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ORIGINAL ARTICLE

Vision Stations: Addressing Corrective Vision Needs With Low-cost Technologies

视力站：使用低成本技术来解决视力矫正需要

Estaciones de la vista: afrontar las necesidades de corrección de la vista con tecnologías de bajo coste

Stephen A. Martin, MD, EdM, *United States*; Elizabeth A. Frutiger, MD, *United States*

ABSTRACT

Eyeglasses, required for functional vision by nearly half the world's population, are still needed by more than a billion people. There are a number of constraints on the provision of eyeglasses: product cost, durability, and appearance; traditional approaches to evaluating refraction; and sustainably scaling potential distribution methods. We offer our experience with an immigrant population in a US urban setting using a "Vision Station." The station allowed for immediate provision of adjustable glasses using self-refraction, ordering of custom lenses from a low-cost website, and referral to primary and eye care physicians for those with medical eye concerns. As with models in development by other groups, Vision Stations connect people with the life-changing provision of functional vision.

摘要

世界上近半人士需要眼镜来获得功能性视力，有超过十亿人需要佩戴眼镜。佩戴眼镜有以下几个局限：产品成本、耐用性以及外观；量度屈光度的传统方式；以及可持久地剥离分配法。我们介绍在美国某城市移民人口中设立视力性和成本效益。在此站，您可以以自行屈光的方式马上获得可调式眼镜，也可从廉价网站订购镜片，以及如果需要医生，这里可以推介您到医生和眼科护理医生处。与其他团体开发的模式一道，视力站将大家联系到一起，为大家提供功能性视力，改变人的一生。

SINOPSIS

Las gafas, requeridas para una visión funcional por casi la mitad de la población mundial, siguen siendo necesarias para más de 1000 millones de personas. Existen numerosas limi-

taciones para la provisión de gafas: el coste del producto, la durabilidad y el aspecto; los enfoques tradicionales para evaluar la refracción; y la modificación de manera sostenible de la escala de los métodos de distribución potenciales. Ofrecemos nuestra experiencia con una población inmigrante en un emplazamiento urbano de los EE. UU. usando una "Estación de la vista". La estación permitía suministrar de manera inmediata gafas ajustables usando autorrefracción, encargar lentes personalizadas desde una página web de bajo coste y referir a médicos de atención primaria y oftalmólogos aquellos pacientes con problemas médicos oculares. Al igual que con modelos en desarrollo de otros grupos, las Estaciones de la vista conectan a personas con la provisión de una visión funcional, algo que puede suponer un cambio en sus vidas.

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INTRODUCTION

Use of optical lenses has been described as "the largest onetime IQ boost in human history" and rated the fifth most important invention since the wheel.¹ Technology for glasses has not changed significantly during the past 800 years. But eyeglasses remain too expensive for many due, in part, to an industry that

has been observed to be "ripping consumers off for decades."² A recent survey of American eyeglass retailers found prices ranging from \$171 to \$300 for those with little or no insurance coverage; this does not include the additional cost of an exam with refraction.³ Surveys of both children⁴ and adults⁵ have found cost to be the major reason for not obtaining eyeglasses.

A growing unmet need persists for those who require visual correction due to reasons of poverty, inaccessibility, or lack of knowledge of available options. Globally, the number of people who have refractive error but do not yet have correction has been estimated at over 1 billion.^{6,7} This need occurs even in wealthy countries such as the United States. A 2008 study found that half of the US population 20 years or older has clinically important refractive error.⁸ In 2006, at least 11 million people in America had unaddressed visual acuity needs⁹ as demonstrated in a recent documentary.¹⁰ The World Health

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Disclosures

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Organization defines impairment as visual acuity of 6/18 (United Kingdom), 20/63 (United States) or worse in the better eye.¹¹ A more functional threshold would be 6/12 (United Kingdom) or 20/40 (United States), which is used for driving examinations.⁷ Interestingly, as noted in a recent review,¹² trials in India have not found refractive cut-offs useful as exclusionary criteria for dispensing glasses.

Determination of need does not mean that need is met. Even when children have their vision screened in schools and primary care, there is a lack of successful follow-up to obtaining eyewear.^{13,14} In addition to expected reductions in school¹⁵ and work performance, decreased visual acuity is associated with outright mortality. Over an 8-year period, noninstitutionalized US adults aged 65 to 84 with decreasing visual acuity had a 78% increased risk of death compared with their normal-sighted counterparts.¹⁶

Multiple hurdles exist for low-income patients who lack insurance coverage to obtain glasses, including lack of access to affordable, nearby optometric care and lack of financial means to pay for glasses once a prescription is obtained.¹⁷ For those who have been able to obtain glasses, a broken pair or a change in prescription can mean that glasses become unusable.

This lack of availability in the 21st century is a tragedy, but it is becoming a resolvable one. We offer our experience with “Vision Stations” that are potentially scalable and adaptable to other countries and financial models. In their own way, these stations represent how the benefit of technology, material, and information advancements can be brought to those who need them most.

Technical Advancements

Centuries of stable glasses design have recently been upended.¹⁸ Variable-focus eyeglasses were first brought into production in 1996 using a fluid-filled lens.¹⁹⁻²¹ This method, developed by Joshua Silver of Oxford University, uses fluid to change the shape of a lens in order to achieve different levels of refraction (Figure 1). An alternative, developed by Nobel laureate Luis Alvarez in 1962,²² slides 2 lenses of complementary shapes alongside each other. Advances in injection molding have more recently allowed production of this approach in a polycarbonate gliding lens (Figure 2). This design was developed at the VU Medical University of Amsterdam in 2004 in collaboration with the d.o.b. Foundation. In 2010, the technology was acquired by Adaptive Eyewear (<http://www.adaptive-eyewear.org/>) for broader dissemination. Whether fluid-filled or Alvarez in design, these lenses are able to fully address approximately 90% of all refractive error. The remaining 10% have astigmatism severe enough that it cannot be addressed by the spherical default of the adjustable glasses. These people still obtain benefit, just not as completely. In a study of Chinese schoolchildren, for example, 96% were able to improve vision to 6/7.5 (comparable to 25/20 in the United States) via self-refraction with adjustable glasses.²³ Accompanying these material advancements has been research validating self-refraction with adjustable spectacles in both children and adults in developed and developing countries.²³⁻²⁵ In essence, most people who need glasses can successfully adjust their own pair.



Figure 1 Fluid-filled adjustable glasses (shown with removable adjusters) (<http://perma.cc/AAU2-E8DP>).



Figure 2 Adlens Emergensee (Alvarez Design) (<http://perma.cc/33VP-EU7E>).

METHODS

Portland, the largest city in Maine, has seen growth in population at all income levels in recent years. Financial, healthcare, and housing assistance from city, state, and nonprofit organizations to immigrants—as well as job and educational opportunities—are more available in Portland than in other parts of the state. In recent decades, the city has seen an influx of asylum-seeking refugees from Somalia, Rwanda, Burundi, Iraq, Sudan, Angola, and Congo, among other places. New asylum-seekers are not eligible to apply for work permits or receive Medicaid health insurance on immediate arrival. Lack of income and lack of insurance makes it virtually impossible for many new immigrants to afford an optometric evaluation and glasses. In other cases, they may have coverage for an eye evaluation and glasses prescription but not for the cost of the glasses themselves.

New immigrants are often eager to learn English and start new independent lives (in keeping with the city motto of Portland, *Resurgam*, Latin for “Again I rise”). Venues for English education in Portland are well known to many new immigrants. The inability to see in class or read due to refractive error, however, makes it difficult for them to succeed in their ambitious efforts to learn English and other skills.

For these reasons, a vision improvement effort is underway in the Greater Portland area. This effort, the Vision Initiative Project (VIP), is a collaboration of the Greater Portland Refugee and Immigrant Healthcare Collaborative, the Cumberland County District Public Health Department, the University of New England CHANNELS program, the Portland Community Health Center (PCHC), and Adlens, a maker of adjustable eyewear. The collaboration developed the concept of “Vision Stations” that could be offered at health outreach events. Our planning began in April 2014.

The intent of these stations was threefold: (1) connect patients with imperfect vision to prescription eyewear or adjustable eyewear; (2) connect patients with medical eye complaints to primary care, if not

already connected; and (3) gather information from patients about vision and eye care needs to inform expansion of access to vision care.

Patients who came to the Vision Station were asked how they needed help with vision and eye care. They were then directed toward 1 of 3 pathways within the vision station:

1. Patients with eye complaints that may be medical (eg, eye pain, eye discharge, varying vision) were directed to a station where PCHC and other event staff assessed insurance status and helped start patient enrollment at the health center.
2. Patients with paper prescriptions for glasses but no insurance coverage for obtaining them were assisted by community health outreach workers (CHOWs) with pre-paid credit cards to order glasses online from Zenni Optical (www.zenni-optical.com, Novato, California), which offers a large selection of glasses for less than \$20 to those who have prescriptions and a credit card. The glasses arrived within 6 weeks. (Zenni has since reported improving turnaround to 2-3 weeks with standard shipping.)
3. Patients who thought glasses might benefit them underwent distance vision screening with the Snellen test. All were offered free adjustable glasses and taught how to adjust them by CHOWs and staff from Adlens, University of New England, and PCHC, regardless of initial Snellen test screening.

Patients who received adjustable glasses were asked 2 questions to help inform us of the impact of the stations: (1) What will having glasses mean to you? and (2) How will they help you the most?

The first Vision Station was part of “Health on the Move,” an outreach program sponsored by the city of Portland. In July 2014, a Health on the Move event took place at the Portland Center for Adult Education on the same day as graduation from the spring term of English as a Second Language (ESL) class. This event

also included blood pressure screening by PCHC staff and opportunities for patients to be referred to sliding-scale or free primary care and dental care and low-cost insurance providers. Other educational stations included nutrition, pharmacy, library, and state agency providers. This 2-hour event was staffed by language-concordant CHOWs translating French, Arabic, Somali, and other languages for patients. Staff from Cumberland County, University of New England, PCHC, Maine Access Immigrant Network, and Adlens, as well as volunteers, helped guide patients to various stations and address their needs. The Vision Station consisted of 2 classrooms within the Portland Center for Adult Education: 1 room contained 2 Snellen testing stations, and the other room contained tables for adjustable glasses fitting (Table).

RESULTS

Event planners anticipated 50 attendees; the actual number of attendees was approximately 140. One hundred twenty Adlens adjustable glasses were provided (both fluid-filled and Alvarez). Because of the unexpectedly large number of attendees, not all attendees were able to be helped at the Vision Station at this initial event. A repeat Vision Station was organized in the same location by VIP stakeholders to accommodate attendees who were unable to be helped at the initial event. This “overflow” event was attended by at least 66 patients, and 34 additional Adlens adjustable glasses were distributed.

A total of 147 participants underwent distance Snellen testing. Based on the best performing eye, 47 (32.0%) had a visual acuity $\leq 20/20$; 85 (57.8%) had a visual acuity between 20/30 and 20/60; 13 (8.8%) had a visual acuity between 20/70 and 20/160; and 2 (1.4%) had a visual acuity $\geq 20/200$. We used criteria for glasses provision to be either visual acuity $\geq 20/40$ or self-report of improved vision using the adjustable glasses.

At the first event, a total of 31 attendees were seen at the Primary Care Station. These patients may have had complaints about eye symptoms other than visual acuity problems; however, our survey did not provide

space to record eye complaints other than Snellen testing results. Of the 81 attendees for whom Snellen test results were recorded at the first event, 41 (50%) remarked on surveys that they hoped that glasses would help them to read. Thirteen (16%) remarked that they hoped glasses would help them write. Six (7%) remarked that they hoped glasses would help them drive. Other hopes for glasses with fewer responses included improved safety, watching television, using computers, and cooking.

DISCUSSION

By developing a new model for glasses provision—the Vision Station—we have found a potentially replicable way to address refractive error that is an alternative to medical/optical insurance and visits. Our Vision Stations demonstrated both a substantial need for glasses among this population and a practical model for providing them. It has been gratifying to hear from those receiving glasses that they are now able to succeed in school, pass driving tests, and improve their employment. They are glad to increase independence and improve their quality of life.

It is clear from the number of attendees at this event that immigrant patients may be at high risk for suffering from lack of vision care; the authors of this paper see this need daily in their primary care clinics among low-income immigrants and citizens. In a busy primary care clinic practice, providers find themselves unable to consistently assess patients' vision needs and help them access free, timely, and accessible optometry and optician appointments. This vision outreach event demonstrated well that adjustable glasses can be a fast, safe, low-cost, and attractive solution for those with refractive error and can be distributed by those who are not medical providers or opticians.

PCHC is developing a protocol to allow medical assistants, nurses, social workers, and CHOWs to give adjustable glasses to patients who report decreased vision without having to have a medical or optometric provider initiate this process. A subsequent

Table Vision Station Materials

Item	Use	Comments	Retail Cost	Website
Tape measure and Snellen or Tumbling E eye charts	For self-refraction			
Mirror	For people to evaluate glasses			
Information on primary and dental care	Referrals for those with medical eye complaints			
Internet access via smartphone, tablet, or laptop	For online purchase of glasses from Zenni Optical, Novato, CA	Would likely use existing capabilities	Varies	
Adlens Hemisphere	Fluid-filled adjustable glasses	Refraction from $-4.5D$ to $+3.5D$ diopters	\$39.98	https://www.adlens.com
Adlens Emergensee/Adjustables	Alvarez sliding lens adjustable glasses	Refraction from $-6D$ to $+3D$ diopters	\$29.99	https://www.adlens.com
Pre-paid credit card	For online purchase of Zenni glasses	For people with existing optical prescriptions	<\$20 for each purchase	http://www.zennioptical.com

Health on the Move event in January 2015 in the neighboring city of Westbrook, Maine, shared this technology with patients as well as law enforcement officers and hospital volunteers. These groups see a need for adjustable glasses for those dealing with health or safety crises who may be displaced from home unexpectedly and find themselves without prescription eyewear. Variations of this community-based, patient-centered approach are beginning to be successfully used in settings as diverse as Peruvian health clinics, substance abuse programs, emergency departments, correctional facilities, and elementary schools. One could easily imagine a spectrum of distribution sites that both provide needed glasses and triage other forms of visual impairment to primary care.

We did experience a number of barriers to our approach and learned ways to improve our process (Box 1). First, adjustable glasses and self-refraction is a substantially different model than the traditional approach. This contrast had us somewhat overthink the process rather than trust in its decentralized potential; perhaps this is a similar feeling to clinicians when home glucose or pregnancy testing was first made available. Second, effectively reaching those in need meant developing new partnerships—with universities, advocates, government, public health, and others—that may not generally exist in

primary care. Third, finding venues, events, and means of engaging those in need was an initial barrier made much easier with our new partnerships. Last, developing our own set of clear instructions for self-refraction was challenging; we have since found helpful examples.^{26,27} These barriers would need to be mitigated when implementing Vision Stations on a larger scale and internationally.

In summary, there is now have a historic confluence of affordable hardware (adjustable glasses, diagnostic tools) and software (websites, payment models) (Box 2). To make them work, funding, human logistics and caring are needed. The new glasses technology described here require substantially less financial investment than traditional approaches. In recognizing the key element of direct and immediate glasses provision, the benefits of self-refraction, and the potential of nonprofessional team members, our model is similar in spirit to other approaches.^{12,28,29} The impact is also similar: rapid improvement in people's ability to achieve their goals and improved quality of life.

Technology and cost considerations will continue to improve and allow solutions for the worldwide crisis of impaired vision due to refraction. However, high-value products are of little use if people do not obtain them or do not use them. Scaling the distribution and uptake of life-changing glasses requires additional skill sets and deliberate attention to considerations of culture, stigma, belief, and appearance. Others are engaged in this key work.^{17,30} Nearly a millennium after the invention of eyeglasses, the limitations of acquiring them are more logistical than financial. With human capital, organization, and a modicum of funding, glasses can be within reach for all who need them.

Box 1 Barriers, Planned Changes, and Scaling Considerations

Barriers

1. "Overthinking" the process
2. Developing initial partnerships
3. Venue and means to engage those in need
4. Clear instructions for self-refraction

Planned Changes

1. More deliberate training on fitting glasses
2. Consider performing visual acuity after (not before) self-refraction
3. Basic video or print instructions for self-refraction in large print and multiple languages (eg, <http://perma.cc/AAU2-E8DP>)
4. Could include automated refraction to allow ordering of specific prescription lenses and frames

Scaling Considerations

1. Funding for prepaid credit cards
2. Web access
3. Shipping addresses for those in transitory housing.
4. Zenni Optical offers standard international shipping for \$9.95 with delivery times varying by country
5. Adjustable glasses may be too large for some children
6. Addressing vision loss due to other reasons than refraction error: eg, severe astigmatism, glaucoma, retinal disease, cataracts

Box 2 Examples of Emerging Low-cost Vision Technologies and Dissemination

Vision for a Nation & Adlens – Adjustable Glasses

<http://perma.cc/AL7U-TU3N>
<http://perma.cc/BW6M-RTT7>

Child Vision

<http://perma.cc/U4TN-UCV9>

Focus on Vision

<http://perma.cc/GJ8M-UHC7>

Eyenetra Smartphone Refraction Measurement

<http://perma.cc/RHU5-D8QZ>
<http://perma.cc/8X2K-M28K>

Peek Vision Smartphone Retinal Camera – London School of Hygiene and Tropical Medicine

<http://perma.cc/Y9GR-JEFY>

i-Optics EasyScan – Nondilated Retinal Camera

<http://perma.cc/RU4W-Y2KH>

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IMAGES OF HEALING, POETRY INVITED

The editors of *Global Advances in Health and Medicine (GAHJM)* invite you to submit images and poetry that evoke powerful feelings and stories of healing.

Images of healing can be in the form of still photos, video (posted on www.gahmj.com), or art (music, paintings, etc). A description of the image or source may also accompany the photo.

For an example of what we have in mind, please see the image above and pages 23 and 24 of this issue.

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