Projected Prevalences of Age-Related Eye Diseases

Barbara E. K. Klein and Ronald Klein

Department of Ophthalmology and Visual Sciences, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin

PURPOSE. To examine projections of age-related eye diseases in the United States for health care planning.

METHODS. Review of published scientific articles, census data, and unpublished research findings.

RESULTS. The numbers of cases of all age-related eye diseases are expected to rise in the coming years. These projections are primarily based upon population projections, but give little consideration to changes in health behaviors, racial/ethnic differences, environmental exposures, and changes in health care practices that may influence estimates of costs of actual health care burden.

CONCLUSIONS. Ongoing monitoring of trends in eye disease distribution is needed rather than projections based on old data that may be inadequate for generating reliable prediction models. There is a perpetual need to train new researchers with expertise in epidemiology, as the exigency for current prevalence estimates is crucial to maximize optimal visual health in the population.

Keywords: age-related eye diseases, prevalence, review

Investigative Ophthalmology & Visual Science

The prevalence of most eye diseases increases with age in virtually all populations. The Eye Diseases Prevalence Research Group (EDPRG) reported on data from ten different prevalence studies to estimate the prevalence of visual impairment and several specific eye diseases in persons 40 years of age or older to estimate the burden of these conditions in the United States (US) in 2000.[1–6] These data and information from the National Health and Nutrition Examination Survey (NHANES) and other sources are compiled in another publication in this volume. In order to plan for future eye healthcare needs, projections for the future are desirable. It is the purpose of this paper to briefly describe current projections and potential limitations thereof.

MATERIALS AND METHODS

Study Population

Population projections to the year 2020 are from published projections from the EDPRG. For POAG, the projections are supplemented by information from 2011.[7]

Measurements

Estimates of prevalence were based on protocols that varied among the studies. Errors and systematic differences among studies are incorporated in the projections because there were no attempts to adjust prevalence data to uniform criteria for diagnostic labeling.

An example of the varying criteria for diagnostic labeling was given for glaucoma. In the EDPRG, six different sets of criteria were given for the studies.[3] Some included disc photography, cutpoints varied for cup/disc diagnostic criteria, some studies included a cutpoint for IOP, each used

different techniques to assess visual fields, and some studies had subjective evaluation of components of glaucoma-related abnormalities, while others used a uniform set of criteria.

Statistical Analysis

The projected estimates from the EDPRG of the numbers and percentages of persons with the conditions were generated by applying the age, sex, and race/ethnicity of the prevalence data estimated for 2000 to projected middle series population projections for 2020.[1–6] For the POAG estimates, Vajaranant and colleagues used prevalence estimates from the Baltimore Eye Survey, the Los Angeles Latino Eye Study, and the Tanjong Pagar Survey and applied these to the US Census population projections from 2011 to 2050 using middle series.[7] Census population projections for 2000 to 2050 as well as methods for the 2012 updated projections were obtained from the US Census Bureau.[8,9] Figures in this paper are reproduced from reports from the US Census Bureau[8,10]; the Table is a summary of projections that appeared in papers from the EDPRG.[1–6]

RESULTS

Predictions of disease prevalence depend upon projections of population changes by age and sex to the same date as the predictions aim for. For example, Figure 1 describes the middle series projections of the population by age and sex for 2012 to 2060 as calculated by the US Census Bureau.

The EDPRG projected prevalences of age-related eye diseases and visual functions from the year 2000 to 2020 based on projections of the US population to 2020 (Table). The estimated number of cases of each disorder was projected to increase over the 20-year period. They made the

ORSF14

TABLE. Eye Diseases Prevalence Research Group[1-6] Estimates of Age-Related Eye Disease Prevalences in 2000 and Projections to 2020 in Persons Aged 40 Years and Older

Eye Disease	2000 N in Millions (%)	2020 N in Millions
Cataract*	20.5 (17.2)	30.1
Pseudophakia†	6.1 (5.1)	9.5
Diabetic retinopathy	4.1 (3.4)	6.1
Vision-threatening diabetic retinopathy	0.9 (0.8)	1.4
Open-angle glaucoma	2.2 (1.9)	3.4
Late age-related macular degeneration	1.8 (1.5)	3.0
Large drusen	7.3 (6.1)	13.7
Blindness	0.9 (0.8)	1.6
Low vision	2.4 (2.0)	3.9

* Omits Mexican Americans.
† Includes Mexican Americans.

assumption that prevalence would remain the same; the projected increase in number is a reflection of the increase in the population size. However, projections should also account for shifting demographics of the population, as these may affect disease estimates. The US Census Bureau provided estimates by region of origin of foreign-born immigrants (Fig. 2).

The US Census Bureau projected that the non-Hispanic, white population will peak in 2024 and then fall by nearly 20.6 million to approximately 179 million by 2060, while the Hispanic population will increase to approximately 128.8 million, the black population will increase to approximately 61.8 million, and the Asian population will increase to approximately 34.4 million.[11] Members of other racial/ethnic groups including American Indians, Alaskan Natives, Native Hawaiians, and other Pacific Islanders as well as those who identify themselves as being of two or more races/ethnicities will also increase. The older population will still be primarily non-Hispanic white in 2060 but this will change in subsequent years as the increasing numbers of persons of other races/ethnicities age.

Attempting to adjust for racial/ethnic shifts in demography, Vajaranant and colleagues[7] projected the burden of POAG in 2050 based on the estimated prevalence in 2011. Their assumption was that more recent population projections accounting for shifts in race/ethnicity, especially for Hispanics and Asians, would improve upon the estimates made by the EDPRG. They estimated that there were 2.71 million persons with POAG in 2011 and that this number would increase to 7.32 million by 2050. However, population projections tend to be imperfect and the longer the time period in the forecast, the less accurate it tends to be.[12] A comparison of US population projections made in 2008 and again in 2012 to the year 2050 illustrates this problem (Fig. 3). The estimated population projections differ by nearly 10%. Those data will be reflected in different predictions of estimates of disease prevalence.

There are other factors that predictions based solely on projected differences in population by demographic changes do not account for. There are temporal changes in the distribution of risk factors (e.g., changes in care of persons with diabetes, increasingly frequent cataract surgery,[13,14] changes in socioeconomic status,[15] access to care,[16] and changes in environmental exposures, such as exposure to UV-B light).[17] In addition, there appear to be temporal patterns in disease incidence, which are also likely to affect prevalence in
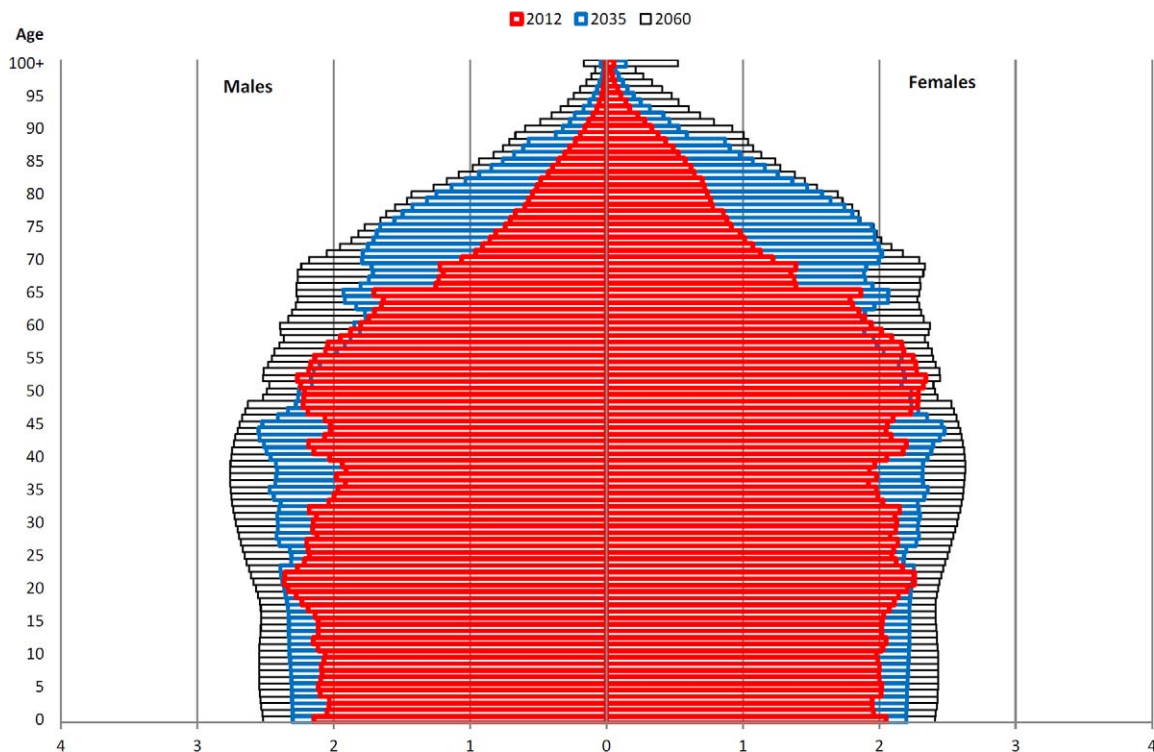
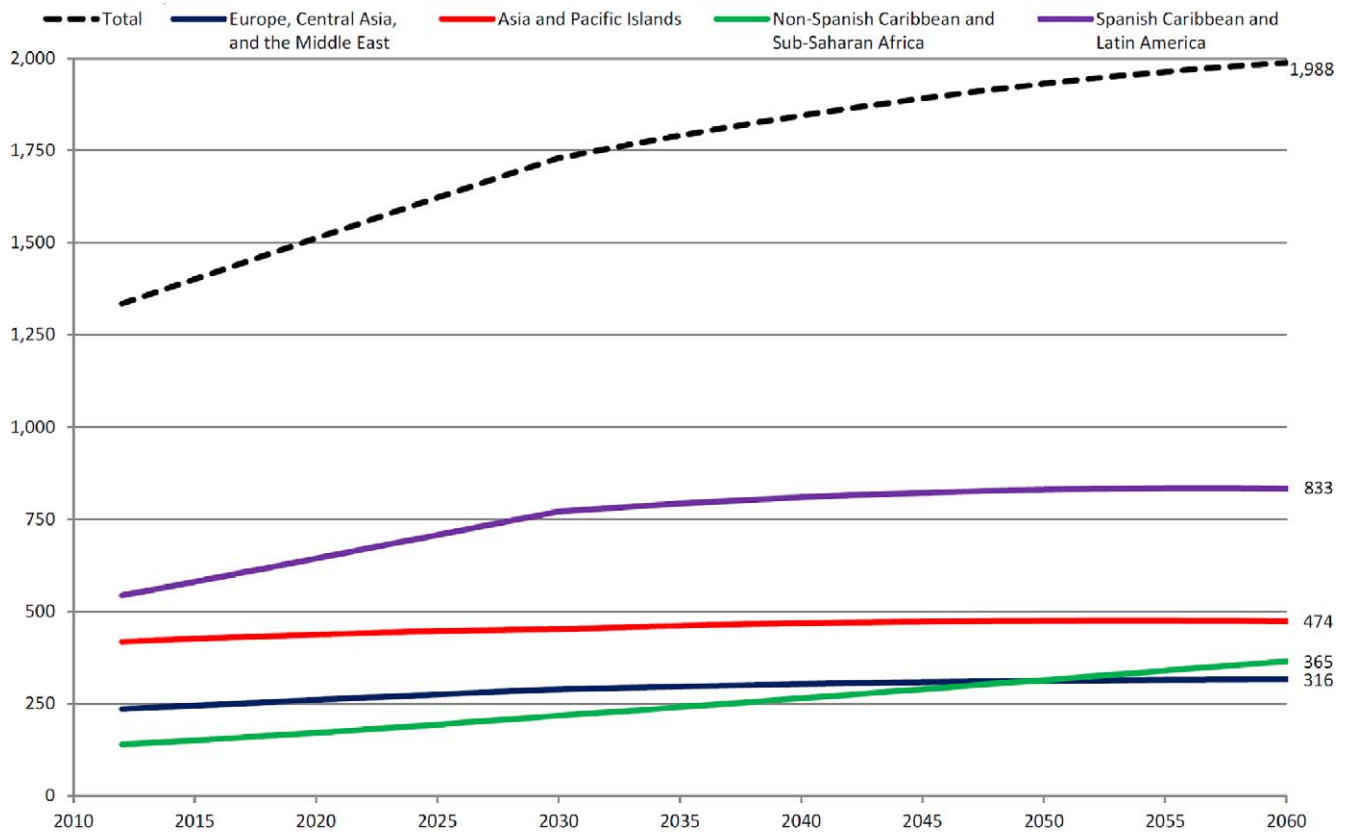FIGURE 1. Middle series projections of the population of the US by age and sex, 2012 to 2060 (in millions).[8]

FIGURE 2. Middle series projections of foreign-born immigration to the US by sending region: 2012 to 2060 (in thousands).[8]

the future. For example, Klein and colleagues[18] found a decrease in early AMD in more recent birth cohorts, which to date is not known to reflect decreases in risk factors.

DISCUSSION

Current projections of eye disease prevalence have been based largely on data that were collected many years ago and are restricted to a few eye conditions that are considered to be responsible for either visual loss (visual acuity poorer than 20/40 in the better seeing eye) or legal blindness (visual acuity poorer than 20/200 in the better seeing eye). These projections have been made for at best a handful of eye conditions. There are no known population projections for prevalence of dry eye, retinal vein occlusions, or many corneal conditions, which seem to be as prevalent as those for which projections have
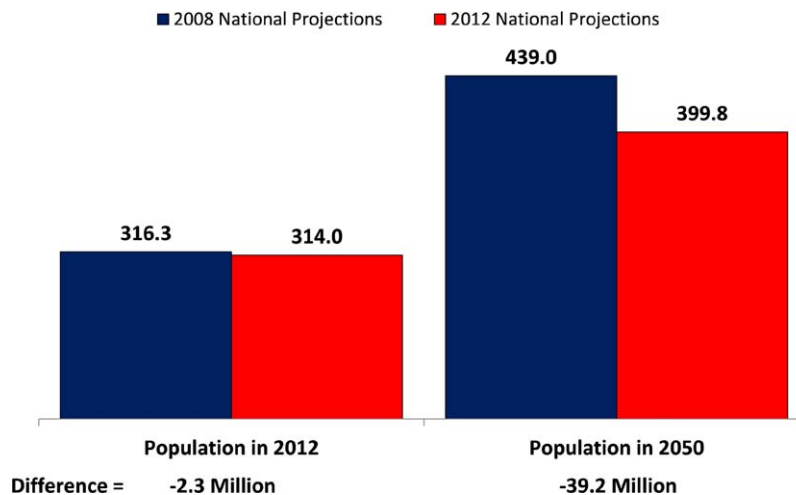

FIGURE 3. Projected population of the US: 2012 and 2050.[10]

been made. These conditions should be considered when projecting disability from and remediation of age-related eye conditions.

Accurate estimates of prevalence and projections for future health care needs depend upon inclusion of all subgroups in the population. This implies systematic inclusion of samples of all persons including those currently undercounted and underserved. Access to care is likely to be improved by the Patient Protection and Affordable Care Act and the Health Care and Education Reconciliation Act. In addition, information about such improved access as well as education about the benefits of using such care needs to be implemented.

In summary, projections of prevalence are critical for planning for preventive and health care services with implications for function, quality of life, and costs; accurate projections are difficult to make and should be time-limited; every effort must be made to consider factors that the census does and any important known risk and preventive factors as well as temporal changes in them; frequent reassessment of outcomes and risk/protective factors is essential; and funding and encouragement for training of ocular epidemiologists is imperative to optimize planning for public health priorities to prevent or diminish the toll of age-related eye disease.

Acknowledgments

Disclosure: **B.E.K. Klein**, None; **R. Klein**, None

References

1. Friedman DS, O'Colmain BJ, Munoz B, et al. Prevalence of age-related macular degeneration in the United States. *Arch Ophthalmol*. 2004;122:564–572.

2. Kempen JH, O'Colmain BJ, Leske MC, et al. The prevalence of diabetic retinopathy among adults in the United States. *Arch Ophthalmol*. 2004;122:552–563.

3. Friedman DS, Wolfs RC, O'Colmain BJ, et al. Prevalence of open-angle glaucoma among adults in the United States. *Arch Ophthalmol*. 2004;122:532–538.

4. Congdon N, Vingerling JR, Klein BE, et al. Prevalence of cataract and pseudophakia/aphakia among adults in the United States. *Arch Ophthalmol*. 2004;122:487–494.

5. Congdon N, O'Colmain B, Klaver CC, et al. Causes and prevalence of visual impairment among adults in the United States. *Arch Ophthalmol*. 2004;122:477–485.

6. Kempen JH, Mitchell P, Lee KE, et al. The prevalence of refractive errors among adults in the United States, Western Europe, and Australia. *Arch Ophthalmol*. 2004;122:495–505.

7. Vajaranant TS, Wu S, Torres M, Varma R. The changing face of primary open-angle glaucoma in the United States: demographic and geographic changes from 2011 to 2050. *Am J Ophthalmol*. 2012;154:303–314.

8. U.S. Census Bureau. Methodology and Assumptions for the 2012 National Projections. Available at: https://www.census.gov/population/projections/files/methodology/methodstatement12.pdf. Accessed June 7, 2013.

9. U.S. Census Bureau. 2000 National Population Projections. Available at: https://www.census.gov/population/projections/data/national/natproj2000.html. Accessed June 7, 2013.

10. U.S. Census Bureau. What a Difference Four Years Make: U.S. Population Projected to Grow at a Slower Pace Over the Next Five Decades. Available at: http://blogs.census.gov/2012/12/12/what-a-difference-four-years-make-u-s-population-projected-to-grow-at-a-slower-pace-over-the-next-five-decades/. Accessed June 7, 2013.

11. U.S. Census Bureau. U.S. Census Bureau Projections Show a Slower Growing, Older, More Diverse Nation a Half Century from Now. Available at: http://www.census.gov/newsroom/releases/archives/population/cb12-243.html. Accessed July 1, 2013.

12. Cohen JE. Population forecasts and confidence intervals for Sweden: a comparison of model-based and empirical approaches. *Demography*. 1986;23:105–126.

13. Lundstrom M, Stenevi U, Thorburn W. The Swedish National Cataract Register: a 9-year review. *Acta Ophthalmol Scand*. 2002;80:248–257.

14. Klein BE, Howard KP, Lee KE, Klein R. Changing incidence of lens extraction over twenty years: the Beaver Dam Eye Study. *Ophthalmology*. In press.

15. Tavernise S. The Health Toll of Immigration. Available at: http://www.nytimes.com/2013/05/19/health/the-health-toll-of-immigration.html. Accessed June 10, 2013.

16. Vickery KD, Sauser K, Davis MM. Policy responses to demand for health care access: from the individual to the population. *JAMA*. 2013;309:665–666.

17. Norval M, Lucas RM, Cullen AP, et al. The human health effects of ozone depletion and interactions with climate change. *Photochem Photobiol Sci*. 2011;10:199–225.

18. Klein R, Knudtson MD, Lee KE, Gangnon RE, Klein BE. Age-period-cohort effect on the incidence of age-related macular degeneration: the Beaver Dam Eye Study. *Ophthalmology*. 2008;115:1460–1467.