An Accessibility Infrastructure for the Global South

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ABSTRACT

We propose an "accessibility infrastructure" view to understanding accessibility in real-world settings for people with visual impairments in the Global South. We study six cities — Blantyre, Freetown, Kigali, Mumbai, San Jose, and Seoul — all major cities from signatory nations of the United Nations Convention on the Rights of Persons with Disabilities (CRPD). Using mixed methods including a survey of 219 respondents and 59 in-depth interviews, we examine the gap between the policy promise of technological accessibility and existing social and economic infrastructure. We examine the idea of accessibility infrastructure and specifically focus on its social components through two factors — stigma related to disability, and the community around technology users — both of which emerge as important factors in enabling or excluding AT use. We propose that efforts around accessibility, particularly in the post-CRPD global awareness need to closely examine the reasons behind the gaps between the technological capabilities, and the real world possibilities for people with visual impairments where a social infrastructure provides a major barrier to meaningful accessibility.

Keywords

Accessibility, Rwanda, Malawi, Korea, India, Costa Rica

CCS Concepts

• Human-Centered Computing → Accessibility theory, concepts and paradigms.

1. INTRODUCTION

The United Nations Convention for the Rights of Persons with Disabilities (CRPD) was signed by 82 nations on its opening day, the most signatures ever recorded in U.N. history. The CRPD has led to the inclusion of the provision of assistive technologies (AT) and accessibility in policy documents in several nation states for the first time. But while the convention was heralded as a landmark effort in promising access to people with disabilities, the promise on paper for greater accessibility has been incongruent with people's public experiences.

We specifically examine the experiences of people with vision impairments who use mobile devices. Mobile devices serve as a primary AT for people with vision impairments in a variety of public and private interactions, especially as these devices become cheaper and more widely available. As the technical capabilities of mobile devices improve, these devices become more central to public interaction, as they both enhance communications and enable various forms of digital access. Their uses in conditions typical to Western nations serve as exemplars for what technology can do, and indeed how an individual with a visual impairment and technology access can navigate social, architectural, and economic spaces.

Such access takes for granted much of the underlying infrastructure that enables its use. Therefore, the focus of both the accessibility industry that designs the products and arguably the policy-making behind CRPD has focused on the relationship between the individual and the design artifact as fundamental to the accessible experience.

The CRPD, for instance, obligates its signatories to promote research and development of AT and accessible information (General Obligations 1.g. and 1.h). Article 9 of the CRPD calls out accessibility including architectural accessibility, information systems, and training; Article 26 obligates the promotion of availability to accessible technologies for habilitation and rehabilitation; and Article 27 requires access to technical vocational guidance for employment.

In this paper, we use evidence from major cities in six signatory states of the CRPD to explore ways in which mobile devices, as AT, are impacting the lives of people with vision impairments. We examine independence, social participation, and safety — factors that the CRPD mentions as part of its vision for accessibility. India, South Korea, Malawi, Sierra Leone, Rwanda, and Costa Rica all signed the convention within a year of its 2007 opening, and of these states Rwanda and Costa Rica even ratified the optional protocol allowing for independent review of their implementation of the convention.

This paper examines the gap between policy promises and the ground realities of these nations in the Global South, a broad category used to refer to what were once derisively called Third World countries. The Global South includes nations with a range of development indicators, but these nations are united by shortages in their economic and institutional capacities to provide

ICTD '16, June 3–6, 2016, Ann Arbor, Michigan, USA

http://dx.doi.org/10.1145/2909609.2909666

necessary services to their populations. Here, we introduce the concept of an accessibility infrastructure to conceptualize ways in which policies around accessibility need to approach implementation. Specifically, we look at accessibility infrastructure from the perspective of technology designers to highlight the role that design thinking can play in the complex task of moving toward greater accessibility. Accessibility infrastructure, in this case, refers to the social, economic, and technical conditions that form the larger environment in which accessible technologies are usable.

Within the accessibility infrastructure, social factors refer to the interpersonal relationships and social structures in a society that enable or restrict the use of a given technology in its intended form, such as cultural attitudes toward people with disabilities, and access to communities of and for people with disabilities. Economic factors refer to the cost of technology artifacts and infrastructure to the individual and the larger collective. Digital factors refer to the networks and management of the infrastructure on which technologies operate, such as network bandwidth and language support.

The accessibility infrastructure thus includes the individuals and collectives around the users of AT — including the policymakers who create legal frameworks for technology use, the technology designers and the production chain that create and deliver technologies, and the people in contact with technology users, such as employers, friends, and family that AT users encounter daily.

The changing nature of devices and the technologies on which they exist means the infrastructure must constantly evolve. There are two ways of approaching the accessibility infrastructure from a functional perspective with regard to technology use. For policy makers, it offers a framework for thinking about the usability of the technological tools that their policies propose. For technology designers, the accessibility infrastructure is a lens toward understanding the conditions in which their products will be used.

Building on those themes that emerged most strongly in our conversations with respondents in six cities, we focus on social elements of the accessibility infrastructure. Specifically, we consider how social attitudes towards people with severe visual impairments, and the community resources of people with visual impairments influence the accessibility of the devices they use. In that, we critique the notion that the focus on AT in and of itself provides a significant value without the corresponding attention to lacking underlying social accessibility infrastructure. We argue that an accessibility infrastructure framework offers a means of thinking about the relationship between the ideal of what technology promises and the reality of what is possible within existing constraints.

2. RELATED WORK

2.1 Sociotechnical studies of infrastructure

Information theorists have long called for package views of technology [17] that try to understand the infrastructures that enable their use. Work seeking the re-imagination of infrastructure has argued for a study of its organizational, political, and ontological dimensions [4], beyond something that simply exists in the background [28]. Infrastructure is defined and redefined over time as its relationships to its parts evolve alongside its ability to support the functions within an ecosystem.

Infrastructure includes physical artifacts, but it also includes human and technical networks, institutions and facilitations. We build on this rethinking of infrastructure, studying systems as a network of interdependences [18]. Domain-specific examples include examinations of the social infrastructures for learning technology [1], which argue that the use of technology for learning goes beyond the functional elements of technology to cultural beliefs, practices, sociotechnical relations, and interactions between the learning environment and the outside world. Conceptualizations of a broader "infrastructure thinking" that include elements of social capital (referring to the value of social networks and relationships) and functional elements of practice have been applied in other domains, such as the idea of an "entrepreneurial infrastructure," which argues for linking physical resources with leadership and community development [9]. In human–computer interaction, this idea of infrastructure has been applied to the need for HCI to look beyond methodological toolboxes relating primarily to an individual–system relationship to a broader thought process about the interactions involved with the building of technical systems [7].

An infrastructure perspective is relevant to the planning of resources around the creation of laws or earmarking of funding related to accessibility, since it helps bureaucrats understand what is lacking in this space. Understanding the technical considerations of accessibility infrastructure need a careful examination of the technologies, the systems that support them, and their interaction with legacy systems. The economic infrastructure of accessibility involves looking at the systems that shape the affordability of commonly used AT individually and in group settings, and how in turn that has long-term consequences on the potential of broad-based impacts of these technologies. Social aspects of the accessibility infrastructure are in this equation arguably the hardest to measure or incorporate into a "package view" [17] since they relate the individual and collective cultural attitudes towards people with visual impairments, and by extension the technologies that they use. While discussions on the role of social and cultural barriers on various facets of disability and social access have been part of a long discussion on accessibility, there has been little thought on how these form an infrastructure for supporting accessible technology use.

2.2 Social aspects of accessible design

Accessibility as part of a package goes beyond the binary have and have-not conception of the digital divide. It looks at access to technology as mediated by a range of socio-economic realities. Many such factors are relevant to our study sites, which also differ on various metrics. There is therefore not just the potential of the disability digital divide [30], but a further complexity of the intersectionality of exclusions, defined as an exclusion of people from access to social and economic opportunity as their disability intersects with another form of marginalization such as poverty, gender, or geographical exclusion [31].

The similarities and distinctions among these people's experiences acting upon the affordances of AT artifacts form the backbone of the idea of an accessibility infrastructure. We build on the expansive work on social factors around accessibility for people with visual impairments. Design research has examined how people identify themselves through the technologies they use, and that they, in turn, can be stigmatizing [27] and how the use of AT is mediated by various adaptations that individuals must figure out

for themselves, which in turn can create vulnerabilities and dependencies [5, 15].

Most accessibility research is conducted in the economically developed Global North, as is the design of products. A small but growing field of work has started looking at the issues of accessibility in low- and middle-income regions [29], issues that go beyond the technological challenges in building appropriate technology. Besides the obvious constraints of electricity and network coverage, device cost is a dominant issue, especially in environments where welfare schemes do not exist and individuals must obtain AT with their own limited resources [8]. The lack of network economies in low- and middle-income countries further increases the cost of AT, technical support, re-use markets, and local technologies [21].

The accessibility community has also been proactive in making designers accountable for individual abilities in terms of providing technology that is adaptable, transparent, measurable, contextual, and easily available [32]. Our work extends the individual-focused "ability-based design" approaches by considering the ways use and adoption of technology are comparable among countries in the Global South on issues of the social issues that define peoples' access and ability to continue using these technologies. In this, our goal is not to seek unique perspectives, but rather underline those commonly occurring challenges that can be significant barriers to peoples' ability to participate in an accessible public.

2.3 Stigma and accessibility

Two components of the accessibility infrastructure emerge most significantly in this research — the ideas of stigma and community. Both are related to the social infrastructure of AT use, and we build on past work that has looked at these two components, primarily in the West and in more individual rather than social contexts of AT use. Here we use stigma in the sense of an attribute that is socially discrediting and in turn associated with separation from an in-group (in this case non-disabled) populations [11]. Stigma has been a critical frame for studying disability generally and AT use specifically. In this study, we examine stigma as it relates to the larger social context of "out-grouping" people with disabilities. This, in turn, has consequences for AT use among entire groups of people. Extending the research beyond Western contexts, we also examine the components of stigma and community in the Global South.

We primarily find stigma to be a negative influencer in the accessibility infrastructure, and an external-facing factor – i.e. people outside the group of AT users play a large role in the articulation of stigma. However, community comprises the user foundation of the accessibility infrastructure and can have positive and negative influences on technology adoption. Community is largely an internal-facing factor, i.e. in-group members of AT users drive the community factors that influence technology adoption.

The themes of stigma and community have been addressed in studies of accessibility and AT adoption over the years. The stigmatization of AT users has long been documented through the "hearing aid effect" in that AT users are believed to be less intelligent, or that a sensory disability of one kind is perceived as implying other kinds of intellectual or social disabilities [2]. Public visibility and the technology itself can be identifiers of disability [22], which in turn can be a deterrent for use.

Shinohara emphasizes the misperceptions of others about AT, and the importance of technology as being a destigmatizing means to appear like everyone else even when access to AT alone does not make things equal regarding social interactions [25]. Her research on various AT uses shortlists some key factors that impact adoption, including socialization (referring to both stigma on the negative side and the need to interact socially on the positive side), efficiency (referring to the ability to do things more effectively), and independence and control (referring to individuals' ability to manage their own interactions) as elements of the usability and adoption of technology in peoples' lives [26]. Stigma brings the element of performativity into public AT use, wherein AT becomes an object of spectacle that defines the abilities of people with a disability. This indeed is part of an important theoretical frame in the aesthetics and representation of disability in society [24].

Hersh [12], working with the experiences of deafblind travelers from various European nations, delves deeply into stigmatization and its impact on continued AT use. She uses Link and Phelan's conceptualization of stigma, which comprises labeling, the application of negative stereotypes, separation from dominant in-groups, and status loss as the four components of stigma [20], and shows ways in which stigma is internalized and differs from region to region within the same continent based on attitudes toward disability, and extends in some cases to "courtesy stigma" of those associated with the AT user. This is relevant to parts of low- and middle-income countries where access to AT may be driven by non-disabled companions, given the relative newness of AT in those locations.

2.4 Community infrastructure and accessibility

On community, our work builds on the technological sustainability and infrastructure studies relevant to the operating environment of AT users [23]. A large body of research across domains has examined the importance of network effects in technology adoption in general [16], though less so specifically on the effects of a user base on AT adoption [10]. The community of users serves as the network through which the adoption of a technology is mediated; consequently, the historical way of doing things is an important element in guiding the success of new initiatives. Rooted here is the idea of path dependence, or when a function is conducted through a historically preferred means rather than a purportedly technologically superior means.

Our research extends this idea to people with vision impairments in middle- and low-income settings. The idea of path dependence is particularly relevant with regard to AT for people with vision impairments because adoption and continued use or willingness to switch technologies depend on a range of factors including the learning curve and usability challenges [3], high cost of personal technologies, comfort with the fallibilities of existing technologies [19], and the need to incorporate immediate circles such as families into technology use [6]. These challenges are accentuated in low- and middle-income settings, where access to the technologies themselves can be spotty because of poor sales networks, and issues like cost can present even greater challenges. Consequently, issues such as the perceived risk for early adopters of technology are more pronounced in these settings.

3. METHODOLOGY

We survey perceived impacts of AT, based on the CRPD's use of independence, social participation, and safety as key factors of accessibility, and follow that with a qualitative examination of the social elements that help us understand AT use beyond the perceived impact on those key factors. Two instruments were constructed around this. The first, a survey, was used to collect demographic information, experience with AT and mobile devices, and places of access (see appendix) as potential elements of analysis. The second, a semi-structured interview protocol, was used to dig deeper into experiences surrounding mobile device accessibility. All research focused solely on the use of mobile devices as AT, and all respondents were individuals with severe vision impairments, from low vision to total sight loss.

We studied six cities among the signatory nations of the CRPD. Three were in low-income nations: Blantyre, Malawi; Kigali, Rwanda; and Freetown, Sierra Leone. Two were middle-income cities: San Jose, Costa Rica; Mumbai, India. The sixth city, Seoul, South Korea, was included in the sample to provide contrasts seen in societies with greater access to technology. For context, annual per capita gross national income (USD GNI) for the countries in this research are: S. Korea $27,970, Costa Rica $9,750, India $1,610, Sierra Leone $720, Rwanda $650, and Malawi $250 (IMF 2013 estimates). Market-dominant screen-readers for desktops cost US$1,000, whereas mobile screen-readers cost about US$150 at the time of this work.

The study sites were selected from urban locations to increase the possibility of reaching the study population. Ten interviews were conducted in each region except Mumbai, where there were nine. Our goal of 40 surveys and 10 interviews for each location was difficult to fulfill because in some locations we exhausted all contactable individuals who fit the study requirements. The sample in Seoul was extended to 50 surveys because it was done last and provided an important contrast to other locations.

Surveys were conducted between March 2013 and May 2014. All respondents used mobile devices daily. In each country, we recruited the first five respondents through local disabled peoples' organizations (DPOs) and worked outward by snowball sampling. All surveys and interviews were conducted using local languages and were transcribed verbatim. Surveys had questions regarding mobile device purchasing and usage. Interviews lasted 30–60 minutes. Interview data were coded by researchers not involved in data collection using open coding based on an initial reading of all the interviews. Two coders separately annotated three interviews each, without access to each other's work. These codes were refined by collapsing them into parent categories or expanding them into new child categories when the data were sufficiently unique to merit a separate category.

A third researcher assessed the inter-coder reliability and arbitrated disagreements. Disagreements and low inter-coder scores were resolved during group discussions. Each new categorization required re-coding. Seven iterations produced a final structure of 53 children nodes at a 2-level hierarchy, and 3,839 code instances. Inter-coder reliability was κ (Cohen's kappa) = 0.70, which is high given that we were open-coding the transcripts. Data from 219 surveys were overlaid into an NVIVO file and linked to the individual interviews (since each interviewee also filled out a survey). The interviewees were selected to represent demographic diversity and a breadth of experience with AT use. Our thematic analysis method [14] included six sub-nodes related to the theme of "technology adoption" and five sub-nodes related to "technology use challenges," and sub-nodes could cross-cut both parent themes. Stigma and community were prominent cross-cutting themes and are discussed in greater detail in the Results section.

3.1 Data Limitations

As we see in **Table 1**, there are some skew elements in the data. First, we were unable to get equal numbers of women; second, we speculate that respondents have higher rates of college graduation or access to fixed employment than the typical person with a severe visual impairment, since access to mobile devices and accessible technologies is invariably more concentrated among the relatively better off in the sites. This indeed highlights a separate challenge of doing AT research in the Global South, where high rates of exclusion from public participation among the lowest-income individuals still prevail. While not necessarily generalizable to the entire population of persons with vision impairments, such work is useful in conjunction with in-depth qualitative data to paint a picture of AT use in real-world settings.

4. RESULTS

We first examine demographic variables against survey findings on self-perception of independence, participation (social participation, economic participation, and income), and safety, following which we describe our thematic analysis of the underlying social infrastructure.

4.1 Impacts on Independence, Participation, and Safety

A look at the sample description in **Table 1** shows gender, education and employment status across the six cities. The mean years of phone use were significant (between-groups ANOVA, $P<0.01$), roughly increasing as cities got relatively wealthier. The mean age of respondents ranged from 30.9 years (India) to 35.2 years (Malawi).

Table 1. Sample demographics, mean years using phone (n=219)

City (sample size)	Gender		College degree	Job holder	Years using phone
	F	M			
Blantyre (40)	14	26	30.0%	67.5%	6.6
Freetown (33)	14	19	24.2%	42.4%	7.4
Kigali (36)	10	26	41.7%	36.1%	6.6
Mumbai (29)	4	25	72.4%	72.4%	8.0
San Jose (31)	9	22	61.3%	67.7%	10.1
Seoul (50)	12	38	80.0%	74.0%	13.2

As we see in **Table 1**, the relatively wealthier countries tend to have had access to mobile devices longer, as would be expected. As with the high rates of college completion relative to people with disabilities, we can also speculate that the rate of job holding in our sample is not representative of people with disabilities in the countries studied, given as mobile users are a relative elite within the population.

In **Table 2**, we see fairly wide differences between the sites in terms of what people spend on devices as well as monthly plans.

We cheaper devices used by people in the poorer cities, and also a relatively higher rate of access to used phones in the poorer cities (P<.01, **Table 2**). While we find a higher number of smartphones in Blantyre than other poorer cities, interviews suggest that this in part a result of a second-hand market of low-end smartphones. We see, for instance in Blantyre, that on average each device was used for relatively longer time periods, over 4 years (P<.01, **Table 3**), than all the other locations

Mobile phone users in Blantyre, Freetown, and Kigali spent as little as one-tenth of what the typical sampled users in Mumbai, San Jose, and Seoul spent on devices. It is also relevant that the cost of devices is Mumbai and San Jose is relatively comparable to that in Seoul, despite the latter being a much wealthier city with higher overall smartphone penetration. Respondents in the lower-income countries used their mobiles mainly for voice functions..

Table 2. Device costs, type, and monthly cost (n=219)

City	Device median cost US$	Mean monthly cost US$	Percent-age using used phones	Percent-age using smart-phones
Blantyre	20.0	11.82	47.5	12.5%
Freetown	27.9	23.48	18.2	3.0%
Kigali	19.5	11.56	22.2	2.8%
Mumbai	182.5	21.92	3.4	69.0%
San Jose	240.0	28.09	8.1	71.0%
Seoul	293.0	60.74	0	86.0%

We also find relatively higher rates of second-hand devices being used by respondents in the three African sites, which in turn increase the likelihood that the devices have older hardware and software. The three African sites also have relatively higher rates of donated devices, suggesting that the respondents had less control over the financial resources needed to make the purchases In India and Costa Rica, alongside smartphones, there was a relatively high penetration of feature phones with screen-readers that could be used to navigate data functions such as social networking. This explains some instances of social network service (SNS) use despite the lack of a smartphone.

Table 3. Mean years per mobile device used, use of Internet, social networks (SNS) and screen-readers (n=219)

City	Mean years per device	Screen-reader on device	Internet use on device	SNS use on device
Blantyre	4.08	2.5%	17.5%	2.5%
Freetown	n/a	3.0%	12.1%	9.1%
Kigali	2.27	8.3%	19.4%	13.9%
Mumbai	2.50	93.1%	75.0%	51.7%
San Jose	3.16	100.0%	77.4%	66.0%
Seoul	2.18	100.0%	84.0%	84.0%

Although the lack of access to mobile-based screen-readers in Rwanda, Malawi, and Sierra Leone holds true outside of this sample, we found a skew in the Mumbai sample: studies in smaller cities in India have shown comparatively lower rates of access to screen-readers [13]. Also, while it would be good to compare SNS use with aggregates for the non-disabled populations, such data have not been collected at the city level uniformly. Collecting data on smartphone use is important because smartphones imply access to not only to a screen-reader but also the app space and a community of users, but such access isn't always a given.

We asked survey takers to indicate their perceived impact of AT on a Likert scale of 1–5, from strongly disagree to strongly agree, with statements such as "Has the mobile phone increased or decreased your sense of…" independence, safety, participation in economic activities, social activities, and income. Economic activities were further clarified as activities such as shopping and banking.

The results (in **Table 4)** show these factors against gender, education, SNS use, and employment status through independent sample *t*-tests. We find that self-perceptions of all four factors are fairly consistent, and we find no significant differences based on gender, employment, or SNS use. The income variable did not give us valuable information because even when family income is high, individuals might not exercise control over funds.

Table 4. Perceived mean positive impacts of mobiles on independence (Ind), social participation (SP), and economic participation (EP) (Likert scale 1–5, n=219)

City	Ind	SP	EP	Safety	Income
Female	4.44	4.51	3.89	4.24	3.55
Male	4.47	4.50	3.97	4.14	3.49
SNS user	4.37	4.51	3.90	3.99	3.49
SNS non-user	4.51	4.49	3.98	4.28	3.54
Employed	4.42	4.51	3.95	4.08	3.48
Unemployed	4.56	4.49	3.96	4.33	3.62

Comparing means using location as a factor yields significant differences (inter-location ANOVA P<0.01). While all five factors have positive rankings overall, independence is ranked highest in four of six locations, and social participation highest in two others, whereas economic participation has a comparatively low positive rank in five of the six locations. Seoul and San Jose, with the most advanced access to mobile devices, have relatively lower reported positive effects (**Table 5**). Higher impacts of access to technology are perceived in the three locations where both the access to technology is relatively more recent, and the technology being used is itself primarily the less advanced smart devices.

This is a helpful lens to examine the social infrastructure of accessibility -- those sites with the least accessibility, extending beyond just digital accessibility to elements of architectural accessibility such as paved streets, accessible public transit, or institutional accessibility such as higher education for people with visual impairments, appear to perform slightly better. The mobile device here offers a technological artifact, largely controlled by the individual person, in a public setting where much else is outside of one's control and inaccessible.

Freetown has the highest overall perceived impacts; even the lowest-rated factor (income) was rated above the mean for all other locations. Here, the history of relatively extreme forms of social exclusion for people with disabilities was relatively fresh in recent memory, mobile devices provided new means of independent social access that were often missing in the past. In Mumbai, the interviews reinforced the survey finding of an increased sense of independence because of lesser restrictions on transportation and social interaction.

Table 5. Perceived mean positive impacts of mobiles on independence (Ind), social participation (SP), economic participation (EP), and safety (Likert scale 1–5, n=219)

City	Ind	SP	EP	Safety	Income
Blantyre	4.53	4.28	3.98	3.88	3.30
Freetown	4.84	4.75	4.44	4.72	4.09
Kigali	4.51	4.72	4.03	4.53	3.77
Mumbai	4.72	4.17	3.63	4.29	3.50
San Jose	4.39	4.26	3.68	3.87	3.12
Seoul	4.04	4.64	3.90	3.96	3.45

In summary, the surveys provide a window into the kinds of perceived impacts. While income and economic participation are still perceived as having had an overall net neutral effect from access to mobiles, these (and particularly income) are relatively lowest in all locations suggests that the respondents still feel significant challenges with regard to getting access to means of financial support. This leads us into the thematic analysis of the social infrastructure which helps understand both why mobiles are rated so highly, and indeed why the barriers to their functional use in many ways are still very significant.

4.2 Thematic Analysis

The survey results on independence and participation are useful in setting up the thematic analysis of the social infrastructure, in this case evidenced through the discussions around understandings of stigma associated with disability, and by extension assistive technology. We start by examining the ways stigma appears as a theme in the interviews.

Stigma

Stigma emerged as a central element of the accessibility infrastructure around economic participation, often in explanations of why respondents felt they (or others) were excluded from economic opportunities and income despite being AT users. The idea of stigma appeared 95 times in 45 interviews. Another code, which we called "lack of awareness" (as respondents referred to unawareness of AT or abilities of people with disabilities) also emerged as a regular theme: 81 instances were coded in 40 interviews. Lack of awareness fed into stigma by allowing for the reinforcement of commonly held notions of dependence related to disability. The infantilization of disability is captured by the comments of CR31:

People think that every blind person is a 'pobrecita' [poor little thing]. That word has destroyed this country. The 'pobrecita' is conception that the blind person is useless, that depends on charity… so when people see that you can do something … they are amazed!

CR31, Female, San Jose

The term "stigma" itself appeared in 33 instances. There was no direct question related to stigma, but stigma was most commonly noted in the survey responses around workplace access and social inclusion. One way in which respondents found the stigmatization to be problematic with relation to their AT use was when they were expected by those around them to "behave disabled." The individual thus is defined not as a co-worker, colleague, co-passenger, or citizen, but rather as a person with a disability first and as one with other identities later. Thus, the technologies one may expect a co-passenger or colleague to use as a daily practice are excluded from the imaginary of what a person with a disability would be expected to use.

Once I explain them how to use them, they would say, 'Is it even working?' It is an underlying prejudice that persons with vision disabilities would do everything slowly, and we would not understand things.

K29, Male, Seoul

Dealing with such conceptions emerges as a daily concern for the respondents we spoke with. Unlike a non-disabled person whose technology use is largely invisible, the lack of awareness in the general public turns the assistive technology into an object of an external gaze, wherein its use needed to be explained to colleagues, friends, and passers-by, even among the most urban pockets of Seoul, our sample site with the most widespread access to technology in the general population.

The related problem with stigmatization then is that the AT itself is the focus of "ability" when the individual user achieves something with it. Respondents reported that when they do regular tasks associated with technology users — running communications or managing spreadsheets — the focus is on the wonder associated with the technology that enables this rather than the individual behind it. Although this was a common sentiment among people in professional settings, in places where white-collar options for people with disabilities were themselves absent, respondents reported little awareness of AT in society and even among the potential users of AT.

In Freetown, the majority of respondents had never used a screen-reader, and many had never heard of it. Even DPOs had people using computers through sighted intermediaries who would read out to them. The assignment of sighted intermediaries to work with blind members of such DPOs underlined the lack of a social infrastructure, wherein the default assumption was that a blind person needed a sighted person to work effectively. Thus donated copies of screen-readers were unused for lack of staff training. A respondent in Blantyre noted similar lack of awareness of AT even among university teaching staff.

Even here at the university you can be shocked that lecturers or professors are astonished upon seeing the screen-reader, what JAWS does. 'Oh, do we have this on campus?'… If they're *not aware, what of the man on the street, or employers just out in their office?*

M1, Male, Blantyre

The lack of awareness of AT in many cases to use of a screen-reader being seen as performative act by the user him or herself, aware that being watched means some expectation of constantly being aware that using a device in public is likely to bring unwanted attention. As K2 explained:

Even when walking in the subway station, someone asked me if I could hear or not, which was a bit humiliating. It is a kind of prejudice and reflection that people with disabilities are fools. It is a great wonder to see me using computer or smartphone as if they see animals in the zoo as spectators...

K2, Female, Seoul

The gaze of ableism assumes the blind person is hard of hearing, as well, or even incapable of independent decision-making. So the technological artifact is perceived not just as a tool in the hands of the user but as the very element that "normalizes" the individual by allowing that person to interact with society on its terms. To an extent, this refers to the visibility of disability in public spaces. The white cane, for instance, has been a commonly recognized item of assistive technology, and consequently, popular ideas among people without disabilities about the abilities of people with vision impairments have been constructed around the affordances of a cane. The cane, as the identifier, and therefore in this sense the stigmatizer, suggests to people without disabilities that people with vision impairments can be hired only for jobs that involve no sighted interaction, for jobs enabled by a cane.

In the same way, the astonishment of watching a person who uses a screen-reader work independently is overlaid with the assumption that blind or low-vision people cannot effectively use technology, or that they learn at a slower pace. Respondents who could afford smartphones had the advantage of indistinguishability. Their phones were the same as those of sighted persons. The devices did not look like phones with specialized speech synthesizers or like screen-reader-enabled laptops. Neither iOS nor Android devices with pre-loaded voice output look like earlier phones such as the Nokia N series, which used software like Talks that signaled to everyone that the phones were specialized. The iOS/Android phones have a recognizable form factor and are assumed to be multi-purpose computing devices rather than just voice phones. I19 noted:

(The iPhone) is small enough, so I can, in the local train I can, you know, read my book, without actually drawing attention to myself, which is actually, you know, a great thing for me, I don't want to be a target of people's attention.

I19, Male, Mumbai

However for others, being asked about technology was an opportunity to advocate for the community by signaling normalcy. Stigmatization did not impact the positive view of the role of AT itself by respondents. The relationship between stigma and AT use is not as much in the perceived value of the devices or the individual's ability to act on the devices' affordances. The challenge lies in where the utility of AT relies on factors relatively outside of one's individual control. Thus, economic participation and income were ranked lowest among all the variables in the survey, the exact variables that most directly require the buy-in of others, such as employers, into the abilities of the individuals.

We see stigma acting on two very distinct planes. First, at the level of embodied technology use, we find stigma emphasized when the interaction itself becomes an object of dissonance. This indeed has some immediate design implications, such as the creation of more fluid interactions. Second, and the larger issue is widespread awareness. Here, the second effect of stigmatization, the questioning of what the individual can do with or without AT, is a bigger issue that can only be dealt with through greater awareness in the public sphere.

Community

There were 266 coded instances of social exclusion, the most commonly coded theme in the interviews. Social exclusion almost necessarily ties to another theme – that of community. The sense of exclusion people felt could be as individuals or as holders of a group identity. By its nature, exclusion frequently leads to the need for greater reliance on a community defined around the nature of the intervention (in this case technology) around the sensory impairment. The resulting segregation has itself been an important theme of disability studies since its inception.

Community here refers primarily to the sense of shared identity respondents felt with other people with visual impairments. While there was mention of disabilities as a root of community, respondents had little actual community in their social lives with people with other sensory impairments, unless through the occasional civil society organization.

In interviews, governments are frequently faulted for not living up to expectations, not just on making digital information accessible, but more generally on failing to create a culture of accessibility. Despite the action around the CRPD, there were rarely any positive comments on the role of the state, when it came up in conversation. Thirty-nine noted instances had negative perceptions of the state, supporting a separate finding that people rely on their own community or informal mechanisms for access to AT.

The lack of institutions facilitated by the government for access to information on new devices, such as libraries, government departments, or even blind schools, meant that people learned about their AT through snowballing. Twenty-seven percent of the entire sample got some form of help from a non-governmental organization (NGO) in getting access to AT. In each location, we came across individuals who self-identified as leaders on AT opinion, or respondents who pointed at one or another friend within their larger community of visually impaired persons as a source of knowledge. In an environment where technology and interfaces change drastically and quickly, and sources of information such as online reviews and magazines (common in the Global North, for instance) are not available, it can be challenging to find necessary technical access and support. For these informal knowledge centers it was often challenging to come up with the right recommendation for someone who asked for help.

The problem is they're having their own [GUIs]. Let's say in Blackberry, iPhone, Samsung, Sony Ericson Outline of icons different, where you have to access certain applications different. That's, I think, the challenge, because it's not only one button; [if someone comes to me with a problem] I don't know which one would be the best to use for me to actually teach or assist my friend.

M2, Male, Blantyre

Civil society groups such as NGOs and disabled persons organizations (DPOs) play a de-facto institutional role in such cases. In Kigali, Freetown, and Blantyre, mobile phones were available at stores, but pre-loaded AT software such as Nuance Talks was uncommon and awareness of smartphones was low. In contrast, Mumbai and San Jose had Symbian-based phones with Talks in an active off-the-shelf and second-hand market. For most people, though, more powerful smart devices made little difference. Even when word spread that smartphones were easier to use, few people wanted to give up an older interface they had invested a lot to learn and had grown attached to. Many respondents were still using the first system they learned. When

people decided to switch to smartphones, they faced a significant challenge, as CR16 pointed out:

If I were you I would not change my old phone for an iPhone, because the navigation system and the fact that it is tactile is too different and more difficult. I got it through a friend that helped me to choose it and to buy it. He also helps me to get the Accessible software. ... For me to have the AT meant a radical change. … People feel very insecure because they cannot feel anything ... is like if you were blind, already been blind! Because your hands are your eyes.

CR16, Female, San Jose

Irrespective of the transition from one device to another, managing AT for most people presented daily challenges, as we see in **Table 6**. In all but one city, everyone reported a major incident such as a device crash that required another person (not something solved by oneself on the Internet). We also find that users of used phones have almost a 20% greater chance of needing assistance from another person ($P<0.01$) over a problem with a device. In **Table 6**, one thing distinguishes Blantyre from the other locations, and that is a very high presence of used phones and low-end smartphones that require relatively higher amounts of assistance.

Table 6. Technology failures and frequency (n=217)

	At least one major incident last year when needed help	Frequency of AT issues		
		Rare / never	Once / twice month	Over twice monthly
Blantyre	80.0%	22.5%	17.5%	60.0%
Freetown	66.7%	66.7%	24.3%	9.1%
Kigali	90.6%	30.5%	58.4%	11.1%
Mumbai	73.3%	82.8%	10.3%	6.9%
San Jose	41.4%	73.3%	13.3%	13.3%
Seoul	72.2%	70.0%	12.0%	18.0%

If we turn to the source of assistance, we find a different set of issues. In most locations, friends and family form the majority of assistance with managing problems with the devices. The use of professionals is negatively related to having used phones ($P<0.01$). In **Table 7**, two rows in the "other" column are of interest: Seoul and Freetown show significant numbers for very different reasons. In Freetown, we found a number of people who asked passers-by or random acquaintances for help with their phones. In Seoul, on the other hand, online contacts were an important source of help with phone problems.

Table 7. Help-seeking behavior during AT problems (Fr=friends, Fa=family, Pr=professionals, Co=colleagues, O=other) n=134

Location	Fr	Fa	Pr	Co	O
Blantyre	52.9%	35.3%	0.0%	2.9%	8.8%
Freetown	20.7%	24.1%	10.3%	6.9%	37.9%
Kigali	43.5%	21.7%	26.1%	4.3%	4.3%
Mumbai	46.2%	23.1%	23.1%	0.0%	7.7%
San Jose	50.0%	37.5%	12.5%	0.0%	0.0%
Seoul	18.5%	22.2%	29.6%	3.7%	25.9%

The interviews reveal an aversion to radical change regarding the sense of lost control of device functions during transitional periods of switching phones, particularly in San Jose and Mumbai. In both cities, we find a "group mentality" of first adopting Symbian phones like Nokia's E63 or E70 models with Nuance Talks, which were bundled by DPOs. The subsequent shift to basic Android phones had a "jump straight in" shock. The easy existence of dual SIM was an enabling factor (harder in other countries where SIMs are tied to company contracts) whereby early adopters within the community would recommend people start using a smartphone without dropping the older phone during the transition. Nonetheless, feature phones with Talks persisted in both locations, and early adopters of these feature phones actively proselytized them and offered themselves as a sounding board for technology support. Both K3 from Korea and C25 from San Jose were early adopters, and they summarize this point.

When I bought the Nexus [it] was very difficult to use and to learn to activate the screen. I coordinate a tech forum called www.tiflocel.com. Through this group I share my experience and findings with the community. … For example, I did an mp3 demo of how to use an Android. The idea is that people get excited about trying new things.

C25, Male, San Jose

Some risk-takers tried [touchscreen smartphones] and they found out they could use it ... so we created the club. Vision-impaired people were afraid of touching smartphones. Because able-bodied people would never be able to answer their questions, we decided to share the information, about VoiceOver, about which apps are accessible, etc. Now, we have about 1,000 members.

K3, Female, Seoul

The community serves as an essential part in supporting the mobile app infrastructure, as is arguably true for any other population of technology users. However, people with vision impairments in low-resource settings have access to a relatively small population of AT users, making their AT use even more dependent on a core community of regular users. In Seoul, users talked about using GPS for navigation and discussing it on forums. In Mumbai and San Jose, the relatively lower reliability of the accessible architectural infrastructure (e.g., walkable streets, timely transit) made these features less used and therefore dismissed on community groups. As I19 noted:

Although we have GPS and although we have maps, Bombay is not a place which you can rely on maps. I mean, I had a terrible experience. Even if I am using maps, I am not sure it is giving me right direction. ... So, nothing beats, like you know, asking somebody for directions. ... I would rather rely on a passerby, to ask him directions, than relying on a map.

I19, Male, Mumbai

Despite the low use of GPS outside Seoul, all cities showed a majority of users reporting some navigational use of mobiles, primarily calling for directions. The most common non-communication use was listening to music — even with low-end phones in Freetown, Blantyre, and Kigali. Here, the community through DPOs or informal friend circles enabled the exchange of music files and also educational material. As with sighted interfaces, many elements of AT were discovered through

exploration, but word of mouth through the community played a very important role in enabling awareness of higher functions, especially where AT users found themselves around non-AT users in most of their daily lives. For instance, we found that many users took a long while to start using mobiles as recording devices because they were not aware of the function.

[There is difficulty in the] conceptualization of the phone as a computer in the sense that I have to install different 'programs.' So when people used to tell me: 'why don't you install a recorder to you phone,' I used to think: 'how do I do that?... and 'why would I use a phone for recording my classes, it is a phone!' [Laughs]. However, if I had learned from the beginning that I could do that I would not have carried my laptop to class to record my classes.

CR31, Female, San Jose

A final element of community in the interviews emerged in carrier selection. In four of the six cities — Kigali, Blantyre, Freetown, and Mumbai — respondents reported switching companies to be on the same network as friends in order to save money. In Blantyre and Freetown, having multiple SIM cards was common. In each of the cities, there were discussions about word in the community on what plans were best for peoples' needs.

5. DISCUSSION

That mobiles have a perceived positive impact on the key factors studied is constructive, but our findings give us pause when thinking about those factors where the larger social infrastructure impacts peoples' ability to make the best use of their devices. Furthermore, cities with relatively better accessibility infrastructure are seen to have fewer perceived benefits, suggesting a different sensibility among the individuals themselves on how they see the functional value of AT in their respective societies. This, we suggest, grows out of the longer experience with AT, and the consequent heightened expectations from both the technology and the systems that support its use.

We also see these data as suggestive of individuals' recall of the pre-AT condition of navigating infrastructure with much more dependence on other human intermediaries, as reflected in interviews from Freetown, Blantyre, Mumbai, and Kigali. Consequently, the very affordance of being independent — or less reliant on those around oneself — is very highly rated, whereas elements of economic participation, such as willingness to hire people or invest in AT infrastructure for public use in banking or shopping, which involve greater reliance on de-stigmatization of disability, have lower perceived impacts.

Interviews also indicate that the financial decisions to invest in AT, even for the users themselves, may be controlled by someone else, such as a family member. Arguably the way to move ahead is not merely improved design at the device level, but it involves de-stigmatization at a social level in terms of the ways mobile devices are marketed and made available to the general population.

In all the locations studied, we noticed advertisements from device manufacturers and networks that targeted ethnic, linguistic, and racial diversity. However, people with disabilities were rarely, if ever, featured as a user population in the public sphere. There is an urgent need for a public discussion about including empowering images of people with disabilities as part of policy steps toward accessibility, and potentially including such outreach as a factor in CRPD progress updates from nation states.

The lines between where design ends and where marketing and policy begin are increasingly thin, particularly as design professionals adopt the talk of universal accessibility in their practice. Some of this is already being done implicitly. For instance, the centrality of accessibility features in settings and menus of smart devices is a design choice, and this engages the curiosity of sighted users who can better appreciate multiple modes of interacting with mobile devices. As more forms of multimodal input and output become common as the dominant means of using mobile devices, designers have the ability to incorporate accessibility awareness into the interfaces they create. The socialization of AT and the sense of managing one's own communication need to be not just conceptualized individually but reciprocated through a social system that embraces accessibility.

At the device level, we find that a range of positions on AT can reinforce or counteract stigma. Individuals might want to be anonymous or invisible, or they might feel their work brings greater social awareness of the affordances of accessible technology. Destigmatization of the devices themselves will emerge over time with a strengthening social infrastructure for people with disabilities, but the emergence of recognizable form factors, such as iPhones, into the repertoire of AT devices seen and used in the public is already a step toward normalizing the idea that people with disabilities use the same devices that others do.

Even without the social infrastructure to support the creation of communities in much of the Global South (institutions, access to the Internet), we find across all sites that people not only create but maintain communities with other AT users and influence one another's behavior factors ranging from carrier choice to device options. Nonetheless, the lack of that social infrastructure has meant that there is the continuing distance between respondents and their daily technical environments, and those of the non-disabled people they interact with, particularly in casual ways.

Much of mobile technology is moving towards a model of fairly intricate personalization of devices as well as self-managed maintenance at the software level, particularly for sighted users. Availability of plug-and-play accessibility features in smartphones in itself does not (and need not) change the culture of or need for consultation across sites, as we find in Seoul, where despite greater access and longer experience with smartphones, people instinctively turn to those they see as their community in making decisions about selecting and using technology. The lack of a social infrastructure to support communities creates the need for design thinking around formal and ad hoc virtual communities and social network interfaces that are easy to segue into and navigate for people with no prior experience with such systems.

Choices are mediated through close networks, but also increasingly through casual online connections with people who provide technical support. When a technology is working, letting it go and switching to another disrupts one's control over the ecosystem of technology use. Social provision of services (e.g., inclusive architectural spaces, education, and workplace accessibility) is relevant to mobile assistive technology, and lack of such services weakens the accessibility infrastructure and increases stigmatization as well as individual dependence on community for access to technology and support.

In all locations except Seoul, the majority of users had first used AT as adults, and for most of the population in Blantyre, Malawi, and Freetown, use of AT such as screen-readers was restricted to desktop environments (if that, because roughly a third in each location had no screen-reader access), because most people's mobiles were basic voice devices. Late access to AT typically means delayed access to an awareness of the information environment available. This affects the professional aspirations of individuals with disabilities, as other studies have shown, because the community they exist within is neither aware of AT nor offers examples of the social and economic possibilities for people with disabilities. This prolongs the stigmatization of disability and clouds the awareness that such exclusion is in fact socially constructed by the lack of access to what should rightly be available.

6. CONCLUSION

We cannot strive for accessible societies with chronically low awareness of accessibility on digital technologies. Nation states attempting to create accessible societies need to look beyond instituting laws and acquiring technological expertise to work towards an accessibility infrastructure, with all its elements. At the outset, investing in social campaigns that destigmatize disability broadly and encourage a broad-based social model of thinking about disability and society.

After almost a decade of the CRPD, it is time for policy-makers to seriously consider the continuing challenges in digital accessibility across societies and think anew to how social and cultural elements have contributed to some of these, and what can be done to mitigate them. Much thought has been put into the development of new devices and the networks that they operate on – but industry has had a large role in innovating in this space. On the other hand little if any effort has been put into how public awareness campaigns can be run, how accessible institutions can be made second nature. How the idea of accessibility can, in a nutshell, be made "invisible" such that people come to expect it.

It is here that there can be little replacement for good government, since such broad social change and rethinking need involvement from the key stakeholders in society.

The role of design in active engagement for the needs of a community otherwise underserved by market forces is not new. The design community played a huge part in the growth of Information and Communications Technology and Development (ICTD) community over recent years. The intersection of design sensibility with research imperative has contributed not only to ICTD's evolution but to the corresponding growth within HCI of a community of practice that sees working with user populations with unique needs as both a research and practical challenge.

If we are to think in terms of ability-based design, it is important to take that beyond individual ability into how the accessibility infrastructure enables real-world populations to use such design. Assistive technologies must go beyond the functions of technology alone to address the infrastructure that both people with disabilities and those they interact with share. Although the accessibility infrastructure has been examined here in the domain of mobile device adoption and use for one small population of AT users among people with disabilities, we propose that the framework is useful in thinking across the board to all forms of AT adoption in low-resource environments.

With the dearth of researchers available to work on digital accessibility from within nation states, the international ICTD and accessibility researchers are increasingly becoming a primary source of knowledge on most social research around accessibility. It is imperative for the scholarly communities at the intersection of disability and technology studies to think deeply about aligning their rewards structure with the needs of the community. Our focus on innovation as an output has arguably been a contributor to the lack of deep thinking about possibly obvious, but deeply relevant problems around technology adoption and functional use.

Such a focus on innovation invariably results in the research and design being focused on the individual as the unit of technology use rather than the broader collective. Our lens on stigma as part of the social infrastructure broadens the discussion from stigma as a negative influencer at the level of the individual to something that permeates society's perceptions and willingness to engage with people who have vision impairments in larger social and economic settings. The corollary thus would be investing in AT as something that benefits not just the individual but society as a whole.

We are at a moment in history when access to AT, primarily through the move from feature phone environments to smartphone environments, is about to increase dramatically, particularly in the Global South. Here, the access to opportunity and the understanding of social and economic possibilities for people with disabilities have been limited by the social constructs of the accessibility infrastructure.

The idea of an accessibility infrastructure thus sits at the intersection of what policy-makers understand as the immediate need to increase accessibility in their regions and what designers bring to the table as a framework for thinking about what it takes to enable the affordances of an intended technology artifact to be workable within an ecosystem.

7. ACKNOWLEDGMENTS

The authors would like to acknowledge the anonymous reviewers who helped with valuable comments and suggestions. We would also like to acknowledge the partners for this research, including Cyprien Semushi, Meera Lakshmanan, and Rahul Cherian, and various researchers who have participated in the coding, analysis or feedback for this paper including Tawfiq Ammari, Gavin Strassel, Margaret Young. Finally we would like to acknowledge the respondents for this research who took time out to talk to us, share their stories and experiences, and help us with our work.

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