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A Survey on the Use of Mobile Applications for People Who Are Visually Impaired

Nora Griffin-Shirley, Devender R. Banda, Paul M. Ajuwon, Jongpil Cheon, Jaehoon Lee, Hye Ran Park, and Sanpalei N. Lyngdoh

Structured abstract: *Introduction:* The literature indicates that few studies have been conducted with persons with visual impairments (that is, those who are blind or have low vision) concerning mobile application or "app" usage. The current study explores the use of mobile apps with this population globally. *Methods:* A total of 259 participants with visual impairments completed an online survey. Descriptive statistics and bivariate tests were used to examine associations between demographic characteristics and mobile app use. *Results:* The participants rated special apps as useful (95.4%) and accessible (91.1%) tools for individuals with visual impairments. More than 90% of the middle-aged adult group strongly agreed with the practicality of special apps, a significantly higher percentage than was observed in the young and old adult groups. In addition, the participants with low vision considered special apps less accessible than did those with blindness ($p < .05$). *Discussion:* Results show that persons with visual impairments frequently use apps specifically designed for them to accomplish daily activities. Furthermore, this population is satisfied with mobile apps and would like to see improvements and new apps. *Implications for practitioners:* Developers of apps for individuals with visual impairments need to refine and test the existing apps. Practitioners need to be knowledgeable about app usage so they can provide effective instruction to their students or clients. This study provides preliminary information regarding app usage among persons with visual impairments.

One of the most common barriers that people who are visually impaired (that is, those who are blind or have low vision) experience pertains to the daily challenge of coping with visual impairment in a world in which the majority of individuals interpret their surroundings with vision (Koestler, 1976). In most societies, individuals with visual impairments encounter difficulties in safe and independent mobility that deprive them of typical professional and

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social functioning (Tuttle & Tuttle, 2004). Furthermore, they face more problems related to communication and access to information (Arati, Sayali, Sushanta, & Harshata, 2015). In the modern, developed world, however, technology is helping to reduce many of these barriers. Through the use of computer technology for tasks such as reading, writing, communicating, navigating, and searching for information, trained individuals with blindness are capable of performing a wide range of activities independently. As technology has evolved from computers to tablets and smartphones, manufacturers have recognized the need for applications or "apps" that make activities of daily living easier for the general population (Lewis, 2016; Rodriguez-Sanchez, Moreno-Alvarez, Martin, Borromeo, & Hernandez-Tamames, 2014).

Apps are programs or software that run on mobile devices. Recently, they have gained popularity among persons with visual impairments because of their portability, cost, easy access to information, and ease of use. For example, BlindSquare, a Global Positioning System (GPS) app designed for iOS (Apple's proprietary mobile operating system) costs $39.99, while the Trekker Breeze, a dedicated handheld talking GPS device, costs $699. Some of the apps that people with visual impairments are currently using include: ScanLife Barcode and QR (Quick Response code, a matrix barcode) Reader to use a smartphone's camera to scan codes to receive more information; Aipoly and AudioLabels for object recognition and color identification; EyeSight and Ultra Magnifier+ for magnification; MessagEase Keyboard, AccessNote, and BrailleTouch for writing; Braille Audio Reading Download for reading, recreation, and entertainment; and BlindSquare and iMove for indoor, outdoor, and point-of-interest navigation.

In spite of the technological advances, persons with visual impairments and other disabilities continue to face barriers to computer use worldwide (Ajuwon & Chitiyo, 2016; Lewis, 2016; Rodriguez-Sanchez et al., 2014). Specifically, modern devices typically function through the use of touch screens (Morris & Mueller, 2014), which presents challenges for people with visual impairments because touch screens rely on visual cues (Sanchez & de Togores, 2012).

A majority of studies have focused on developing or testing the usability of specific devices or apps for people with visual impairments (Dim & Ren, 2014; Frey, Southern & Romero, 2011; Venugopal, 2013; Wagner, Vanderheiden, & Sesto, 2006; Yousef, Adwan, & Abu-Leil, 2013). Recently, Crossland, Silva, and Macedo (2014) conducted an online survey with 132 persons with visual impairments from the United Kingdom, Portugal, and the United States to examine the types of devices they utilized, the accessibility features of the devices and their usefulness, and the types of apps they used and their usability. Results indicated that 81% of the participants used a smartphone for making telephone calls, texting, reading, browsing the Internet, and identifying objects. Furthermore, results also showed that the use of smartphones was found to decline among individuals over the age of 65 years.

Morris and Mueller (2014) surveyed 1,348 respondents with disabilities about the ease of use, perceived importance of, and their own satisfaction with Android (the mobile operating system created by

Google) or iOS mobile devices. Of those participants, 85 were blind and 122 were deaf, and two focus groups were conducted with these individuals based on their form of sensory loss. For individuals who are blind, results indicated that most of them felt they had to choose to own iPhones and that they learned how to use the devices on their own. Some users who are blind, however, indicated that they relied on peers and family members to help them select and learn how to use mobile devices. The majority of users of iOS devices (85%) felt their devices were easy or very easy to use and were very satisfied (77%) with them. Since these studies only provided preliminary data on the use of mobile apps, a need exists for more research on the use of mobile apps among individuals with visual impairments. The purpose of the exploratory study presented here is to understand how people with visual impairments use and perceive mobile apps in terms of usability and accessibility, and how they identify challenges in usage.

Methods

Recruitment

Prior to conducting the study, the researchers obtained human subjects permission from two universities. A letter of invitation was sent to the American Council of the Blind (ACB), the National Federation of the Blind (NFB), and other major organizations that serve persons with visual impairments around the world. Then these organizations in turn e-mailed a recruitment letter through their electronic discussion groups with a link to an anonymous online survey. The researchers also sent an invitation letter to professionals with visual impairments in the United States and other countries and regions such as India, Australia, Africa, and Europe. These professionals then posted the survey link on various social media platforms such as Facebook. When participants clicked on or followed the survey link, that action denoted their explicit consent to complete the study. Two and four weeks after sending the first e-mail, the researchers sent two reminder e-mails containing the same invitation letter to the above-mentioned organizations and professionals. The professionals and organizations were requested to share the recruitment letter with their students, clients, and members.

Survey development

The researchers developed the survey to explore the current use of mobile devices and apps among people with visual impairments, as well as their perceptions of the apps. The survey consisted of sociodemographic information (age, gender, visual functioning, ethnicity, country, geographical location, education, occupation, and annual income), use of mobile devices and apps in general (device type, years of using a mobile device, the number of apps downloaded in a month, apps in use, frequently used apps, and usability and accessibility of apps), and use of apps specifically designed for people who are visually impaired (ownership, usability, accessibility, and desire to purchase).

Seven professionals with visual impairments were contacted to review all survey items. Based on their feedback, survey items were revised for clarity and accessibility. The final version of the survey was placed on SurveyMonkey, which was fully accessible for screen readers.

The survey took no more than 15 minutes to complete. The participants' responses to survey items were saved automatically into a database. After eight weeks, the survey link was disabled and data were analyzed using SAS 9.4 (SAS Institute, 2002–2012).

Participants

A total of 259 participants who were legally blind completed the survey. *Legal blindness* is defined as "central visual acuity of 20/200 or less in the better eye with corrective glasses or central visual acuity of more than 20/200 if there is a visual defect in which the peripheral field is contracted to such an extent that the widest diameter of the visual field subtends an angular distance of no more than 20 degrees in the better eye" (Koestler, 1976, p. 45). Visual impairment was the only disability for most participants (84.2%). There were relatively more participants who were blind (55.6%) than those who had low vision (44.4%; existing visual acuity and visual field) in the sample; they were comparable in terms of age, gender, ethnicity, education, employment, and annual income (all $p > .05$).

Table 1 shows the demographic profiles of the sample. The average age of the participants was 44.51 years (range = 16–77). The majority of the participants were female (56%), Caucasian (76.1%), living in an urban area or cluster (91.1%), and living in the United States (86.1%). Most participants (86.5%) attended college. More than half of the participants (55.2%) had paid employment. Among those who were not employed, 30.4% were high school, college, or graduate students. About one-third (34.4%) earned less than $25,000 annually.

Data analysis

Descriptive statistics were calculated to summarize demographic characteristics of the participants and their use of mobile devices and apps. In addition, a *chi*-square test for independence was performed to determine whether participant subgroups differed in terms of mobile device and app use at .05 alpha level. More specifically, the participants were divided by age (young: aged 10 to 29 years, middle-aged: aged 30 to 49 years, or old: aged 50 years old or more); visual function (blindness or low vision); annual income (less than $25,000 or equal to or above $25,000); and the type of mobile devices they use (Android only or iOS only). The subgroups were compared for the distribution of responses to each survey item. Effect sizes (Cramér's *V*) were also calculated.

Results

Mobile device and app use

The participants' use of mobile devices and apps is presented in Table 2. All participants were currently utilizing at least one mobile device ($M = 1.68$, $SD = 0.82$; range = 1–5): smartphone (95.4%), tablet (40.5%), or other (19.7%; for instance, iPod or braille notetaker). About 80% of the participants had iOS devices, 7% had Android devices, and 13.1% had both types. The majority of the participants (82.2%) have used mobile devices for more than two years, and four years (26.6%) was the most common duration of mobile device usage. There was no significant difference in mobile device experience between age groups (young vs. middle-aged vs. older adults; $p = .09$, $V = 0.23$) or visual function groups

Table 1
Sample demographics ($N = 259$).

Variable	*n*	*M* (%)	*SD*
Age (years)	259	44.51%	14.65
Gender			
Male	111	42.9%	
Female	145	56.0%	
Prefer not to disclose	3	1.2%	
Visual function			
Blindness	144	55.6%	
Low vision	115	44.4%	
Ethnicity			
African American	14	5.4%	
American Indian	1	0.4%	
Asian	16	6.2%	
Asian American	4	1.5%	
Caucasian	197	76.1%	
Hispanic	16	6.2%	
Native Hawaiian or other Pacific Islanders	1	0.4%	
Prefer not to disclose	10	3.9%	
Geographical location			
Rural (population of $<$ 2,500)	23	8.9%	
Urbanized cluster (population of 2,500–50,000)	59	22.8%	
Urbanized area (population of $\geq$ 50,000)	177	68.3%	
Education			
Less than high school degree	3	1.2%	
High school degree or equivalent	32	12.4%	
College attendance or equivalent	57	22.0%	
Bachelor's degree	83	32.0%	
Master's degree	64	24.7%	
Doctoral degree	20	7.7%	
Employment			
Yes	143	55.2%	
No	115	44.4%	
Missing	1	0.4%	
Annual income			
Less than $15,000	64	24.7%	
$15,000–$24,999	25	9.7%	
$25,000–$34,999	27	10.4%	
$35,000–$49,999	35	13.5%	
$50,000–$74,999	38	14.7%	
$75,000–$99,999	21	8.1%	
$100,000 and above	6	2.3%	
Prefer not to disclose	43	16.6%	

(blindness vs. low vision; $p = .28$, $V = 0.21$), but the participants with higher incomes indicated they had been using devices significantly longer than those with lower incomes ($p < .05$, $V = 0.31$).

Most participants (90.3%) reported that they utilize both free and paid apps (that is, apps that cost money). About 15% of the participants with low vision used only free apps as compared to 5.6% among

Table 2
Use of mobile devices and apps ($N = 259$).

Variable	*n*	%
Mobile devices in current use		
Smartphone	247	95.4%
Tablet	105	40.5%
Both smartphone and tablet	96	37.1%
Other	51	19.7%
Type of mobile devices in current use		
Android	18	7.0%
iOS	207	79.9%
Both Android and iOS	34	13.1%
Mobile device experience		
Less than 1 year	26	10.0%
2 years	20	7.7%
3 years	38	14.7%
4 years	69	26.6%
5 years	42	16.2%
6 years	36	13.9%
7 years	13	5.0%
8 years	6	2.3%
9 years	3	1.2%
10 years	6	2.3%
Free or paid apps		
Only free	25	9.7%
Only paid	0	0.0%
Both free and paid	233	90.3%
App downloads per month		
1 to 2	159	61.4%
3 to 5	66	25.5%
More than 5	34	13.1%
Most frequently used apps		
E-mail	63	24.5%
Tools for visual impairment	32	12.5%
Social networking	29	11.3%
Entertainment	27	10.5%
Leisure reading	23	8.9%
Special apps in mobile device ($N = 1{,}104$)		
Visual identification	325	29.4%
Screen reading and writing	225	20.4%
GPS navigation	149	13.5%
Leisure reading	144	13.0%
News	85	7.7%
Special apps wanted to purchase ($N = 167$)		
Screen reading and writing	62	37.1%
GPS navigation	38	22.8%
Visual identification	29	17.4%
Leisure reading	6	3.6%
Education	4	2.4%

those with blindness ($p < .05$, $V = 0.16$), indicating that the blind group has a relatively higher tendency of purchasing paid apps. The majority of the participants (61.4%) downloaded three to five (free and paid) apps in a month. Younger participants downloaded significantly more apps than older participants ($p < .05$, $V = 0.15$). Also, the low vision group downloaded more apps than the blind group, but this difference was marginal ($p = .08$, $V = 0.14$). The income groups did not differ in the number of app downloads ($p = .92$, $V = 0.03$).

The participants used apps for a variety of different reasons. The most frequently used apps were for e-mail (24.5%); followed by tools for visual impairment (12.5%; for instance, screen readers and writers or visual identification tools); social networking (11.3%); entertainment (10.5%; for instance, radio, sports, or relaxation); and leisure reading (8.9%; for instance, books, magazines, or library services). The participants were asked to list up to 10 apps that they utilize most frequently, and then all reported apps were classified on the basis of their main function. Of a total of 2,082 lists, the most reported apps were for tools for visual impairment (12.6%), followed by entertainment (11.6%), leisure reading (7.5%), social networking (7.4%), and e-mail (6.1%). As depicted in Figure 1, younger participants used apps for social networking significantly more frequently than did older participants ($p < .001$). The participants who were blind or of higher income utilized app tools for people with visual impairments such as screenreaders significantly more often than did their counterparts ($p < .01$ and .05, respectively).

The participants' perceptions about usability and accessibility of apps is presented in Figures 2 and 3, respectively. In general, mobile apps were perceived as user-friendly (83.1%) and accessible (80.7%). Neither the age nor income groups differed in their overall appraisals for ease of use and accessibility (all $p > .05$). The participants with low vision, however, considered apps less user-friendly and less accessible than did those with blindness ($p < .05$ and .01, respectively). The participants who were currently utilizing iOS devices considered apps more accessible than those who were using Android devices ($p < .01$, $V = 0.28$).

Special apps for individuals with visual impairments

More than 90% of the participants indicated they were currently using apps that were especially designed for people with visual impairments. Of a total of 1,104 special apps listed by the participants, the most frequently mentioned apps were for visual identification (29.4%; for example, Be My Eyes, ColorID, CamFind, and ColoredEye); followed by screen reading and writing apps (20.4%; for example, KNFB Reader, AccessNote, Fleksy, TalkBack, and BrailleTouch); GPS navigation apps (13.5%; for example, BlindSquare, Ariadne GPS, Seeing Eye GPS, Sendero GPS LookAround, and Seeing Assistant); leisure reading apps (13%; for example, NLS BARD, Read2Go, and Learning Ally Audio); and news apps (7.7%; for example, NFB-Newsline, Blind Bargains, and *AccessWorld*). As shown in Figure 4, about 93% of the middle-aged and old adult groups together used special apps as compared to 83% in the young adult group, but this difference was only mar-

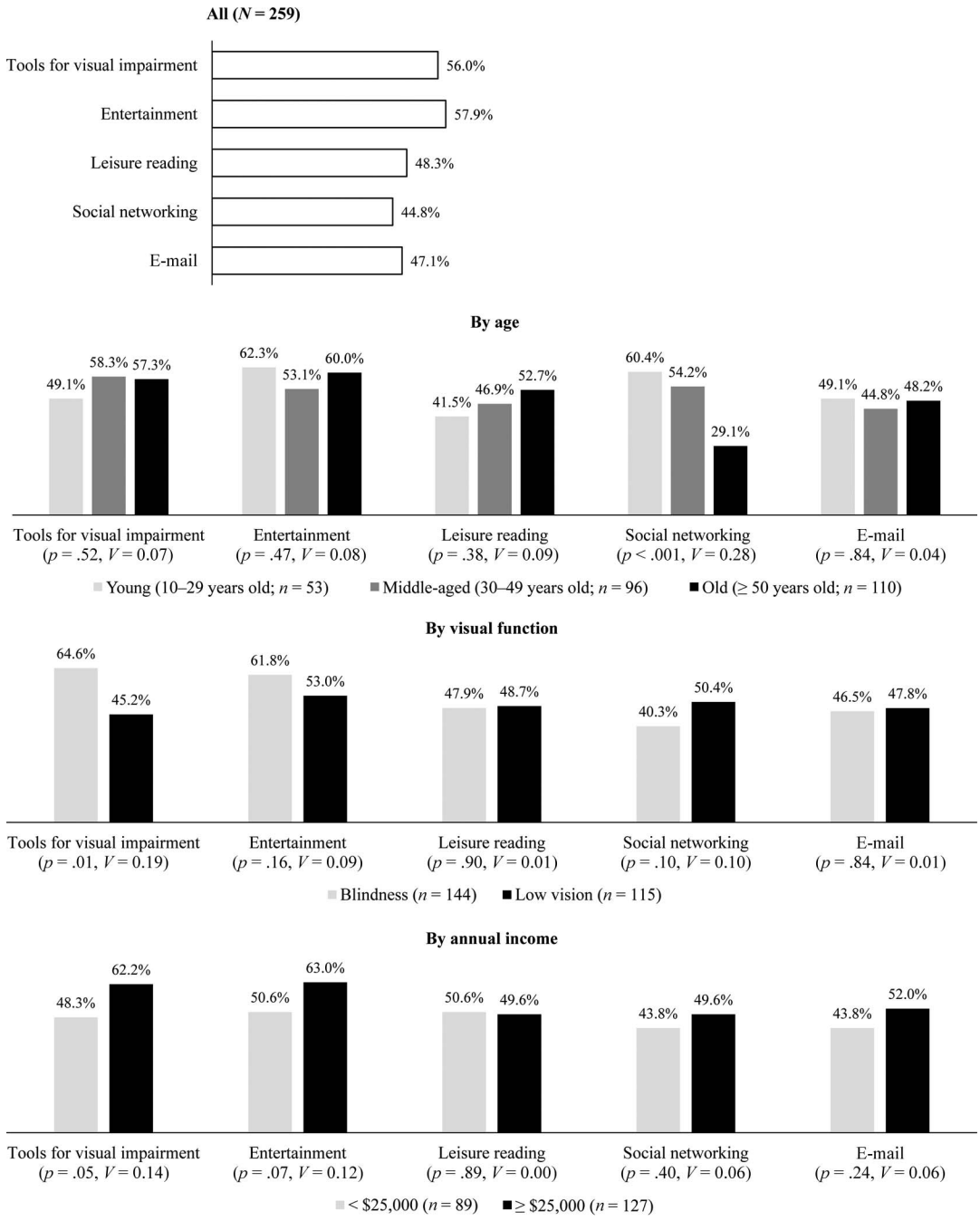

Figure 1. Top five most frequently used apps.

ginally significant ($p = .05$). The participants with blindness were significantly more likely to have special apps than those with low vision ($p < .001$). No significant difference was found between the income groups ($p = .31$).

The majority of the participants (52.9%) reported that they want to purchase new

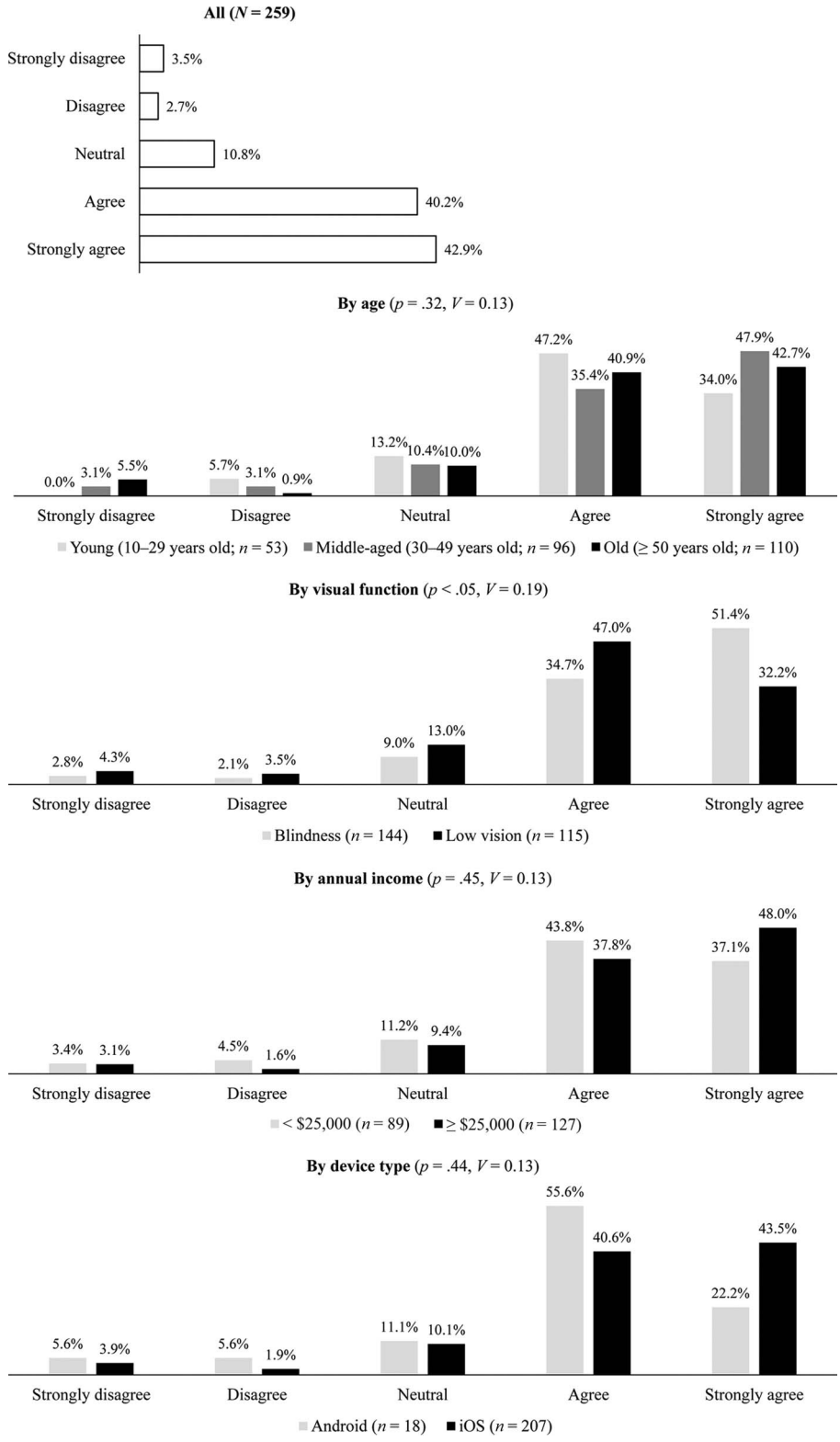

Figure 2. Apps are user-friendly in general.

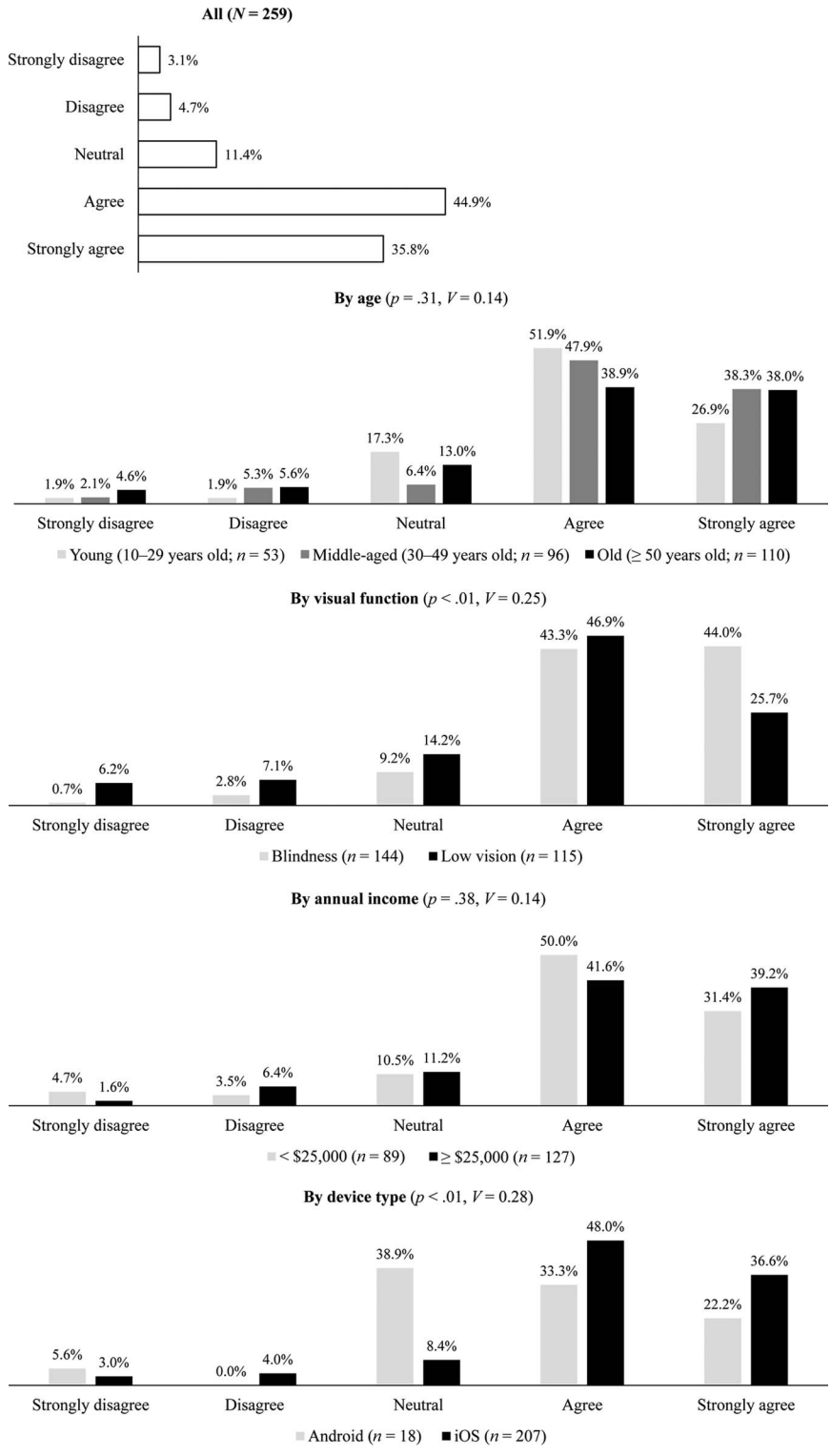

Figure 3. Apps are accessible in general.

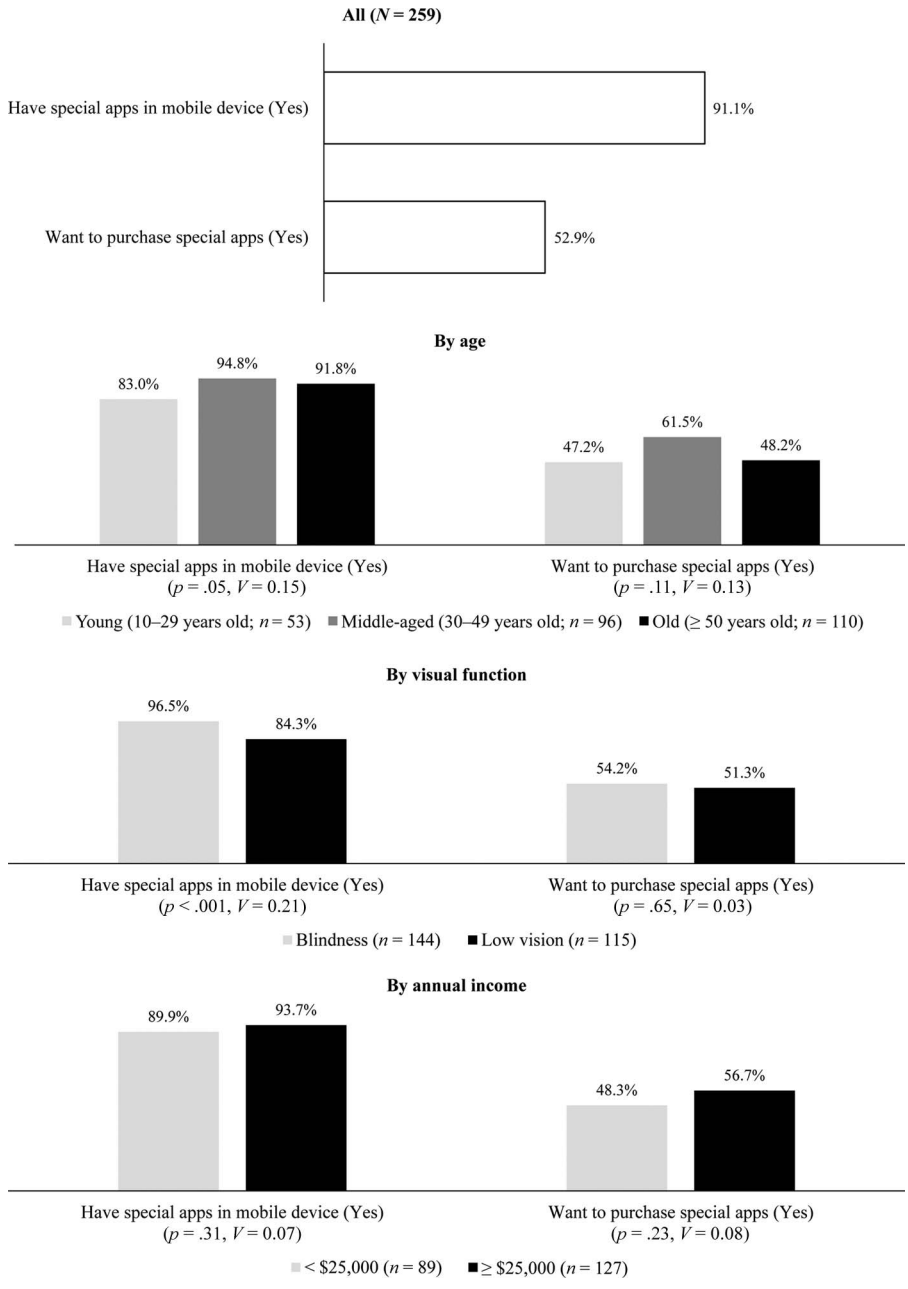

Figure 4. Special apps.

apps designed to help people with visual impairments; similar percentages were observed across different age, visual function, and income groups (all $p > .05$). Of a total of 167 wish-lists given by the participants, the most reported apps were for screen reading and writing (37.1%; for example, KNFB Reader, Voice Dream, and Eloquence Text To Speech); followed by GPS navigation (27.5%; for example, BlindSquare, Seeing Eye GPS, and Nearby Explorer); and visual iden-

tification (17.4%; for example, Be My Eyes, LookTel Money Reader, and Digit-Eyes).

The participants' perceptions about usability and accessibility of special apps are illustrated in Figures 5 and 6, respectively. Overall, the participants considered special apps as useful (95.4%) and accessible (91.1%) tools for individuals with visual impairments. More than 90% of the middle-aged adult group strongly agreed with the user friendliness of special apps, which was significantly higher than 77.4% and 73.6% observed in the young and old adult groups, respectively ($p < .01$). Similarly to the findings for general apps, the income groups did not differ in their evaluations for usefulness and accessibility of special apps (both $p > .05$). The participants with low vision considered special apps less accessible than did those with blindness ($p < .05$). The participants who were currently utilizing iOS devices considered special apps more useful ($p < .05$, $V = 0.24$) and more accessible ($p < .01$, $V = 0.27$) than those who were using Android devices.

Discussion

The study presented here explored the use of and perceptions about mobile apps among individuals with visual impairments. Overall, we found that persons with visual impairments frequently use apps to accomplish daily activities. Although this population reported they were satisfied with mobile apps, they also indicated they would like to see improvements made to existing apps and new apps to be developed that are useful to people with visual impairments. The current study outcomes are similar to those of Morris and Mueller (2014), who reported that the majority of their study participants were very satisfied with their wireless devices and they thought that Android and iOS devices were easy to use. In the study presented here, the majority of participants used iOS devices, which was also shown by Morris and Mueller (2014). The results of the current study add to the scant literature on how persons with visual impairments utilize mobile apps.

For many years, the general population has used mobile apps. Similarly, the participants in this study have only used mobile devices for the past two years or more. In the United States, younger people are more likely to use certain apps than are older people (Pew Research Center, 2015), and the current study supports this trend in the download and use of apps.

This study's results revealed that e-mail, social networking, and entertainment apps used by our participants are similar to those apps enjoyed by sighted people (Pew Research Center, 2015). The implication here is that individuals with visual impairments may function at a higher level and be more independent when completing activities of daily living with the help of apps than they would be without apps—a person with low vision can use a smartphone to take a photograph of a street sign, then read the sign by magnifying the image rather than by carrying a monocular to identify the street name by sight, for example. The apps that were most frequently reported by the study participants were tools designed for people with visual impairments to access information that is commonly accessible to sighted people, such as those used for daily living tasks (visual identification,

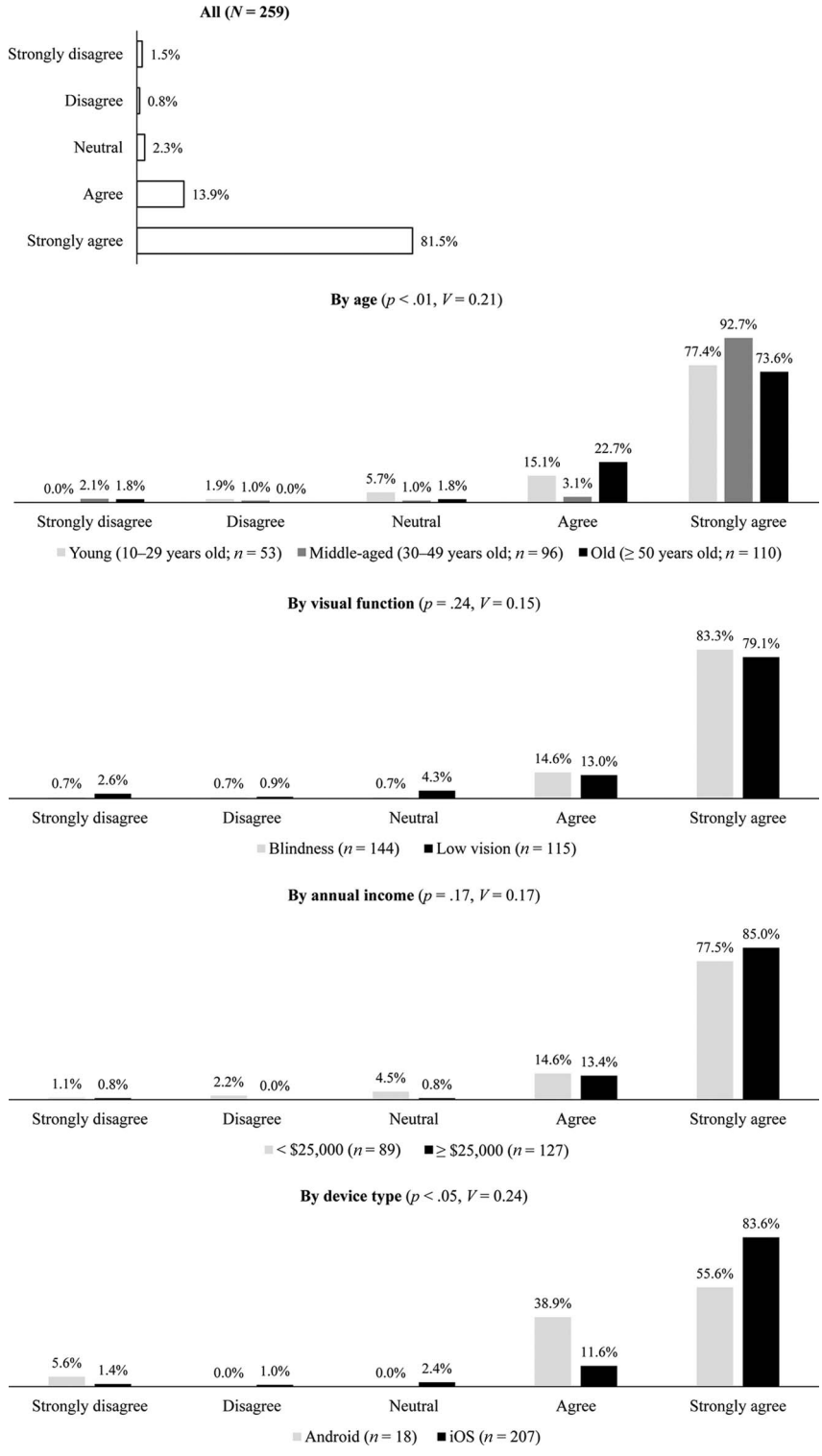

Figure 5. Special apps are user-friendly in general.

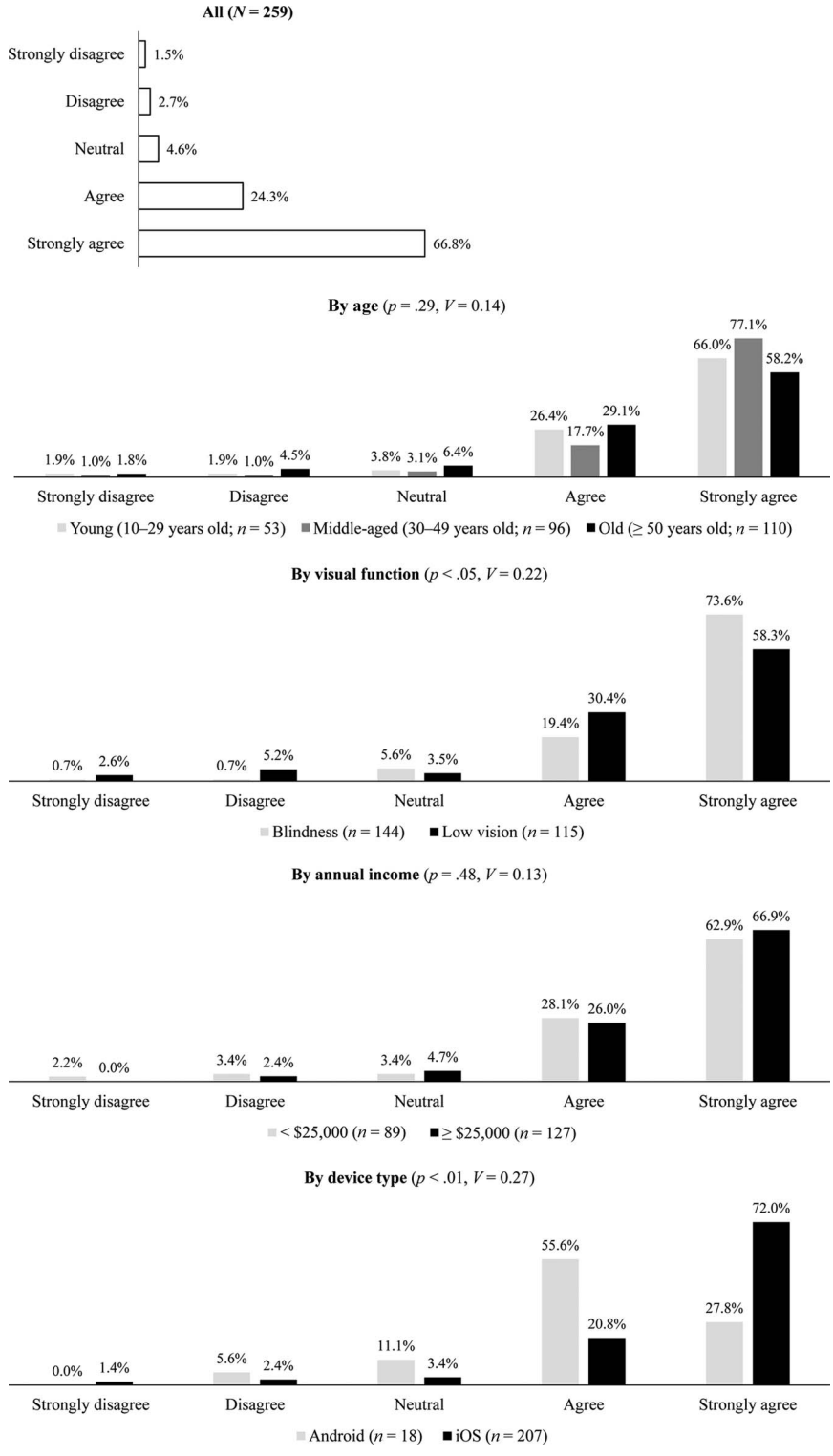

Figure 6. Special apps are accessible in general.

GPS navigation, leisure reading). Furthermore, study participants wanted apps to be developed that will meet their daily needs. This finding is consistent with the Morris and Mueller (2014) statement "some smartphone features, such as GPS, offer services that have not previously been available through stand-alone assistive technologies" (p. 72).

People with low vision consider apps that are specifically designed for individuals with visual impairments as inaccessible. Such people may hold this opinion because they are used to using apps designed for people with sight, rather than those that are designed for individuals who are blind. Sanchez and de Togores (2012) suggest that apps should be specifically developed for those with low vision.

The results also indicate that users who are totally blind have a higher tendency to purchase paid apps. Future researchers may need to explore why such a pattern exists among the totally blind population. Also, a majority of the participants indicated that they prefer to buy apps for screen reading and writing, GPS navigation, and visual identification. Thus, it will behoove developers of mobile apps to give priority to designing more efficient apps for these purposes.

This study also shows that middle-aged adults with visual impairments find special apps more practical as compared to young or older adults with visual impairments. A possible reason for this finding is the causes and degree of vision loss among different population groups. The reason for this finding is unclear. Further research is needed to examine the age differences of people who are visually impaired regarding mobile app usage.

The researchers were uncertain about the significant difference between the income levels of participants with low vision and those with blindness concerning the use of apps for persons with visual impairments. One reason for the income differences could be that a higher percentage of individuals who are blind receive social security benefits, while those with low vision may be employed.

Limitations

The limitations of this study include the participants, access to the Internet, and recruitment. The majority of the participants were employed, middle-aged female Caucasians, who had higher educations, and resided in urban areas in the United States; however, the majority of people who are visually impaired are unemployed. Would there have been different results if there were a more equitable distribution of participants representing different age groups, ethnicities, educational levels, and employment statuses? Since the survey was only available online, persons with visual impairments with limited or no access to the Internet were likely excluded. If they had been included, would these individuals have similar or different responses to the survey items? The researchers used only the Internet to recruit participants, which limited the generalizability of the results.

Implications for practice

This study's implications include better refinement and testing of the existing apps for individuals with visual impairments (Crossland et al., 2014). Practitioners working with individuals with visual impairments need to be aware of new apps as they are created and be competent

in their usage so that they can provide effective instruction in these apps to their students (Lewis, 2016; Wong & Tan, 2012). Initial instruction should focus on teaching students how to use screen readers and navigation apps. Furthermore, when practitioners prescribe low vision devices, it is important that they consider whether the prescribed technology is compatible with the mobile devices used by their patients with low vision (Crossland et al., 2014).

Future research in this area needs to recruit participants who are more representative of the population with visual impairments with respect to age, income, ethnicity, and education, for example; survey potential participants using various means (for example, interviews and mailing); and find participants through multiple sources such as rehabilitation agencies that serve adults with visual impairments, more consumer organizations, and residential schools for blind students. These efforts may increase the number of participants, thereby making the study results more generalizable.

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Nora Griffin-Shirley, Ph.D., *professor, Department of Educational Psychology & Leadership, College of Education, Texas Tech University, P.O. Box 41071, Lubbock, TX 79409; e-mail: n.griffin-shirley@ttu.edu.* ***Devender R. Banda, Ph.D.,*** *professor, Department of Educational Psychology & Leadership, College of Education, Texas Tech University; e-mail: devender.banda@ttu.edu.* ***Paul M. Ajuwon, Ph.D.,*** *professor, Department of Counseling, Leadership, and Special Education, Missouri State University, 901 South National Avenue, Springfield, MO 65897; e-mail: paulajuwon@missouristate.edu.* ***Jongpil Cheon, Ed.D.,*** *associate professor, Department of Educational Psychology & Leadership, College of Education, Texas Tech University; e-mail: jongpil.cheon@ttu.edu.* ***Jaehoon Lee, Ph.D.,*** *assistant professor, Department of Educational Psychology & Leadership, College of Education, Texas Tech University; e-mail: jaehoon.lee@ttu.edu.* ***Hye Ran Park, Ph.D.,*** *post-doctoral research fellow, Institute for Measurement, Methodology, Analysis and Policy, College of Education, P.O. Box 43150, Texas Tech University, Lubbock, TX 79409; e-mail: hye-ran.park@ttu.edu.* ***Sanpalei N. Lyngdoh, M.A.,*** *doctoral student, Department of Educational Psychology & Leadership, College of Education, Texas Tech University; e-mail: sanpalei.lyngdoh@ttu.edu. Address correspondence to Dr. Griffin-Shirley.*

(cont. from p. 303)

The *Journal of Visual Impairment & Blindness* (ISSN: 0145-482X) is published bimonthly by AFB Press, American Foundation for the Blind, 2 Penn Plaza, Suite 1102, New York, NY 10121; subscription information is listed in the masthead.