China, India, Nigeria, and the United States.[30−33] Age-specific mean and standard deviation amplitude of accommodation from these studies were translated via cumulative probability statistics to a percentage of people in each age group and level of ametropia who lack the appropriate accommodation for near tasks at 40 cm. We compared these presbyopia prevalence estimates with the epidemiologic evidence in the 11 regions with data, and then refined the model using a global constant. Level of agreement in regional presbyopia prevalence between estimates based on direct epidemiologic evidence and our model is shown in Figure S2 (available at www.aaojournal.org).

We extracted country-specific population data for 2015 and each decade from 2000 through 2050 in 5-year age groups from 0 to 90 years or older from the United Nations World Population Prospects.[36] Population data from the United States Census Bureau were used for a small number of low-population states aggregated within the available United Nations data.[37]

We estimated age-specific presbyopia prevalence in all countries using the adjusted amplitude of accommodation or myopia model. We applied amplitude of accommodation data from China to countries in Asia (Central), Asia (East), Asia (Southeast), and Asia Pacific High Income.[30] Amplitude of accommodation data from India were used in Asia (South),[31] whereas data from Nigeria were used in Caribbean, Sub-Saharan Africa (Central), Sub-Saharan Africa (East), Sub-Saharan Africa (Southern), and Sub-Saharan Africa (West),[32] and data from the United States were used in Australasia, Europe (Central), Europe (Eastern), Europe (Western), Latin America (Andean), Latin America (Central), Latin America (Southern), Latin America (Tropical), North Africa and Middle East, North America High Income, and Oceania.[33] The age- and country-specific average prevalence data, together with upper and lower 95% CI, were combined with the population data to estimate number of people with presbyopia in each country of the world in 2015 plus each decade from 2000 through 2050.

Presbyopia Spectacle-Correction Coverage: Systematic Review and Modelling

We performed a systematic search for presbyopia correction rates, coverage, or both, summarized in Figure 1. Our inclusion and exclusion criteria were the same as the review of presbyopia prevalence, except that in this search, studies needed to quantify presbyopia spectacle-correction rates, coverage, or both. In addition to 160 articles identified by systematic search, 12 published articles and 17 studies from the Rapid Assessment of Avoidable Blindness Repository were identified by key informants 23 and reference lists of identified studies.[38]

Data from the 43 accepted studies were translated into presbyopia spectacle-correction coverage, and then analyzed against health and development indicators from the country and year of data collection. We assessed gross domestic product per capita