Assistive Technology
The Official Journal of RESNA

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uaty20

Are we there yet? The developing state of mobile access equity

Salimah LaForce & Dara Bright

To cite this article: Salimah LaForce & Dara Bright (2021): Are we there yet? The developing state of mobile access equity, Assistive Technology, DOI: 10.1080/10400435.2021.1926372

To link to this article: https://doi.org/10.1080/10400435.2021.1926372

Published online: 24 Jun 2021.

ASSISTIVE TECHNOLOGY
https://doi.org/10.1080/10400435.2021.1926372

Are we there yet? The developing state of mobile access equity

Salimah LaForce, MS and Dara Bright, MSPP

Center for Advanced Communications Policy, Georgia Institute of Technology, Atlanta, Unites States

ABSTRACT

The purpose of the studies presented in this paper was to inform federal regulatory policy concerning the mobile phone industry's level of compliance with the Twenty-First Century Communications and Video Accessibility Act of 2010. The Mobile Phone Accessibility Reviews included phone models from the top four wireless carriers, one prepaid carrier, and five randomly selected Lifeline Carriers. Using the providers' web pages as a reference, researchers identified 215 phone models for the 2015 sample, 214 for the 2017 sample, and 141 mobile phones for the 2019/20 sample. For each phone model, data were collected on the presence of features that impact accessibility and/or were designed to provide access to people with vision, hearing, cognitive, and mobility disabilities. To illuminate the current state of mobile phone accessibility for people with disabilities, a comparative analysis of mobile phone accessibility features by disability type, phone type (smartphone compared to non-smartphone), and data collection period (2015, 2017, 2019/20) are detailed. Findings showed that, in the aggregate, the accessibility of mobile phones is improving. But accessibility features are not uniformly available in all phone models, and gaps in the accessibility experience persist. Enabling individuals with disabilities to select from the full range of commercially available devices would ensure continued progress toward a more universally inclusive mobile phone market.

ARTICLE HISTORY
Accepted 29 April 2021

KEYWORDS
accessibility; equity; smartphones

Introduction

People with disabilities are the largest minority population in the United States. According to data published by the U.S. Centers for Disease Control and Prevention (CDC), 25% of the U.S. population is comprised of adults with disabilities (Okoro et al., 2018); up from the U.S. Census Bureaus' estimated 20% (U.S. Census Bureau, 2012). As such, people with disabilities represent a significant market segment with 511 USD Billion in disposable and discretionary income (i.e., purchasing power) (Shaewitz et al., 2018). Using the CDC's data, one in four persons with a disability is a potential customer, and consumers with disabilities expect meaningful choices for wireless technologies that enable them to engage with and fully participate in society. Despite their purchasing power being on par with and in some cases exceeding other market segments, the road to mobile access equity has been long and sometimes uphill, but not without marvels along the way. This paper discusses the context in which mobile access equity has developed, providing some insights about the sociopolitical factors that have influenced the initial exclusion and eventual inclusion of people with disabilities in mobile phone design and development.

For people with disabilities, enabling the phone's accessibility features and utilizing various applications can be a challenge due to design, usability, and accessibility issues. For example, a person who is blind and requires a screen reader to navigate the phone and consume content displayed on the phone often must depend on someone else to make the phone ready for use. Similarly, for a wheelchair user who requires assistive technology such as switch access technology to navigate the device, interoperability, and upgradability to newer smartphone models is a concern. Such help in modifying the device or enabling features may or may not be received, limiting the phone's functionality for that consumer, specifically, based on their disability status and circumstances surrounding technical help. To put it simply – same smartphone, different access levels based on disability status, digital literacy, and proficient technical assistance. Because of these challenges, some people with disabilities choose to retain their basic phones and forego the so-called mobile revolution.

To illuminate the current state of mobile phone accessibility for people with disabilities, a comparative analysis of mobile phone accessibility features by disability type, phone type, and data collection period (2015, 2017, 2019/20) is presented. The complete analyses from each period have been reported elsewhere (LaForce & Bright, 2020; LaForce et al., 2019; Mitchell et al., 2015), but this paper is a distillation of the findings across the reporting periods to illustrate the broader implications of the results of the Accessibility Reviews. Namely, showing how accessibility trends have improved, where gaps remain, and offering recommendations on ways to achieve access equity.

Sociopolitical context and the role of perception and bias

Attitudinal barriers have pushed people with disabilities to society's margins, without parity of access to economic, educational, social, and civic engagement. The access barriers that people with disabilities encounter, in large part, are not due to the nature of their disability, but to the construction of

CONTACT Salimah LaForce salimah@cacp.gatech.edu Center for Advanced Communications Policy, Georgia Institute of Technology, 500 10th Street, NW, Atlanta, Georgia 30332-0620, Unites States

environments (physical and virtual) that exclude them from opportunities afforded to people without disabilities (Smart & Smart, 2006). The barriers are further compounded by negative attitudes and perceptions of people with disabilities as less capable than their non-disabled cohorts (Sue & Sue, 2016). How individual differences, such as disability status, are perceived and valued by society can influence one's lived experience. Individual differences refer to choices (e.g., religion), circumstances (e.g., socioeconomic), and demographic characteristics (e.g., ethnicity, age, disability status) that contribute to the development and crystallization of one's identity. Identity, however, is both projected and perceived. How one is perceived interacts with the perceiver's own identity and experiences. Often, people harbor biases, implicit and explicit, that inform decision-making. While these automatic cognitive processes have developed as a method of quickly assessing a situation to determine how to react, they have bled into decisions unrelated to survival and safety, for example, decisions related to policy, environmental, and technological designs. In response to these perceptual and attitudinal barriers to access, the disability rights movement sounded the call to action with the motto "Nothing About Us, Without Us." It resonates across disciplines and domains.

In the mobile technology industry, the low representation of people with disabilities in the design and engineering fields has contributed to the disability perspective's absence. Historically, this shortfall led to the creation of mobile devices with low levels of usability and utility for people with disabilities. However, the industry response to address accessibility concerns has led to greater inclusion and improved technical accessibility. In support of this move to include disability stakeholder input in the regulatory process increased recognition that people with disabilities can be considered proactively in developing communications policies to preclude the need for lengthy revisions to policy. Likewise, the inclusion of people with disabilities in the research and development of products and services has facilitated an industry practice where accessibility is built into the products and services at the front-end; preempting, in many cases, the need for expensive retrofitting of devices by manufacturers and after-market add-ons by consumers.

A concerted effort: research, regulations, and industry

The Twenty-First Century Communications and video Accessibility Act of 2010 (CVAA) marked a major step toward codifying technology access rights for Americans with disabilities. Now, ten years later, while the Americans with Disabilities Act of 1990's applicability to digital platforms is being interpreted by the high courts, the power and reach of the CVAA reside in the Federal Communications Commission's (FCC) federal regulatory process. The FCC has a statutory obligation to evaluate the impact of regulations implementing the CVAA. Every two-years, the FCC submits a report to Congress on the state of industry compliance. In anticipation of the FCC's call for stakeholder input to inform their CVAA Biennial Reports, the Wireless RERC has conducted biennial Mobile Phone Accessibility Reviews (Accessibility Review(s)). Over the years, the FCC has requested, among other things, "input on the state of accessibility of "mobile" or wireless services" (FCC, 2018), and whether the "the input, control, and mechanical functions of telecommunications and advanced communications services and equipment are locatable, identifiable, and operable (1) without vision, hearing, speech, or color perception; (2) with limited vision, hearing, color perception, manual dexterity, reach and strength, or cognitive skills; (3) with prosthetic devices" (FCC, 2020). As expected, the wireless industry is well represented in the regulatory record concerning their compliance with the CVAA. Endeavoring to provide an objective measure, the Wireless RERC's Accessibility Reviews and other pertinent research are also entered into the record. The following sections discuss the findings of a comparative analysis of mobile phone accessibility features in answer to the FCC's questions about the state of mobile phone accessibility.

Evaluating wireless industry efforts: gains and gaps

Methods

There have been three biennial reviews of mobile phone accessibility. The Accessibility Reviews included mobile phone models from the top four wireless carriers, one prepaid carrier, and five Lifeline Carriers.[1] Using the providers' web pages as a reference, researchers identified 215 phone models for the 2015 sample, 214 for the 2017 sample, and 141 mobile phones for the 2019/20 sample. For each phone model, data were collected on the presence of features that impact accessibility and/or were designed to provide access to people with vision, hearing, cognitive and mobility disabilities. Sources of accessibility feature data included the Mobile Manufacturers Forum Global Accessibility Reporting Initiative (GARI) database,[2] user manuals from several different sites,[3] and phonescoop.com. The Wireless RERC continues to collect data on the presence of an FM Radio and wireless emergency alert (WEA) message features to inform ongoing mobile emergency communications research that aims to maximize emergency message diffusion and ensure timely and effective access to alerts and warnings for people with disabilities. In the context of the Accessibility Reviews, the rate of inclusion of WEA and FM Radio in mobile devices speaks to the availability and accessibility of these services. Earlier research identifying gaps in WEA effectiveness for people with disabilities (Mitchell et al., 2015) required an examination of all of the influencers along the continuum of message creation, sending, and receipt (WEA Message Continuum). This included considering limitations potentially introduced by the system itself, the alert originators, and the device on which the messages are received, and recipient characteristics. The WEA-capable mobile phones' accessibility levels (as measured by the presence of accessibility features) could impact selecting a phone with the appropriate assistive features, which in turn could impact the ability to receive WEA messages in an accessible manner.

[1]A random number generator was used to select five Lifeline carriers for inclusion in the review.
[2]The GARI is a project of the Mobile & Wireless Forum (MWF). Some of the data referred to in this paper was sourced from the information available from the GARI website www.gari.info and used with permission of the MWF, although all views and conclusions are the authors alone.
[3]These sites include the carrier's webpage and the phone's manufacturer.

Except for FM Radio and WEA messages, the accessibility features identified for the study include those that are used to operate the phone, consume content displayed on the phone, or to connect to external assistive technology (AT) or other smart devices that can be controlled via the phone. Except for hearing aid compatibility (HAC) rating, accessibility features were coded as either 1 = "yes," 0 = "no," or 2 = "information not available." A summary and comparative analyses were produced using Microsoft Excel.

Results

In the aggregate, the accessibility of mobile phones is improving. The most recent analysis showed that more accessibility features are available, and many of these features are customizable (e.g., rate of speech, vibration, font) (Figure 1). These are much-appreciated gains, but accessibility features are not uniformly available in all phone models, and gaps in the accessibility experience persist. These gaps are more easily seen when the data is disaggregated based on disability type and phone type.

Accessibility by disability type

The study examined accessibility features for four disability types: vision, hearing, cognitive, and mobility/dexterity.

Accessibility features for vision disabilities

In evaluating the accessibility features for vision disabilities, the study evaluated individual features that improve access for people with vision disabilities. Eighty-nine percent (89%) of phones had the ability to adjust font; 87% voice input; 84% screen magnifier; 80% biometric log-in; 79% accessibility menu; 76% built-in TTS; 74% digital assistant; 64% contrast adjustment; 61% color contrast; 57% full access screen reader; 50% color inversion; 35% dark theme; 32% grayscale; 30% braille access; 23% FM radio; 17% physical # keypad; 15% procure TTS; 9% physical QWERTY. These data suggest a general trend toward

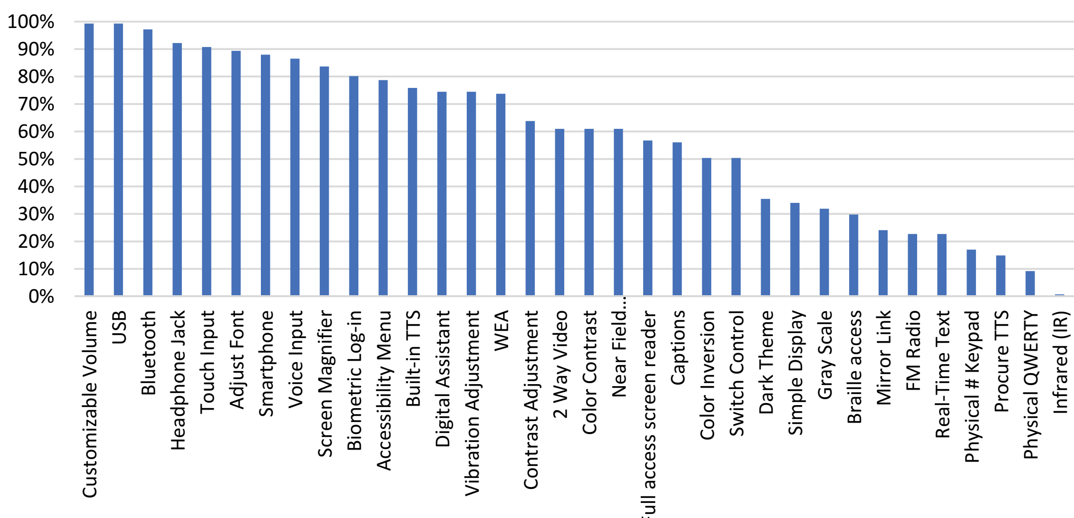

Figure 1. All accessibility features (2019/20* data). * Phone models were identified in October 2019, and again in April 2020, at which time, additional phone models were available.

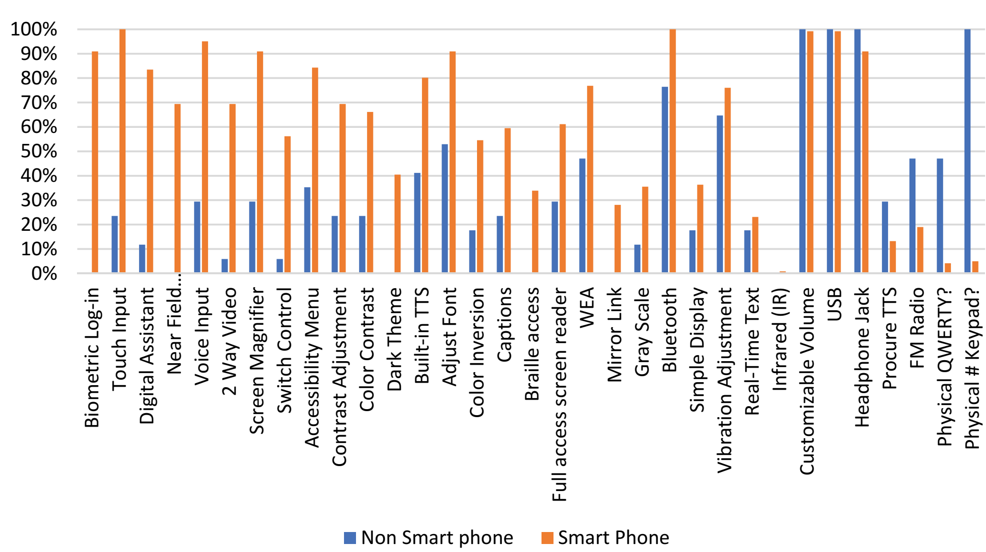

Figure 2. Comparison of smartphone and non-smartphone features (2019/20).

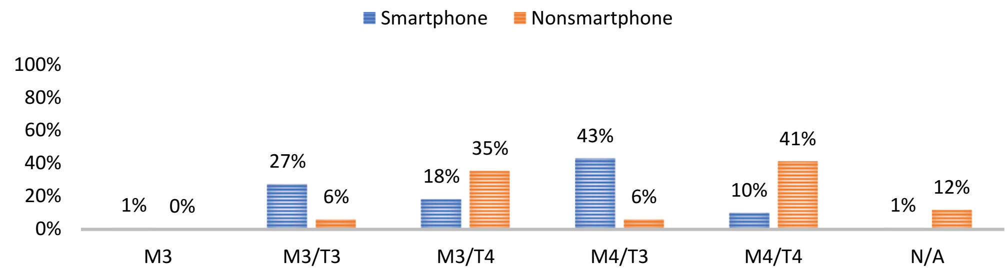

Figure 3. Comparison of smartphone and non-smartphone HAC ratings.

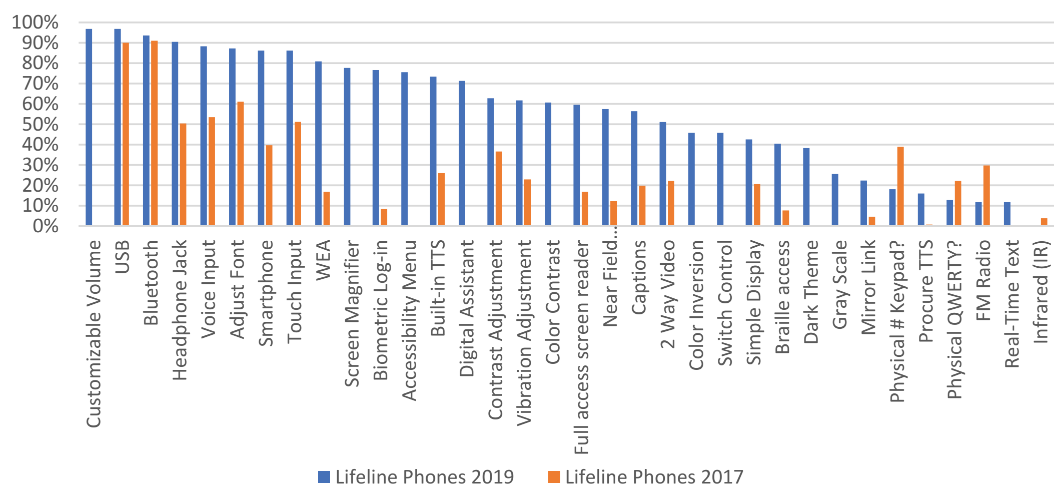

Figure 4. Comparison of lifeline phone features between 2019/20 and 2017.

improved accessibility for people with vision disabilities, particularly regarding input, output, and display customization features. Braille access and biometric log-in had the most significant percentage point increase from 2017 to 2019. Five of the features are assistive to people with color perception difficulties.

Accessibility features for hearing disabilities

The accessibility features and phone characteristics that are important for people with hearing disabilities included customizable volume (99%), Bluetooth (97%), touch input (91%), accessibility menu (79%), customizable vibration (74%), 2-way video capabilities (61%), caption feature (56%), and real-time text (23%). Touch input was included as an input alternative to voice input, and Bluetooth was included because of the availability of Bluetooth-connected hearing aids. Hearing Aid Compatibility is discussed separately in the following paragraph. The above data indicate that accessibility for people with hearing disabilities is trending up. In 2019, phone manufacturers introduced real-time text (RTT). As it is a relatively new accessibility feature, a low presence was expected, and the study's findings support this as only 23% of sampled phones included RTT. There was an increase in the availability of two-way video capability. This feature is essential for people who are Deaf and whose primary language is American Sign Language (ASL). If communicating in ASL is not a preference but a requirement for effective communications, then for people who are Deaf, 60% of the phones in the sample would be appropriate for their communication needs.

Another important phone characteristic for people who use hearing aids and cochlear implants is the HAC rating. Without a HAC-compliant device, a user with a hearing aid or cochlear implant would experience interference. HAC ratings were found for 98% of the sample, which is an increase of 18% from the 2017 sample. Out of the 138 mobile phones,[4] all had at least a HAC rating of M3 or T3, on a scale of 1 to 4, with four considered excellent.[5] M4/T3 HAC ratings accounted for 39% of phones sampled, M3/T4 (24%), M4 (20%), M4/T4 (14%), N/A (2%), M3 (1%), and M3/T3 (0%). Compared to the HAC ratings found in 2017, the percentage of phones that were HAC compliant noticeably improved. The ratings shifted from most devices falling into the M3/T3 category in 2017, to a majority of the mobile phones landing into the M4/T3 rating in 2019/20. If one wanted a phone with an excellent microphone HAC rating, they could select from 73% of the phones in the sample (up from 29% in 2017). For an excellent telecoil HAC rating, they could select from 38% of the sample (up from 30% in 2017). However, some hearing aids have both microphones and telecoils, and users can switch between the M and T settings depending on the listening situation. These users would need a device with a dual M/T HAC rating. While most phones had dual ratings, only 14% of the phones in the sample had excellent M and T ratings (M4/T4), showing no increase across data collection periods.

[4]Researchers were able to identify HAC ratings for 138 of the 141 phones in the sample.
[5]The M and T in the HAC ratings stand for microphone and telecoil. M3 or T3 is considered good and M4 or T4 is considered excellent.

Accessibility features for cognitive disabilities

Accessibility features and phone characteristics that may improve the usability of the device for people with cognitive disabilities included adjust font (89%), voice input (87%), biometric log-in (80%), accessibility menu (79%), built-in TTS (76%), digital assistant (74%), contrast adjustment (64%), color contrast (61%), full-access screen reader (57%), color inversion (50%), simple display (34%), and procure TTS (15%). Features for customizing the display, the appearance of on-screen text, and alternative logins can be assistive to people with cognitive disabilities, as they allow for:

- Shorter word counts per line (adjust font),
- Auditory information processing (TTS and screen reader),
- Removal of distracting stimuli (simple display),
- Readability (color contrast and color inversion),
- Limiting dependence on typing (voice input and digital assistants), and
- Limiting dependency on memory (biometric log-in).

These data indicate an increase in the percentage of phones with features available for people with cognitive disabilities. Specifically, for people who use the voice output features and the alternative log-in, there was a significant increase in TTS presence, full access screen readers, and biometric log-in.

Accessibility features for mobility/dexterity disabilities

In the Review, seven features were identified as aiding people living with mobility/dexterity disability in unlocking, navigating the device, and interacting with external systems. Eighty-seven (87%) of phones had voice input, 80% had biometric log-in, 79% accessibility menu, 74% digital assistants, 61% had NFC, and 50% of phones had switch control, a feature designed to allow for hands-free navigation of a device. Only 34% had a simple display option, which is useful for people with dexterity disabilities who want to improve the ease of selecting icons. The percentage of phones with a simple display option remained flat across the two most recent data collection periods.

Phone Type: Smartphones Compared to Non-smartphones

Mobile phone accessibility features were evaluated by phone type: smartphone or non-smartphone (Figure 2). Eighty-eight percent (88%) of the phones in the 2019/20 Accessibility Review sample were smartphones, and 12% were non-smartphones. The results indicate that both phone types contained features that can be assistive to people who are blind, have low vision, cognitive disabilities, and/or physical disabilities. In the smartphone subsample, the most frequently incorporated (top five) features were Bluetooth (100%), touch input (100%), USB (99%), customizable volume (99%), and voice input (95%). For the non-smartphone subsample, the top five features included a physical keypad (100%), headphone jack (100%), customizable volume (100%), USB (100%), and Bluetooth (76%).

Smartphones outperformed non-smartphones in the percentage of accessibility features present, pulling higher percentages for 26 of the 35 features examined, showing that smartphones not only have a greater variety of accessibility features, but they outperform non-smartphones in many categories of accessibility. Six features, including infrared, mirror link, braille access, dark theme, NFC, and biometric log-in, were only available in smartphone models. A noteworthy phenomenon observed in the data showed that non-smartphones could have advanced features. Twelve percent (12%) of non-smartphones had digital assistants, and 18% of non-smartphones had real-time text (RTT). To better compete with smartphones, it appears that non-smartphone manufacturers are integrating popular smartphone features into their core models.

The features present in both phone types, the ones with the steepest differentials, are shown in Table 1. These data indicate that consumers with disabilities seeking to purchase smartphones have more device options with a greater variety of accessibility features. Of concern, however, is that some users prefer non-smartphones for their perceived durability (Mitchell et al., 2014, 2018), and this preference could inhibit access to WEA messages since only 47% of non-smartphones were WEA-capable compared to 77% of smartphones in 2019/20.

Looking at HAC separately (Figure 3), the non-smartphones sampled had the greatest percentage of phone models with dual M4/T4 ratings (41% compared to 10%) and M3/T4 ratings (35% compared to 18%). In contrast, smartphones had greater percentages of phone models with M3/T3 HAC ratings (28% compared to 6%) and M4/T3 HAC ratings (43% compared to 6%). These data reveal a tension between HAC rating and other accessibility features if the individual is seeking a smartphone, as non-smartphones outperformed smartphones on the availability of devices with excellent M and T ratings. However, the opposite is true for other accessibility features useful to people who are hard-of-hearing, such as

Table 1. Non-smartphones to smartphones – top 10 steepest percentage point differentials.

Feature	Non %	Smart %	Difference
Physical Number Keypad	100%	5%	95 points
Biometric Log-In	0%	91%	91 points
Touch Input	24%	100%	76 points
Digital Assistant	12%	83%	71 points
Near Field Communications	0%	69%	69 points
Voice Input	29%	95%	66 points
2 Way Video	6%	69%	63 points
Screen Magnifier	29%	91%	62 points
Switch Control	6%	56%	50 points
Accessibility Menu	35%	84%	49 points

Table 2. Longitudinal comparison of mobile phone accessibility.

Accessibility Features	2015	2017	2019/20
2 Way Video	40%	80% (↑ 40%)	63% (↓ 17%)
Adjust Font	70%	95% (↑ 25%)	95%
Braille Access	27%	44% (↑ 17%)	36% (↓ 8%)
Built-in TTS	75%	89% (↑ 14%)	82% (↓ 7%)
Contrast Adjustment	35%	83% (↑ 48%)	72% (↓ 11%)
Full access screen reader	3%	53% (↑ 50%)	62% (↑ 9%)
Physical # Keypad	12%	12%	13% (↑ 1%)
Physical QWERTY	26%	3% (↓ 23%)	6% (↑ 3%)
Procure TTS	13%	1% (↓ 12%)	15% (↑ 14%)
Simple Display	47%	63% (↑ 16%)	40% (↓ 23%)
Touch Input	81%	88% (↑ 7%)	93% (↑ 5%)
Vibration Adjustment	40%	53% (↑ 13%)	75% (↑ 22%)
Voice Features	90%	93% (↑ 3%)	93%

captions and Bluetooth. So, an individual seeking a smartphone with a suite of accessibility features that are inclusive of people who use hearing aids might find themselves selecting from a limited supply of phone models with excellent HAC ratings and other accessibility features combined on a single device.

Longitudinal comparison of mobile phone accessibility

In looking at the change in the presence of accessibility features over the past five years, it is encouraging to see a steady rise (in many cases) in mobile phone accessibility features. Because the 2015 sample only included WEA-capable devices, to achieve equivalency in the samples being compared across all three years, a subsample of WEA-capable devices was pulled from the 2017 and 2019/20 samples. As shown in Table 2, six of the 13 features had increased presence from year to year, some were modest increases, but a standout for an exponential increase is the presence of full access screen readers, jumping from 3% in 2015 to 62% in 2020. The other seven features fluctuated. Of significance is the decrease in 2-way video, braille access, and simple display, as these features are assistive to people who are Deaf, blind, and have cognitive disabilities, respectively.

The intersection of accessibility and affordability

Lifeline phones are government-discounted mobile phones for consumers earning low-incomes. The FCC characterized qualified recipients as individuals whose income is at or below 135% of the federal poverty guidelines. Those who are eligible can use the Lifeline program for either a phone or internet service. Users must connect their phones to one of the participating carriers to access services. In a comparison of phones provided via the Lifeline phone plan (i.e., Lifeline providers) and phone models provided by Tier 1 providers,[6] mobile phone models provided via Tier 1 providers outperformed Lifeline provider phone models on twenty-four of the thirty-five accessibility features (Figure 4). The rates of feature inclusion in Tier 1 phone models exceeded those of Lifeline providers, in many cases, by quite a large margin. The features and characteristics with the greatest percentage point differentials include Vibration Adjustment (88% for Tier 1 and 62% for Lifeline), Real-Time Text (RTT) (31% for Tier 1 and 12% for Lifeline), 2-Way Video (72% for Tier 1 and 51% for Lifeline), Switch Control (64% for Tier 1 and 46% for Lifeline), and Grayscale (42% for Tier 1 and 26% for Lifeline). These data indicate that Lifeline consumers have a more limited selection of accessible phone models. Specifically, if they want or require RTT or switch control, they can select from less than one-half of Lifeline provided models.

Notably, headphone jacks and screen magnifier were present at greater percentages in Lifeline provider phone models. The screen magnifier feature is considered advanced and typically associated with the latest digital mobile phones. The presence of this feature, at higher rates, on Lifeline phones indicates Lifeline phone providers are sourcing more phone models with advanced accessibility options. This shift diverges from the 2017 Accessibility Review findings on Lifeline phones that found diminished levels of accessibility on *all* advanced features. Despite Tier 1 phone models outperforming Lifeline-provided models on the presence of accessibility features, there is a more encouraging finding that shows devices obtained from Lifeline providers have improved accessibility levels compared to 2017 data. The Lifeline program was designed to close the income-based access gap i. Figure 17 illustrates that the gap may be narrowing by noting the increase in accessibility features present in Lifeline phone models in the 2019 sample compared to the 2017 sample.

Discussion

Ideally, all accessibility features would be present across available devices at rates similar to features that are seemingly now part of standard mobile phone designs, such as customizable volume (99%), USB (99%), and Bluetooth (97%). However, currently, the ideal state has not been achieved, and the inconsistencies may be especially frustrating for those who use several types of accessibility features to access the device. Having more than one disability (i.e., comorbidity) makes identifying an appropriate mobile device more complex, particularly if they are the disabilities that have a fewer number of associated accessibility features. For example, an individual with comorbidities, possibly caused by a condition like diabetes, may have mobility and vision limitations and be confronted with making a choice between a mobile phone that is better apt to assist with one functional limitation but not the other. Likewise, 2,835,949 non-institutionalized civilians are living with comorbid hearing and cognitive disabilities.[7] These smartphone users would likely search for devices that offered features that are assistive to both functional limitations. However, on average, only half, or in some cases less than half, of the accessibility features important for people with dexterity/mobility, hearing, vision, and cognitive disabilities were present on mobile devices (LaForce et al., 2019).

There are disparities in the number of accessibility features based on disability type. For people with vision disabilities, the study analyzed 17 features. In contrast, the study identified twelve accessibility features for people with cognitive disabilities, nine for people with hearing disabilities, and seven for people with mobility/dexterity features. The variance in accessibility features in mobile devices highlights that even between disabilities, there are differential access challenges. These differences are also reflected in other mobile phone accessibility databases, except with cognition-related features having the lowest number and vision having the greatest number. One could argue that the number of accessibility features for a given disability is inconsequential to access, so long as the features that are present sufficiently enable meaningful use. However, while smartphone satisfaction rates are generally high, respondents with hearing disabilities reported greater dissatisfaction

[6]Tier 1 providers are the large internet service providers that ensure global interconnectivity and typically considered the "backbone" of the Internet. providers included in this study are AT&T, T-Mobile, Verizon, and Sprint

[7]Calculations based on U.S. Census Bureau, 2017 American Community Survey, Public Use Microdata Sample. Based on a sample and subject to sampling variability. Durham, NH: University of New Hampshire, Institute on Disability.

with smartphones than those with vision disabilities (Wireless RERC, 2021). Plausibly, the devices may not be optimally accessible to people with hearing disabilities, impacting satisfaction with the device.

To further illustrate this access feature disparity, 16.5% of American adults have a hearing disability, and 16.3% of American adults have a mobility/dexterity disability (Center for Disease Control, 2018). Still, these two disability types have the lowest number of accessibility features in mobile phones in our sample. In contrast, approximately 3% of American adults have a cognitive impairment, and the sampled mobile phones had twelve applicable accessibility features. This phenomenon is particularly notable because people with hearing and mobility/dexterity disabilities have fewer on-device accessibility resources to navigate mobile phones even though they make up over 30% of American adults with disabilities. Whereas people with vision disabilities appear to have the most accessibility features but account for approximately 5% of American adults (National Institutes of Health, 2016). This suggests that the number of accessibility features for people with vision disabilities may not be by design, but rather a consequence of (a) greater advocacy for vision-related disability access, and (b) industry trends toward voice-controlled user interfaces and display customization.

Prior studies demonstrated how integral smartphones are to people with disabilities in executing daily life activities (DePompei et al., 2008; Lancioni et al., 2017; Morris et al., 2017). As such, their increased levels of accessibility stand to deepen these devices' significance to task performance, productivity, social connections, and of course, information and communications access. However, it is important to note that some users with disabilities may prefer non-smartphones, so accessibility for these types of phones should remain a priority. While non-smartphones have fewer accessibility options, for some, the physical input options present (e.g., number keypad) offer the accessibility they are seeking as they may have no interest in using their mobile phone for anything other than a communication device. Also, non-smartphones outperformed smartphones on HAC ratings, which may lead people who use hearing aids or cochlear implants to select non-smartphones. They should not have to trade-off call quality with other desired accessibility features such as captions.

The broader implication of the lower levels of accessibility features in non-smartphones is the effected demographic. Though various factors influence an individual with a disability to select a non-smartphone, socioeconomic state[8] (SES) may have a major impact. Studies illustrate that people with disabilities have higher rates of poverty than people without disabilities. In 2017, the poverty gap between people with and without disabilities was 16.4 percentage points (National Disability Institute, 2018). Concomitantly, there are income disparities between people with disabilities and those without. Perhaps, most notably, the relationship between disability and poverty is complex. People with disabilities are "more likely to become impoverished, and people living in poverty are more likely to have or acquire a disability" (National Disability Institute, 2018, p. 12). Because people with disabilities "may be excluded from the workforce, have limited educational opportunities or face institutional barriers that restrict their earnings" (National Disability Institute, 2018, p. 13), there is a relationship between disability status and poverty rates. This relationship extends to mobile access inequity.

Two studies were found that examined how cost, and financial limitations, impact mobile phone selection for people with disabilities. As smartphones became popular, Kane et al. (2009) conducted a qualitative study to determine mobile device adoption barriers. Of the 12 participants, only six indicated that they had a mobile phone that provided accessibility features. The remaining six participants had "commodity," or standard mobile devices. They shared that though they knew "more accessible devices existed," they did not inquire about them because they thought the phones were "too expensive" (p. 117). In a subsequent study, participants also indicated that they viewed a smartphone as "too expensive" even though they were aware of the potential benefits (Rodrigues et al., 2015, p. 26). These studies suggest that people with disabilities may select a less suitable mobile device due to affordability even though a phone with more robust features would benefit the user's needs.

It is worth noting that the studies mentioned above do not provide income data for the participants, which may shed insight on how these behaviors and attitudes may change by income bracket. For example, the Wireless RERC' 's Survey of User Needs (SUN) data suggests that income is a predictor of smartphone ownership and basic phone ownership, with those in higher income brackets owning more advanced technologies (Moon et al., 2020; Morris et al., 2016). Despite the limitations in the literature on cost, income, ownership, and access, people with disabilities are more than twice as likely to be in poverty than people without disabilities (Houtenville & Boege, 2019). This statistic indicates that financial barriers are likely a significant issue, and affordability concerns may lead mobile phone users with disabilities to make sub-optimal device choices. However, additional research is required to support this assertion.

Study limitations

A limitation of the results of the Accessibility Reviews is that the features included in the Reviews are not exhaustive lists. Consumers use device features in novel ways to improve access. For example, the cameras on smartphones can be used as QR code readers to access print materials in an electronic format, which can improve information access by people with vision and print disabilities. However, that feature was not assessed in the study. Another limitation of the results that has persisted across all data collection periods (2015, 2017, and 2019) is that for many of the features, information about whether it was included in the phone could not be found using three consumer-facing sources. Thus, we cannot conclusively state that the features *are* or *are not* present. However, the difficulty in locating information about certain features is important to note, as consumers with disabilities may

[8]The term *socioeconomic state* is used in lieu of the more commonly used term, socioeconomic status, as this author considers the former a less biased way of referring to individual's and family's financial circumstances. The hierarchical nature of the term low socioeconomic *status* can invoke numerous stereotypes about those labeled as such.

experience a similar problem when comparing and purchasing phone models. While people without disabilities can compare phone models based on preferences, people with disabilities may have functional limitations that necessitate certain accessibility features for the phone to have utility (e.g., video calling, screen reader, AT connection). If a user with a disability cannot find the features he or she needs, then the consumer might purchase a phone that is not fully accessible to them or not purchase a phone model that would have been accessible to them.

Conclusion

The industry's growth in the accessibility and affordability of advanced communications technologies is encouraging. As evidenced by the increasing presence and richness of new accessibility features on mobile devices, they are well on the way to achieving mobile access equity. But, no, we are not quite there yet. During the conduct of the Reviews, it became evident that there is low transparency between manufacturers and consumers on the topic of inclusive features. Three different consumer-facing sources were utilized to evaluate mobile phone devices' input, control, and mechanical functions. The average consumer with a disability may not be willing to go through considerable lengths to determine a phone's accessibility. Furthermore, for many of the features, information about whether it was included in the phone could not be found using the numerous sources in this study. This is a missed opportunity, as clarity on whether a device has the accessibility features that consumers seek could improve consumer satisfaction and potentially reduce call center complaints concerning access issues. The ideal state would enable individuals with disabilities to select from the full range of commercially available devices. As it stands now, people with disabilities have a more limited selection. More research is required on the part of the consumer before purchase to determine if the device will meet their accessibility requirements. To ensure continued progress toward a more universally inclusive mobile phone market, accessibility features should be equally available across devices with customizability of input and output features.

Funding

This work was supported by the National Institute for Disability, Independent Living, and Rehabilitation Research (NIDILRR) [Rehabilitation Engineering Research Center for Wir].

ORCID

Salimah LaForce http://orcid.org/0000-0001-8135-166X

References

Center for Disease Control. (2018). *Disability and functioning—noninstitutionalized Adults aged 18 and over*. National Center for Health Statistics. https://www.cdc.gov/nchs/fastats/disability.htm

DePompei, R., Gillette, Y., Goetz, E., Xenopoulos-Oddsson, A., Bryen, D., & Dowds, M. (2008). Practical applications for use of PDAs and smartphones with children and adolescents who have traumatic brain injury. *NeuroRehabilitation*, *23*(6), 487–499. https://doi.org/10.3233/NRE-2008-23605

FCC. (2018). *FCC invites public comment in the preparation of the biennial report to congress*. Consumer and Governmental Affairs Bureau. https://docs.fcc.gov/public/attachments/DA-18-340A1.pdf

FCC. (2020). *Consumer and governmental affairs bureau seeks comment on the accessibility of communications technologies for the 2020 biennial report required by the twenty-first-century communications and video accessibility act [CG Docket No. 10-213]*. Consumer and Governmental Affairs Bureau. https://docs.fcc.gov/public/attachments/DA-20-216A1.pdf

Houtenville, A., & Boege, S. (2019). *Annual report on people with disabilities in America: 2018*. University of New Hampshire, Institute on Disability. https://disabilitycompendium.org/sites/default/files/user-uploads/Annual_Report_2018_Accessible_AdobeReaderFriendly.pdf

Kane, S. K., Jayant, C., Wobbrock, J. O., & Ladner, R. E. (2009). Freedom to roam: A study of mobile device adoption and accessibility for people with visual and motor disabilities. In *Proceedings of the 11th international ACM SIGACCESS conference on Computers and accessibility* (pp. 115–122). Pittsburgh, Pennsylvania, USA.

LaForce, S., & Bright, D. (2020). *Biennial analysis of mobile phone accessibility: Comparative analyses reveals pain points and progress*. Rehabilitation Engineering Research Center for Wireless Inclusive Technologies. http://www.wirelessrerc.gatech.edu/biennial-analysis-mobile-phone-accessibility-comparative-analyses-reveals-pain-points-and-progress

LaForce, S., Bright, D., & Garcia, A. (2019). *Mobile phone accessibility review*. Rehabilitation Engineering Research Center for Wireless Inclusive Technologies. http://www.wirelessrerc.gatech.edu/mobile-phone-accessibility-review

Lancioni, G. E., Singh, N. N., O'Reilly, M. F., Sigafoos, J., Alberti, G., Zimbaro, C., & Chiariello, V. (2017). Using smartphones to help people with intellectual and sensory disabilities perform daily activities. *Frontiers in Public Health*, *5*, 282. https://doi.org/10.3389/fpubh.2017.00282

Mitchell, H., LaForce, S., Bennett, D., Levy, L., Chiodo, K., & Lucia, F. (2014). *Gaps in WEA effectiveness for people with disabilities*. (Contract # HSFE5-13-R-0031). FEMA's Integrated Public Alert and Warning System Project Management Office.

Mitchell, H., LaForce, S., Moon, N., Baker, P. M. A., Garcia, A., & Jacobs, B. (2018, May 3). *Comments submitted in response to the public notice in the matter of the accessibility of communications technologies for the 2018 biennial report required by the twenty-first century communications and video accessibility act [CG Docket No. 10-213, consumer and governmental affairs bureau]*. Federal Communications Commission.

Mitchell, H., Presti, P., LaForce, S., Linden, M., Bennett, D., & Touzet, C. (2015). *Prototype findings report/vibration scale final report*. U.S. Department of Homeland Security, Science & Technology Directorate (DHS S&T). https://cacp.gatech.edu/sites/default/files/2020-03/WEA-Optimizing.pdf

Moon, N. W., Griffiths, P. C., LaForce, S., & Linden, M. (2020). *Wireless device use by individuals with disabilities: Findings from a national survey*. California State University.

Morris, J. T., Sweatman, M., & Jones, M. L. (2016). Smartphone use and activities by people with disabilities: User survey 2016. *The Journal on Technology and Persons with Disabilities*. http://scholarworks.csun.edu/bitstream/handle/10211.3/190202/JTPD-2017-p50-66.pdf?sequence=1

Morris, J. T., Sweatman, M., & Jones, M. L. (2017). *Smartphone use and activities by people with disabilities: User survey 2016*. http://scholarworks.csun.edu/bitstream/handle/10211.3/190202/JTPD-2017-p50-66.pdf?sequence=1

National Disability Institute. (2018). *2018 annual report on people with disabilities in America*. Institute on Disability, University of New Hampshire. https://disabilitycompendiu.org/sites/default/files/user-uploads/Annual_Report_2018_Accessibile_AdobeReaderFriendly/pdf

National Institutes of Health. (2016). *Visual impairment, blindness cases in the U.S. expected to double by 2050*. National Eye Institute. https://www.nih.gov/news-events/news-releases/visual-impairment-blindness-cases-us-expected-double-2050

Okoro, C. A., Hollis, N. D., Cyrus, A. C., & Griffin-Blake, S. (2018). Prevalence of disabilities and health care access by disability status and type among adults. *Morbidity and Mortality Weekly Report*, *67* (32), 882–887. https://www.cdc.gov/mmwr/volumes/67/wr/mm6732a3.htm

Rodrigues, A., Montague, K., Nicolau, H., & Guerreiro, T. (2015). Getting smartphones to talkback: Understanding the smartphone adoption process of blind users. In *Proceedings of the 17th international ACM sigaccess conference on computers & accessibility* (pp. 23–32). Lisbon Portugal.

Shaewitz, M. Y. D., Overton, C., & Smith, D. M. (2018). *A hidden market: The purchasing power of working-age adults with disabilities*. American Institutes for Research.

Smart, J. F., & Smart, D. W. (2006). Models of disability: Implications for the counseling profession. *Journal of Counseling & Development*, *84*(1), 29–40. https://doi.org/10.1002/j.1556-6678.2006.tb00377.x

Sue, D. W., & Sue, D. (2016). *Counseling the culturally diverse: Theory and practice* (7th ed.). John Wiley & Sons, Inc.

U.S. Census Bureau. (2012). *Nearly 1 in 5 people have a disability in the U. S*. Census.gov. https://www.census.gov/newsroom/releases/archives/miscellaneous/cb12-134.html

Wireless RERC. (2021). *Survey of User Needs [raw data/computer file]. Version 8*. Rehabilitation Engineering Research Center for Wireless Inclusive Technologies, Georgia Institute of Technology.