

Confronting Autism in Urban Bangladesh: Unpacking Infrastructural and Cultural Challenges

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Abstract

Autism Spectrum Disorder (ASD) is a critical problem worldwide; however, low and middle-income countries (LMICs) often suffer more from it due to the lack of contextual research and effective care infrastructure. Moreover, ASD in LMICs offers unique challenges as cultural misperceptions and social practices often impede effective care there. However, the recent growth in mobile phone adoption in many LMICs has created a timely opportunity for improving ASD care practices through digital means. We present qualitative findings on the challenges of designing mobile assistive technologies for ASD in Bangladesh. Our data reveals a set of technical, social, and cultural challenges with caregivers and care professionals for designing a meaningful technology for them. We show how those challenges are deeply rooted in the broader infrastructural and cultural tensions of the country. We also present embedded design implications to overcome these challenges.

Keywords: autism, Bangladesh, stigma, mental health, mobile health, understanding users, ecological design, ICTD

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1. Introduction

Autism is a global phenomenon with local implications [1]. Autism Spectrum Disorder (ASD) is a pervasive neurodevelopmental disorder that is often characterized by impairment in verbal and nonverbal communication, deficits in emotional and social reciprocity, and repetitive behavioral patterns [2]. This affects more than 7.4 million people worldwide, with a 600% increase in prevalence in the last two decades [3]. Studies have shown that cultural perceptions affect diagnosis and treatment of

autism, shape familial beliefs about autism, influence intervention techniques, and are integral in the acceptance of persons with autism in society [1, 6]. Samadi and McConkey, who studied autism in Iran stress the “need to view autism within a cultural context and not just as a medical condition requiring standard interventions” [6]. Their claims are substantiated by a World Health Organization disability report that also recommends that culturally situated understanding of a disability is necessary in order to properly address it [7].

Research in autism, however, has hardly been contextualized in LMICs despite more than half of the

Distribution of professional designation among the participants	Title	Count
	Psychiatrist	17
	Psychologist	2
	Pediatrician	2
	Pediatric Neurologist	3
Other	4	

Technological proliferation but lack of transfer

Similar to the uptake in smartphone adoption and internet usage amongst caregivers, care professionals exhibited an increased desire to use technology in their professions. Citing the ubiquity of smartphones, the need for contextually adaptive technology, and importance of connectivity afforded by technology, one participant commented:

“Smartphones are in everyone’s pocket these days. Technology can improve connectivity between us and them [caregivers]. The diagnostic criteria have changed in DSM-5, so an adaptive system will be great because who knows what will change in DSM-6.” (CP2, Associate Professor, NIMH, Bangladesh)

Despite their desire to extend the use case of mobile technology to the professional setting, it is still mainly limited to their personal use. One of the participants pointed out that there was no prevalent culture and established guidelines to introduce the use of mobile technology to the medical professional services. When probed if there is a lack of technology training for care professionals and whether they typically leverage technology beyond personal use, the same participant (CP2) commented:

“We know how to use our phones. It’s not the basic training we need. I use Skype and Uber, and other apps all the time. [However,] there is no established and standardized practice of using mobile phones to help with diagnosis and care. Without a culture of using it, we are not exposed to how to use it in [the diagnostic] context. That’s why we need to have a culture of using [technology] more.”

It should be noted here that many of our participants were aware of several mobile-health applications that were being used in many other countries, but they were not confident enough to use those in Bangladesh, mainly because those were not evaluated in the local context and not part of the community of practice [69].

Need for longitudinal monitoring and database

All our participants highlighted the need for and the various benefits of a context- and resource-aware centralized database that provides longitudinal data about symptoms and behavior for ASD. One of the participants highlighted the benefits of longitudinal monitoring and use of databases as follows:

“Due to societal stigma or denial or forgetfulness, caregivers often provide inaccurate information that we rely on for diagnosis. A reliable database with long term data can improve diagnosis precision. It will save

time from my end and theirs. Most importantly, when they need to come, they can as they didn’t waste visits.” (CP10, Associate Professor, NIMH, Bangladesh)

There are two notable insights: first, verifiable longitudinal data can address issues of under- or over-reporting of symptoms, enabling better diagnosis and care. Second, a digital tracking method can facilitate regular monitoring without the need for in-person visits. With time-constraints and traffic jams in mind, the reduced need for in-person visits can lessen the burden for both the caregivers and care professionals, as our participants opined.

Barrier of language

Highlighting how linguistic differences in symptom-reporting impact diagnosis, care professionals called for the need of technology to address a diverse set of sociocultural challenges. Advocating the need for the system being able to handle variances in Bengali and provide proper scaffolding for low-English literacy caregivers, one participant said:

“We need a way to account for linguistic differences in the dialects as they affect diagnosis. I think a central repository of different word usages and their agreed meanings would be useful. We can’t rely on English as many caregivers aren’t fluent and often misuse terms which adds to the confusion.” (CP14, Assistant Professor, IPNA, Bangladesh)

The linguistic differences have roots in dialects of the Bengali language as well as SES levels that affect English literacy. Based on the district location, Bangladesh has a diversity of dialects. As a result, the same symptoms may be described differently in different districts. With varied English literacy levels that is tied to SES, we cannot always rely on using English. As a result, any technological intervention should incorporate contextual research into the linguistic differences across geographic and demographic differences.

Generational impact of technology adoption

During our FGDs, we noticed that younger professionals had a higher affinity and trust towards technology than the older, more senior ones. This presents a unique challenge because senior members have more experience, making them an important stakeholder of any intervention. The comments of the following two participants, a medical professor and resident intern, aptly summarize the phenomenon and challenge:

“I am about to retire soon and my generation didn’t grow up with computers. Moreover, I prefer the in-person interactions. I don’t really trust the technology, but I think training senior practitioners can help.” (CP1, Professor, NIMH, Bangladesh)

“Technology makes sense to me...because I grew up with it. Laptops and smartphones are staple in my generation. A paperless digital tracking method can also facilitate seamless continuity of care even when the medical care provider is changed.” (CP10, Resident, NIMH, Bangladesh)

Given the affinity of the younger demography towards technology adoption, they can be targeted for early adoption of any intervention. The collaboration with early adopters not only facilitates iterative design evolution, but also has the potential to give rise to a culture of electronic health records, addressing a key issue of continuity of care as mentioned by CP10. While the digital divide between generations is not unique to Bangladesh, the severity of it and the confounding context around it makes it a noteworthy challenge. In fact, if we can address the challenge of generational digital divide in as extreme a case as it is in Bangladesh, the transferrable insights can also benefit interventions in other LMICs and developed ecosystems.

6. Discussion

Our findings reveal some important infrastructural and cultural issues that are crucial in understanding the challenges and opportunities of designing such technologies for ASD care in Bangladesh. Our findings are important to conceptualize some crucial challenges around designing a digital technology to support the ASD care in Bangladesh.

First, our data reveals a set of critical infrastructural challenges, specifically around digital and transportation infrastructures, that inhibit advancements in autism-related care. Like most other developing countries in the world, Bangladesh lacks a robust digital infrastructure. This weakness can be explained by the lack of an effective and efficient power, network, and Internet infrastructure. Such infrastructural vulnerabilities exacerbate when we start moving from urban to rural areas of the country. However, it is important to note that electricity and cellphone infrastructures are often weak and uncertain in urban areas too. These include regular power shutdowns and “no cellular network” situations. Internet connections, despite becoming cheaper and easier to get, are often very weak and infrequent. Often times, it is hard for the citizens to rely on these digital platforms for a mission-critical important task. Disconnections and interruptions limit the scope of any potentially ubiquitous digital services.

Furthermore, in terms of transportation infrastructure challenges, localization of care resources compounded by traffic congestions entail that both care professionals and caregivers have to spend a lot of time on the roads being stuck in traffic due to a weak and unplanned transportation system of the country. There is a sunk cost of lost time, which they cannot utilize in any meaningful manner. These infrastructural weaknesses limit the ways existing technologies could better address many challenges of their life, including ASD.

Second, Bangladeshi citizens are still new to digital communication platforms and online social networks. Their social media are often flooded with unreliable information which significantly reduces the credibility. Exposure to unreliable information (often called 'fake news') has emerged as a global phenomenon with several negative consequences. While this concern is prevalent world-wide, the impact of misinformation can be severe in LMICs. Because of language

barriers, unfamiliarity with technical knowledge to verify an information, and the culture of having a "blind trust" among the community members increases the chances that such information spreads rapidly and is believed by more people in these countries. At the same time, the Internet often appears to the local communities as a medium controlled by those in the "West", and because of a long history of colonization and forced domination, these communities often hesitate to suspect an information found over the Internet (such cultural imperialism over digital world is often reported in post-colonial computing research) [14, 73]. As a result, the parents of CWA in Bangladesh often struggle to find their required information on online forums. Similarly, although care professionals are using mobile technologies in their personal life, they are not able to use them in their profession. Like other non-western, non-English speaking countries, the care practice is also often affected by the language barriers which could likely be addressed by some digital translation platform (e.g., Google Translator Toolkit [55]), which is not in place here.

Third, our data shows that there are strong cultural factors that impact on the life of CWA and their parents, and also shape the use and non-use of digital technologies in Bangladesh. A big part of this cultural challenge comes from the stigma and misconceptions around ASD. Various misconceptions, unscientific and unfounded beliefs, and superstitions constitute a wide-spread stigma around autism. Religious beliefs intertwined in the cultural fabric also impact people's perceptions in Bangladesh like many other LMICs in the world. For instance, based on a belief that the individual with autism is supposed to be closer to spirituality or God, some cultures do not prefer seeking interventions that can improve high functioning symptoms [56]. On the other hand, some Latino mothers view autism as punishment from God [57]. Some have the unfounded suspicion that the age of the mother during conception is also the determining factor for child's ASD [39]. All these stigma and misconceptions limit CWA's access to many social resources, and make the life of their parents more stressful and difficult.

Fourth, the social hierarchy in many Bangladeshi communities also plays a vital role in determining the impact of a digital technology for supporting the care of a CWA. For example, the relationship between the caregivers and the care professionals is often very distant and aloof. This relationship is often affected by the care professionals' real or assumed higher social status in the community, and a cultural trend of “educating” the patients and their relatives. Such paternalistic and patronizing attitude in the Indian subcontinent is often attributed to their colonial history [58] and the politics of expertise [59]. Hence, any technology that conveys information between the care professionals and the caregivers must tackle this power imbalance. Besides this, the gender hierarchy in many Bangladeshi communities also plays an important role in childcare [60] and how technology is used [61]. While mothers are often the primary caregiver for a CWA, their use of mobile phones and other computing and communication devices is often conditioned, surveilled, and limited by the male members of the family [62]. Hence, the gender bias in a community is directly affecting the impact of

a digital technology on a CWA. A successful technology must need to address these internal politics of Bangladeshi families and communities.

Fifth, our data shows that people's socio-economic status, education, family structure, and life-opportunity impacts their attitude toward ASD care. People from lower socio-economic classes are often losing their hope about their CWA, and seeing the treatment "less profitable" for their future. On the other hand, people from very high economic status often consider the treatment unnecessary as they can make arrangements for all necessary supports for their CWA using their money. At the same time, people of middle-income vacillate between caring for their CWA or investing more into their neurotypical child. All these tensions and resistances are largely influenced by hopelessness that ASD can be cured or that it can be taken to a state where it is no longer a challenge for an individual to live in a society with others. Sharing the stories of successful therapies in a responsible manner, one that does not inspire false hope, may alleviate the stress and take people out of such resistance.

All these infrastructural and cultural challenges explain the role of contextual requirements of designing technology in LMICs – an issue that has been core to the scholarship of Information and Communication Technology and Development (ICTD). Researchers have come up with several ideas to overcome the challenges of weak communication network [63], information unavailability [64], tech literacy [65], and uncertain infrastructure [66]. For handling the cultural challenges, researchers have focused on situated design of technologies that align themselves with the local culture and norms [67].

While this paper presents some valuable insights of an understudied topic, the ASD and mental-health interventions in Bangladesh, there are some limitations in our study, too. First, our study only focuses on urban areas, where ASD care is significantly better than the other parts of the country. Our study, therefore, may not represent the situation of the whole country. Second, all our participants had mobile phones and they were fluent in using those, which is again not a generalizable scenario even in urban Bangladesh. There are many underprivileged and low-literate people in Dhaka and Chittagong who are not represented by our participant pool. Third, our study is also influenced by our social network which we used for recruiting our participants. As a result, despite our best efforts at impartiality, some unconscious bias may still remain in our data. Because of these limitations, we do not claim our findings to be generalizable. Instead, we rely on the strength of qualitative research that focuses on making situated arguments [54] to report a set of practices that are present in the ASD care ecology in urban Bangladesh. We believe that the lessons revealed through our findings can later be leveraged to create a broader and deeper understanding of this domain beyond the population we studied.

These studies and interventions offer important lessons on how technology can be designed in a resource-constrained environment by factoring in the situated values and practices. Taking inspiration from ecological design philosophies that take an asset-based and value-sensitive approach to

ecosystem affordances [4, 5], we present a preliminary design considerations and implications for a voice-based peer-to-peer system that connects caregivers in the following section.

7. Design considerations & implications

Our findings shed light on the stigma around autism and highlight the need for social support amongst caregivers. Caregivers shared how peer support can strengthen communal bonds and foster resilience through shared experiences. Moreover, they also shared how time lost in traffic significantly impedes their abilities to adequately seek autism-related care. We also discussed the notion of transforming lost time in traffic into useful cycles of information exchange and learning. Based on this understanding, we facilitated 2 exploratory participatory design (PD) sessions with 6 caregivers where researchers and parents ideated around spaces for interaction that can address some of the challenges. Below, combining insights from the sessions, we present preliminary design considerations and implications. We share the motivation behind the design, share an outline of the user journey, and avenues for evaluation-based iterations of the design.

7.1 Voice-based, peer-to-peer, and moderated interaction spaces

Design motivations and considerations

The ideation sessions led to the concept of a social support system that can help the parents of CWA by leveraging the efficacy of peer-to-peer learning, exchanging relevant information, raising awareness, spreading empathy, and fostering resilience.

Caregivers were unanimous in their preference for a digital interaction space, mainly because the heavy traffic in Dhaka made in-person support groups impractical. In terms of methods of communication within the digital space, purely text-based approaches (such as web forums) were unfamiliar and considered impersonal while exclusively video-based approaches (such as skype calls) were classified as too forward from a sociocultural perspective, resource intensive, and privacy-invasive. Interestingly, voice-based approaches (phone calls) had the perfection of the right balance of personal touch and privacy. Caregivers mentioned how affective qualities of voice (tone, pace, pauses, etc.) could help establishing empathy. From a logistics perspective, partnership with telecommunication companies and social enterprises like Dnet, who have prior experience in phone-based services, can facilitate toll-free numbers and user-side integrations reducing burden of cost and resources for both the end-user and researchers.

Moreover, a voice-based approach can target the time caregivers lose in traffic jams in Bangladesh. In addition to other time slots, sessions (like conference calls) can be scheduled during the times of the day when most parents are in traffic (self-reported to be between 5-7pm). Caregivers were enthusiastic at the prospect of transforming this (self-

reported) “boring” lost time into useful cycles of potential engagement with peers on a shared journey.

In addition to addressing the infrastructural challenges, there were design considerations addressing cultural challenges. Cognizant of the sensitivity of autism-related topics and with the intention to buffer against insensitive dialogue, we thought of adding a moderator who can be a trained volunteer or a public health official from a potentially collaborating social enterprise like Dnet or BRAC. The moderator can facilitate the interactions between the speakers and passive listeners, keep the conversation relevant, buffer against insensitive language, and take notes that can provide invaluable grounded data around conversation topics and nature of interactions enabling proper analysis. The inclusion of a moderator can also reduce the risk of spreading incorrect information by pointing caregivers to proper resources.

In addition to moderated sessions that involve both mothers and fathers, caregivers highlighted the potential for separate discussion channels for males and females in order to better address their different needs. Mothers were interested in the option to have “moms only” sessions where they can openly discuss caregiver challenges specific to motherhood while fathers were keen on discussing how Bangladeshi conceptions of masculinity impacts their role as a parent of a CWA. Figure 2 represents a digitized version of a preliminary sketch our participants conceptualized about the design of the voice-based peer-to-peer support system.

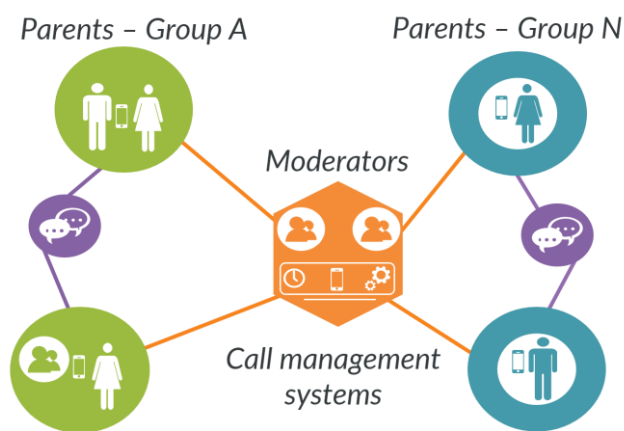


Figure 2. A (digitized) version of a sketch by our PD participants outlining the basics of the voice-based peer-to-peer support system. This schematic diagram depicts parental groups connected to each other through moderated conversations that can facilitate peer-to-peer learning and information sharing.

User journey outline

Based on the design ideas and considerations, a preliminary outline of potential user journey that emerged in the PD sessions is as follows: caregivers register with the project providing verifiable IDs, preferred times to talk, topics they would like to discuss, and address in Dhaka (at a region

level). Each user is assigned an alias which is tied to their real credentials. This pseudo-anonymization allows for anonymity in the chat room with accountability should unwanted things happen (for instance, use of abusive language or inappropriate actions). Once users are matched by their schedules, a group introductory call is made with ice-breakers and moderators setting the context. Given the cultural norms, PD participants felt the introductory group calls are essential to set the tone for the rest of the journey. Users are strongly recommended to stay with their group for the entire duration of the pilot study (helps in estimating any pre and post study impacts). After the introductory call, caregivers dial in at the designated slots to reach other members. If users wish to continue the conversation over other platforms, such as WhatsApp or Telegram, we can work with them to hand over the conversation. In addition, users can mutually agree to connect one-on-one should after the group chats—taking the relationship from a group context to a one-on-one can also signify fostering of rapport and trust, which can be an interesting avenue to study in the future.

Evaluation-based iterations

In terms of evaluation-based iterations of the interaction space, focus group discussions can be carried out pre-, post-, and mid-way through a pilot phase of 8-10 weeks, seeking feedback and iterating on the design. One of the biggest challenges will be to evaluate the efficacy of the voice-based peer to peer support system, especially since recorded calls are unlikely due to the sensitive contents of the discussion. This is where notes from the moderators can be invaluable to analyze overall efficacy. Based on the notes, follow-up interviews with participants and pre and post surveys can also flesh out areas that are working well, those that need tweaking, and ones that require major changes.

While considering the technological design considerations and implications, we want to highlight the need to avoid any kind of technological determinism in designing contextual interventions. Technology, alone and for the sake of technology, will not be able to address complex sociocultural challenges around ASD. The issues around it are critical and sensitive, especially in a resource-constrained ecosystem like Bangladesh. In addition to technological development and innovation, we need other aspects of the ecosystem to improve: social awareness, education, law, and policy. News and social media can play an important role here by creating awareness amongst people. Necessary facts about ASD can be taught in schools so that the society can slowly get rid of the misconceptions and stigma around it. The government should impose strict laws against any kind of unfair discrimination against the persons with autism. The government should also make policies to protect their human and civil rights. Such a holistic effort can not only help in autism-related care, but also catalyze successful integration of persons with autism into the workforce and their contribution to the society at large.

8. Conclusions

Autism is nuanced, and its challenges are unique and situated in the sociocultural framework. As a result, a culturally embedded design is essential for any successful technological intervention for ASD, especially in LMICs. Taking Bangladesh as an analytic lens and focusing on the challenges of caregivers and care professionals, in this paper, we have presented the findings from our original qualitative study in Bangladesh that highlight the design challenges from infrastructural and cultural perspectives. Based on our findings, we have also presented technology design considerations and implications using the concept of a voice-based peer-to-peer support groups for caregivers. We advocate that we should focus on leveraging the increasing proliferation of mobile technology in Bangladesh to address the sociocultural and infrastructural challenges around ASD. We believe that our findings and design implications will help future development of appropriate technologies to support the care practice for ASD in Bangladesh. We hope that the lessons gleaned through this study will also be beneficial for advancing autism-related health services in many other LMICs around the world and potentially improve established practices in other matured ecosystems (e.g., in developed countries).

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References

- [1] Ennis-Cole, D., Durodoye, B. A., & Harris, H. L. (2013). The impact of culture on autism diagnosis and treatment: Considerations for counselors and other professionals. *The Family Journal*, 21(3), 279-287.
- [2] Latest Update on DSM-5. (January 2014). <http://europepmc.org/abstract/med/24640552>
- [3] Speaks. Facts about Autism. Retrieved January 20, 2018 from <https://www.autismspeaks.org/what-autism/facts-about-autism>
- [4] Ahmed, S. I., Jackson, S. J., Zaber, M., Morshed, M. B., Ismail, M. H. B., & Afrose, S. (2013, December). Ecologies of use and design: individual and social practices of mobile phone use within low-literate rickshawpuller communities in urban Bangladesh. In *Proceedings of the 4th Annual Symposium on Computing for Development* (p. 14). ACM.
- [5] Ehsan, U.*, Wong-Villacres, M.*, Solomon, A., Pozo Buil, M., & DiSalvo, B. (2017, June). Design Guidelines for Parent-School Technologies to Support the Ecology of Parental Engagement. In *Proceedings of the 2017 Conference on Interaction Design and Children* (pp. 73-83). ACM. (*equal contribution)
- [6] Samadi, S. A., & McConkey, R. (2011). Autism in developing countries: Lessons from Iran. *Autism research and treatment*, 2011.
- [7] World Health Organization and others. (2011). World report on disability: World Health Organization 2011. WHO Press: Geneva.
- [8] World Population Data Sheet 2013. Retrieved January 20, 2018 from <http://www.prb.org/Publications/Datasheets/2013/2013-world-population-data-sheet.aspx>.
- [9] CDC Newsroom. Retrieved January 20, 2018 from <https://www.cdc.gov/media/releases/2014/p0327-autism-spectrum-disorder.html>
- [10] Chapman, J. S. (1961). The changing epidemiology of tuberculosis. *Missouri medicine*, 58, 1123-1125.
- [11] Fombonne, E. (2009). Epidemiology of pervasive developmental disorders. *Pediatric research*, 65(6), 591.
- [12] Williams, J. G., Higgins, J. P., & Brayne, C. E. (2006). Systematic review of prevalence studies of autism spectrum disorders. *Archives of disease in childhood*, 91(1), 8-15.
- [13] Daley, T. C. (2004). From symptom recognition to diagnosis: children with autism in urban India. *Social science & medicine*, 58(7), 1323-1335.
- [14] Irani, L., Vertesi, J., Dourish, P., Philip, K., & Grinter, R. E. (2010, April). Postcolonial computing: a lens on design and development. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 1311-1320). ACM.
- [15] BTRC Report on internet subscription. Retrieved January 20, 2018 from <http://www.btrc.gov.bd/telco/internet>
- [16] BTRC Report on internet subscription. Retrieved January 20, 2018 from <http://www.btrc.gov.bd/telco/mobile>
- [17] Dhaka Declaration on Autism Spectrum Disorders and Developmental Disabilities 25 July 2011. Retrieved January 20, 2018 from <https://www.autismspeaks.org/science/initiatives/global-autism-public-health/dhaka-declaration>
- [18] Damiano, C. R., Mazefsky, C. A., White, S. W., & Dichter, G. S. (2014). Future directions for research in autism spectrum disorders. *Journal of Clinical Child & Adolescent Psychology*, 43(5), 828-843.
- [19] Zwaigenbaum, L., Bauman, M. L., Stone, W. L., Yirmiya, N., Estes, A., Hansen, R. L., & Kasari, C. (2015). Early identification of autism spectrum disorder: recommendations for practice and research. *Pediatrics*, 136(Supplement 1), S10-S40.
- [20] Bot, B. M., Suver, C., Neto, E. C., Kellen, M., Klein, A., Bare, C., & Friend, S. H. (2016). The mPower study, Parkinson

- disease mobile data collected using ResearchKit. *Scientific data*, 3, 160011.
- [21] Axelrod, S., McElrath, K. K., & Wine, B. (2012). Applied behavior analysis: autism and beyond. *Behavioral Interventions*, 27(1), 1-15.
- [22] Cho, K. W., Lin, F., Song, C., Xu, X., Hartley-McAndrew, M., Doody, K. R., & Xu, W. (2016). Gaze-Wasserstein: a quantitative screening approach to autism spectrum disorders. In *Wireless Health* (pp. 14-21).
- [23] Autism Speaks. Autism Tracker Pro: Track, Analyze and Share ASD Daily | Autism Apps | Autism Speaks. Retrieved January 26, 2018 from <https://www.autismspeaks.org/autism-apps/autism-tracker-pro-track-analyze-and-share-asd-daily>
- [24] Poh, M. Z., Swenson, N. C., & Picard, R. W. (2010). A wearable sensor for unobtrusive, long-term assessment of electrodermal activity. *IEEE transactions on Biomedical engineering*, 57(5), 1243-1252.
- [25] Hussein, H., Taha, G. R., & Almanasef, A. (2011). Characteristics of autism spectrum disorders in a sample of Egyptian and Saudi patients: transcultural cross sectional study. *Child and adolescent psychiatry and mental health*, 5(1), 34.
- [26] Kobak, K. A., Stone, W. L., Wallace, E., Warren, Z., Swanson, A., & Robson, K. (2011). A web-based tutorial for parents of young children with autism: results from a pilot study. *TELEMEDICINE and e-HEALTH*, 17(10), 804-808.
- [27] McConkey, R., & Samadi, S. A. (2013). The impact of mutual support on Iranian parents of children with an autism spectrum disorder: a longitudinal study. *Disability and rehabilitation*, 35(9), 775-784.
- [28] Mertz, L. (2012). Ultrasound? Fetal monitoring? Spectrometer? There's an app for that!: biomedical smart phone apps are taking healthcare by storm. *IEEE pulse*, 3(2), 16-21.
- [29] Jeeon. Retrieved January 21, 2018 from <https://www.jeeon.co/>
- [30] We Build. Retrieved January 21, 2018 from <http://dnet.org.bd/>
- [31] About Aponjon. Aponjon. Retrieved January 26, 2018 from http://www.aponjon.com.bd/aponjon_inner
- [32] Soron, T. R. (2017). Telepsychiatry-From a Dream to Reality in Bangladesh. *Journal of the International Society for Telemedicine and eHealth*, 5, 53-1.
- [33] Maya Apa | Home. Retrieved January 26, 2018 from <https://www.maya.com.bd/>
- [34] Bardhan, S., Mridha, G. M. M., Ahmed, E., Ullah, M. A., Ahmed, H. U., Akhter, S., & Al Mamun, K. A. (2016, May). Autism Barta—A smart device based automated autism screening tool for Bangladesh. In *Informatics, Electronics and Vision (ICIEV), 2016 5th International Conference on* (pp. 602-607). IEEE.
- [35] Blake, J. M., Rubenstein, E., Tsai, P. C., Rahman, H., Rieth, S. R., Ali, H., & Lee, L. C. (2017). Lessons learned while developing, adapting and implementing a pilot parent-mediated behavioural intervention for children with autism spectrum disorder in rural Bangladesh. *Autism*, 21(5), 611-621.
- [36] Robins, D. L., Fein, D., Barton, M. L., & Green, J. A. (2001). The Modified Checklist for Autism in Toddlers: an initial study investigating the early detection of autism and pervasive developmental disorders. *Journal of autism and developmental disorders*, 31(2), 131-144.
- [37] Soron, T. R., Deshpande, S. N., Rabbani, G., & Chakraborty, S. (2018). Development of Bangla Autism Assessment Mobile Application World Congress of the International Association for Child and Adolescent Psychiatry and Allied Professions. *Prague, The Czech Republic. 23-27 July 2018*.
- [38] Lane, N. D., Lin, M., Mohammad, M., Yang, X., Lu, H., Cardone, G., & Choudhury, T. (2014). Bewell: Sensing sleep, physical activities and social interactions to promote wellbeing. *Mobile Networks and Applications*, 19(3), 345-359.
- [39] Voida, S., Matthews, M., Abdullah, S., Xi, M. C., Green, M., Jang, W. J., & Rahman, T. (2013, September). Moodrhythm: tracking and supporting daily rhythms. In *Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication* (pp. 67-70). ACM.
- [40] Boyd, B. A. (2002). Examining the relationship between stress and lack of social support in mothers of children with autism. *Focus on autism and other developmental disabilities*, 17(4), 208-215.
- [41] Soron, T. R. (2016). Telepsychiatry for Depression Management in Bangladesh. *International Journal of Mental Health*, 45(4), 279-280.
- [42] Hospital Services Management, DGHS including Shishu Bikash Kendra (Child Development Center). Retrieved January 26, 2018 from <https://www.hsmgdghs-bd.org/>
- [43] Goodman, L. A. (1961). Snowball sampling. *The annals of mathematical statistics*, 148-170.
- [44] O'reilly, M., & Parker, N. (2013). 'Unsatisfactory Saturation': a critical exploration of the notion of saturated sample sizes in qualitative research. *Qualitative research*, 13(2), 190-197.
- [45] Aronson, J. (1995). A pragmatic view of thematic analysis. *The qualitative report*, 2(1), 1-3.
- [46] Strauss, A., & Corbin, J. (1994). Grounded theory methodology. *Handbook of qualitative research*, 17, 273-85.
- [47] The Bangladeshi Traffic Jam That Never Ends. The New York Times. Retrieved January 26, 2018 from <https://www.nytimes.com/2016/09/23/t-magazine/travel/dhaka-bangladesh-traffic.html>
- [48] Azar, S. T., & Bornstein, M. H. (2002). Handbook of parenting: Social conditions and applied parenting.
- [49] Chadha, N.K. (1995). "With age human beings gain lots of experiences to share and wisdom to pass on. They are the building blocks who stand in the middle of past and future. Hence it is really important to utilize and respect such an immense source of knowledge." Mullatti: 1-15
- [50] Retrieved January 20, 2018 from <http://www.btrc.gov.bd/telco/internet>
- [51] Gray, D. E. (1993). Perceptions of stigma: The parents of autistic children. *Sociology of Health & Illness*, 15(1), 102-120.
- [52] Sandin, S., Hultman, C. M., Kolevzon, A., Gross, R., MacCabe, J. H., & Reichenberg, A. (2012). Advancing maternal age is associated with increasing risk for autism: a review and meta-analysis. *Journal of the American Academy of Child & Adolescent Psychiatry*, 51(5), 477-486.
- [53] Castillo, J. J. (2009). Convenience sampling. Retrieved on October, 2, 2013.
- [54] Charmaz, K. (2008). Grounded theory as an emergent method. *Handbook of emergent methods*, 155, 172.
- [55] Garcia, I., & Stevenson, V. (2009). Reviews-Google translator toolkit. *Multilingual computing & technology*, 20(6), 16.
- [56] Boujarwah, F. A., Hong, H., Abowd, G. D., & Arriaga, R. I. (2011, October). Towards a framework to situate assistive technology design in the context of culture. In *The proceedings of the 13th international ACM SIGACCESS conference on Computers and accessibility* (pp. 19-26). ACM.
- [57] Blacher, J., & McIntyre, L. L. (2006). Syndrome specificity and behavioural disorders in young adults with intellectual disability: Cultural differences in family impact. *Journal of Intellectual Disability Research*, 50(3), 184-198.
- [58] Eriksson Baaz, M. (2005). The paternalism of partnership: A postcolonial reading of identity in development aid.

- [59] Jasanoff, S. (Ed.). (2004). *States of knowledge: the co-production of science and the social order*. Routledge.
- [60] Cain, M., Khanam, S. R., & Nahar, S. (1979). Class, patriarchy, and women's work in Bangladesh. *Population and Development Review*, 405-438.
- [61] Ahmed, S. I., Ahmed, N., Hussain, F., & Kumar, N. (2016, June). Computing beyond gender-imposed limits. In *Proceedings of the Second Workshop on Computing within Limits* (p. 6). ACM.
- [62] Ahmed, S. I., Guha, S., Rifat, M. R., Shezan, F. H., & Dell, N. (2016, June). Privacy in Repair: An Analysis of the Privacy Challenges Surrounding Broken Digital Artifacts in Bangladesh. In *Proceedings of the Eighth International Conference on Information and Communication Technologies and Development* (p. 11). ACM.
- [63] Heimerl, K., Hasan, S., Ali, K., Brewer, E., & Parikh, T. (2013, December). Local, sustainable, small-scale cellular networks. In *Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers-Volume 1* (pp. 2-12). ACM.
- [64] Patel, N., Chittamuru, D., Jain, A., Dave, P., & Parikh, T. S. (2010, April). Avaaj otalo: a field study of an interactive voice forum for small farmers in rural india. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 733-742). ACM.
- [65] Ahmed, S. I., Zaber, M. H., Morshed, M. B., Ismail, M. H. B., Cosley, D., & Jackson, S. J. (2015, December). Suhrid: A Collaborative Mobile Phone Interface for Low Literate People. In *Proceedings of the 2015 Annual Symposium on Computing for Development* (pp. 95-103). ACM.
- [66] Ahmed, S. I., Mim, N. J., & Jackson, S. J. (2015, April). Residual mobilities: infrastructural displacement and post-colonial computing in Bangladesh. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 437-446). ACM.
- [67] Sengers, P., Kaye, J., Boehner, K., Fairbank, J., Gay, G., Medynskiy, Y., & Wyche, S. (2004). Culturally embedded computing. *IEEE Pervasive Computing*, 3(1), 14-21.
- [68] Hassan, E. (2006). Recall bias can be a threat to retrospective and prospective research designs. *The Internet Journal of Epidemiology*, 3(2), 339-412.
- [69] Wenger, E. (1998). *Communities of practice*. Cambridge University Press, Cambridge, U.K.
- [70] Chan, A. (2005). Aging in Southeast and East Asia: issues and policy directions. *Journal of Cross-Cultural Gerontology*, 20(4), 269-284.
- [71] Sung, K. T. (2001). Elder respect: Exploration of ideals and forms in East Asia. *Journal of Aging Studies*, 15(1), 13-26.
- [72] Das Gupta, M., Zhenghua, J., Bohua, L., Zhenming, X., Chung, W., & Hwa-Ok, B. (2003). Why is son preference so persistent in East and South Asia? A cross-country study of China, India and the Republic of Korea. *The Journal of Development Studies*, 40(2), 153-187.
- [73] Dourish, P., & Mainwaring, S. D. (2012, September). Ubicomp's colonial impulse. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing* (pp. 133-142). ACM.
- [74] A Modern Dhaka is Key to Bangladesh's Upper-Middle Income Country Vision. Retrieved from <https://www.worldbank.org/en/news/press-release/2017/07/19/modern-dhaka-key-bangladesh-upper-middle-income-country-vision>
- [75] Govindarajan, V., & Ramamurti, R. (2011). Reverse innovation, emerging markets, and global strategy. *Global Strategy Journal*, 1(3-4), 191-205.