

**Next Generation Wireless Device Adoption and Use among Individuals
with Disabilities: Findings from a National Survey of User Needs,
2019-2020**

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Next Generation Wireless Device Adoption and Use among Individuals with Disabilities: Findings from a National Survey of User Needs, 2019-2020

We present findings from the Rehabilitation Engineering Research Center for Wireless Inclusive Technologies (Wireless RERC) Survey of User Needs (SUN) for 2019-2020. The Wireless RERC has surveyed wireless technology adoption and use among individuals with disabilities since 2002, and this article presents findings from the seventh iteration of the SUN. Broadly, it continues to find growing rates of adoption of smartphone technologies among people with disabilities relative to the general population. With an increase of smartphone use among individuals with disabilities from 54% in 2012-2013 and 71% in 2015-2016, to 88% in 2017-2018, and remaining at 88% in 2019-2020, our findings suggest further narrowing of the digital “disability divide.” SUN respondents generally indicated that their devices were easy to use. Regarding device satisfaction, over three-fourths of smartphone users indicated that they were satisfied or very satisfied with their smartphones. Relatively less established, newer features such as real-time-text and intelligent personal assistants have yet to be widely adopted. However, the higher-than-average use of real-time-text among individuals who reported deafness or difficulty hearing suggests this features’ potential for increasing usability and accessibility of these devices, specifically, and communications, in general. For this version, we added new questions on the adoption and use of next-generation wireless devices, as part of a growing trend toward Internet of Things (IoT)-based “smart homes.”

Keywords: smartphones, wireless devices, intelligent personal assistants, emerging assistive technologies, information and communications technology (ICT), and software

Introduction

Smartphones have transformed mobile phones from merely telecommunications devices to multifunction computing devices. They serve as a news and information

source, enable communications for people with hearing disabilities without an intermediary, offer assistance during and in the wake of emergencies, facilitate telehealth, and can be a key route to employment through job searches and the online application process. We present findings from the Rehabilitation Engineering Research Center for Wireless Inclusive Technologies (Wireless RERC) Survey of User Needs (SUN) for 2019-2020. Wireless RERC's ongoing SUN data collection and analysis identifies trends in access to wireless technologies by people with disabilities. Now in its fourth cycle of funding by the National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR), the Wireless RERC has surveyed wireless technology adoption and use among individuals with disabilities since 2002.

This survey, now in its seventh iteration, builds on prior versions of the survey (Morris, Jones, and Sweatman; Morris et al.; Moon et al.) through inclusion of next-generation wireless technologies, such as wearables and the Internet of Things (IoT), and their prospective applications for monitoring, sensing, assistance, guidance, and navigation. Our final validated sample size was N=231. Of this sample, **98.3% (N=227)** reported use or ownership of a wireless device, while 1.7% respondents (N=4) reported that they did not use or own a wireless device. Below, we provide data based on the sample, of users who indicated owning or using a wireless device such as a traditional cell phone, smartphone, tablet, or wearable device. This proceedings article comprises three main areas of analysis: 1) overall adoption and use of wireless devices among users with disabilities, with comparison to prior iterations of the SUN and against the general population as surveyed by the Pew Research Center, 2) use of specific wireless device features generally associated with greater accessibility or usability for specific disability categories, and 3) activity-based use of wireless devices by individuals with disabilities, which is new to this version of the SUN.

Materials and Methods

Originally launched in 2002, the SUN is updated periodically to be responsive to the rapid pace of technological change. For this version, we added new questions based on Wireless RERC focus group research on the adoption and use of next-generation wireless devices, including “smart speakers” such as Amazon Echo with Alexa or Google Home with Google Assistant (Wireless RERC). As part of a growing trend toward Internet of Things (IoT)-based “smart homes,” these technologies represent, in essence, the next generation of home automation and accessibility solutions (Atzori, Iera, and Moribito; Domingo; Moon, Baker, and Goughnour). It is worth noting that devices such as smart lights and thermostats can be controlled through smartphone apps, further reflecting the continued integration of wireless technologies. We also refined disability categories in response to prior findings, in order to more accurately capture this demographic information, as well as revised the wording for items to reduce ambiguity and erroneous responses.

The SUN is a national survey administered online, as well as by telephone. Recruitment relied upon convenience sampling, drawing upon the Wireless RERC’s Consumer Advisory Network (CAN), which totals about 2,100 individuals with disabilities, as well as web-based recruitment through partnering universities and organizations. Disability demographics are based upon categories used by the American Community Survey (ACS), augmented with categories adapted from the National Health Interview Survey (NHIS) for a more robust listing of functional limitations (Lauer and Houtenville; McGuire et al.). However, the categories allowed for finer segmentation of respondents by disability sub-type, such as distinctions between individuals who are blind and who have low vision.

Results

Device Ownership and Use

A total of **10.1% (N=22)** of wireless device users indicated ownership of a *basic cell phone* (sometimes referred to as a feature phone) described as having the form factor of earlier-generation phones, with button-based input and a small display. This proportion continues to decline, downward from 13.4% in 2017-2018 and a similar level in 2015-2016 and 31% in 2012-2013 (Moon et al., 2020). This decline may be attributed to increasing ownership of smartphones among users with disabilities, owing in part to greater affordability, accessibility, and user preference. It also may be due, in large part, to decreasing availability of, and support for, feature phones on the market. These rates of use and ownership are slightly lower than for the general population, with the latest Pew survey reporting 15% of U.S. adults who own cell phones but not smartphones (Pew Research Center).

Regarding users of basic cell phones in the current survey, a majority of these users are over 50 years of age, male, Caucasian, and have an income of less than \$35,000 per year. Over three-quarters (3/4) of basic cell phone owners (76%) reported owning their devices for more than four years, up from 52% in 2017-2018. Only two people reported owning their device for less than one year. Interestingly, 18% of basic cell phone users also reported ownership of a smartphone, a tablet (32%), and a wearable device (9%) such as an activity tracker.

To maintain consistency with previous surveys, respondents were asked to self-identify and select all categories of disability that applied to them. In doing so, some respondents indicated more than one disability. With a range of 0 to 5 and a standard deviation of 1.3 difficulties, the average number of functional difficulties reported by users of basic cell phones is 2.2 difficulties. In rank order, these difficulties include

lower-body physical limitation (59%), upper-body physical limitation (50%), speech or communication limitation (27%), cognitive or learning disability (23%), emotional, psychiatric, or behavioral disability (18%), and vision limitation other than blindness (14%).

Among individuals who indicated the use of a wireless device, **88.5% (N=192)** reported owning a *smartphone*. The proportion of respondents with a disability who indicated use of a smartphone continues to increase, as compared to 54% in 2012-2013, 71% in 2015-2016, and 88% in 2017-2018 (Moon et al., 2020). Interestingly, SUN respondents continued reported higher smartphone adoption rates than the Pew national sample of the general population (81%) in its most recent survey (Pew Research Center). This continues a trend also seen in the early versions of the SUN, in which people with disabilities similarly reported slightly higher smartphone use.

Regarding current SUN users of smartphones, a majority of these users are under 60 years of age, female, Caucasian, and have an income of over \$25,000 per year. Some smartphone users indicated more than one disability. With a range of 0 to 6 and a standard deviation of 1.1 difficulties, the average number of functional difficulties reported by users of smartphones is 1.7. In rank order, these difficulties include lower-body limitation (34.9%), upper body limitation (22.4%), Deafness (18.8%), hearing difficulties other than Deafness (18.8%), blindness (18.2%), and vision limitations other than blindness (17.7%).

Regarding *smartphone type by operating system*, more Apple iPhones (68%) were reported than Android-powered smartphones (35%), such as the Samsung Galaxy and Google Pixel, continuing a trend of more reported iPhone ownership and use from 2017-2018 (54% vs. 46% Android ownership/use). One respondent indicated the use of a Windows-powered smartphone, and one individual indicated the use of a BlackBerry

phone. Interestingly, a small proportion of smartphone owners (4%) reported ownership of two smartphones, more than the 80% of users who reported owning only one phone. Eight (8) out of 9 of these individuals owned both Android and Apple phones and one owned Apple and, these were reported to be used for different reasons (e.g., work, personal), or simply older models that the owner had retained.

Regarding the *duration of ownership*, 57% of smartphone owners have owned their devices for more than four years, while an additional 10% reported owning their phones for 3-4 years, and 9% reported owning their devices for 2- 3 years. Of the remaining users, 16% have owned their devices for at least one year, while only 9% have owned their devices for less than one year. The following chart (Figure 1) shows the duration of device ownership for smart and basic cell phones, with comparisons to other wireless devices queried by the SUN.

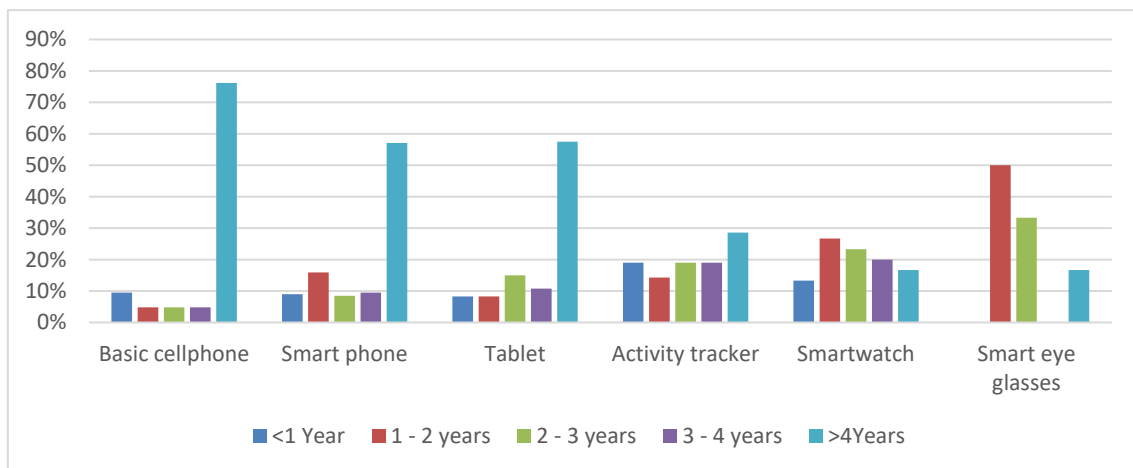


Figure 1: “How Long Have You Had Your Device?”

This continues a trend from the previous SUN of long-term ownership and use. By comparison, in 2017-2018, 43% of smartphone owners had owned their devices for more than four years, while an additional 8% reported owning their phones for 3-4 years, and 16% reported owning their devices for 2- 3 years.

Ease of Use and Device Satisfaction

Regarding *overall ease of use* for wireless devices, a majority of users of smartphones indicated that their devices were easy to use while basic phone users did not. Regarding *basic cell phones*, 24% indicated that they were very easy to use, and 14% indicated they were easy to use, for a total of **38%** (rounded up). Of remaining basic cell phone users, 43% indicated they were somewhat hard to use, 14% indicated they were hard to use, and 5% indicated they could not use them without help.

Regarding *smartphones*, 42% indicated them as very easy to use, and 36% indicated them as easy to use, for a total of **78%**. Of remaining users, 18% indicated they were somewhat hard to use, 2% indicated they were hard to use, and only 5 users (3%) indicated not being able to use it without help. Figure 2 provides a complete breakdown of responses to the question, “How easy it is to use your device?” with comparisons to other wireless devices surveyed by the SUN.

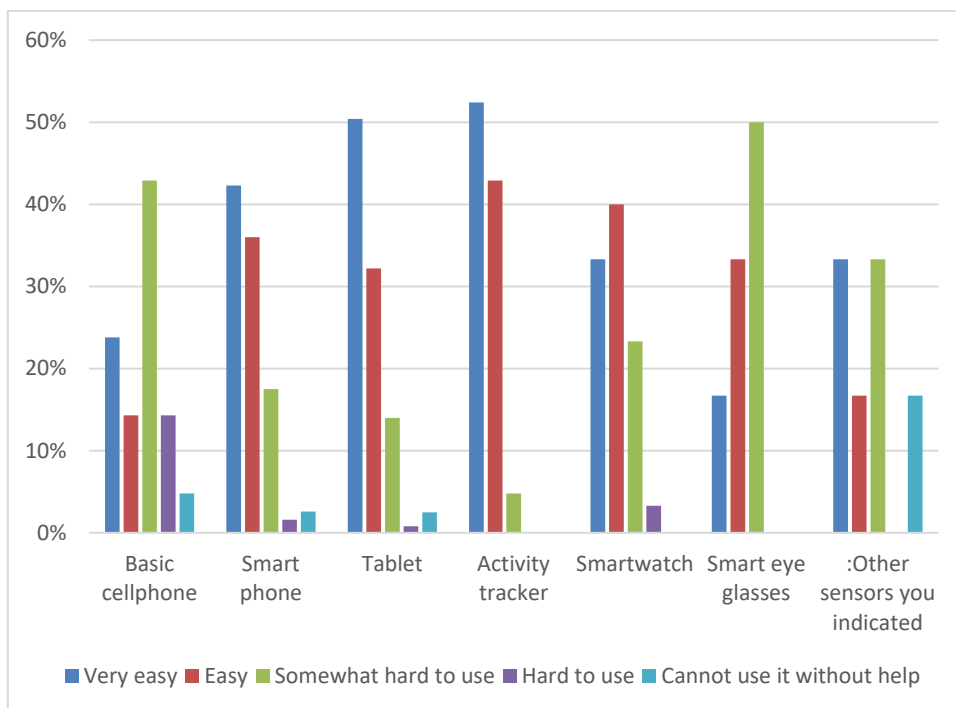


Figure 2. “How easy is it to use your device?”

Regarding *device satisfaction*, over three-fourths (77%) of smartphone users indicated that they were satisfied or very satisfied with their smartphones (Figure 3), continuing a trend from the 2017-2018 SUN in which 75% of users expressed satisfaction with their smartphones. By contrast, a decrease was noted in the satisfaction of **basic phone users**, with just **35% reporting that they were satisfied or very satisfied** with their devices and the same proportion reporting that they were dissatisfied or very dissatisfied.

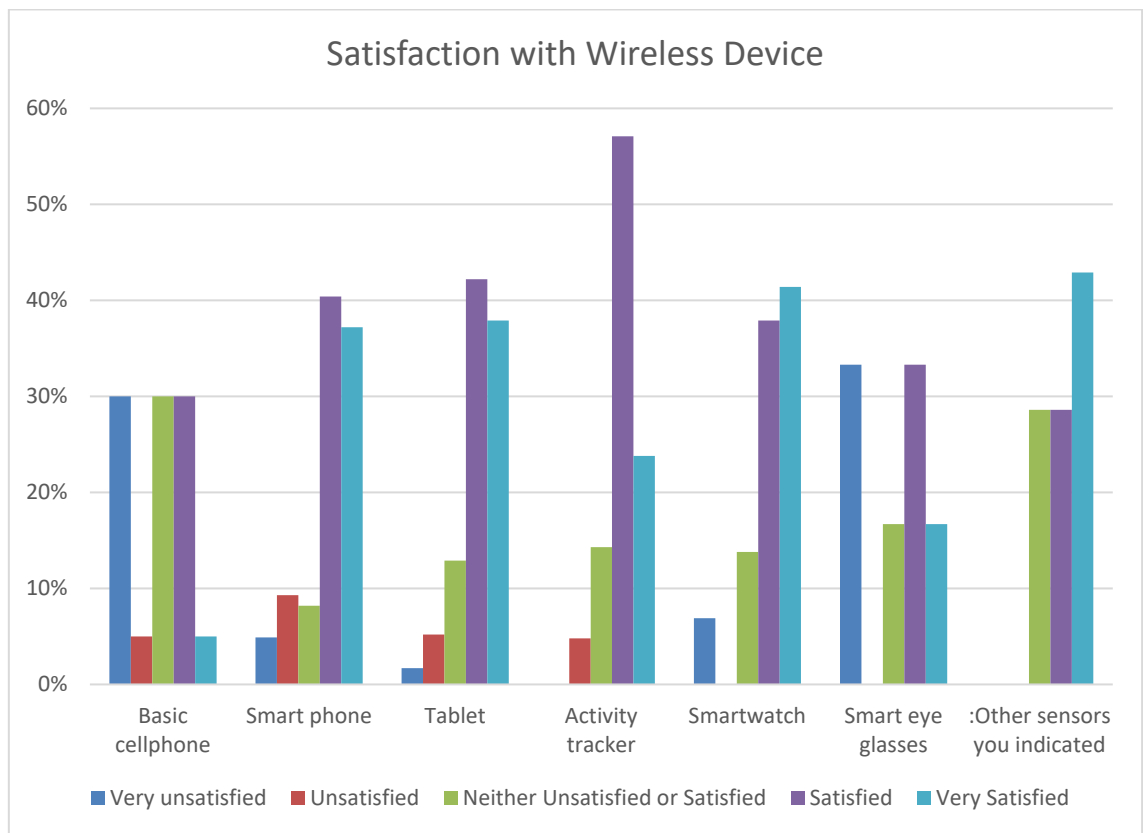


Figure 3. User Satisfaction with Wireless Devices

Regarding *the selection and purchase of devices*, personal recommendations were the most important source of information with 57% of respondents indicating very important and important, followed by online consumer sources (51%), consumer reviews (51%) and package labels (47%) comprising either important or very important sources of information (See Figure 4).

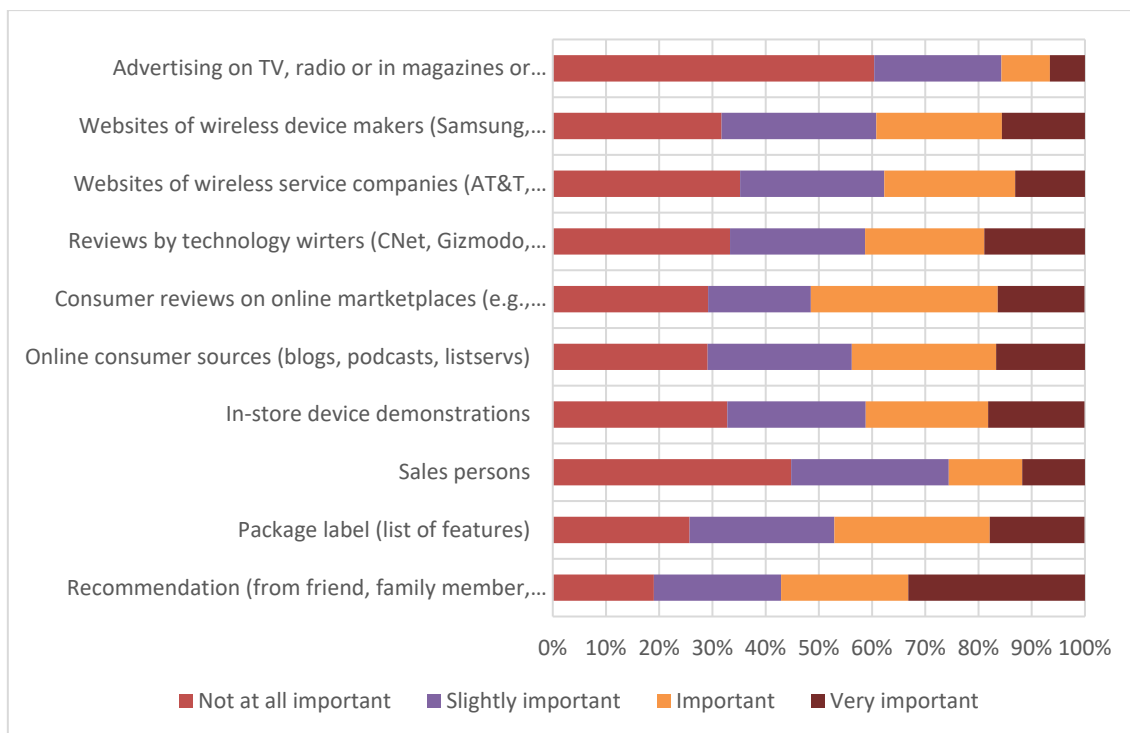


Figure 4. Factors in Selection and Purchase of Wireless Devices

Visual and Audio Display Technologies: Screen Reader and Screen Magnifier Technologies

The SUN probed on the use of technologies to present textual or graphical content in alternate formats to make this content accessible for users, including individuals who are blind, individuals with low vision, or for individuals with other vision-related disabilities. Of our total valid sample (N=223), a total of 115 indicated one of the vision impairments listed. Of the valid Vision sample, 32 respondents, or 37%, indicated their use of *screen-reader* technology. Of this group, 33 individuals, or 79%, reported blindness, 7 (17%) reported having a vision difficulty, 2 respondents indicated (5%) indicated either a cognitive (1) or speech (1) impairment. *Respondents were allowed to indicate multiple difficulties so percentages may exceed 100% due to reported comorbidities.* However, over 20% of screen-reader users report difficulties with cognition, anxiety, hands and fingers, or mobility.

Screen-reader technology users reported 1.7 ± 1 difficulties on average. Of this group, 62% of the sample reported only one difficulty, 33% reported 2 or 3 difficulties, and 5% reported four or more. Sixty-two percent (62%) of screen-reader users in the SUN sample were female; 86% identify as white or Caucasian; 62% had a bachelor's degree or higher; and 48% are currently employed either full or part-time. The average age of screen reader users was 53 years of age.

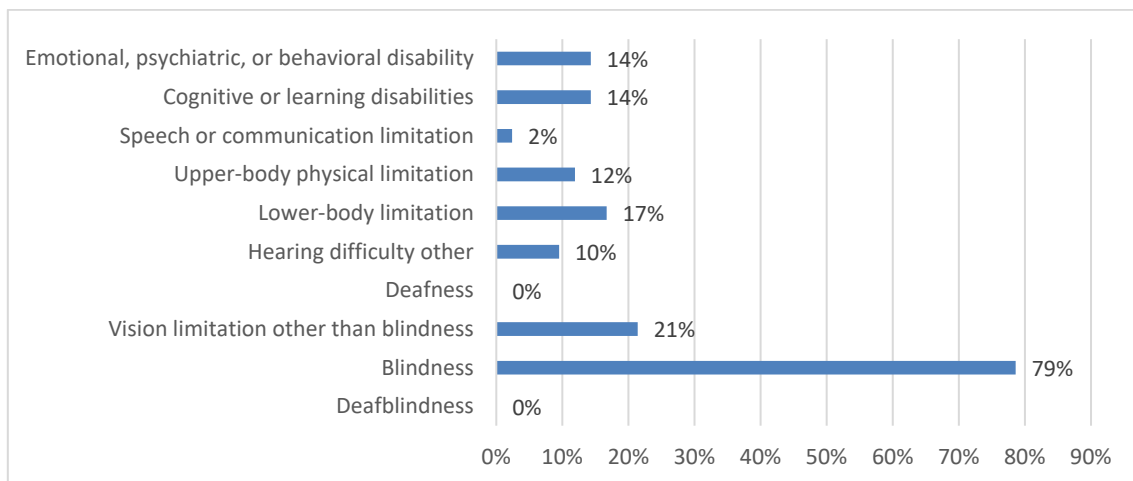


Figure 5. Use of Screen-Reader Technologies, by Reported Disability

A total of 32 respondents, or 15% of the SUN sample, reported the use of *screen magnifier* technologies for their wireless devices. Of this group, 21 individuals, or 66% of these users, reported a vision difficulty, while 25% reporting being functionally blind. Considering the application of this technology and its reliance on vision, these findings may be as expected. *Because the questionnaire does not specify the nature of blindness in diagnostic terms, it is possible that respondents that indicated as “blind” may have some usable vision.* Interestingly, over 31% of screen magnifier users reported difficulties with mobility, and 56% reported difficulties with cognition or emotional, psychiatric or behavior, as shown in the following graph.

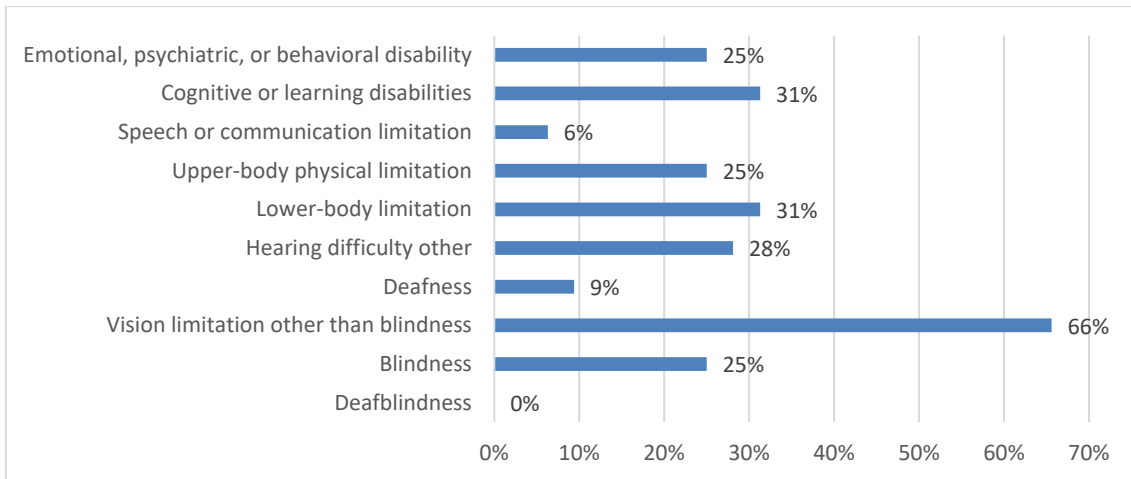


Figure 6. Use of Screen Magnifier Technologies, by Reported Disability

Screen magnifier technology users, on average, reported 2.5 ± 2 difficulties. The median number of difficulties was 2. Sixty-nine (69%) of screen magnifier technology users in the SUN sample were female; 81% identified as white or Caucasian; 53% had a bachelor's degree or higher; and 41% were employed full or part-time. The average age of these users was 52 ± 15 years old, with 41% of users being 50 years of age or older. While these findings strongly suggest a relationship between vision difficulty and the use of this technology, it also implies a possible relationship between age and screen magnifier use, as well.

Wireless Device Features: Real-time Text and Intelligent Personal Assistants

The SUN also probed on features and applications generally not considered as assistive technologies, but which may support accessibility and usability within specific contexts. Two of these features, real-time-text (RTT) and intelligent personal assistants are presented here.

A total of 78 respondents indicated the use of *real-time text (RTT)*, which may be defined simply as text messaging that is transmitted instantly as it is typed or created. Of these users, 18 individuals, or 23% RTT users reported difficulty with hearing. An

additional 22% of respondents reported functional deafness. Also, over 32% of RTT users reported upper or lower body limitations.

The total number of difficulties reported by RTT users ranged from 0-6, with 1.9 difficulties reported on average. Forty-one percent (41%) of the sample reported only one difficulty; 45% reported 2 or 3 difficulties; and 9% reported four or more. Sixty-three (63%) percent of RTT users in the SUN sample were female; 77% identified as Caucasian; 64% reported earning a bachelor's degree or higher; and 31% reported annual incomes of \$50,000 or greater. Thirty-four percent (49%) were currently working either full or part-time. The average age of RTT users was 52 ± 15 , and 37% of users were over age 60. The SUN also queried on the use of *intelligent personal assistants* for wireless devices, such as Apple Siri, Google Now, Microsoft Cortana, and Amazon Alexa. A total of 112 respondents, or 50% of the SUN sample, indicated their use of intelligent personal assistants. Users indicated a diverse range of functional abilities, with lower and upper body limitations tied as the top two difficulties (N=50 (45%) upper and 40 (36%, respectively.) Vision difficulties including blindness were reported by 43% of users (N=48). The following chart presents a breakdown of intelligent personal assistant use by functional difficulty.

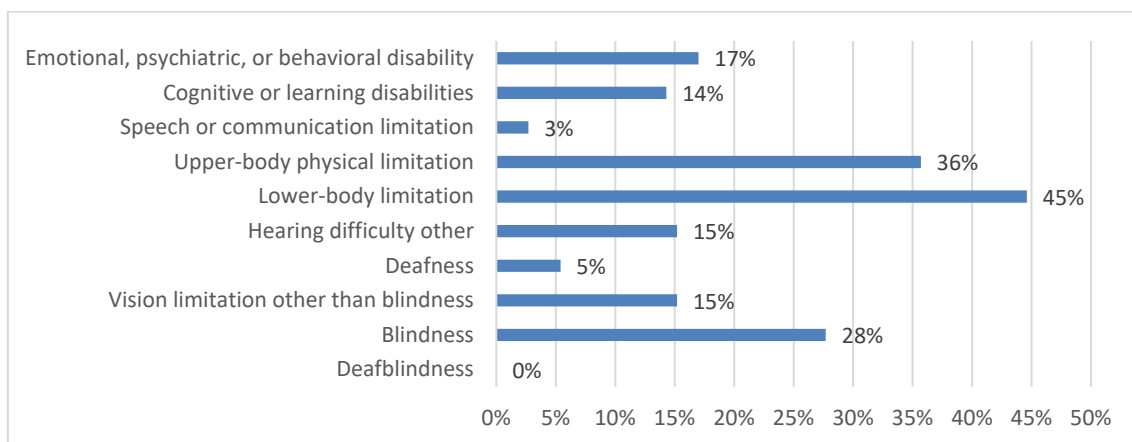


Figure 7. Use of Intelligent Personal Assistants, by Reported Disability

Forty-percent (40%) of the sample reported only one difficulty; 43% reported two or three limitations; and 9% reported four or more. Sixty-one percent of intelligent personal assistant users in the SUN sample were female, and 78% identified as Caucasian. Fifty-three percent (53%) reported obtaining a bachelor's degree or higher, and 37% reported annual incomes of over \$50,000. Fifty-four (54%) were currently working full or part-time. The average age of users of intelligent personal agents was 51 ± 14 years of age. Fifty-five percent (55%) of this group 50 years of age or older.

Device Use by Activity and Disability

The SUN also queried respondents with disabilities regarding the activities for which they used their wireless devices beyond “core” communication functions. We present the findings for six categories, based upon the key functions associated with many frequently used applications for smartphones, tablets, and other wireless devices. These may include address books, electronic calendars, notepads, and voice recorders for organization. They also may include GPS and map-based apps such as Google Maps, Waze, or Apple Maps for navigation and directions. A variety of apps exist to assist individuals with saving or managing money, as well as the apps provided by banks for online banking and bill-pay apps provided by many utilities and service providers. Rather than consider specific apps, this version of the SUN took a functional approach.

Organizational Activities

SUN participants were queried about the use of their wireless devices for organizational activities for everyday activities, such as time management or keeping up with contacts. The most commonly indicated uses included keeping a directory of contacts (87%), keeping a calendar of appointments (72%), and recording notes or

reminders (60%). A minority of respondents, only 42%, indicated using their devices for completing work activities, such as word processing or creating and showing presentations. From the four options provided, respondents indicated an average of 2.5 ± 1.4 activities reported in this category. Respondents who identified as having a hearing difficulty, functionally deaf, blind, or individuals who had a vision difficulty used their devices organizational activities most frequently. However, at least 76 percent of respondents in all disability categories indicated using their devices for organizational activities.

Community Mobility Activities

Next, the SUN queried on the use of wireless devices for assisting individuals with navigation and wayfinding, which are commonly associated with apps such as Google Maps or Apple Maps. A sizable majority of respondents used their devices for two uses, in particular, navigating and wayfinding through GPS and map-based apps (89%) and locating places of interests such as restaurants and stores (85%). Wireless devices were used for an average of $1.5 \pm .77$ community mobility activities. In particular, respondents who identified as having a vision limitation used their devices for community mobility far more than any other group, at 86%, closely followed by individuals who had a hearing difficulty. However, at least 74% of all SUN participants indicated the use of their devices for community mobility, regardless of disability or functional limitation.

Money Management and Personal Finances

SUN participants were asked about the use of their wireless devices for managing money and finances. The most commonly indicated uses included shopping online either to compare prices or make purchases (74%), banking online (63%), or

paying bills (54%). Only 34% of respondents indicated their use of instant payment applications such as Apple Pay or Google Pay. Use of wireless devices for the five finance activities listed had an average of 2.2 ± 1.5 activities, which suggests that while no one activity was performed by a majority of respondents, over sixty-four percent of SUN participants used their devices for at least one of the possible options. Users who identified as having a hearing difficulty (77%), deaf (74%), having a vision difficulty (64%), blind (74%), or having a speech difficulty (70%) were the most frequent users of devices for managing money or finances.

Health, Wellness, and Home Environment

SUN participants were asked about the use of their wireless devices separately for health and wellness, as well as control of the home environment. Taken together, however, these activities were the least commonly indicated uses for wireless devices. In no instance, did any activity receive a response of greater than 40%. In order, use of the wireless devices for these activities included, tracking personal fitness such as steps taken, calories burned, or nutrition (40%), monitoring personal health such as weight, blood sugar, blood pressure, or heart rate (37%), using wireless devices for home automation such as control of lights, thermostats, or other environmental devices (27%), using wireless devices to control home security systems (21%). Only 21 SUN participants (13%) indicated using their devices either for personal medical alerts such as Alert1 or LifeAlert. Use of wireless devices for the health, wellness and home environment activities listed had an average of 1.3 ± 1.3 activities.

Leisure and Social Activities

Finally, SUN participants were queried regarding the use of their wireless devices for and leisure and social activities, which range from the use of social media to

entertainment to gaming. Use of wireless devices for watching videos and movies or videos on sites such as YouTube were the most commonly indicated recreation and leisure activity (76%) followed closely by social networking on such sites as Facebook, LinkedIn, Twitter, and Instagram, and sharing photos (both at 75% each.) Use of wireless devices for other related activities included, in order, listening to audio content such as music, podcasts, radio, or audiobooks (71%), reading or studying (59%), and playing games (56%). Use of wireless devices for the six recreation and leisure activities listed had an average of 3.9 ± 2.1 activities reported.

Discussion

Based upon responses to the Wireless RERC's SUN for 2019-2020, consumers with disabilities generally report high usability and satisfaction with their mobile phones. Demographics suggest that basic cell phones tend to be owned more frequently by individuals who are older or who report lower incomes, while higher incomes tend to characterize users of smartphones, which aligns with prior Wireless RERC SUN analyses, as well as other national surveys of mobile phone usage among individuals with disabilities. No single indicated functional difficulty seems to explain ownership preferences between basic cell phones and smartphones.

In either case, however, owners of these devices tend to use them for a relatively long duration. This finding suggests the need for additional analysis regarding whether these smartphones have different operating systems or simply older models that are being kept by their owners over time. In all cases, owners of these devices report high levels of ease of use and satisfaction, which suggests increasing levels of usability.

Drawing upon the SUN's sample of users with disabilities, it remains clear that certain wireless technology features for accessibility continue to experience high levels

of use based on their utility to certain groups. The use of screen readers and screen magnifiers at high levels by individuals who reported blindness or vision difficulties provide but one example of how built-in accessibility features remain vital to technology access. By contrast, relatively less established, newer features such as real-time-text and intelligent personal assistants have yet to be widely adopted. However, the higher-than-average use of real-time-text among individuals who reported deafness or difficulty hearing suggests this features' potential for increasing usability and accessibility of these devices, specifically, and communications, in general. Meanwhile, the use of intelligent personal assistants, while rather lower than average overall, has a more diffuse group of users, which may suggest these features' usefulness across multiple disability categories. The voice control associated with intelligent personal assistants may benefit people with vision-related disabilities and individuals who have difficulty using their hands or fingers in equal measures.

Regarding the use of devices for more general activities, it is clear that some uses are more established than others. The relative novelty of "smart home" technologies that rely upon wireless devices for controlling the home environment or specific devices for health probably explain their lagging adoption by individuals with disabilities. On the other hand, activities that are enabled by applications intrinsic to the devices themselves, such as those for organization, enjoy wider use among individuals with disabilities.

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Table 1. Interview Participant Demographics