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Factors related to training time and achieving proficiency with visual-assistive mobile applications in visually impaired older adults

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SIGNIFICANCE: A majority of visually impaired older adults were able to learn to proficiently use visual-assistive iPhone applications (apps) following a median 1 hour and/or multiple training sessions, which should be considered when planning vision rehabilitation service delivery, including the option for remote telerehabilitation for those who prefer that modality.

PURPOSE: Older adults with low vision are increasingly using technology to improve their visual functioning. We examined whether age-related comorbidities were potential barriers to success in learning to use visual-assistive apps on a smartphone.

METHODS: A clinical trial assessed visual-assistive apps in 116 older adults aged 55+ years (mean [standard deviation], 72 [10] years). Subjects were randomized to use an app (SuperVision+, Seeing AI, or Aira) preloaded to a loaner iPhone and completed one-on-one training. App proficiency was measured by the participant's ability to use the iPhone/app without cueing at the end of training sessions. Training time was recorded for the initial session and totaled after subsequent sessions. Multiple regression models explored significant factors associated with training time and proficiency.

RESULTS: Median initial and total training times were 45 and 60 minutes, respectively. Increased initial and total training times were both significantly related to increased age (p<0.001), legal blindness (p<0.007), Seeing AI versus SuperVision+ app (p<0.03), and participants from New England versus California (p<0.001). Most (71%) achieved proficiency after the initial training session; those odds were significantly greater among younger participants (p=0.04), those who opted for telerehabilitation (p=0.03), those who had higher cognitive scores (p=0.04), or those who were from New England (p=0.04). The majority (90%) was ultimately proficient with the app; those odds were significantly greater among participants who already had an optical magnifier (p=0.008), but were unrelated to other factors including study site.

CONCLUSIONS: Following multiple, extensive training sessions, age, mild cognitive loss, or level of visual impairment did not preclude gaining proficiency with visual-assistive apps by visually impaired seniors, but those factors were associated with longer training times. Telerehabilitation can be a viable option to provide app training remotely for visually impaired seniors who choose that modality.

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Smartphone technology has become indelible in our society for a wide range of tasks, many of which utilize mobile applications (apps). There is limited research on the impact of vision impairment in the use of mobile app technology, especially in older adults as most previous studies have focused on younger individuals.[1–4] These studies showed good usability and effectiveness of apps as low vision aids for a variety of tasks including reading. Systematic reviews by Al-Razgan et al.[5] and Tan et al.[6] explored a large number of studies on assistive technology. In addition, a recent review[7] of all smartphone apps for low vision has identified key gaps in the existing literature. In particular, there is a gap in scientific study of the apps and a reliance on surveys and qualitative data.[7]

The prevalence of low vision is increasing exponentially as the population ages,[8] which highlights the importance of studying whether visual-assistive technologies on mobile devices can be utilized specifically by seniors. A recent systematic review has shown that some assistive technologies (i.e., apps for disease management) can be effective in older adults,[9] although there are still questions about the feasibility across the geriatric population. Additionally, this review included only one study specific to vision impairment. According to a survey of our US-based patients, ~90% of adults with low vision have a smartphone,[10] and there is a wide range of ways in which they are utilized. Some older adults limit usage to calls and texts, whereas others access online web content, email, and apps. Even among those who use mobile apps, a vast majority of older adults with low vision were unaware that there were apps available to help provide visual assistance.[10]

Some people with vision impairment will utilize their smartphones as a type of visual-assistive device, by using either the built-in magnifier accessibility feature or the smartphone camera to read hard copy materials. Additional options include numerous smartphone apps that are available for iOS and the Android operating system, which are specifically designed to be used by people with vision impairment. Some apps will allow the user to use the smartphone as a digital magnifier, others provide text-to-speech output (optical character recognition) or can identify objects or people, whereas other apps can connect the visually impaired user to a sighted agent who uses the smartphone camera to provide assistance with any visual task. In a randomized clinical trial (Community Access for Remote Eyesight [CARE]), we assessed one app

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in each of these three major categories of visually assistive apps (i.e., magnification, optical character recognition, and remote human assistance) in visually impaired older adults.

It is important for vision rehabilitation providers to give information regarding visual-assistive apps to overcome patients' lack of awareness. Some patients are aware of visual-assistive apps but have not implemented their use due to lack of training. Therefore, beyond providing the names and descriptions of possible visual-assistive apps, it is important to determine the amount of training and support that is required for patients to become proficient with such apps, especially for older adults who are first learning them because age-related comorbidities may be potential limitations. Based on our previous focus groups with visually impaired seniors who tried the apps for the first time, we found that they would require more than just a brief ~10- to 15-minute training session (Ross N, et al. IOVS 2021;62: ARVO E-Abstract 3570). A successful training program would enable patients to use the app independently and proficiently for tasks without cueing guidance and become familiar with the app features.

One goal of the CARE trial was to evaluate the amount of training, considering both the total duration and number of sessions, required for older adults with low vision to achieve proficiency with visual-assistive mobile apps. We hypothesized that it would be possible for the vast majority to become proficient with sufficient time and multiple training sessions. We also anticipated that older participants with mild cognitive impairment and severe vision loss may require more time and sessions to gain proficiency. Therefore, we developed a protocol to provide comprehensive training sessions with multiple follow-ups over a period of a month. This training was customizable to participants' unique needs and preferences but covered the same specific content areas across all participants. Some participants benefited from the use of their habitual visual-assistive equipment for the training. Additionally, customization for only a few participants included adding bump dots, activating Siri, and/or the use of VoiceOver. A better understanding of which patients are suitable candidates to learn visual-assistive apps and the requisite amount of training will be valuable to allow vision rehabilitation providers to plan accordingly.

METHODS

The multicenter protocol was approved by the institutional review board at the University of California, Los Angeles (UCLA), and followed the tenets of the Declaration of Helsinki. All participants provided written informed consent in-person or oral informed consent by phone, obtained by the study coordinator at the site where they enrolled, either UCLA or the New England College of Optometry (NECO). UCLA enrolled participants from the state of California (n = 38; 33%), and NECO enrolled participants from the New England region, which included Massachusetts, Rhode Island, Connecticut, and New Hampshire (n = 78; 67%). The study protocol was preregistered on ClinicalTrials.gov (identifier NCT04926974) prior to enrolling the first participant.

Participants were English-speaking older adults aged 55+ years with Best-Corrected Visual Acuity worse than 0.28 logMAR, an established history of ocular disease, and no greater than mild cognitive impairment (scores 20+ on the modified Telephone Interview for Cognitive Impairment [TICS-M] to exclude those with moderate to severe cognitive loss). There were no participants disqualified based on their TICS score. All participants had an ocular or low vision exam within 12 months. The majority of participants had previously received low vision rehabilitation services (~98%). A total of 116 participants were randomized to one of three visual-assistive apps: SuperVision+ magnifier (n = 40; 35%), Seeing AI (n = 43; 37%) for optical character recognition, or Aira (n = 33; 29%) for remote human assistance. Each of these apps is available for free (or with a free version) from the iPhone App Store. Participants who had received low vision rehabilitation services with an optometrist were allowed to continue to use their low vision device or aid (e.g., optical or electronic magnification device, or telescope), but were excluded if they had previously used any of the three study apps.

We conducted a minimal-risk randomized clinical trial with 1:1:1 allocation to one of the three study apps. Randomization was administered on an individual basis rather than to groups. Randomization procedures attempted to balance two potentially important covariates: participating site and visual impairment group (i.e., 0.28 to 0.99 logMAR, 1.0 to 1.6 logMAR, or legally blind due to visual field constriction <20°). The principal investigator at each site (AKB at UCLA and NCR at NECO) created a unique randomization scheme using an online application tool (https://clinicalresearch-apps.shinyapps.io/rrapp/) for the other site that involved blocking (sizes of 4 and 6) with stratification by visual impairment group. The principal investigators and assigned study coordinator at NECO, who was not involved with the training of participants, maintained sole access to the randomization schemes and provided randomization assignments to the study team at the other site after participants completed the enrollment process and baseline assessment.

Training setting was not randomized, which allowed participants to receive app training either virtually via telerehabilitation (n = 25; 22%) or in-person at our research centers (n = 91; 78%) as per their preference. The vast majority (n = 104; 90%) was already using a smartphone of their own at the time of study enrollment but still used a loaner phone for the duration of the study. Some (20%) of the participants (n = 23) used their own phone throughout the study. At the time of the study, the Seeing AI app was available only for iPhones; therefore, to accommodate participants who had Android phones or no smartphone, we provided loaner iPhones (model SE [60% of subjects], model 11, or model 12) that were limited to the use of the study app only (no calls or web-browser access).

Study team members used a large instructional guide detailing the features of the smartphone app for which training was provided to ensure consistency across trainers and sites; however, training was customized to each patient's needs to ensure complete understanding of app use to promote proficiency. Additionally, participants were provided with this large-print instructional guide on how to use the smartphone and the app to use at home after the training, which was the same guide used by the trainers. Accessibility settings were enhanced for the participants' benefit, including increasing text size, increasing contrast, enabling zoomed view, and turning on button labels. Participants who indicated difficulty visualizing either smartphone controls or the app itself were given the option to utilize tactile markings (i.e., two subjects used bump dots on the phone). If the participants were already existing speak-screen or voiceover users, they were given the option to utilize this accessibility tool (three participants opted to use this feature). However, explicit training on these approaches was not provided. For those interested in using Siri, training was provided on opening a smartphone app using Siri dictation (one participant used this feature). The session was determined to be complete once all aspects of the training handout had been explained, and the participant had ample opportunity to practice and ask questions. We planned to allot up to 2 hours per training session, with a rare participant exceeding this time frame.

Proficiency was assessed by the study team member(s) who performed the training, which included trained optometry student research assistants, low vision optometrists, and clinical support staff. Participants were rated on their ability to perform the following tasks: identifying the power and home buttons on the phone, connecting the charging cord to the phone, identifying and opening the study app, performing a near task with the app, and describing two additional features (e.g., beyond magnification) of the study app. At the end of the training session, if the participant could perform all of the above tasks without cueing, they were categorized as

proficient. The initial training time was recorded for the first session, and total training time included the duration across multiple sessions to gain proficiency. All participants were contacted 2 weeks after their initial training to reassess proficiency through a phone call repeating the proficiency questionnaire. Those who were not proficient received additional training and a follow-up assessment after another 2 weeks. If participants did not achieve proficiency by the end of this third training session at 1 month, they were not able to continue in the study.

Participants who received telerehabilitation training completed a satisfaction survey to give feedback on the session using multiple-choice rating scales. All surveys were administered to participants by research assistants at NECO or UCLA who were not involved in the telerehabilitation session, but later called the participant by phone within 1 week following the session. The majority of the participants who had telerehabilitation (88%; n = 22 of 25) completed the survey.

Data analysis

Descriptive statistics summarized the baseline data and findings. Multiple linear regression models evaluated whether there were any significant factors related to the duration of training time for the initial session or the total amount of time across all sessions. Multiple logistic regressions evaluated whether there were any significant factors related to the odds of proficiency with the app at the end of the initial training session or the last follow-up (i.e., eventual proficiency). The factors included in the regression models were related to demographics, visual status, technology, or age-related comorbidities that we hypothesized could be related to training time and/or app proficiency. Multicollinearity among variables in the regression models was explored using the variance inflation factor statistic. For the multiple linear regression on training time, with our sample size of 116, we had power of 1.0 to detect significance of all of the coefficients in our model given the R^2 values that we obtained (0.41 and 0.39, for initial and total time, respectively). Our sample size had power of greater than 0.9 to detect significance of all covariates in our multiple linear regression if it had an R^2 value of >0.19 and our R^2 values exceeded 0.19 by more than double. Data were analyzed using Stata/IC version 15.1 (Stata Corp., College Station, TX) and IBM SPSS Statistics v29 (IBM Corp., Armonk, NY).

RESULTS

For a total of 116 participants, the mean and median age was 72 years (standard deviation [SD], 10; range, 55 to 93 years), and 53% were women. The majority of participants (n = 83; 72%) identified as non-Hispanic White. Thirty-nine percent of participants (n = 45) were legally blind due to either reduced visual acuity >1.0 logMAR or constricted visual fields <20°. Participants' mean total TICS score was 37.6 (SD, 5; range, 23 to 50). Participants' ocular diagnoses included age-related macular degeneration (n = 40; 35%), glaucoma (n = 22; 19%), inherited retinal degenerations (n = 13; 11%), optic neuropathies or optic atrophies (n = 11; 10%), diabetic retinopathy (n = 4; 4%), and other retinal conditions (n = 26; 22%), for example, albinism, retinopathy of prematurity, myopic degeneration, chorioretinal scars, or retinal detachment. For other traditional low vision aids that were used by participants during the trial, 17% (n = 20) did not have another aid, half (50%; n = 58) had an optical magnifier for near, 16% (n = 18) used an electronic device, and 17% (n = 20) had both an optical magnifier and electronic device.

Median training time was 45 minutes (range, 5 to 150 minutes) for the initial training session. Increased initial training time was significantly related to older age (p<0.001), legal blindness (p=0.006), the Seeing AI app versus SuperVision+ app (p=0.01), and participants from New England (p<0.001), but not other factors (shown in Table 1; Figs. 1A, B). Total training time for the initial and follow-up sessions was a median of 60 minutes (range, 10 minutes to 4.25 hours). Longer total training time was significantly related to increased age (p<0.001), legal blindness (p=0.003), the Seeing AI app versus SuperVision+ app (p=0.03) (Fig. 2), and participants from New England (p<0.001), but not other factors (shown in Table 1).

Most participants (71%) were proficient with the randomized study app at the end of the initial training session. The odds of initial proficiency were significantly greater among participants of younger age (p=0.04), who were smartphone users (p=0.04), who had opted for telerehabilitation (p=0.03), who had greater TICS scores (p=0.04), or who were from the NECO site (p=0.04), but were not significantly related to other factors (shown in Table 2 and Fig. 3). TICS mean scores were 38.4 (95% confidence interval [CI], 37.5 to 39.4) for participants who were initially proficient, versus mean

TABLE 1. Associated factors with initial and total training time

	Training time at initial session (min)	Total training time (min)
Age (for every 1-y inc.)	12.8 (95% CI, 6.4 to 19.3); p<0.001*	18.1 (95% CI, 8.9 to 27.3); p<0.001*
Female	2.30 (95% CI, −6.9 to 11.5); p=0.62	1.3 (95% CI, −11.9 to 14.5); p=0.85
Non-White	10.4 (95% CI, −0.9 to 21.6); p=0.07	13.7 (95% CI, −2.4 to 29.8); p=0.10
TICS (for every 1-point inc.)	−0.74 (95% CI, −11.2 to 9.7); p=0.89	−3.2 (95% CI, −18.1 to 11.8); p=0.67
AMD vs. other diagnoses	1.09 (95% CI, −12.0 to 8.4); p=0.87	5.2 (95% CI, −13.5 to 23.8); p=0.58
Not college graduate vs. graduate	−1.7 (95% CI, −11.9 to 24); p=0.74	−0.7 (95% CI, −15.3 to 13.8); p=0.92
Legally blind	14.1 (95% CI, 4.1 to 224.1); p=0.006*	22.2 (95% CI, 7.9 to 36.4); p=0.003*
Smartphone user	−0.99 (95% CI, −16.5 to 14.6); p=0.90	1.3 (95% CI, −20.9 to 23.5); p=0.91
Optical mag. user vs. no LV aid	−2.6 (95% CI, −15.5 to 10.3); p=0.69	−11.3 (95% CI, −29.7 to 7.1); p=0.23
Electronic mag. user vs. no LV aid	−11.8 (95% CI, −27.5 to 4.0); p=0.14	−20.6 (95% CI, −43 to 1.9); p=0.07
Both electronic and optical vs. none	4.3 (95% CI, −10.8 to 19.4); p=0.57	−6.1 (95% CI, −27.6 to 15.5); p=0.58
Telerehabilitation	8.3 (95% CI, −2.9 to 19.5); p=0.15	11.4 (95% CI, −4.6 to 27.4); p=0.16
Seeing AI vs. SuperVision+	13.3 (95% CI, 2.9 to 23.7); p=0.01*	16.6 (95% CI, 1.7 to 31.5); p=0.03*
Aira vs SuperVision+	3.2 (95% CI, −8.1 to 14.6); p=0.57	2.1 (95% CI, −14.2 to 18.3); p=0.80
Seeing AI vs. Aira	10.1 (95% CI, −1.4 to 21.5); p=0.08	14.5 (95% CI, −1.9 to 30.9); p=0.08
New England vs. California	39.6 (95% CI, 29.0 to 50.1); p<0.001*	53.6 (95% CI, 38.5 to 68.6); p<0.001*

*p<0.05. AMD = age-related macular degeneration; inc. = increment; LV = low vision; mag. = magnifier; TICS = Telephone Interview for Cognitive Impairment.

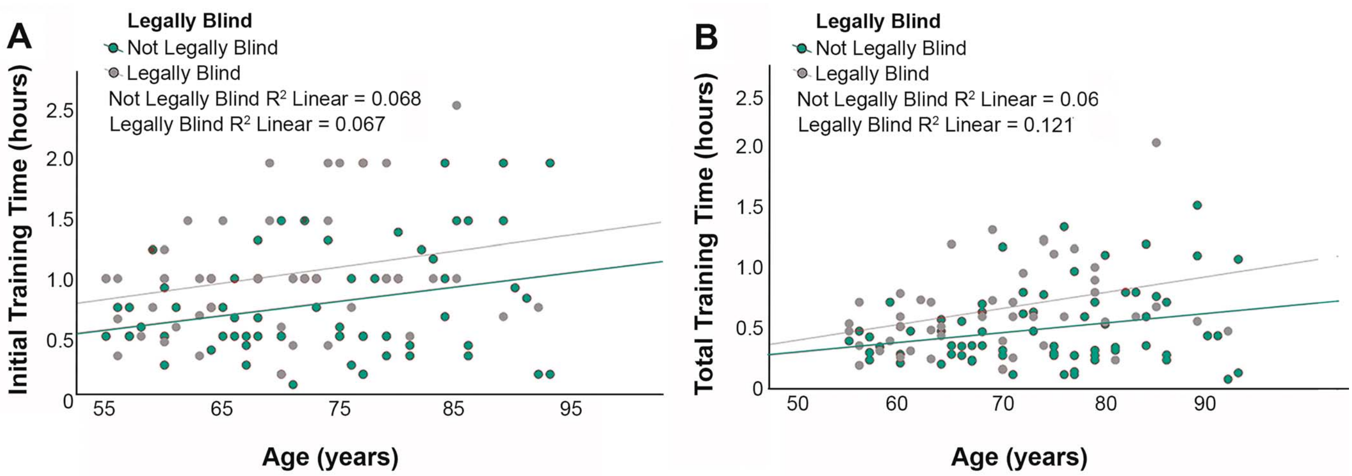

FIGURE 1. (A) Initial training time by age according to visual status. Initial training times increased with older age; however, there was considerable variability across participants ($R^2 = 0.067$ in legally blind group, $R^2 = 0.068$ in visually impaired but not legally blind group). (B) Total training time by age according to visual status. Overall training time across sessions was significantly correlated with age (p<0.001), especially for the legally blind group ($R^2 = 0.121$ in legally blind group, $R^2 = 0.066$ in visually impaired but not legally blind group).

TICS of 35.5 (95% CI, 33.5 to 37.5) for those who did not achieve proficiency during the initial session.

A vast majority of participants (90%) were ultimately proficient with the app at the end of the last follow-up training session. The odds of ultimate proficiency were significantly greater among participants who had an optical magnification device for near vision (p=0.008), but were not significantly related to other factors (shown in Table 2).

Lack of ultimate proficiency was infrequent (10%; n = 12), and those participants each had multiple tasks on the app that they were unable to complete without cueing. There was no task that emerged as a common issue, as there were similar rates of deficiencies for finding the app icon on the home screen, opening the app, using the app for a near task, and describing two key features of the app. Based on trainers' comments, most who were nonproficient ultimately had difficulty seeing the content on the iPhone screen secondary to the level of their vision loss (primarily visual field loss).

Satisfaction survey ratings are shown in Fig. 4. The majority of participants agreed strongly or mostly that they were comfortable with training via telerehabilitation (96%), agreed strongly or mostly that telerehabilitation was as accurate as in-person (91%), believed that the technology did not interfere with the session (86%), indicated they were very satisfied with telerehabilitation training (77%), and were somewhat to very interested to receive telerehabilitation training again in the future for a new app (100%).

When comparing participants at our two regional study sites, there were significantly greater odds of being from California among those who had greater age (odds ratio [OR], 1.07; 95% CI, 1.01 to 1.13; p=0.02) and opted for telerehabilitation (OR, 3.2; 95% CI, 1.15 to 8.9; p=0.03). On the other hand, there were significantly reduced odds of being a participant from California among those who had greater TICS scores (OR, 0.88; 95% CI, 0.80 to 0.98; p=0.02), whereas other factors in Table 1 were not significantly

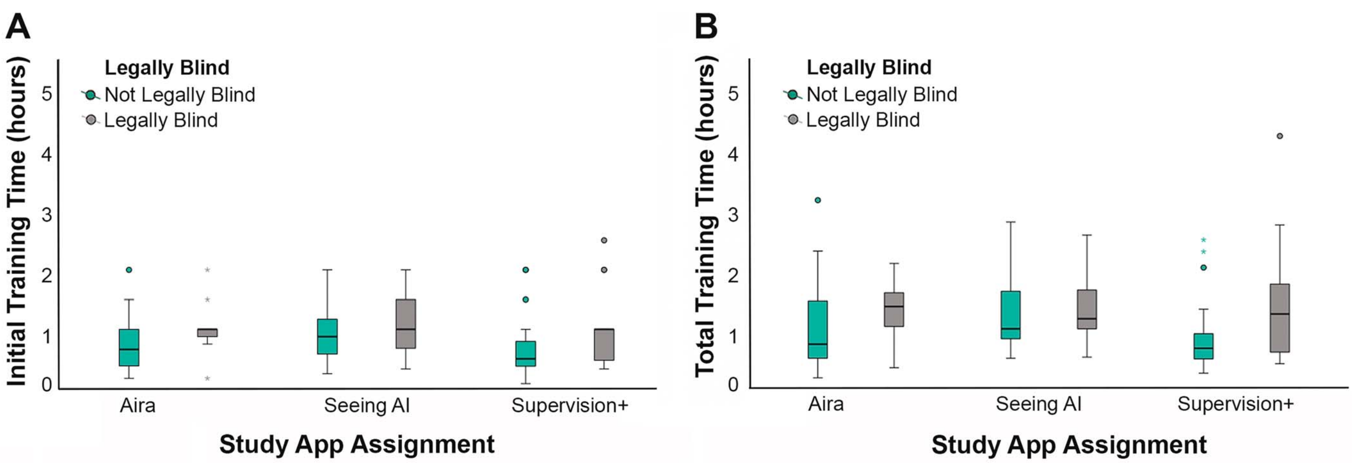

FIGURE 2. Box plot of training time (initial [A], overall [B]) according to study app assignment by visual status. The perimeter of the box represents the interquartile range, and the dark line represents the median. The whiskers represent two standard deviations from the median. Longer training times were associated with the Seeing AI app, likely as this app offers more features that were reviewed.

TABLE 2. Associated factors with proficiency at the end of the initial session and last training session

	Proficiency at end of initial session (OR)	Ultimate proficiency (OR)
Age (for every 1-y inc.)	0.93 (95% CI, 0.86 to 0.99); p=0.04*	0.93 (95% CI, 0.84 to 1.04); p=0.19
Female	0.54 (95% CI, 0.20 to 1.52); p=0.24	0.81 (95% CI, 0.16 to 4.0); p=0.80
Non-White	0.37 (95% CI, 0.10 to 1.35); p=0.13	0.59 (95% CI, 0.09 to 3.9); p=0.58
TICS (for every 1-point inc.)	1.14 (95% CI, 1.009 to 1.29); p=0.036*	1.01 (95% CI, 0.86 to 1.19); p=0.88
AMD vs. other diagnoses	0.95 (95% CI, 0.22 to 4.0); p=0.94	0.31 (95% CI, 0.04 to 2.5); p=0.27
Not college graduate vs. graduate	1.09 (95% CI, 0.33 to 3.6); p=0.89	0.99 (95% CI, 0.18 to 5.5); p=0.99
Legally blind	0.55 (95% CI, 0.17 to 1.73); p=0.31	0.88 (95% CI, 0.16 to 4.8); p=0.89
Smartphone user	5.8 (95% CI, 1.12 to 30.5); p=0.037*	8.3 (95% CI, 0.91 to 75); p=0.06
Optical mag. user vs. no LV aid	1.90 (95% CI, 0.45 to 8.2); p=0.39	17.2 (95% CI, 2.07 to 144); p=0.008*
Electronic mag. user vs. no LV aid	1.17 (95% CI, 0.23 to 6.1); p=0.85	6.9 (95% CI, 0.73 to 66); p=0.09
Both electronic and optical vs. none	2.13 (95% CI, 0.39 to 11.8); p=0.38	6.2 (95% CI, 0.66 to 57); p=0.11
Telerehabilitation	5.50 (95% CI, 1.15 to 26.3); p=0.03*	0.60 (95% CI, 0.10 to 3.44); p=0.56
Seeing AI vs. SuperVision+	1.64 (95% CI, 0.50 to 5.4); p=0.42	1.17 (95% CI, 0.20 to 6.7); p=0.86
Aira vs. SuperVision+	0.81 (95% CI, 0.22 to 2.9); p=0.74	0.49 (95% CI, 0.07 to 3.3); p=0.46
Seeing AI vs. Aira	2.03 (95% CI, 0.53 to 7.8); p=0.30	2.38 (95% CI, 0.33 to 17); p=0.39
New England vs. California	3.28 (95% CI, 1.04 to 10.3); p=0.04*	2.47 (95% CI, 0.49 to 12.5); p=0.27

*p<0.05. AMD = age-related macular degeneration; inc. = increment; LV = low vision; mag. = magnifier; TICS = Telephone Interview for Cognitive Impairment.

related to participants' region in a multiple logistic regression model. Two of the factors that were related to being a California participant (increased age and lower TICS scores) were significantly associated with reduced odds of becoming initially proficient with the app. On the other hand, Californians were more likely to have telerehabilitation, which was significantly associated with greater odds of becoming initially proficient with the app.

In this sample, there was a trend for the mean binocular visual acuity at enrollment ($F = 2.48$, p=0.065) (one-way analysis of variance after Bonferroni correction) to be slightly better among participants with no low vision aid for reading (mean [SD], 0.61 [0.41] logMAR; n = 18), when compared with those who used optical low vision aids (mean [SD], 0.66 [0.32] logMAR; n = 56), and those with electronic low vision aids (mean [SD], 0.84 [0.36]; n = 18) or both optical and electronic aids (mean [SD], 0.84 [0.43] logMAR; n = 19). The majority of older adults in our study had some prior smartphone experience even if they had never used a visual-assistive app. With training as needed, a majority of people in this study were able to achieve proficiency with the study apps regardless of age, cognitive ability, and visual status.

DISCUSSION

Understanding the factors that impact older adults' ability to integrate new technology is critical for those providing vision rehabilitation to this population. Here, we explored factors related to both training time and ultimate proficiency with three different visually assistive smartphone apps in older adults. Significant factors

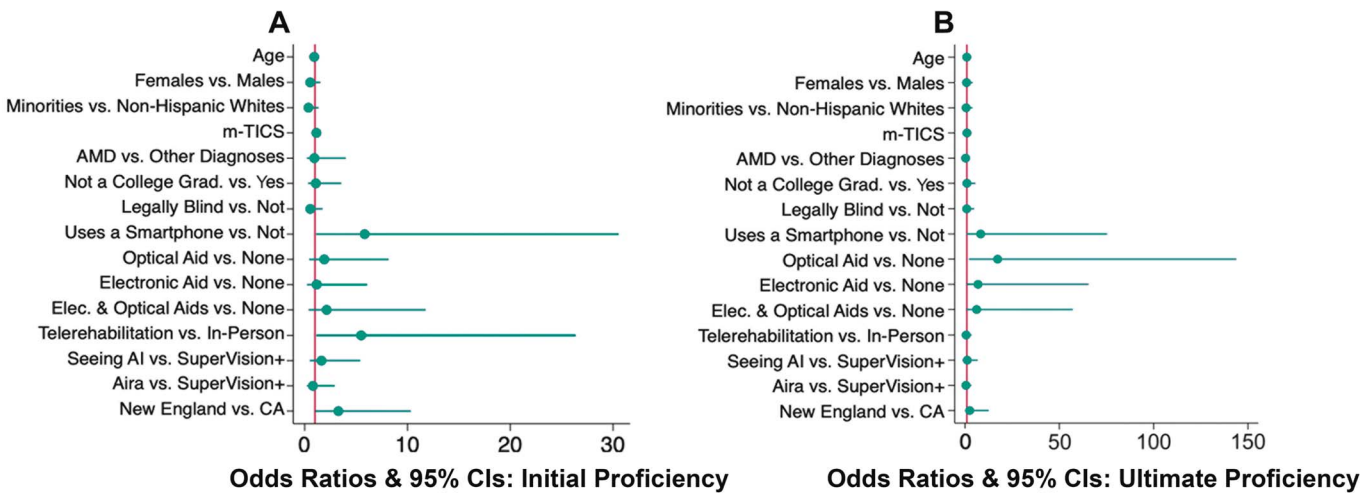

FIGURE 3. Forest plots of potential factors related to proficiency after the initial training session (A) and final training session (B). Significant factors associated with initial proficiency included younger age (p=0.04), previous smartphone use (p=0.04), telerehabilitation training sessions (p=0.03), greater TICS scores (p=0.04), or participants from New England (p=0.04). The odds of ultimate proficiency were significantly greater among participants who had an optical magnification device for near (p=0.008), but were not significantly related to other factors. TICS = Telephone Interview for Cognitive Impairment.

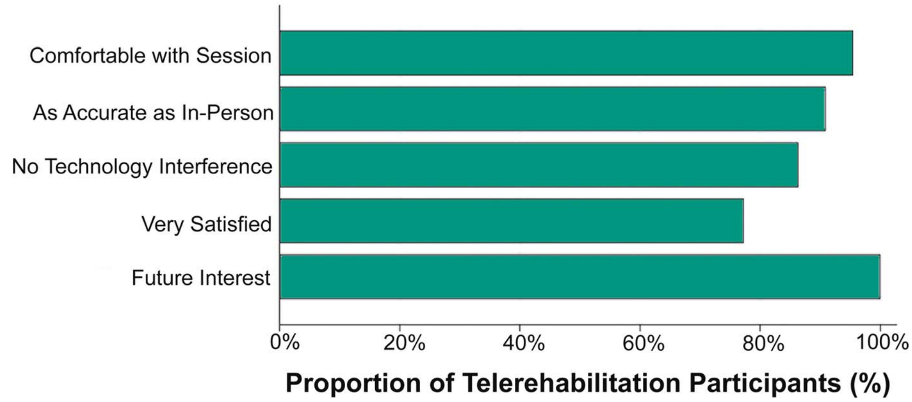

FIGURE 4. Post-session participant ratings for those who completed training sessions via telerehabilitation.

associated with longer training times included the following: older age, legal blindness, and study app assignment (with longer training times being associated with randomization to the SeeingAI app). Study site (NECO for participants from New England) was significantly associated with longer training times (mean difference, 30 minutes); however, study site was not significantly associated with eventual proficiency. This indicates that the training protocol employed could successfully be implemented across different clinical environments and individuals with diverse credentials who can provide the training.

A vast majority of participants were able to achieve eventual proficiency with the study app (90%). Factors significantly associated with better odds of proficiency included younger age and previous smartphone use (for initial but not ultimate proficiency), as well as concurrent use of optical magnification devices for ultimate proficiency. It is also possible that the motivation and/or manual dexterity skills required to use an optical magnifier may translate to the same factors required to use a visual-assistive app, but these were not directly assessed in this study. Additionally, we hypothesized that those with better visual acuity may be more likely to use an optical device than an electronic one and that those with better visual acuity would be less likely to use any traditional optical or electronic magnifier prior to the study.

Participants who opted for telerehabilitation had higher odds of initial proficiency, but not of eventual proficiency as both telerehabilitation and in-person training similarly led to eventual proficiency. Participants in this clinical trial self-selected their preferred training modality, and thus, those who opted for telerehabilitation may have had a higher degree of comfort with technology than those who wanted in-person training, which may account for the difference in initial proficiency. The option to choose the training modality was necessitated by the COVID-19 pandemic (telerehabilitation vs. in-person) and is similar to what would likely be offered in clinical practice; thus, our trial findings are translatable to clinical practice. We suggest that clinics should not mandate the use of telerehabilitation for app training, but could consider it as an option, especially for those who are comfortable with technology and the remote modality. Additional studies that randomize the training modality are needed to determine if telerehabilitation is acceptable with comparable outcomes to in-person app training across patients whose preference might be to receive training in-person or those who do not have a preference for the training modality.

Among participants with mild to no cognitive impairment, higher TICS cognitive scores were also associated with higher odds of proficiency after the initial session but were not significantly associated with eventual proficiency. However, as participants required a TICS score of 20+ for study eligibility, there was a limited range by which this variable could be explored. Clinical providers may reassure patients with mild cognitive loss that they may require more than one training session, but it is likely that they can ultimately become proficient. Providers of vision rehabilitation should take into consideration that older adults may require specific training over an extended period of time (i.e., beyond one office visit) to achieve proficiency with a new technology. Accounting for this training time and multiple follow-up visits will likely lead to better outcomes and then better acceptance of the app technology by the patient.

Generalizability

Our clinical trial included a diverse sample of people (28% non-White) with low vision in two different regions with varied experience with technology and traditional low vision aids. In this population, a majority of people were able to achieve proficiency with a new app after training. Including patients from two different geographic areas improves the generalizability of our findings and demonstrates that, although there were differences in initial proficiency between sites, ultimate proficiency was unrelated to where the person lived or received training. Our study did not explore the use of smartphones in a population outside of the United States, but our findings may be relevant and important to other countries given the relative accessibility of smartphones worldwide. The apps we studied are available for use on Android operating systems, adding to the generalizability of our findings for those who do not have an iPhone. Unique to our sample was that a majority of participants who were legally blind were of younger age (mean difference, 4.94 years; p=0.014) and did not have a diagnosis of macular degeneration (80%). Additionally, those with mild cognitive loss were not excluded, which is important because previous work has shown that nearly half (47%) of people with low vision self-reported periods of forgetfulness and 10% reported frequent forgetfulness.[11]

The types of iPhone visual-assistive apps used in this study varied in complexity, design, and number of features. However, we did not evaluate apps of similar type for smartphones with Android operating systems, which should be considered for future investigation for patients with smartphones other than iPhones. Randomizing participants to each of these apps allowed us to explore whether there were differences in training time and ability for patients to become proficient with any of the three apps that were selected to represent their specific functionality (i.e., magnification, Optical Character Recognition, or human guide). We included participants with a wide range of visual acuities whose app usage was assessed over several months following the app training; thus, we

plan to explore in future analyses whether any of the three apps we studied were preferred by patients with a specific level of vision (i.e., mild visual impairment users may prefer a magnification app vs. those with severe impairment may be more likely to utilize the Optical Character Recognition app). Although previous studies have explored use and proficiency of visual-assistive apps in young adults,[2] this study is novel in that our participants were seniors with low vision and more representative of the patient population of those with visual impairment.

The majority of participants used a loaner iPhone during the study, which may have impacted initial proficiency and training time if the software version, model, smartphone manufacturer, or operating system varied from what they traditionally used as their own smartphone. Furthermore, use of a loaner smartphone required most users to have access to and carry another smartphone in addition to their own, which may have created an additional burden. On the other hand, use of loaner smartphones ensured that all participants could have access to the apps included in the study, regardless of whether they owned an iPhone.

This study was focused on the ability of users to learn a novel iPhone app. Training time was measured by the individual performing the training, and it was recorded in 1-minute increments. The trainer was instructed to stop the clock during any off-topic discussions. Practitioners should consider that training across individuals with low vision is likely to fall into a range of time and visits to ensure success with the new app or device. Although individual results could vary, our study provides some guidance for planning that we expect would apply to most cases.

Future directions

Further research could explore the role of more extensive training with additional accessibility technologies (e.g., voiceover, speak screen, Siri, tactile markings) to further support individuals with more severe visual impairments or for those who do not gain proficiency after the initial session. We found that some participants who were unable to see the images on the screen of the iPhone were unable to become ultimately proficient even with modifications through built-in accessibility features and with use of best near correction. Thus, we suggest that it could be valuable to develop a protocol for an initial screening to determine whether a patient has sufficient vision to learn apps or can learn to utilize nonvisual accessibility features on the smartphone. It would be helpful to study which different approaches and modalities are most effective to further benefit this group, for example, speak screen, voiceover, Siri, and/or use of tactile markings. Training in this study was typically limited to one near and one distance task, which warrants further exploration into outcomes of more targeted or rigorous training to address specific difficulties with activities of daily living. We also did not develop or evaluate training videos for the apps; thus, it is currently unknown if they could potentially be valuable to patients as a reference between training visits or to reduce in-person training time.

The CARE study demonstrated that older adults with low vision are able to learn to utilize iPhone apps as visual-assistive devices to independently complete tasks at near. Low vision care should include the exploration of mobile apps for older adult patients with consideration given to appropriate training time and protocols. A key finding in our study was that age-related comorbidities were not a limitation to gain ultimate proficiency for the vast majority of seniors who were interested to learn to use a visual-assistive app, but lengthy (45- to 60-minute) initial sessions were required and multiple sessions were valuable to help support their proficient use of the apps. Consideration of the duration and need for one to two follow-up sessions for visual-assistive app training is important when planning vision rehabilitation services to help promote successful use of apps by seniors.

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