Biennial Analysis of Mobile Phone Accessibility

Comparative analyses reveals pain points and progress

Salimah LaForce and Dara N. Bright
September 2020

Center for Advanced Communications Policy (CACP)

The Georgia Institute of Technology

The Rehabilitation Engineering Research Center for Wireless Inclusive Technologies (Wireless RERC) is sponsored by the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR grant number 90RE5025-01). NIDILRR is within the Administration for Community Living (ACL), Department of Health and Human Services (HHS). The contents of this paper do not necessarily represent the policy of NIDILRR, ACL, HHS, and you should not assume endorsement by the Federal Government.

Table of Contents

Table of Figures

Executive Summary

The Rehabilitation Engineering Research Center for Wireless Inclusive Technologies (Wireless RERC) provides substantive input to regulatory agencies and other interested stakeholders to reduce access barriers and increase the development and deployment of accessible wireless products and services. We accomplish this by understanding user expectations and experiences concerning current and emerging wireless technologies and services and promoting adoption and meaningful use by the consumer. Over the 19 years that the Wireless RERC has been researching the accessibility of wireless devices, mobile phone and wirelessly connected device adoption by people with disabilities has steadily increased, as has the accessibility and usability of the devices. As we have observed and recognized accessibility gains, we nonetheless, continue to find that some gaps remain. As it pertains to the inclusive design of wireless devices, this *Mobile Phone Accessibility Review* quantifies accessibility levels of mobile phones available in the U.S. market as of February 2020.

The study analyzed 141 phones from the Tier 1 wireless carriers (e.g., Verizon and Sprint), one prepaid carrier, and five Lifeline carriers. The Review assessed the presence of 35 features associated with device accessibility for people with disabilities. This report provides an analysis of mobile phone accessibility features across the sample, including disability type, and comparative analyses based on phone type (smartphone compared to non-smartphone), the data collection period (2017 compared to 2019/20), and carrier types (Tier 1 compared to Lifeline providers). Major findings include:

- In the aggregate, there was growth in accessibility features for people with a wide range of disabilities. Upon disaggregating the data, except for features for vision disabilities, the sampled mobile phones in 2019/20 outperformed the sampled phones in 2017 in the hearing, cognitive, mobility and dexterity disabilities categories.
- There was an increase in the percentage of phones with features available for people with cognitive disabilities, including significant increases in the presence of text-to-speech, full access screen readers, and biometric log-in.
- The growth of accessibility features between 2017 and 2019 shows a shift towards the integration of novel and more advanced technology.

- 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.
- Compared to the hearing aid compatibility (HAC) ratings found in 2017, the percentage of phones that were HAC compliant noticeably improved. The ratings shifted from a majority of 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.
- Data indicated that having more than one disability (i.e., comorbidity) makes identifying an appropriate mobile device more complex, particularly if the concurrent disability has a fewer number of associated mobile device accessibility features.
- Tier 1 provided mobile phones outperformed Lifeline provider phone models on twenty-four of the thirty-five accessibility features.
- Despite Tier 1 phone models outperforming Lifeline-provided models on the presence of accessibility features, there is a more encouraging finding that shows 2019/2020 devices obtained from Lifeline providers have improved accessibility levels compared to 2017 data.
- The data indicates that WEA-capable devices have more accessibility options than non-WEA-capable phone models and the percentage of WEA-capable phones increased from 35% in 2017 to 74% in 2019.

In response to these findings, we offer several recommendations. Foremost, as new features are developed, mobile phone manufacturers are encouraged to continue to incorporate users with disabilities into all stages of the design process so that accessibility, and consequential usability, is intentional within digital designs instead of a fortuitous byproduct of innovative technology. Also, with mobile phones of all types dominating how we communicate, manufacturers should continue expanding options that allow customizability of devices and services for individual user needs and preferences.

Introduction

The Wireless RERC has been funded since 2001 by the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR), a Center within the Administration for Community Living (ACL), U.S. Department of Health and Human Services (HHS). The Wireless RERC mission is *to integrate established wireless technologies with emerging wirelessly connected devices and services for a transformative future where individuals with disabilities achieve independence, improved quality of life, and enhanced community participation*. Over the past 19 years, the Wireless RERC has researched and developed prototypes of accessible wireless devices and evaluated market devices, our findings have found that mobile phone adoption by people with disabilities has steadily increased, as has the accessibility and usability of the devices.

Regarding overall ease of use for wireless devices, the Wireless RERC's 2017-2018 Survey of User Needs (SUN) found that a majority of users of both basic mobile phones and smartphones indicated that their devices were easy to use. Regarding basic mobile phones, 64% of respondents indicated they were easy to use. In contrast, a small percentage (8%) indicated they could not use them without help and the remaining basic mobile phone users indicated they were hard to use. Regarding smartphones, 77% indicated them as easy to use while the remaining respondents indicated they were hard to use. Only one respondent indicated not being able to use their smartphone without help. These SUN data, from the end-user perspective, complements the research reported in this paper, as both indicate the industry's growth in the accessibility of mobile phones.

Some of the aims of the Wireless RERC is to reduce access barriers and increase the development and deployment of accessible wireless products and services. We are able to do this by understanding user expectations and experiences concerning current and emerging wireless technologies and services, and promoting adoption and meaningful use by end-users. We provide substantive input to regulatory agencies by providing written comments and testimony, monitor regulatory activities, and collaborate with experts from the wireless industry and disability stakeholders. In anticipation of the Federal Communications

Commission's Public Notice seeking comment on the 2020 CVAA Biennial Report, the Wireless RERC conducted a 2019/20[1] Mobile Phone Accessibility Review (Accessibility Review/Review).

Methods

The Accessibility Review included mobile phone models available as of April 2020 from the top four wireless carriers, one prepaid carrier, and five Lifeline Carriers.[2] Researchers, using the providers' web pages as a reference, identified 141 mobile phones for evaluation. Data were collected on the presence of 35 features that impact accessibility and/or were designed to provide access to people with vision, hearing, cognitive and mobility disabilities in each phone model. Sources of accessibility feature data included the Mobile Manufacturers Forum Global Accessibility Reporting Initiative (GARI) database,[3] user manuals from several different sites,[4] and phonescoop.com. The Wireless RERC continues to collect data on the presence of an FM Radio feature to inform our ongoing mobile emergency communications research. With the exception of FM Radio and the wireless emergency alert (WEA) message feature, the features identified for the study include those that are used to access the phone, the 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.

Study Limitations

A limitation of the results of this Accessibility Review is that the 35 features included in the Review are not an exhaustive list. 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 has the advantage of improving information

[1] Phone models were identified in October 2019, and again in April 2020, at which time, additional phone models were available.

[2] A random number generator was used to select five Lifeline carriers for inclusion in the review.

[3] 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.

[4] These sites include the carrier's webpage and the phone's manufacturer.

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 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 be usable by them (e.g., video calling, screen reader, AT connection). If a user with a disability is not easily able to 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. Notwithstanding the limitations of this study, the results provide a snapshot of the accessibility of a sample of mobile phone models commercially available in 2019 through April 2020.

Results and Implications

Phone Type

Of the 141 mobile phones included in the sample, 88% of them were smartphones, and 12% were non-smartphones (Figure 1). After the identification of the phone type, mobile phones were categorized by the operating system (OS). Eighty-three percent (83%) of the mobile phones in the sample had an Android OS, and 10% were iOS, while the remaining 7% of the phones were proprietary operating systems (Figure 2).

Figure 1: 2019/20 Phone Type

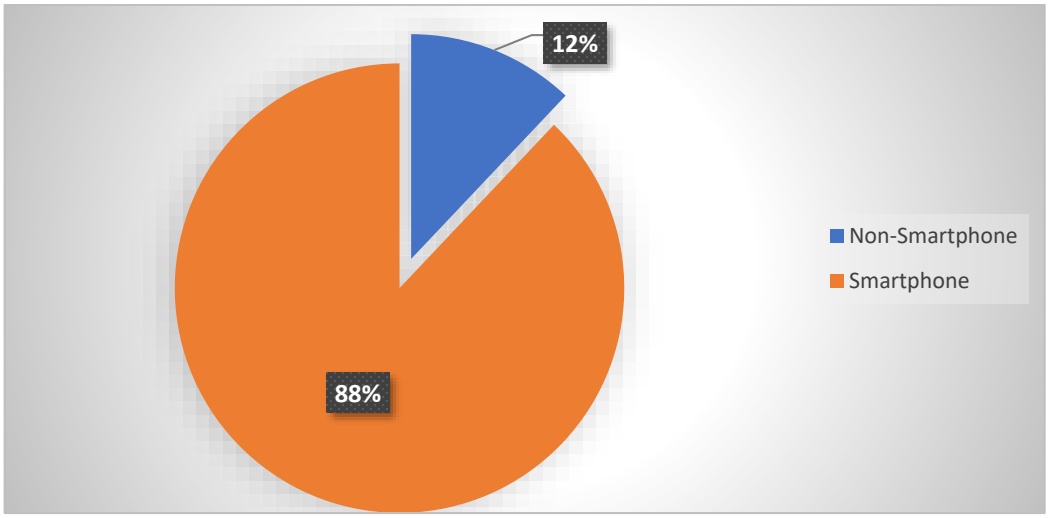
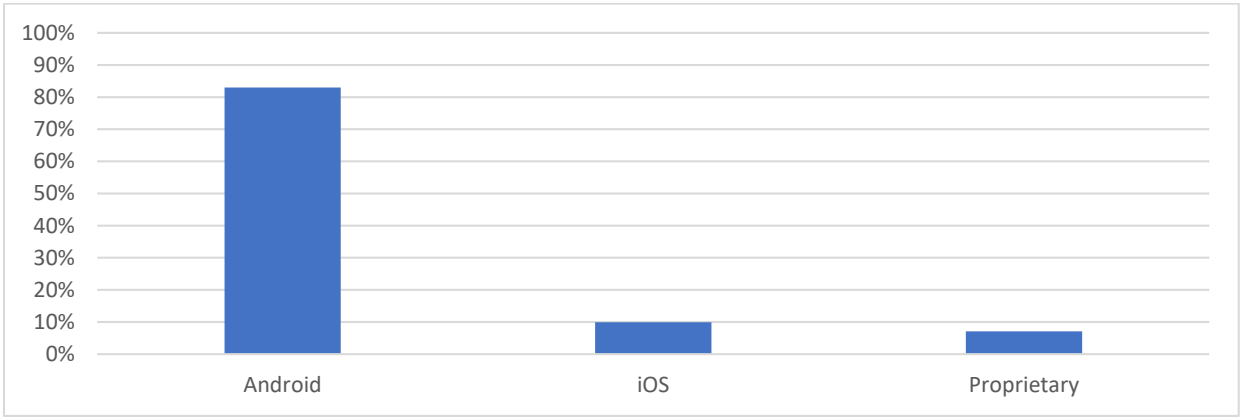


Figure 2: 2019/20 Operating System

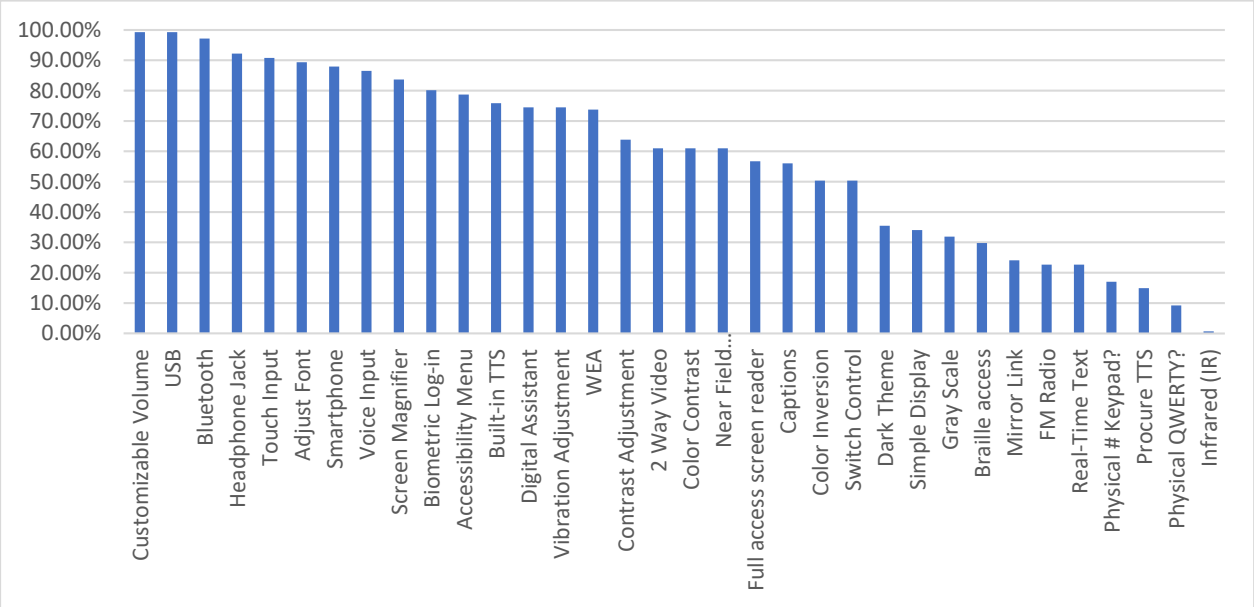


Accessibility Features

The accessibility features included in the study are: Hearing Aid Compatibility (HAC) rating, Bluetooth, USB, adjust font, voice input, headphone jack, smartphone, contrast adjustment, built-in text-to-speech (TTS), two-way video, captions, FM radio, WEA-capable, simple display, vibration adjustments, full access screen reader, physical number keypad, biometric log-in, near field communications (NFC), braille access, physical QWERTY keyboard, mirror link, infrared (IR), procure TTS, real-time text, screen magnification, switch control, touch input, color contrast, color inversion, dark theme, customizable volume, gray scale, screen reader, and digital assistant. With the exception of HAC rating, Figure 3 notes the percentages of the accessibility feature on all mobile phones included in the sample. Figure 4 shows that, in the aggregate, there was growth in accessibility features for people with a wide range of disabilities. Upon

disaggregating this data, as shown in Figures 6, 8, 11, and 13, except for features for vision disabilities, the sampled mobile phones in 2019/20 outperformed the sampled phones in 2017 in the hearing, cognitive, and mobility and dexterity disabilities categories.

Figure 3: All Accessibility Features (2019/20)



Longitudinal Comparison

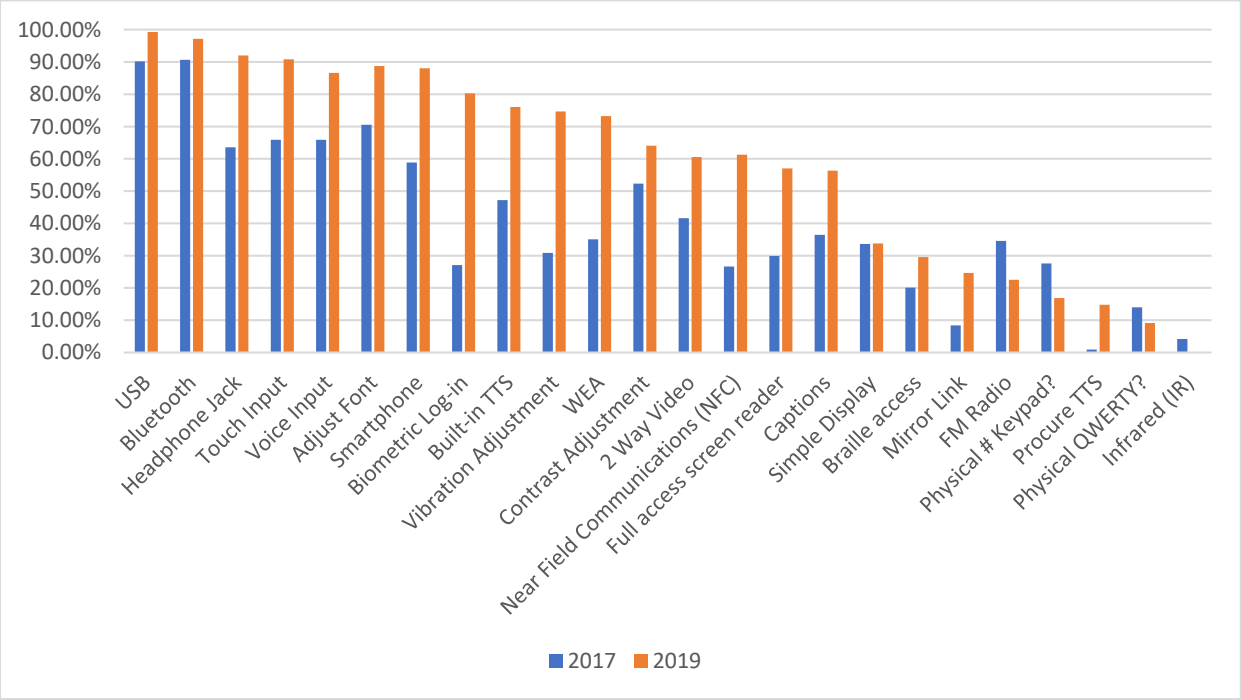
For the 2020 report, ten more accessibility features were assessed than were in 2017. The accessibility features in Table 1, included in both data collection periods showed growth in the percentage of phones that carried these features.

Table 1: Comparison of Accessibility Features - Top 10 Steepest Percentage Point Differentials

Feature	2017	2019	Difference
Biometric Login	27%	80%	53 points
Vibration Adjustment	31%	75%	44 points
Near Field Communications (NFC)	27%	61%	34 points
Built-In TTS	47%	76%	29 points
Headphone Jack	64%	92%	28 points
Full Access Screen Reader	30%	57%	27 points
Touch Input	66%	91%	25 points
Voice Input	66%	87%	21 points
Captions	36%	56%	20 points
2-Way Video	42%	61%	19 points

The growth of accessibility features between 2017 and 2019 also shows a shift towards the integration of novel and more advanced technology. As society moves towards contactless interactions and better security, such as near field communications (NFC) and biometric log-ins, people with disabilities may continue to see the secondary effects of improved accessibility of mobile phones. However, as new features are developed, mobile phone manufacturers should continue to incorporate users with disabilities into all stages of the design process so that accessibility is intentional instead of a fortuitous byproduct of innovative technology.

Figure 4: Comparison of Accessibility Features between 2017 and 2019/20[5]



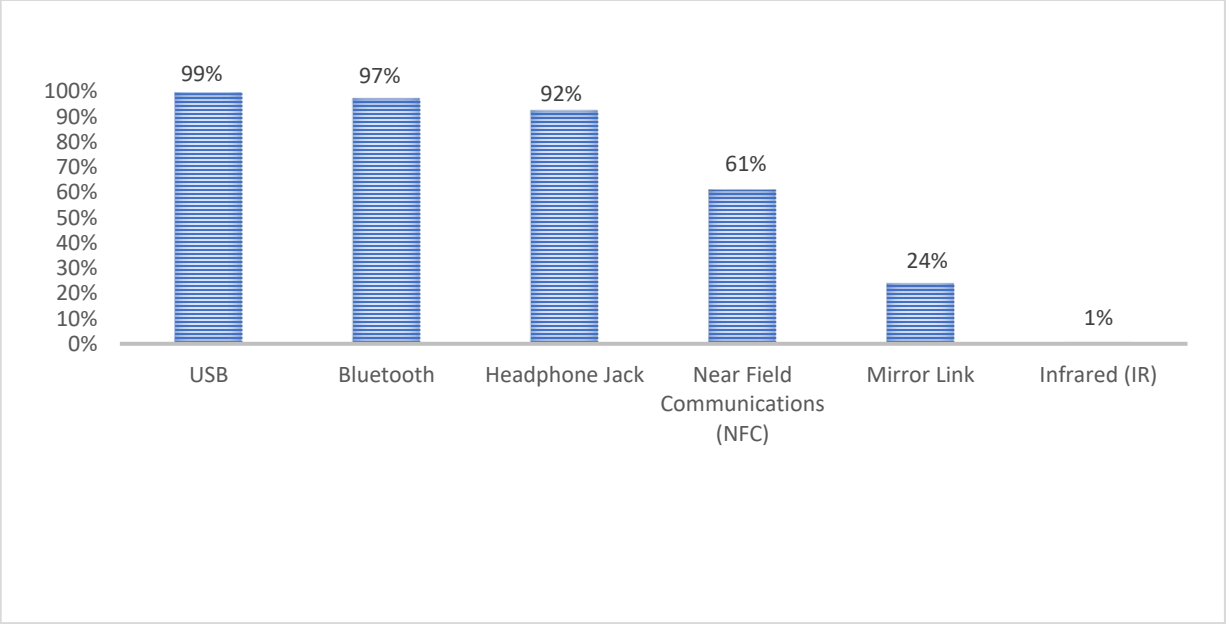
Assistive Technology (AT) Connections

Having multiple ways to connect a device to external AT is critical for some people with disabilities' use of a smartphone. AT connections are particularly pertinent to those who are blind who use refreshable Braille displays, those with quadriplegia who use switch access, or individuals who utilize neck-loops to amplify sounds. Connectivity options such as Mirror Link, NFC, and infrared allow users to connect to their vehicles, perform cashless transactions, and utilize a smartphone as a universal remote. Furthermore, Bluetooth technology is increasingly

[5] This chart only shows features assessed both in 2017 and 2019.

used to connect smartphones to smart prosthetic devices and hearing aids. As shown in Figure 5, of all mobile phones in the sample, 99% had USB capabilities, 97% had Bluetooth, while 92% had a headphone jack, 61% had NFC, 24% had mirror link, and 1% had Infrared (IR).

Figure 5:Assistive Technology Connection (2019/20)



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 focused on the percentage of phones that had individual features that improve access for people with vision disabilities. As shown in Figure 6, 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.

Figure 6: Accessibility Features for Vision Disabilities (2019/20)

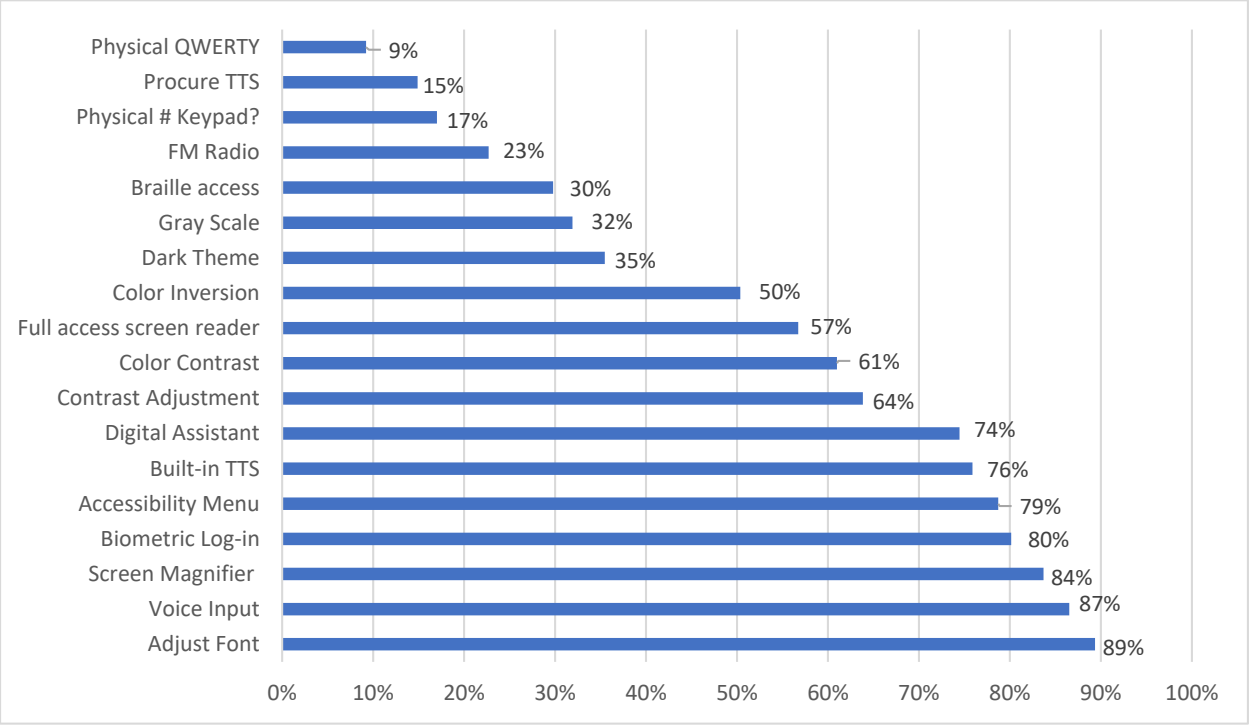
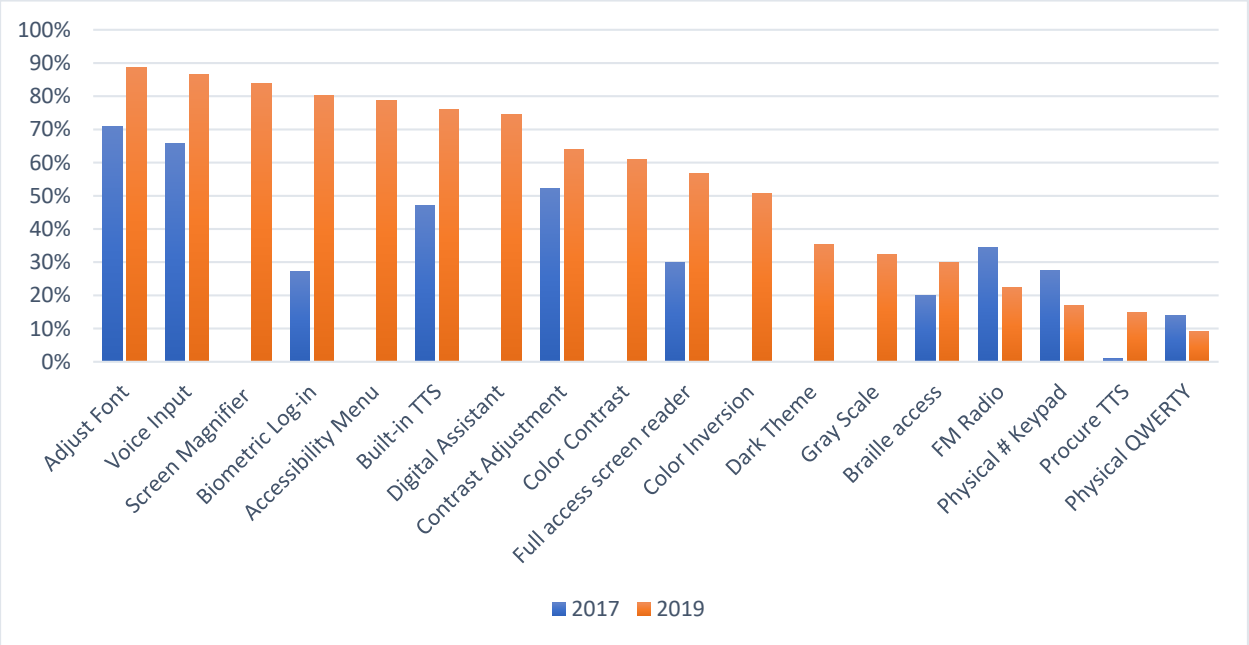


Figure 7 shows the change in the presence of vision-related accessibility features between the 2017 and 2019/20 data sets.

Figure 7: Comparison of Accessibility Features for Vision Disabilities Between 2017 and 2019/20



Following is a breakdown of the presence of features with percentage point changes since 2017.

Percentage point increases since 2017:

- 80% biometric log-in, a 53-point increase
- 76% built-in TTS, a 29-point increase
- 57% full access screen reader, a 27-point increase
- 87% voice input, a 21-point increase
- 30% braille access, a 20-point increase
- 89% adjust font, an 18-point increase
- 15% procure TTS, a 14-point increase
- 64% contrast adjustment, a 12-point increase

Percentage point decreases since 2017:

- 23% FM radio, a 12-point drop
- 17% physical # keypad, an 11-point drop
- 9% physical QWERTY keyboard, a 5-point drop

2019/20-only data:

- 84% screen magnifier
- 79% accessibility menu
- 74% of phones had a digital assistant
- 61% color contrast
- 51% color inversion
- 35% dark theme
- 32% grayscale

These data suggest a general trend towards improved accessibility for people with vision disabilities, particularly with regards to input, output, and display customization features. Braille access and biometric log-in had the most significant percentage point increase. Five of the features are assistive to people with color perception difficulties.

Accessibility Features for Hearing Disabilities

Figure 8 illustrates the accessibility features and phone characteristics that are important for people with hearing disabilities. 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 and results are shown in Figure 10. Ninety-nine percent (99%) of phones had customizable volume, 97% of phones had Bluetooth, 91% had touch input, 79% had an accessibility menu, 74% had customizable vibration, 61% of phones had 2-way video capabilities, 56% had the caption feature, and 23% had real-time text.

Figure 8:Accessibility Features for Hearing Disabilities (2019/20)

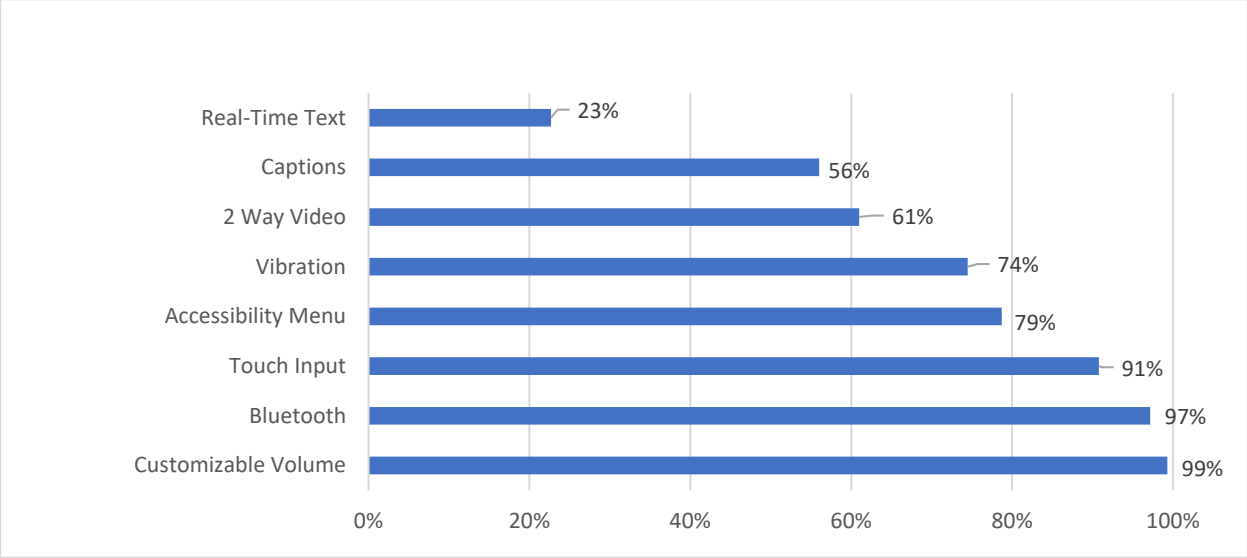
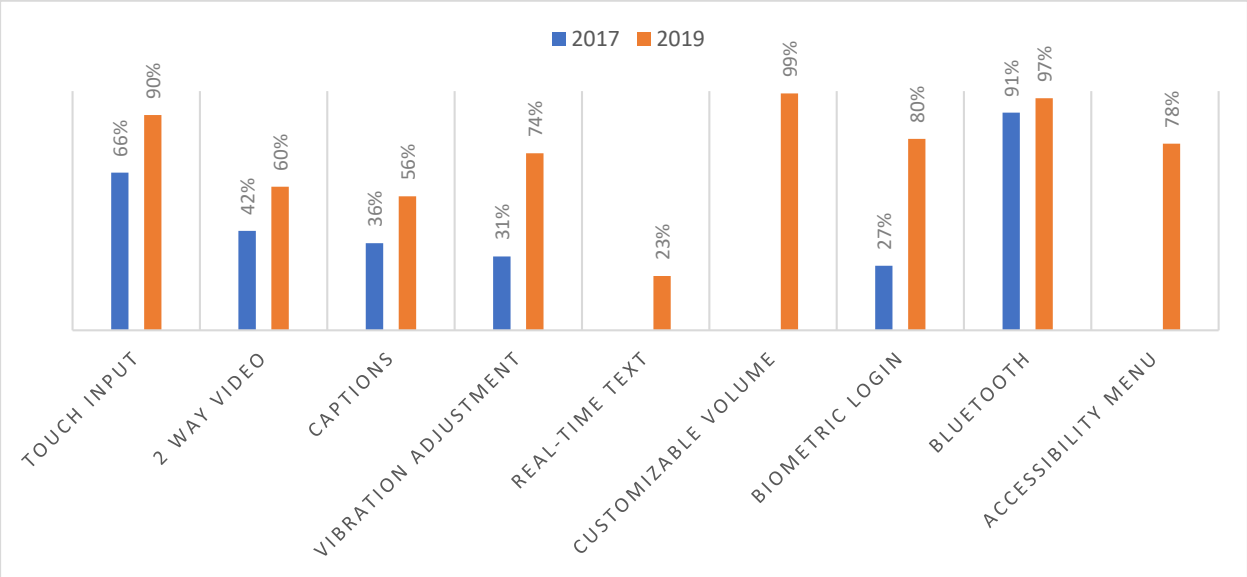


Figure 9 shows the change in the presence of vision-related accessibility features between the 2017 and 2019/20 data sets.

Figure 9: Comparison of Accessibility Features for Hearing Disabilities Between 2017 and 2019/20



Following is a breakdown of the presence of features with percentage point changes since 2017

Percentage point increases:

- 80% biometric log-in, a 53-point increase
- 74% vibration adjustment, a 43-point increase
- 90% touch input, a 24-point increase
- 56% captions, a 20-point increase
- 60% 2-way video, an 18-point increase
- 97% Bluetooth, a 6-point increase

2019/20-only data:

- 99% customizable volume
- 78% accessibility menu
- 23% real-time text

These data suggest a general trend towards improved accessibility for people with hearing disabilities. In 2019, phone manufacturers introduced real-time text (RTT). As it is a relatively new accessibility feature, we expected a low presence, 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.

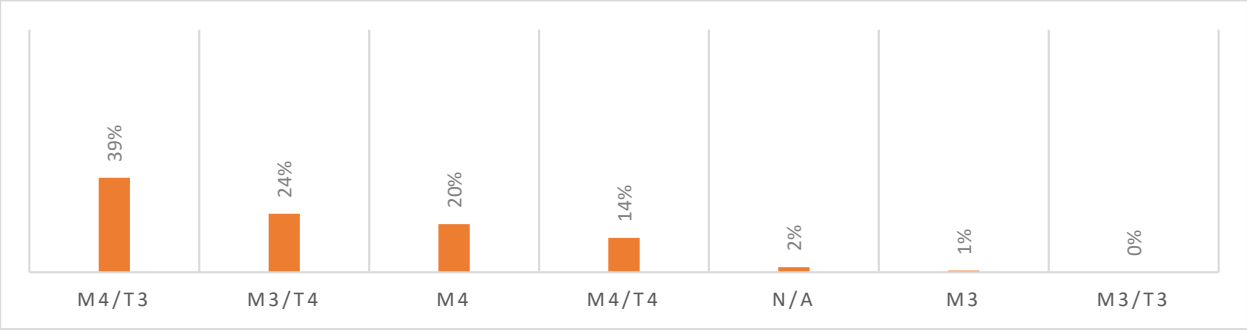
Hearing Aid Compatibility (HAC) Ratings

Another phone characteristic that is important 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[6], all of them had at least a HAC rating of M3 or T3, on a scale of 1 to 4, with four being considered

[6] Researchers were able to identify HAC ratings for 138 of the 141 phones in the sample.

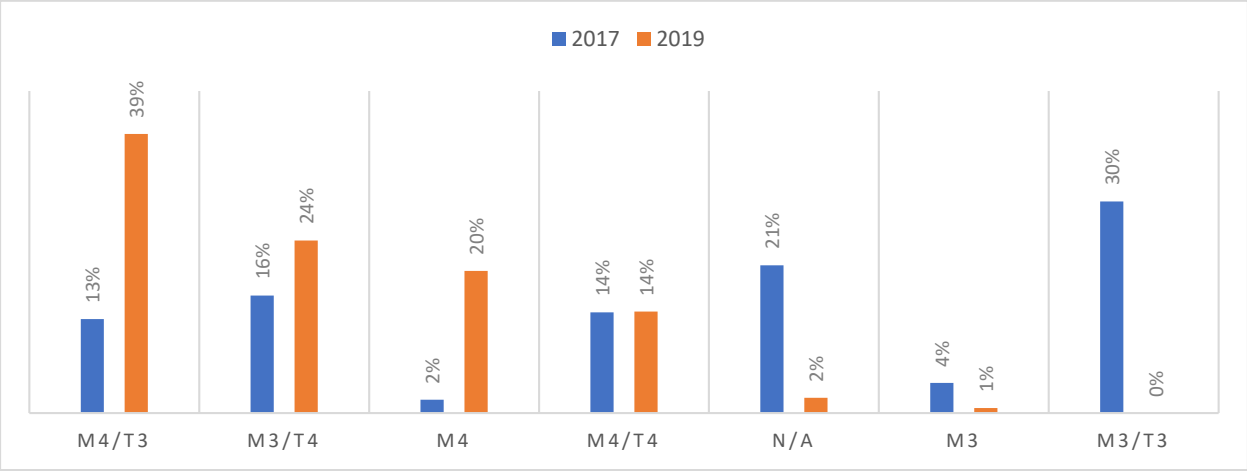
excellent[7]. As shown in Figure 10, M4/T3 account for 39%, M3/T4 (24%), M4 (20%), M4/T4 (14%), N/A (2%), M3 (1%), and M3/T3 (0%).

Figure 10: HAC Ratings (2019/20)



Compared to the HAC ratings found in 2017, the percentage of phones that were HAC compliant noticeably improved. The ratings shifted from a more devices falling into the M3/T3 category in 2017, to more of the mobile phones landing into the M4/T3 rating in 2019/20. Figure 11 highlights the growth in HAC-compliance from "good" to "excellent." Also noteworthy is the increased transparency by mobile phone manufacturers to clearly indicate the HAC ratings of phones. The graph illustrates this as the percentage of mobile devices labeled "N/A" in 2017 (21%) decreased by 19 points in 2019/20 (2%).

Figure 11: Comparison of HAC Ratings (2017 v 2019)



[7] 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.

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 phones in the sample (up from 30% in 2017). Some hearing aids, however, 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 the majority of the 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.

Accessibility Features for Cognitive Disabilities

Figure 12 illustrates accessibility features and phone characteristics that may improve the usability of the device for people with cognitive disabilities. Of the sampled mobile phones, 89% had adjust font, 87% had voice input, 80% had biometric log-in, 79% had an accessibility menu, 76% had built-in TTS, 74% had a digital assistant, 64% of phones had contrast adjustment, 61% color contrast, 57% full-access screen reader, 50% color inversion, 34% simple display, 15% procure TTS. Features for customizing the display, the appearance of on-screen text, and alternative log-ins 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).

Figure 12: Accessibility Features for Cognitive Disabilities (2019/20)

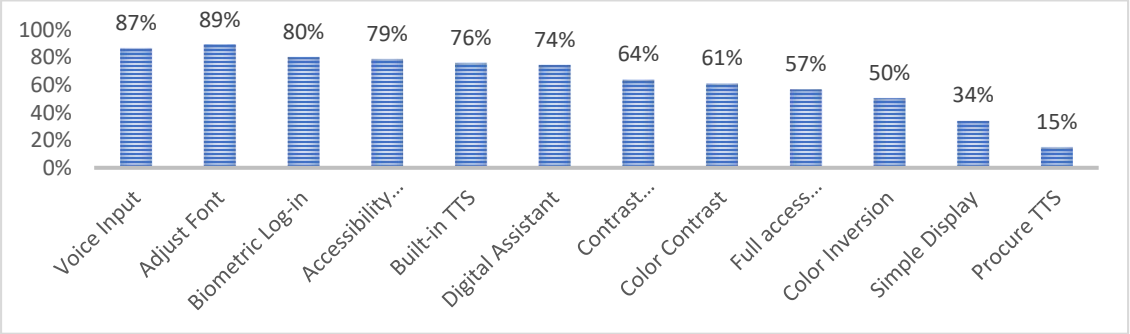
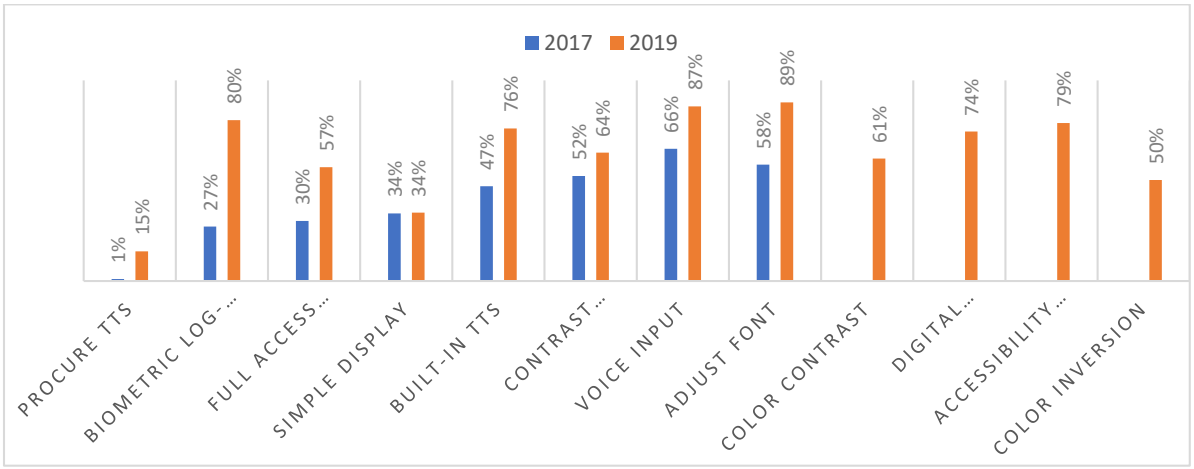


Figure 13 shows the change in the presence of cognitive-related accessibility features between the 2017 and 2019/20 data sets.

Figure 13: Comparison of Accessibility Features for Cognitive Disabilities Between 2017 and 2019/20



Following is a breakdown of the presence of features and percentage point changes since 2017.

Percentage point increases:

- 80% biometric log-in a 53-point increase
- 89% adjust font, a 31-point increase
- 76% built-in TTS a 29-point increase
- 57% full access screen reader a 27-point increase
- 87% voice input, a 21-point increase
- 64% contrast adjustment a 12-point increase
- 15% procure TTS a 14-point increase
- 34% simple display, a .4-point increase[8]

2019/20-only data:

- 79% accessibility menu
- 74% had digital assistants
- 61% color contrast
- 50% color inversion

[8] This study rounds to the nearest whole number for data values. In 2017, Simple Display was present in 33.64% of phones which was rounded to 34%. There was a minute increase between the two years of study (2017 v 2019/20).

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 as there was a significant increase in the presence of TTS, full access screen readers, and biometric log-in.

Accessibility Features for Mobility/Dexterity Disabilities

Figure 14 illustrates accessibility features and phone characteristics that may improve the accessibility of the device for people with mobility and dexterity disabilities. In the Review, seven features were intended to aid 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 data collection periods.

Figure 14: Accessibility Features for Mobility/Dexterity Disabilities (2019/20)

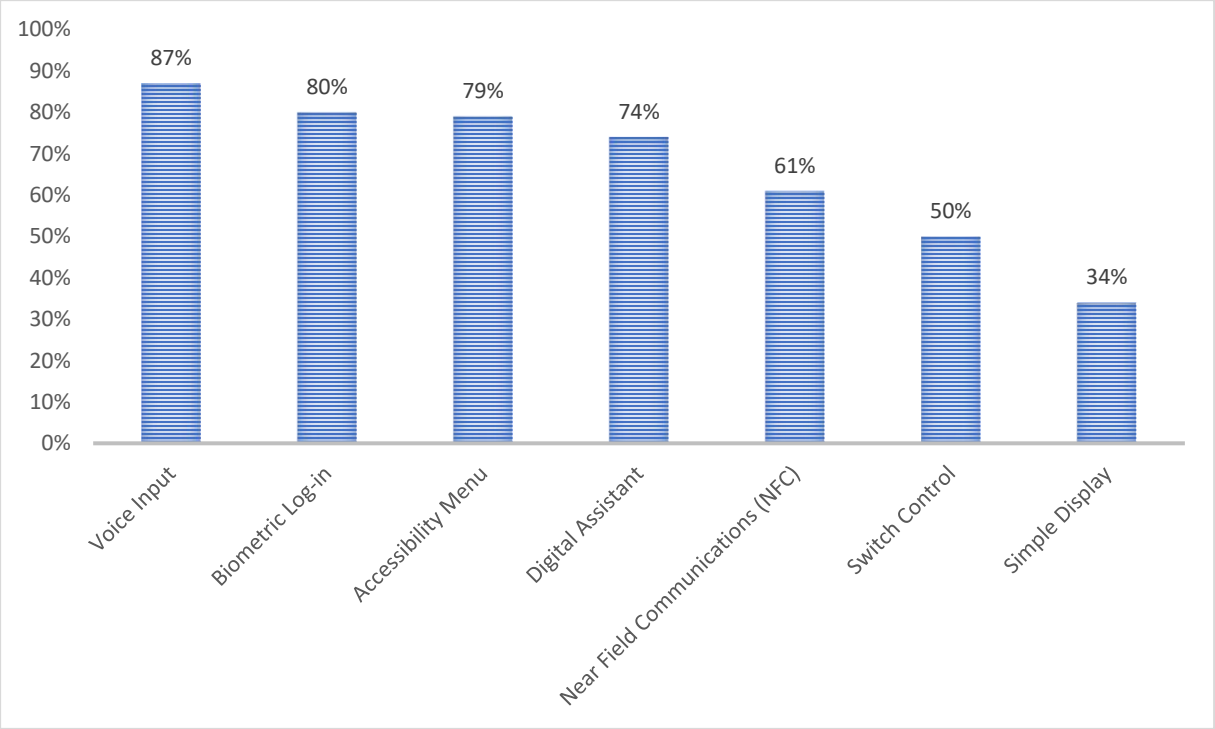
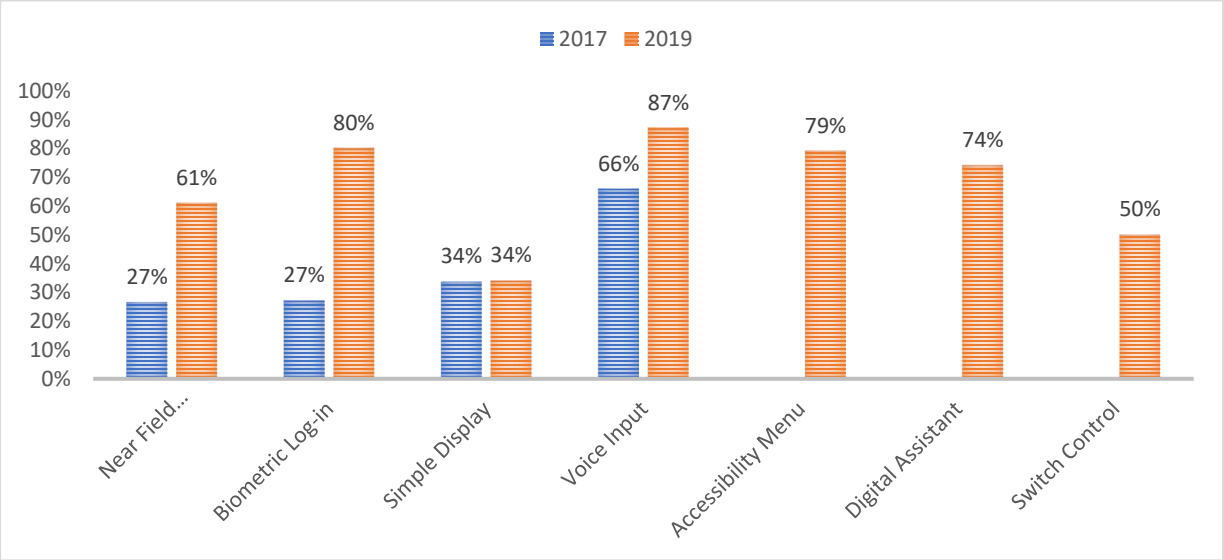


Figure 15 shows the change in the presence of mobility/dexterity-related accessibility features between the 2017 and 2019/20 data sets.

Figure 15: Comparison of Accessibility Features for Mobility/Dexterity Disabilities (2017 v 2019/20)



Following is a breakdown of the presence of features and percentage point changes since 2017.

Percentage point increases:

- 80% biometric log-in, a 53-point increase
- 61% near-field communications, a 34-point increase
- 87% voice input, a 21-point increase

2019/20-only data:

- 79% accessibility menu
- 74% digital assistant
- 50% switch control

Implications

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 applicable 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.

To further illustrate this disparity, 16.5% of American adults have a hearing disability, and 16.3% of American adults have a mobility/dexterity disability.[9] 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 impairments and mobility/dexterity impairments have fewer accessibility resources to navigate mobile phones even though they make up over 30% of the American adults with disabilities. Whereas, people with vision disabilities appear to have the most accessibility features, but only account for approximately 5% of American adults.[10] 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 towards voice-controlled user interfaces and display customization.

The study also notes that 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. Considering how many phones are cost-prohibitive,[11] the study acknowledges that despite the growth in accessibility features, other factors can contribute to the exclusion of some individuals with disabilities.

---

[9] Center for Disease Control (2018). Disability and Functioning—Noninstitutionalized Adults Aged 18 and Over. Retrieved online at: https://www.cdc.gov/nchs/fastats/disability.htm

[10] National Institutes of Health (2016). Visual Impairment, blindness cases in U.S. expected to double by 2050. Online at: https://www.nih.gov/news-events/news-releases/visual-impairment-blindness-cases-us-expected-double-2050

[11] In response to growing digital divide, the Lifeline program ensures "low-income consumers in every state, territory, commonwealth, and Tribal lands" have access to both broadband and mobile phones services. Online at: https://www.fcc.gov/general/lifeline-program-low-income-consumers. Despite the presence of this program, there is relatively low participation in the Lifeline program (Appendix A), likely due to

Comparative Analyses and Implications

Provider Type: Tier 1 Phones and Lifeline Phones

Lifeline phones are government-discounted mobile phones for consumers with low-incomes. The FCC characterized qualified recipients as individuals whose income is at or below 135% of the federal poverty guidelines. This numerical value varies with household size. Those who are eligible can use the Lifeline program for either a phone or internet service; however, there is only one discount per household. Eligible low-income subscribers can expect to pay $9.95/month. Users must connect their phone to one of the participating carriers and companies to access services. Phones provided via the Lifeline phone plan (i.e., Lifeline providers) were compared to phone models provided by Tier 1 providers. [12]

Mobile phone models provided via Tier 1 providers outperformed Lifeline provider phone models on twenty-four of the thirty-five accessibility features (Figure 16). 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.

Eighty-eight percent (88%) of the Tier 1 phones had headphone jacks compared to 90% of Lifeline models, and 88% of the Tier 1 phone models and Lifeline phone models had voice input. Compared to the 2017 dataset, the need to procure TTS software also showed comparable rates; 16% of Lifeline phones sampled have the ability to add TTS software, and 15% of Tier 1 phones can do the same. Whereas in 2017, the need to procure TTS software had practically been eliminated from both provider types, as only 1% of Lifeline phones indicated this

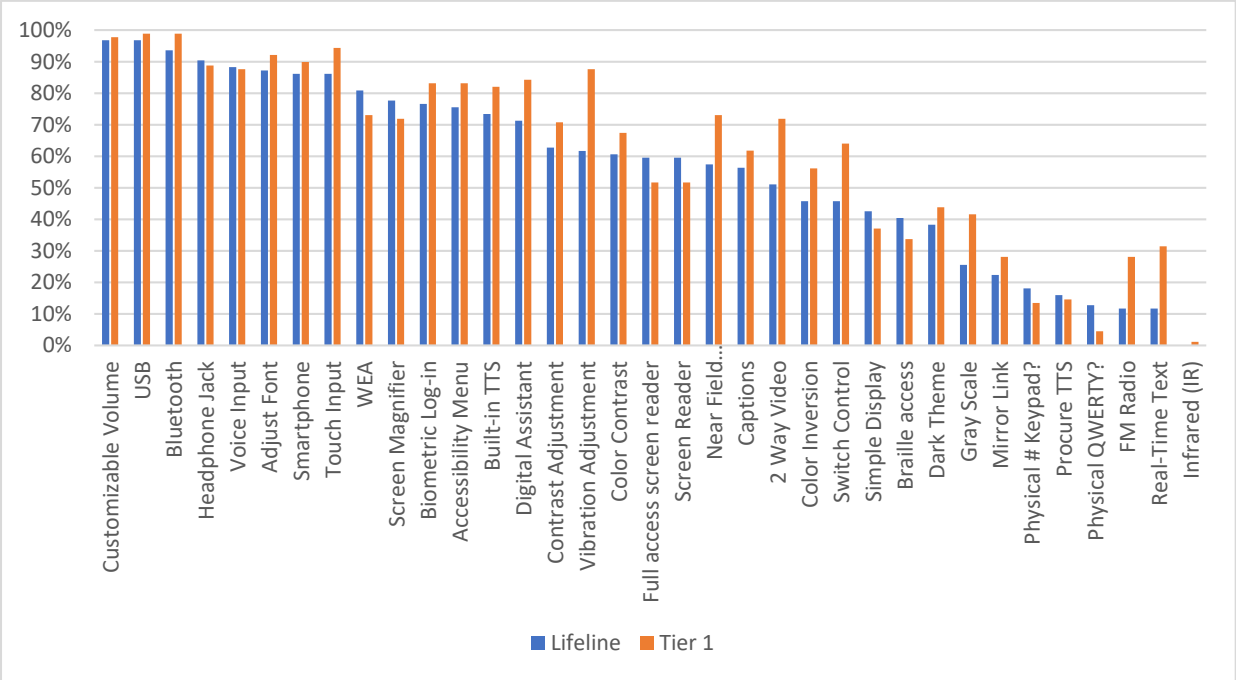
limited awareness which the COVID-19 pandemic has highlighted. Online at: https://themarkup.org/ask-the-markup/2020/05/14/is-the-u-s-governments-lifeline-phone-service-really-a-lifeline

Thompson, S. (2018). Mobile technology and inclusion of persons with disabilities. Online at: https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/13834

[12] 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

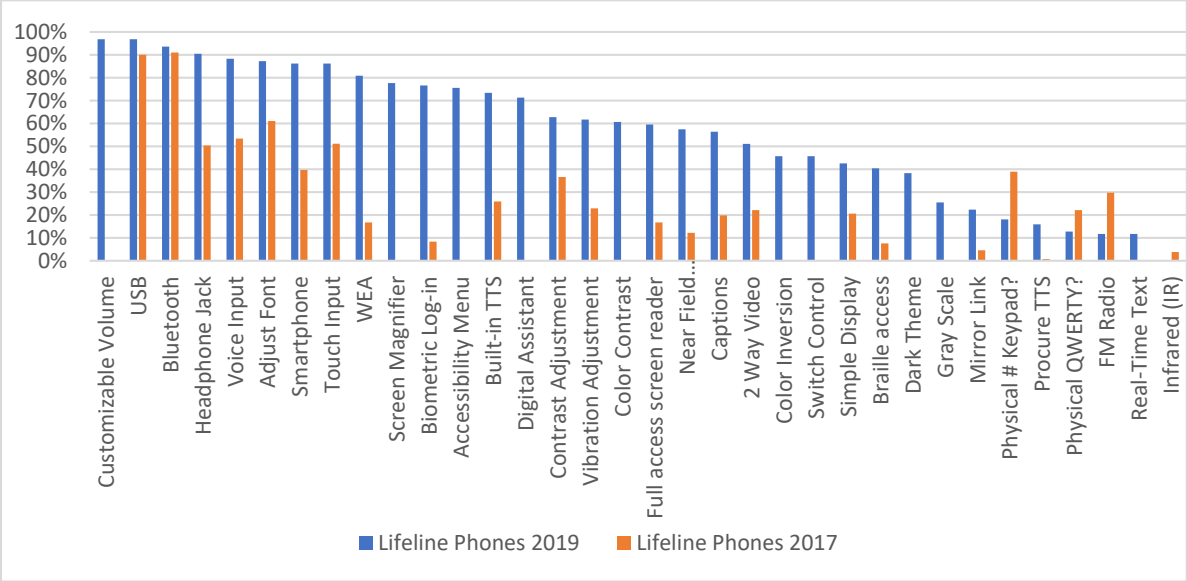
capability (0% for Tier 1 providers), suggesting that the need to procure TTS software for mobile devices was being phased out. Nevertheless, built-in TTS rates remained high at 82% and 73% for both Tier 1 and Lifeline provided phone models. The rates of feature inclusion in Tier 1 phone models exceeded 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).

Figure 16: Comparison of Tier 1 and Lifeline Phone 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 gap in access to technology between low-income populations and higher-income populations. Figure 17 illustrates that the gap is narrowing by noting the increase in accessibility features present in Lifeline phone models in the 2019 sample compared to the 2017 sample.

Figure 17: Comparison of Lifeline Phone Features Between 2019/20 and 2017



Accessibility of WEA-Capable Phones

Within the 2019 dataset, there were 104 WEA capable phones in the sample (74%). The top five accessibility features in WEA-capable devices included Bluetooth (100%), USB (100%), Customizable Volume (99%), Adjust Font (95%), and Touch Input (93%). The bottom five features included Procure TTS (15%), FM Radio (13%), Physical number Keypad (13%), Physical QWERTY Keypad (6%), and Infrared (0%). Of the 23 accessibility features comparable between the two data collection periods (Figure 18), 14 of the accessibility features have seen growth since 2017, and seven of the accessibility features declined.

Figure 19: 2019/20 WEA-Capable Phones' Accessibility Features

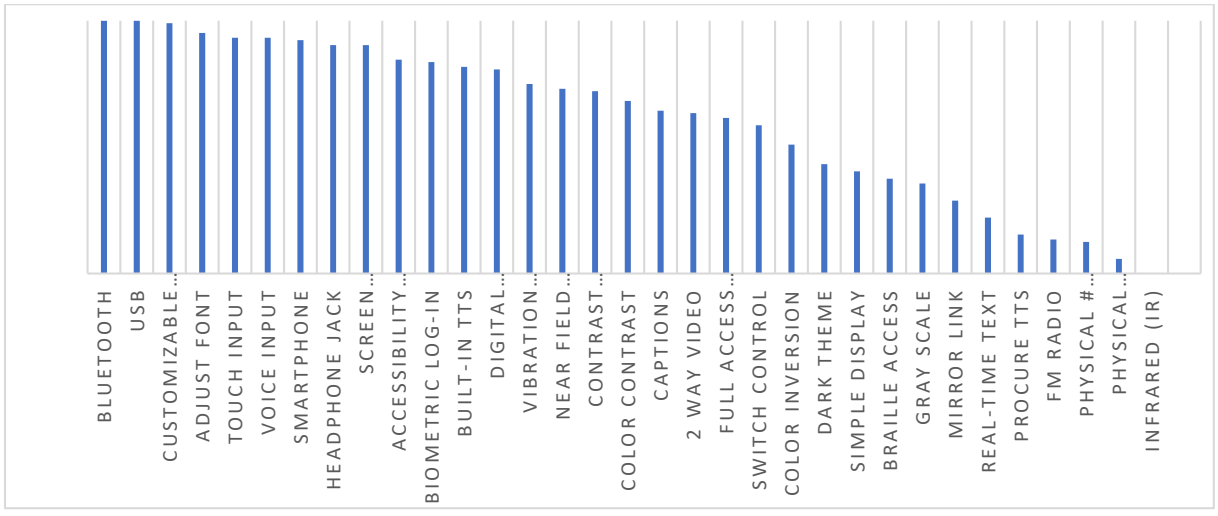
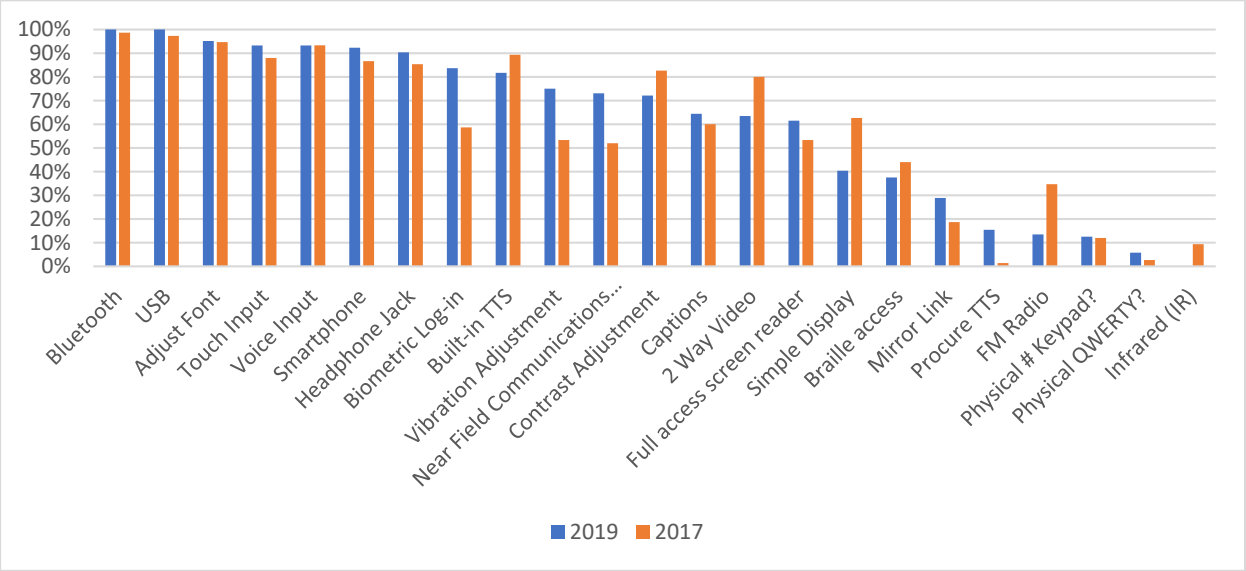
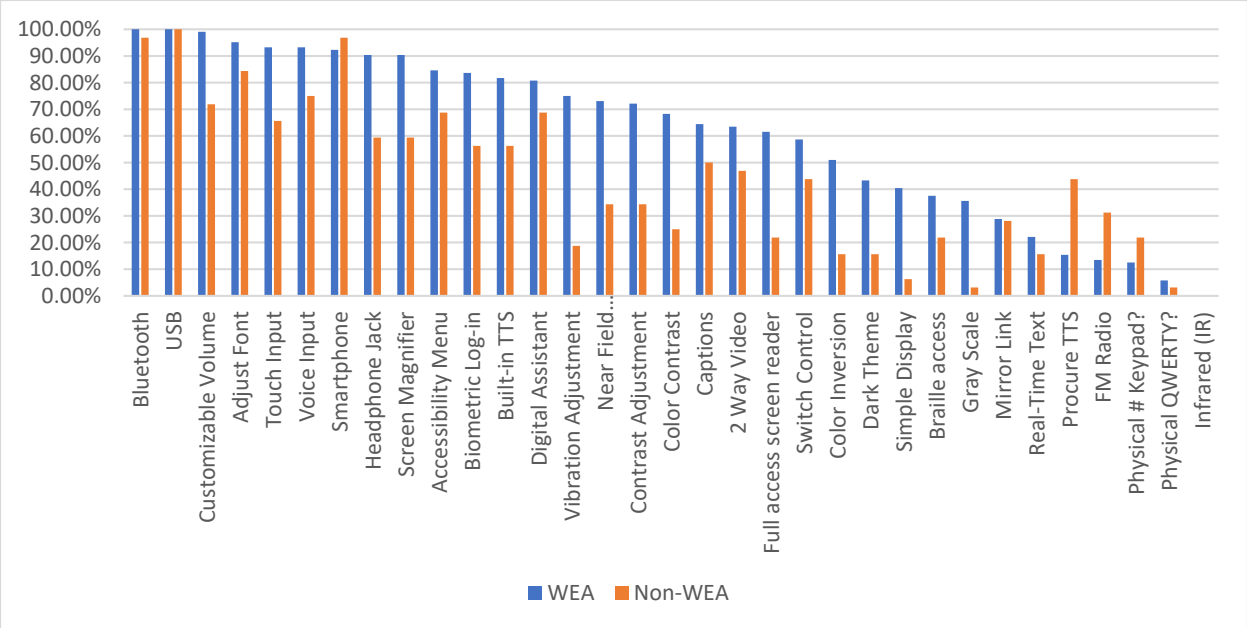


Figure 20: 2019/20 and 2017 Comparison WEA-Capable Phones' Accessibility Features



In Figure 20, the data indicates that WEA-capable devices have more accessibility options than non-WEA-capable phone models. The three features with the greatest differentials include Vibration Adjustment (19% for Non-WEA to 75% for WEA), Color Contrast (25% for Non-WEA to 68% for WEA), and Full Access Screen Reader (22% for Non-WEA to 62% for WEA).

Figure 21: Comparison of WEA-Capable Phones' Accessibility Features to Non-WEA Phones



Implications

Since wireless providers have limited control over cell phone design, many of the accessibility promises concerning WEA rely on mobile phone manufacturers enabling customizability of the device for individual user needs and preferences. But the growth is promising as the percentage of WEA-capable phones increased from 35% in 2017 to 74% in 2019. This substantial improvement in the availability of WEA-capable phones suggests phone manufacturers and wireless providers are being responsive to FCC rulemakings and associated stakeholder input. For example, WEAs are required to be accessible to people with disabilities[13], which, logically, extends to the accessibility of WEA-capable devices. These data support the *2017 Mobile Phone Accessibility Review* conclusion that "increasing the amount of WEA-capable handsets on the market could impact overall accessibility of levels of mobile phones."[14]

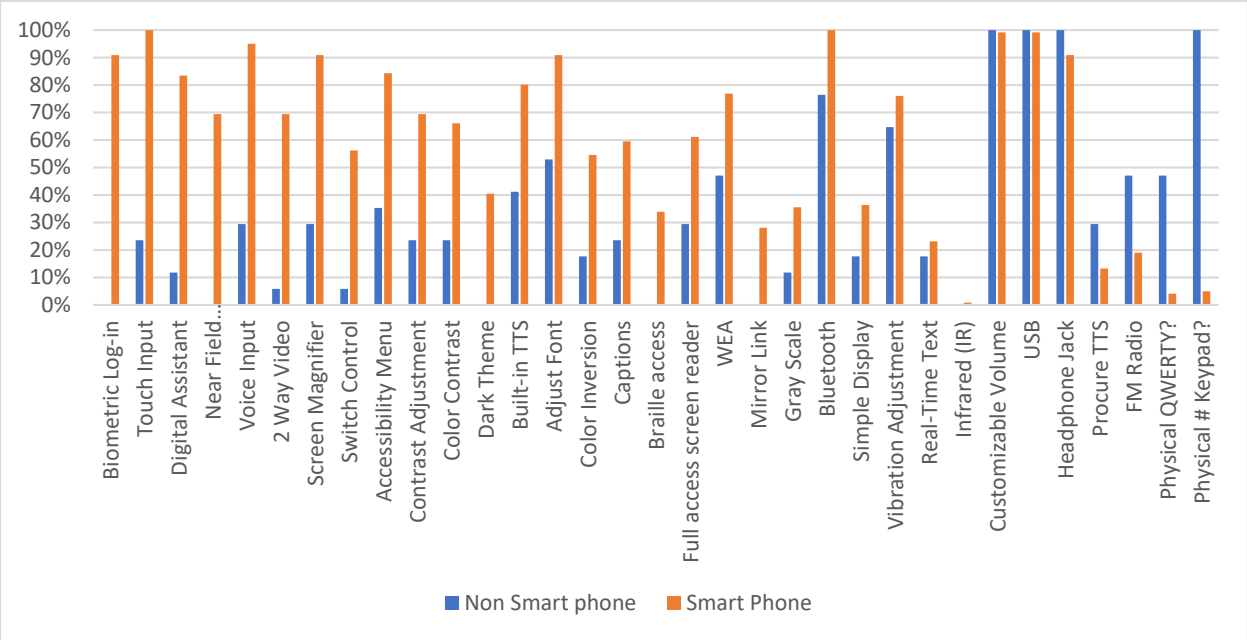
Phone Type: Smartphones Compared to Non-smartphones

Mobile phone accessibility features were evaluated by phone type: smartphone or non-smartphone (Figure 21). 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%), Voice Input (95%). For the non-smartphones subsample, the top five features included Physical Keypad (100%), Headphone Jack (100%), Customizable Volume (100%), USB (100%), Bluetooth (76%).

[13] Twenty-First Century Communications and Video Accessibility Act of 2010. *Pub. L. 111-260*. Online at: https://www.fcc.gov/sites/default/files/21st_century_communications_and_video_accessibility_act_cvaa.pdf

[14] LaForce, S., Bright, D., Garcia, A., "Mobile Phone Accessibility Review," Research Report, National Institute on Independent Living, Disability, and Rehabilitation Research, NIDILRR grant number 90RE5025-01-00, January 2019. Available at http://www.wirelessrerc.org/mobile-phone-accessibility-review

Figure 22: Comparison of Smartphone and Non-Smartphone Features (2019/20)



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. Figure 21 demonstrates a noteworthy phenomenon: non-smartphones can have advanced features. 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.

Of the features that were present in both phone types, the ones with the steepest differentials are shown in Table 2. 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,[15]

[15] 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

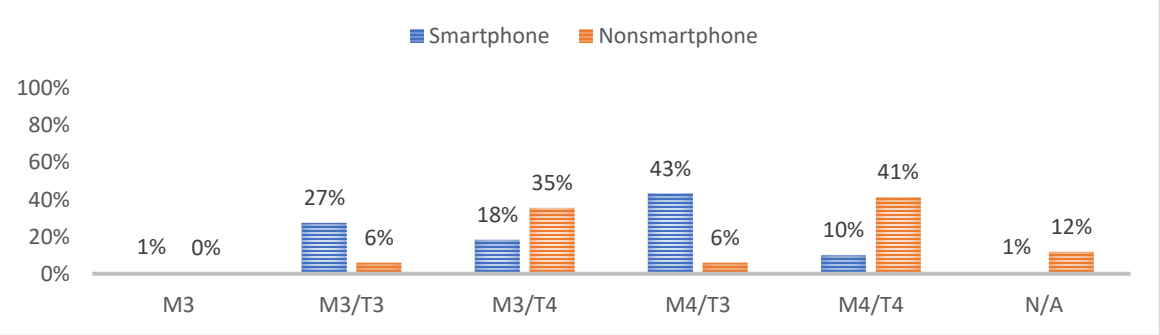
and this preference could inhibit access to WEA messages since only 47% of non-smartphones were WEA-capable compared to 77% of smartphones in 2019/20.

Table 2: Comparison of 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

Looking at HAC separately (Figure 22), 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%). Whereas the smartphones had greater percentages of phone models with M3/T3 HAC ratings (27% compared to 6%) and M4/T3 HAC ratings (43% compared to 6%).

Figure 23: Comparison of Smartphone and Non-Smartphone HAC Ratings



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: Washington, D.C.

Implications

Prior studies demonstrated how integral smartphones are to people with disabilities in executing daily life activities.[16,17,18] 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.

The broader implication of the lower levels of accessibility features in non-smartphones is the effected demographic. Though various factors influence the decision for an individual with a disability to select a non-smartphone, socioeconomic status (SES) often has 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.[19] The National Disability Institute (2019) report found that there are income disparities between people with disabilities and those without; perhaps, more notably, the relationship between disabilities and poverty is complex. They note that people with disabilities are "more likely to become impoverished, and people living in poverty are more likely to have or acquire a disability" (p. 12). Because people with disabilities "may be excluded from the workforce, have limited educational opportunities or face institutional barriers that restrict their earnings" (p.13), there is a relationship between disability status and poverty rates. Based

---

[16] 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.

[17] 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.

[18] Morris, J. T., PhD, Sweatman, M., PhD, & Jones, M. L., PhD. (2017). Smartphone Use and Activities by People with Disabilities: User Survey 2016. Retrieved from http://scholarworks.csun.edu/bitstream/handle/10211.3/190202/JTPD-2017-p50-66.pdf?sequence=1

[19] The National Disability Institute (2018). 2018 Annual Report on People with Disabilities in America. https://disabilitycompendium.org/annualreport

on the 2016-2017 US Census American Community Survey (ACS), 74% of the survey participants with disabilities were eligible for the Lifeline program, but the national Lifeline participation rate was 28%.[20] Therefore, despite finding improved accessibility of Lifeline provided phones, participation in the Lifeline program for people with disabilities is lagging.

Conclusion and Recommendations

The Wireless RERC is encouraged by the industry's growth in the accessibility and affordability of advanced communications technologies, as evidenced by the increasing presence and richness of new accessibility features on mobile devices. However, the limitation of this study, namely the difficulty in finding consistent documentation about accessibility features, illustrate that there is still low transparency between manufacturers and consumers concerning device accessibility. For this study, researchers utilized three different sources to compile the list of input, control, and mechanical functions of these mobile phone devices for persons with limited vision, hearing, color perception, manual dexterity, reach and strength, as well as cognitive skills. 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 are seeking, could improve consumer satisfaction and potentially reduce call center complaints concerning access issues.

To ensure that future technologies continue innovating for access, we offer the following recommendations:

- To improve the experience of people using hearing aids and cochlear implants, increase the percentage of phones with dual M4/T4 ratings.
- Given the disparity between the availability of accessibility features based on disability type, expand research and development into accessibility features that have greater usefulness for people with mobility and hearing disabilities, including others who could benefit during situational environments.

[20] US Census Bureau (2017) Eligible Lifeline Population Statistics.

- Given that WEA-capable devices had greater levels of accessibility than non-WEA capable phones, increasing the amount of WEA-capable handsets on the market could impact the overall accessibility of levels of mobile phones.
- To better ensure access to emergency alerts for users with disabilities that prefer non-smartphones, increase the percentage of non-smartphones that are WEA-capable.
- With mobile phones of all types dominating how we communicate, manufacturers should continue expanding options that allow customizability of devices and services for individual user needs and preferences.

Appendix A:

Persons Age 0 to 64 with a Disability without Internet (No Access or No Subscription to Internet Service)		
State	**ACS Participants**	**Qualify for Lifeline**
ALABAMA	167,661	120,374
ALASKA	13,350	8,547
ARIZONA	109,199	81,855
ARKANSAS	111,297	86,040
CALIFORNIA	470,290	369,162
COLORADO	66,913	48,011
CONNECTICUT	42,511	34,079
DELAWARE	13,849	10,365
DISTRICT OF COLUMBIA	16,242	13,725
FLORIDA	310,152	228,335
GEORGIA	217,138	159,081
HAWAII	13,977	10,180
IDAHO	28,926	21,421
ILLINOIS	189,246	134,617
INDIANA	159,576	113,457
IOWA	52,590	35,879
KANSAS	53,715	36,051
KENTUCKY	140,461	107,396
LOUISIANA	136,501	107,324
MAINE	32,251	24,309
MARYLAND	75,096	51,847
MASSACHUSETTS	83,956	69,478
MICHIGAN	258,707	198,250
MINNESOTA	67,747	46,797
MISSISSIPPI	116,800	88,254
MISSOURI	145,826	103,536
MONTANA	20,227	12,735
NEBRASKA	26,274	18,306
NEVADA	51,006	36,458
NEW HAMPSHIRE	20,780	14,737
NEW JERSEY	87,463	63,966

NEW MEXICO	69,582	56,461
NEW YORK	280,232	227,402
NORTH CAROLINA	231,675	170,023
NORTH DAKOTA	9,177	5,547
OHIO	254,267	191,340
OKLAHOMA	113,055	76,102
OREGON	66,219	50,576
PENNSYLVANIA	243,781	184,948
PUERTO RICO	183,855	160,250
RHODE ISLAND	18,855	14,231
SOUTH CAROLINA	144,593	99,854
SOUTH DAKOTA	17,392	11,180
TENNESSEE	199,591	149,288
TEXAS	558,637	392,226
UTAH	33,209	20,459
VERMONT	9,987	8,159
VIRGINIA	138,920	91,740
WASHINGTON	99,193	70,983
WEST VIRGINIA	59,783	44,281
WISCONSIN	90,671	63,985
WYOMING	8,283	4,350
TOTAL	**6,130,684**	**4,547,957**

[1] 2017 Participation rate derived from data in the 2016 American Community Survey (ACS), U.S. Census Bureau.

[2] 2016 Participation rate and household/person information crosscut derived from data in the 2015 American Community Survey (ACS), U.S. Census Bureau.