Telemedicine diabetic retinopathy screening: rationale and practical considerations in mobile imaging with ultra-widefield photography

Jay M. Stewart[1,2], **Armin R. Afshar**[1,2]

[1]University of California, San Francisco, Department of Ophthalmology, San Francisco, CA, USA; [2]Zuckerberg San Francisco General Hospital and Trauma Center, Department of Ophthalmology, San Francisco, CA, USA

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Correspondence to: Jay M. Stewart, MD. Department of Ophthalmology, University of California, San Francisco, 490 Illinois Street, Floor 5, San Francisco, CA 94143, USA. Email: jay.stewart@ucsf.edu.

Abstract: Several factors drive the need for increased efficiency in telemedicine screening programs directed toward diabetic retinopathy: continually increasing prevalence of diabetes worldwide, growing awareness among physicians and patients of the importance of early detection of retinal damage, and emerging technology in artificial intelligence that enables rapid identification of vision-threatening fundus features. In this context, optimizing workflows in teleretinopathy programs becomes a priority. Recent work has revealed opportunities for improvement in areas of logistics, in particular in finding the best way to get diabetic patients in front of screening cameras as conveniently as possible, as this improves compliance and, ultimately, achieves the widest reach for detection programs. The present review discusses particular aspects of mobile screening programs in which specialized retinal cameras are deployed in a van or similar type of vehicle so that they can reach patients anywhere in order to reduce barriers to access. The rationale for implementing such programs and practical considerations are presented, along with a view toward future expansion of screening and integration with artificial intelligence platforms. Lacking standardization of format and quality control among smartphone-linked approaches at present, translation of eye clinic-based photographic techniques to community-based screening offers a means of expanding the scope of impactful screening programs without the need for adoption of significantly new technology.

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Introduction

Today's worldwide growth in diabetes presents a tremendous challenge for healthcare systems. Diabetes affects over 285 million people worldwide, and one-third have some form of diabetic retinopathy (DR) (1). DR can have a dramatic effect on quality of life, since patients have difficulty maintaining independence and the ability to care for themselves, struggle to read and operate a motor vehicle, and face increased nursing home admissions (2,3). As such, the stakes are high for identifying DR at its earliest stages in order to allow prompt intervention before adverse effects upon the vision can ensue (4). In this context, the use of artificial intelligence (AI) as a tool for screening retinal images for signs of DR offers promise to allow scalability and efficiency as clinicians and policymakers seek to expand screening programs to large populations. However, a screening program is only as effective as its ability to reach patients in need of the service and triage them according to their findings, referring the patients with disease to clinical centers for appropriate care. Therefore, it is critical to design systems that incorporate methods for maximizing the input for potential future AI screening—that is, systems that can obtain the greatest number of retinal images for a given amount of resource deployment.

Rationale for mobile screening

Telemedicine screening programs for DR, in which retinal images are acquired in one location and then reviewed and graded for retinopathy in another, have generally been utilized as a means of capitalizing on clinical encounters taking place in non-ophthalmic settings, such as primary care clinics (5). In such cases, patients visiting their physician for a health care maintenance visit or for a specific complaint can be encouraged to participate in a screening examination with little additional time spent, increasing the likelihood of recruitment. However, several practical considerations may limit the scalability of this approach. First, it requires that a camera or imaging device be deployed in each clinical setting to be used for screening, necessarily restricting the program expansion according to the availability of resources needed to acquire additional cameras. Second, the staff needed to operate the imaging device must be continually trained in its use and maintain standards that will allow ongoing acquisition of high-quality images so that the rate of ungradable photos remains low. [This limitation may be even more critical if images are to be screened by an AI-based system, since alterations in illumination, shadows, or pigment changes may impact the automated interpretation of an image (6)]. Because the staff in primary-care and other non-ophthalmic settings are generally focused on other clinical elements of a patient examination, not eye care and retinal photography as a matter of course, they may not have the same familiarity with quality-control issues in ophthalmic imaging that full-time ophthalmic staff might have. Therefore, some degree of ongoing training and engagement with expert ophthalmic staff will likely be necessary to ensure adequate continuity of service and establishment of reliable workflows for good ophthalmic image acquisition in a routine manner. This arrangement may divert resources and staff time in the coordinating ophthalmic center if remedial or repetitive training of non-ophthalmic staff becomes necessary.

As an alternative and likely more efficient use of resources from an overall healthcare system perspective, a mobile screening service entails deploying a camera or imaging device on a mobile platform such as a van, and then identifying geographical areas of highest need and delivering the van to those destinations so that the screening services can be performed (7). This arrangement offers several advantages. First, multiple sites can be served with a single camera. Second, the rotation of sites and camera time per site can be adjusted in real-time to meet the needs of patient volume and capabilities of each site to organize optimal scheduling of patient visits while the van is on site. Third, staffing of the camera, arguably the most technically demanding portion of the screening program, can be consolidated under the auspices of ophthalmic staff who rotate to the different sites in conjunction with the camera. Therefore, staff at the primary care clinics or other sites need only be charged with identifying patients in need of screening from within their own rosters. Finally, a mobile system allows the screening program to be expanded beyond primary care clinics and other traditional health care settings to other sites such as health fairs and community centers. This may facilitate screening of patients who would be less likely to attend an in-person screening session at a referral center or at a primary care office. In this way, a mobile system can concretely improve access to care for diverse populations. (It should be noted that smartphone-based imaging may offer the ideal mobile system for optimal scalability, but at present, challenges remain in obtaining standardized image quality, lighting, and field of view across devices and users.)

With these advantages, a mobile screening program can be relatively simple to scale up to provide services for larger geographical areas, with minimal additional expenditure of resources. The schedule for a single camera and van can be optimized to ensure full utilization throughout the week, with staff availability often being the limiting factor. If equipment is optimally and fully deployed, only then is serious consideration given to acquiring a second camera and van, doubling the capacity of the system.

Practical considerations

As mentioned above, some logistical aspects must be taken into consideration when establishing a mobile retinopathy screening program. Some facilitate the process, while others make it more difficult. In favor of the mobile program is staffing. In order to maintain smooth and efficient operations, both patient scheduling and the technical aspects of the screening encounter must be optimized. Dividing responsibility between a local staff who schedules patients and an ophthalmic staff who takes the photographs can enable both staff groups to work in their subject matter areas of greatest comfort and capability. Significant effort must be expended to identify and organize suitable screening candidates in order to make the most of the brief time during which the eye van is on site at the destination clinic for screening; that clinic's staff is in the best position to know their patients and the workflow challenges at their own center so that they can maximize the roster for each session. This also represents a challenge of the mobile program, however, since by contrast a fixed-location camera placed in a primary care clinic can allow screening to take place throughout the week without advance arrangement.

On the technical side, an ophthalmic center that plans to send one of its staff on a mobile screening rotation needs to have one or more staff dedicated and trained for this role. Staffing levels at the eye clinic must be adjusted accordingly to account for this technical staff being unavailable to provide routine patient care at the eye clinic center. To economize resources, it could be best if the technical staff also drives the van so that a separate driver is not needed. However, this particular responsibility could be a limitation that would make the role less suitable or appealing for some eye clinic staff.

Ophthalmic imaging devices are not generally manufactured to specifications accounting for the "wear and tear" that comes with daily transport on a van. As such, special preparation of the van may be required to reduce transmission of shocks and bumps to the camera. This can entail modification of the vehicle's suspension as well as creating a special mount to ensure the camera's positioning and stability within the van (7). In addition, despite these precautionary measures, there may be an ongoing risk of damage to the device that could impact its warranty or insurance coverage. Advance notice to the manufacturer or insurer about the camera's intended use can help expedite repairs in the event damage occurs.

A key component of the retinopathy screening program is prompt review of retinal images by qualified graders. This depends upon an infrastructure allowing digital transmission of retinal images, which are often large files, back to the reading center. Whereas with a fixed-location camera, this may not require special arrangement, since high-capacity connections would likely be hard-wired in any such clinical setting, a mobile program requires special attention to this detail. A mobile van can transmit images if it can tap into a wireless internet connection at its destinations, but this is often impractical because the parking location of the van is not close enough to the building to allow the wireless signal to reach. As an alternative, a cellular-based internet adaptor can make it possible to connect with the reading center. Finally, another option is delayed transport of the files using an external storage drive that can be brought to the reading center in person. This avoids the need for an internet connection to the van, but it introduces the risk that photos could be lost if technical problems arise with the storage unit before the files reach the reading center.

Future possibilities

As diabetic retinopathy screening programs mature, they may start to incorporate additional ophthalmic devices beyond color photography. Optical coherence tomography angiography (8,9), visual field analysis (10), and dark adaptometry (11), and other technology could be incorporated into a comprehensive method for detecting early diabetic eye disease. Therefore, it may become all the more useful for ophthalmic tests to be consolidated in a mobile platform so that a single device of each type can be sufficient to serve a population within a given geographical area. While home-based self-evaluation with personal devices may become a possible means of achieving DR screening in the future, in the meantime achieving efficiency and scalability through a mobile, van-based system may offer the best means of obtaining the largest amount of screening images and data in the shortest amount of time. This ultimately will make the best use of grading systems that rely upon AI technology and are not practically limited in their capacity and bandwidth.

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References

1. Ding J, Wong TY. Current epidemiology of diabetic retinopathy and diabetic macular edema. Curr Diab Rep 2012;12:346-54.
2. Fenwick EK, Pesudovs K, Khadka J, et al. The impact of diabetic retinopathy on quality of life: qualitative findings from an item bank development project. Qual Life Res 2012;21:1771-82.
3. Eichenbaum JW, Burton WB, Eichenbaum GM, et al. The prevalence of eye disease in nursing home and non-nursing home geriatric populations. Arch Gerontol Geriatr 1999;28:191-204.
4. Vashist P, Singh S, Gupta N, et al. Role of early screening for diabetic retinopathy in patients with diabetes mellitus: an overview. Indian J Community Med 2011;36:247-52.
5. Daskivich LP, Vasquez C, Martinez C, et al. Implementation and Evaluation of a Large-Scale Teleretinal Diabetic Retinopathy Screening Program in the Los Angeles County Department of Health Services. JAMA Intern Med 2017;177:642-9.
6. Wang YL, Yang JY, Yang JY, et al. Progress of artificial intelligence in diabetic retinopathy screening. Diabetes Metab Res Rev 2021;37:e3414.
7. Afshar AR, Oldenburg CE, Stewart JM. A Novel Hybrid Fixed and Mobile Ultra-Widefield Imaging Program for Diabetic Teleretinopathy Screening. Ophthalmol Retina 2019;3:576-9.
8. Sousa DC, Leal I, Moreira S, et al. Optical coherence tomography angiography study of the retinal vascular plexuses in type 1 diabetes without retinopathy. Eye 2020;34:307-11.
9. Laotaweerungsawat S, Psaras C, Liu X, et al. OCT Angiography Assessment of Retinal Microvascular Changes in Diabetic Eyes in an Urban Safety-Net Hospital. Ophthalmol Retina 2020;4:425-32.
10. Bao YK, Yan Y, Gordon M, et al. Visual Field Loss in Patients With Diabetes in the Absence of Clinically-Detectable Vascular Retinopathy in a Nationally Representative Survey. Invest Ophthalmol Vis Sci 2019;60:4711-6.
11. Hsiao CC, Hsu HM, Yang CM, et al. Correlation of retinal vascular perfusion density with dark adaptation in diabetic retinopathy. Graefes Arch Clin Exp Ophthalmol 2019;257:1401-10.

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