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Refractive Error in Underserved Adults: Causes and Potential Solutions

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Abstract

Purpose of Review—To evaluate the epidemiology of uncorrected refractive errors (URE) in adults both in the US and globally, health outcomes impacted by URE, common barriers to treatment, and propose potential interventions.

Recent Findings—URE is the main cause of visual impairment (VI) and the second leading cause of blindness globally. Rates of URE are rising, and cause disability that reduces productivity, economic earnings, and the quality of life of affected individuals. Economic barriers, health care access, and socio-cultural constraints are among the most fundamental barriers to correcting URE. However, innovative approaches are poised to lower rates of URE.

Summary—URE is a leading cause of preventable VI with serious health consequences. Numerous social and financial barriers are associated with the high prevalence of URE in low-income adults. Novel delivery programs for eyeglasses and programs to provide refractive surgery to correct refractive error could decrease rates of URE.

Keywords

Uncorrected refractive error; refractive error; visual impairment; eyeglasses; global health

Introduction

Uncorrected refractive error (URE) is the leading cause of vision impairment (VI), and the second leading cause of blindness worldwide.(1, 2) Low-cost, practical treatment is available for myopia, hyperopia, astigmatism, and presbyopia.(3–5) Interventions to address refractive error (RE) can reduce or prevent a high proportion of individuals from experiencing

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unnecessary vision loss and blindness, can decrease associated costs to the economy for medical services, lost productivity, and improve the quality of life (QoL) for affected individuals.(2, 6) Key investigators across the nation including the National Academy of Medicine have recommended the inclusion of ophthalmic measures in health surveys to reach the vision-related objectives of Healthy People 2020.(5, 7, 8) Our review explores the scope of URE both in the United States (US) and globally, to identify health and lifestyle consequences associated with URE, to identify the underlying reasons for URE, and to explore interventions for this preventable cause of VI.

Frequency of URE

Naidoo et al. (2016) reported that in 2010 global estimates of URE, 101 million people had VI from URE and 6.8 million people were blind from URE.(1) They estimated a 15% increase in reported VI and a 7.9% increase in blindness over 20 years.(1) In 2016, Varma et al. reviewed six population health studies and estimated that 8.4 million adult US citizens had VI from URE (20/40 or worse) and another 0.29 million people were blind from URE. (2) This study projected a doubling of URE in the US by 2050 and a prevalence of greater than 10% in 15 US states.(2) Approximately 1 in 8 Americans age 50 years have near-VI worse than 20/40.(5) Racial disparities exist as well. McClure et al. showed that American Indians and Alaskan natives had double the prevalence of URE compared to Caucasians or African Americans.(9) African Americans and Hispanics were more likely to have URE compared to non-Hispanic whites.(10)

Societal Cost of URE

Wittenborn and Rein (2016) estimated that the annual cost of failing to correct refractive error (RE) with eyeglasses in the US was \$35.3 billion (\$16.2 billion in direct medical costs, \$11.1 billion in other direct costs, and \$8 billion in productivity losses; all dollar estimates are in US dollars).(6) The annual costs of visual disability from URE was estimated to be \$5.48 billion for medical and informal care.(6) Based on a one-time cost of \$397 for examination, lenses, and frames, the 10-year savings would be more than \$87.7 billion US dollars if people are given eyeglasses.(6) URE impacts global productivity with estimates at \$269 billion.(3) This is the equivalent of purchasing nearly 13.5 million cars (at US \$20,000/each) or 2.7 million homes (at US \$100,000/each). Research has shown that VI is closely linked with lower economic earnings.(3) In Nigeria, URE was strongly associated with poverty, with three times lower frequency of eyeglasses in poorer households.(11) Individuals with corrected vision worse than 20/40 in the better-seeing eye are more likely to be unemployed.(12)

Health Outcomes Impacted by Correction of URE

Visual impairment from URE impacts peoples' health and QoL.(3, 8, 13) VI affects the ability to participate in activities of daily living (ADL), social integration, health and wellbeing.(2, 5) The reduction in ADL were similar regardless of whether near or distance vision was impaired, and ADL reduction was greatest when both were impaired.(12, 14) By 2030, a World Health Organization (W.H.O.) investigation predicts that, in the aggregate,

individuals with URE will cause more disability-adjusted life years than AIDS or HIV and many other systemic diseases.(15)

Underserved adults

URE disproportionately affects low-income and remote populations,(9, 10, 16, 17) and is associated with reduced utility. Nonwhite ethnicity, older age, lower educational level, lack of private health insurance, and poverty were associated with higher risk of near-VI.(5) Underserved adults are especially affected by presbyopia. Presbyopia-related limitations primarily effect near task difficulty. Near-task impairment impacts all QoL domains (physical, psychological, and social).(18) Complete blindness has a utility of 0.26, whereas corrected presbyopia, a utility of 0.98 (where 1 represents perfect health).(14) Providing eyeglasses to American Indians/ Alaskan natives has significantly improved their vision-related QoL (NEI-VFQ-25), greater than interventions for diabetic retinopathy, macular degeneration, and cataract surgery.(9)

Older adults

Visual impairment has serious consequences for older people (aged 65 years). In the Salisbury eye study ($n=2,469$), subjects with URE demonstrated slower near task performance, lower self-reported visual difficulty, more frequent driving cessation, and slower walking speeds compared with individuals with normal vision.(19) Published studies demonstrated a strong correlation between VI and cognitive decline in older people.(20, 21) VI is associated with functional decline including more frequent placements in nursing homes or other assisted living situations, with worsening QoL, and higher healthcare costs. (2, 22) Correcting RE in older people has been associated with enhanced mobility and independence, and a decreased risk of hip fractures.(12, 23) Correction with eyeglasses, magnifiers, or both has been shown to improve perceptions of QoL, better vision, relief of psychological distress, improved social interaction, and fewer depressive symptoms.(2, 7, 20) In nursing home residents, dispensing eyeglasses to treat URE has led to an improved QoL, reduced agitation, and significantly decreased depression.(22)

Social Determinants of URE Correction

People who are the least likely to obtain eyeglasses have numerous barriers including economic stability, health care access, health literacy, and social contexts. Collectively, these are called the “social determinants of health” and are likely to drive the high prevalence of URE in some communities.

Economic stability

Economic barriers to obtaining eyeglasses are prevalent, especially in places of high poverty and low-resources, and include both direct costs (eye examination and eye frames and glasses) and indirect costs (travel expenses and loss of daily wages to eye providers and to optical shops).(6) Many of these costs also exist when replacing lost or damaged eyeglasses. (6) In Mozambique, despite public sector refractive service, 53% of participants stated that the cost of purchasing eyeglasses was greatest barrier to treatment.(24) US Mexican-American and African-American communities have double the prevalence of URE

compared to Caucasians. Much of this differential is attributed to low income, inadequate healthcare coverage, and fewer visits to health services.(10) Some Medicaid programs cover eyeglasses prescriptions and frames. Medicaid beneficiaries with vision coverage, compared to those without vision coverage, are more likely to see an eye doctor annually and less likely to defer getting eyeglasses when needed.(25) In a community-based screening program in Baltimore, although 75% of respondents cited cost as a barrier to seeking care, 72% (65 of 90 responders) did not obtain eyeglasses even with a drastically reduced price for the exam plus eyeglasses to US\$40.(26) Therefore, this price was still too high or other barriers existed.

Health care access

Underserved adults often have limited health care access. Lack of access to eye care providers has been attributed to workforce limitations and poor integration of optical services into existing eye care services.(7) While US eye care providers have been shown to be within reasonable drive times from patients' homes,(27, 28) areas of the developing world have a great shortage of eye care providers who are often restricted to urban centers which limits accessibility.(7)

Health literacy

People with URE may be unaware of their vision limitations or may not equate vision limits with other medical concerns.(24) Adults with complex health and personal demands may prioritize other needs above eyeglasses.(29) In one study, US Hispanic and African American patients had less understanding about eye diseases compared to demographically similar non-minority populations.(30, 31) In London, focus groups and interviews with an Indian population found that patients had misconceptions about sight loss, causes and potential treatments. Misinformation influenced their perception that eye health was not a priority.(32)

Social and community context

Social and cultural norms and beliefs can limit utilization of eye care services. In some societies, wearing eyeglasses is associated with embarrassment and social stigma.(32) Social context may cause higher rates of URE among older adults especially women, the illiterate, and those individuals living in rural areas.(3) Family responsibilities, high dependency on others, and a lack of childcare are often cited examples for neglecting the correction of RE.(33)

Interventions to Address URE

Novel approaches that combine integrative business models and low-cost technologies to profitably meet the community's eye care needs, may be the most sustainable long-term approach to ameliorate URE, especially in low-resource settings.

Efficient screening

The rapid assessment of refractive error (RARE) is a minimally resource-intensive method designed by the W.H.O. to assess the magnitude of URE, eyeglasses coverage and barriers to

access of services. Another screening method is the rapid assessment of avoidable blindness (RAAB), a rapid population based survey to help monitor existing blindness intervention programs among people age 50 years and over. Information gleaned from RARE and RAAB are useful for designing and implementing refraction programs as well as for policy development. The Aravind Eye Hospitals has a community-based comprehensive eye care screening, using a sustainable pyramidal approach, to cover both urban and rural areas in need.(34) Similar outreach programs have been effective at L.V. Prasad.(35, 36)

Integrated care delivery

Most eye centers in the developing world do not have optical shops; when such shops exist, eyeglasses options are often limited. Reorganizing eye care to co-exist with its ancillary services may be a way forward. Screening, refraction, and dispensing of high quality, affordable eyeglasses, such as is done at a higher cost in US optical shops, could be integrated to better serve communities. In several hospitals in India and Africa, where the practice has been set up to enhance their dispensing services, the uptake of eyeglasses has improved dramatically across both urban and rural communities.(48) The Aravind outreach camps include refraction and on-site lens making equipment, and they dispense eyeglasses on site for almost 90% of the patients' served.(48) This high conversion rate demonstrates an example of a refractive service that is properly tailored to the community. However, this is one unique setting and needs to be replicated elsewhere. In several secondary hospitals and outpatient centers that have provided free or subsidized eye surgeries, the hospital's revenue from modestly priced eyeglasses may be close to 50%.(48)

Paraprofessional workforce

One method to improve delivery of refractive services and dispensing of eyeglasses is by enabling paraprofessionals. In some global programs, paraprofessionals, such as the mid-level ophthalmic providers at Aravind, are supervised by a certified eye care provider perform refraction and dispense eyeglasses. These paraprofessionals require training and continuing education (e.g. distance learning) to provide a high quality of services. Use of paraprofessionals may not be necessary in countries like the U.S. because optometric coverage is quite good for most patients, but many international communities may benefit from the expansion of the pool of quality services. Warby Parker, the eyeglasses website, and other eyeglasses makers have facilitated such collaborations between paraprofessionals and providers.(44)

Automated refraction

Prescribing eyeglasses requires travel to an eye care provider and the cost of the visit. Mastering retinoscopy training takes significant training. One alternative, is to use newer, validated auto-refractors, which would likely be effective for adult patients, but not young patients who require eye dilation.(37) The accuracy and reliability of auto-refractors is improving, but higher performing auto-refractors are still relatively expensive compared to retinoscopy. Self-refraction also shows promise with a study in rural China showing vision in the better eye with self-refraction versus subjective refraction were within one line on the eye chart of 98% of subjects.(38) The study postulated that self-refraction could reduce the burden on ancillary staff and reduce the use of expensive refractive equipment.(38) Non-

inferiority trials have shown that the QoL was no different for people wearing eyeglasses based on self-refraction versus from a standard refraction.(39) In the US, refraction services provided by a non-eye care provider has two main issues. First, some have argued that refraction done independently from an eye provider would mean some patients would never get a full eye examination. However, restricting refraction to those who can afford an eye provider visit means patients who cannot afford the eye exam have URE unnecessarily. Second, most state laws require that an ophthalmologist or optometrist prescribe eyeglasses. However, alternative models are being explored in the US. In the Veterans Administration program has developed a system that links patients and paraprofessionals with a remote eye provider who supervises the eyeglasses prescriptions. In this program, eyeglasses have a very low rate (0.59%) of being remade due to errors.(40)

Low-cost eyeglasses and frames

Correcting RE's including presbyopia with eyeglasses (reading glasses, contact lenses, bifocals, or progressive lenses) improves vision related-QoL.(18) The International Agency for the Prevention of Blindness' goal is for those with URE to own fashionable frames that costs \$2.(41) Low-cost eyeglasses and frames such as by Opternative, Warby Parker, and Vision Spring are emerging as online resources to purchase eyeglasses.(42–44) Ready-made spectacles (RMS) with on-site edging equipment are a low-cost alternative that can enable RMS to be dispensed immediately, if custom-made spectacles are not financially feasible. (45) In a prospective double-masked randomized trial with 363 adults aged between 18 and 45 years with 1 diopter of URE, RMS produced large improvements in their QoL and a similar degree of satisfaction with vision at the 1-month follow-ups.(46, 47)

Refractive surgery

Refractive surgery [Laser in Situ Keratomileusis (LASIK) and Photorefractive Keratectomy (PRK)] is an excellent and definitive surgical procedure for many people with REs. Published studies have shown that LASIK is an effective and predictable procedure for obtaining very good to excellent uncorrected visual acuity.(49) Surgical complications rarely occur.(50, 51) Not all patients qualify as candidates and screening protocols are well established.(52) The cost of LASIK varies from \$1500 to \$3000 per eye. The actual cost of the use of the laser per LASIK procedure is low, but the procedure requires significant surgeon and ancillary personnel time to complete the preoperative, surgical, and postoperative care. One method to permanently address RE would be to decrease the patient's costs for refractive surgery (by lower fees or insurance coverage) and obviate the need for eyeglasses. Using the estimates from Wittenborn and Rein (6) at \$87.7 billion in savings and an average cost of \$4500 per patient, 19.3 million bilateral refractive surgery procedures could be performed. Another strategy is to minimize RE at the time of cataract surgery for older adults.(53, 54)

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**of outstanding value

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SUMMARY

Our review identifies the significant health consequences of URE and the social determinants of health related to URE. Given the rising prevalence of URE,(55) due to the growing population and eye provider workforce limitations, the existing models for correcting RE must evolve to meet the increased manpower shortage.(56) While laboratory research is being conducted to prevent or minimize RE, key policy leaders should encourage novel population health approaches to understand the high prevalence of this disease and to manage it. The reports from the National Academy of Medicine and W.H.O. are significant steps towards highlighting the burden of visual disability, especially URE, in the context of health. The ultimate goal for treating and managing RE is a person should see clearly regardless of race, geography, or resources.

KEY POINTS

- URE is a leading cause of preventable blindness worldwide and is expected to double by 2050 in the US at a faster growth rate than the number of available eye care providers.
- URE is a major cause of global disability, drastically reducing productivity, and the quality of life of affected individuals.
- Social determinants of health influence the high prevalence of URE in certain communities.
- Sustainable future approaches to correcting RE will need to combine innovative and integrative business models with low-cost technologies.