Optimizing Screening for Preventable Blindness with Head-Mounted Visual Assessment Technology

Ethan Waisberg[1], Joshua Ong[2], Phani Paladugu[3], Nasif Zaman[4], Sharif Amit Kamran[4], Andrew G. Lee, MD[6-12] Alireza Tavakkoli, PhD[4]

[1] University College Dublin School of Medicine, Belfield, Dublin, Ireland
[2] University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, United States
[3] Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, United States
[4] Human-Machine Perception Laboratory, Department of Computer Science and Engineering, University of Nevada, Reno, Reno, Nevada, United States
[5] Center for Space Medicine, Baylor College of Medicine, Houston, Texas, United States
[6] Department of Ophthalmology, Blanton Eye Institute, Houston Methodist Hospital, Houston, Texas, United States
[7] The Houston Methodist Research Institute, Houston Methodist Hospital, Houston, Texas, United States
[8] Departments of Ophthalmology, Neurology, and Neurosurgery, Weill Cornell Medicine, New York, New York, United States
[9] Department of Ophthalmology, University of Texas Medical Branch, Galveston, Texas, United States
[10] University of Texas MD Anderson Cancer Center, Houston, Texas, United States
[11] Texas A&M College of Medicine, Texas, United States
[12] Department of Ophthalmology, The University of Iowa Hospitals and Clinics, Iowa City, Iowa, United States

Corresponding Author:
Ethan Waisberg
Email: ethan.waisberg@ucdconnect.ie
University College Dublin School of Medicine,
Belfield, Dublin 4, Ireland

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Age-related macular degeneration (AMD) is a leading cause of blindness and is diagnosed as early-stage or late-stage. Early-stage AMD is usually asymptomatic and entails pigmentary changes of the retina (Ayoub & Patel, 2009). As the disorder progresses, there are atrophic or neovascular changes that distort vision, especially the central visual field (Ayoub & Patel, 2009). There are several genetic and non-genetic risk factors for AMD and no proven therapy to slow or reverse late-stage atrophic AMD, while anti-VEGF has effectively treated late-stage neovascular AMD. Several genes of interest have also been investigated thoroughly thus far in their connection to AMD and the CFH and ARMS2 genes have shown promise in understanding the genetic basis of the disorder (Awh et al., 2013). There are other epigenetic and environmental factors as well including smoking and low antioxidant levels (Cano et al., 2010). Ongoing investigations include antioxidant supplementation and a smoking cessation regimen to reverse early-stage AMD (Cano et al., 2010). Progress in treating AMD as a disorder across its varied stages requires newer therapeutics along with a more detailed understanding of the genetic and cellular pathways of pathophysiology is needed to better counter this prevalent disorder of the eye.

Brown et al. recently showed that a significant portion of age-related macular degeneration (AMD) cases are going unreported in England (Brown et al., 2022). This conclusion was based off the steady decrease in AMD certification rates in England from 131.5 per 100,000 in 2010/2011 to 106.7 per 100,000 in 2017/2018, whereas in a country with an aging population the rate should have increased significantly (Brown et al., 2022). This study demonstrates how current screening programs for AMD can still be further optimized as seen in countries such as England with significant investments in ophthalmic services.-Early intervention can prevent sight

loss due to neovascular AMD (nAMD), with anti-VEGF injections allowing 90% of eyes to have a stabilized or improved visual acuity in over 1 year (Brown et al., 2022; Wecker et al., 2019).

With an increase in aging populations worldwide, screening and preventing avoidable blindness becomes even more of a challenge. Diagnosis and close monitoring of AMD is a time-consuming process, requiring trained experts, an ophthalmic examination, funduscopic evaluation, optical coherence tomography, and occasionally fluorescein angiography. Due to the requirement for frequent physical examinations for the detection, diagnosis and treatment of AMD, lower socioeconomic status individuals, those with fewer educational years achieved and those living in developing countries all had comparatively higher AMD burden (Xu et al., 2020).

Our group is currently developing a portable, head-mounted visual assessment system to closely assess astronaut vision during long-duration spaceflight (Ong et al., 2022). This technology offers portable capabilities and an automated system for detecting and quantifying metamorphopsia, two components that may help to increase screening rates for AMD, particularly in remote and underserved areas (Figure 1). Virtual reality (VR) has been successfully utilized with other visual function tests such as visual field perimetry for glaucoma, another cause of irreversible blindness, to increase accessibility and portability compared to gold-standard perimetry (Stapelfeldt et al., 2021). Thus, adding onto VR-based visual assessments allow for accessible and robust detection of various causes of preventable blindness. A common method used to detect late AMD are Paper-based Amsler grids (pooled sensitivity of 0.78 and pooled specificity of 0.97) (Faes et al., 2014). This technology for monitoring visual function in spaceflight may help to address longstanding barriers to screening for AMD terrestrially, especially in underserved communities. By utilizing portable, low-cost technology

that can quantify changes in metamorphopsia rather than self-reported changes in paper Amsler grids, subtle changes in macular function and health may be detected earlier with subsequent earlier intervention (Figure 2). To combat irreversible vision loss from AMD, our group is also actively developing a countermeasure to suppress monocular central visual distortion with a head-mounted wearable headset. Future directions of our work include using VR technology to screen for other leading preventable causes of blindness such as cataracts, which regularly goes undiagnosed in developing countries (Waisberg & Harvey, 2020). All things considered, with the increased usage of VR visual assessment monitoring technologies and the development of novel countermeasures, preventable blindness resulting from AMD can hopefully be significantly reduced in the near future.

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