Pandemic, Repair, and Resilience: Coping with Technology Breakdown during COVID-19

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ABSTRACT

COVID-19 disrupted the existing ecosystem of technology repair and recycle in Bangladesh as visiting repair workshops became difficult and most repairers and e-waste workers had to temporarily close their businesses. Consequently, users were left with very few choices for fixing or recycling their devices. Based on our interviews with 30 repair and e-waste workers and 21 users of electronic devices we capture various aspects of this disruption and the corresponding coping mechanisms. This paper reports how the repair and e-waste worker communities adopted various changes to their work, provided remote services, and yet faced a decline in their business. On the other hand, end-users learned to fix their devices, collaborated with each other, and negotiated with partially broken devices to address this challenge. We further discuss the broader implications of our findings for HCI scholarship in HCI4D, resilience, and sustainability.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**.

KEYWORDS

repair, e-waste, bhangari, Bangladesh, resilience, sustainability, end-user

1 INTRODUCTION

The recent COVID-19 pandemic [86] has impacted both the electronic device usage pattern of end-users and the informal market of repair and recycle [9, 37, 65]. Work from home and online education practices have resulted in extended usage of electronic devices [45, 63], leading to frequent breakdown of those devices [53].

On the other hand, lockdown and social distancing regulations have forced the informal market and repair shops to temporarily shut down their businesses [35, 87]. This disruption in the pre-existing market has presented an unprecedented challenge for end-users to get their devices fixed, and for repairers and e-waste recyclers (known as "bhangaris") to adjust with the new reality to earn their livelihood. The objective of this paper is to explore how both groups of stakeholders in this ecosystem – end-users and repairers/bhangaris – respond to the pandemic crisis and what skills, social capital, and connections they employ to thrive in this infrastructural breakdown of repair and recycle ecosystem.

To explore the infrastructural breakdown of informal repair and recycle practices in Bangladesh due to the pandemic and understand the resilience of the communities to withstand the situation, we situate our work within the emerging literature of repair, recycle, and e-waste handling within HCI. In recent years, repair and e-waste handling practices have emerged as a major topic of interest among the HCI community [36, 38–40]. A series of ethnographic works on repairing electronic devices and recycling electronic waste documented important findings on knowledge, craft, collaboration, efficiency, improvisation, values, care, and sufferings [9, 30, 36, 37, 65, 67] among the repair and bhangari communities. This emerging yet understudied literature brings to the fore the significance of the "broken world" and emphasizes that the after-use phases of technologies should be studied as an equally important site in parallel with the design and use of technologies [30, 40, 41, 65, 66].

While HCI and related fields present a comprehensive narrative of how the repair, recycle, and bhangari communities contribute to agendas of sustainability, and conversely, how the communities sustain their practices in "normal" situations, there is a scarcity of research on how the communities build resilience to sustain their practices in unprecedented infrastructural breakdowns. We contribute to filling this gap in the literature by providing our findings of how repairers, recyclers, and end-users overcome different types of challenges during a pandemic period such as COVID-19.

To this end, we conducted an in-depth interview-based study with 51 participants (15 e-waste workers, 15 electronics repairer, and 21 end-users). Our findings reveal how the pandemic disrupted the repair and bhangari infrastructure in Dhaka, Bangladesh. We show how the lack of workforce, short-supply of raw materials, reduced number of customers, hopelessness, confusion, and insecurity resulted in a broken repair and recycling ecosystem. We further report how the repair and bhangari communities created resilience by adapting to various changes to their work through taking safety measures, establishing community collaboration online, providing remote "fixing" services using video calls, seeking help from small

and weak ties, and taking short- and long-term measures to restore their businesses. Besides reporting findings from repair and recycling communities, we also present our findings on how end-users engaged in repair activities in the absence of regular low-cost repair services. We illustrate end-users' emerging trend of repairing their broken technologies by taking remote assistance from repairers and collaborating with tech-savvy friends and family members. Through the above findings, we investigate both vulnerabilities and resilience of the repair and recycle infrastructure in Bangladesh.

This paper makes three contributions to the HCI literature. First, we demonstrate how repairers and e-waste workers used their knowledge, materials, and social resources to keep running the informal repair and recycle ecosystem during the pandemic. In doing so, we draw on the literature of resilience and informality within HCI and related disciplines. Second, we inform the emerging practices of repairing electronic devices due to the inaccessibility of the formal repair market. We discuss how this new trend of repairing electronic devices results in novel collaborations and innovative opportunities. Third, we discuss technological, social, and infrastructural challenges where HCI can aid repair, recycle, and e-waste processing communities to sustain their practices. Overall, our study strengthens the HCI literature of the after-use phases of technologies by explicating the vulnerabilities of informal repair and recycling infrastructure in the face of unprecedented challenges. Our study also manifests the significance of the broken technology ecosystem's technological and human infrastructure for resilience against crisis moments such as the pandemic.

2 LITERATURE REVIEW

2.1 Repair, Recycle, E-waste Handling, and Sustainability

The post-use phases of technology are the moments of breakdown, repair, recycle, and e-waste processing. The HCI scholarships on the post-use phases of technology broadly fall into two categories: (i) characterization of the works involving broken and obsolete technologies and exploration of knowledge, arts, crafts, skills, cares, and sufferings in the works, and (ii) attending movements of sustainability by addressing issues regarding post-use phases of technology.

Although "breakdown" and its related concepts are still emerging in HCI, sociology has a long tradition of studying moments of a breakdown in social orders and infrastructure [30]. Houston et al. highlight the pragmatic tradition of studying breakdown and repair, and show that pragmatists characterize the moments of breakdown as an opportunity to illuminate hidden features of social life and learn to adjust across situations and contexts [30]. They further argue that the contemporary studies in HCI follow from the pragmatic tradition [30]. Lucy Suchman's celebratory work, *Plans and Situated Actions* [78], is one of the earliest works on repair in HCI. She shows how human labor and care are associated with restoring the functionality of a broken machine. Julian Orr's celebratory work of demonstrating technical works through oral culture builds primarily on an ethnography of photocopier repair workers [57]. Jackson builds on them and pushes forward HCI's agenda of the "broken world" by advocating that repair is a "technological" work with both functional and moral relations to technology [36].

These earlier works have inspired a series of ethnographic studies in HCI and CSCW that characterize the moments of the post-use phase of technology. For example, Rifat et al. study electronic waste workers in Bangladesh and demonstrate the skills, care, and occupational hazards of the communities [65]. Ahmed et al. conduct an ethnographic study in mobile phone repair markets in urban Bangladesh and explores explicit, tacit, and social knowledge through which repairers learn to repair electronic devices [9]. They demonstrate how different forms of social knowledge through everyday oral communications and micro-level technical and non-technical exchanges between workers bind the community together [9]. Houston and Jackson study mobile phone repair practices in Kampala, Uganda, and explain how global and local exchanges of knowledge and collaboration sustain the repair market in developing countries [29]. Building on an ethnographic study in an e-waste handling non-profit, Vyas and Vine make a similar line of argument by demonstrating how recycling communities build their community resilience through acquiring skills based on both their local and global knowledge [85]. These and other works in HCI and CSCW establish repair, recycle, e-waste processing, and maintenance as significant as other dominantly highlighted moments of the technology life cycle (such as design). These works show how the communities grow and sustain in a challenging yet stable infrastructure.

The other line of studies involving the post-use phases of technology contribute to advance the movement of sustainability within HCI. Many of such works in sustainable HCI that engage issues of repair, recycle, maintenance, and e-waste handling go under the hood of sustainable interaction design (SID) introduced by Eli Blevis [17]. Since its inception, SID has inspired many studies concerning the post-use phases of technology. For example, Huang and Truong study material and aesthetic aspects of mobile phones that impact how people perceive the *"value"* of a mobile phone in deciding to keep using a phone or discard them [31]. Their study shows that the primary courses of action after breaking down a phone involve replacing the phone for a discounted price, donating the phone, throwing the phone to the trash, or giving the phone away to a family member; only a handful amount of phones get recycled. In a similar study, Odom et al. study a device's durability in terms of three qualities: functionality, symbolism, and material quality [56]. They conclude that the presence of new technologies with similar functionalities leads to the obsolescence of existing technologies, whereas certain material qualities (such as wood or metal) and personal attachments increase the durability of a device. Kim and Paulos propose a design strategy to inspire the creative re-use of design strategies [44]. In this strategy, they propose a design-reuse vocabulary and a *re-use composition framework* with three components in it: re-use as is, remake, and re-manufacture. They explicate various skill sets and expertise in creatively re-using broken and obsolete technological artifacts. Overall, the studies give insights into the factors that lead to obsolescence or breakdown of technologies. These studies further explicate the general courses of action after a technology breaks down.

Deciding whether to keep or discard a technology does not depend only on the aesthetic or material aspects; instead, a phone's longevity varies based on a community's contextual practices, which Huang et al. call "situated sustainability" [32]. For example, while

exchanging or upgrading phones for a discounted price is a widespread practice in the Western market, people in the Global South usually get their phones repaired after it breaks down because of economic constraints. This is why cheap and informal repair and e-waste markets are bigger in the Global South that is often the only source of income for many workers [2, 3, 9, 19, 39, 40, 89]. In summary, the culture of consumption, obsolescence, and repair of technologies are locally constructed where they are primarily used.

An infrastructure is "a framework that enables a group, organization, or society to function in certain ways, such as the series of pipes, drains, and water sources that comprise a water system [71]." There are social, technological, and human dimensions [16, 33, 71, 77] in an infrastructure. Jang et al. show that the works of after-use phases of technologies themselves embed an infrastructure [41]. This infrastructure consists of diverse human and material factors, which are often subjected to differential access to economic and political resources [38, 41]. People in resource-constraint regions often build this infrastructure through innovation, creativity, and hacking [10, 68]. We build on this literature of "infrastructuring," and demonstrate that the infrastructure of the after-use phases of technologies is prone to breakdown in unprecedented situations, such as the COVID-19 pandemic [86]. We further explicate how the users of after-use phases of technologies–who include repairers, recyclers, e-waste handlers, and owners of broken devices in our case–leverage existing technologies, social connections, skills, experiences, and creative actions to build community resilience.

2.2 Community Resilience, HCI, and Sustainability

To understand the persistence and sustainability of repair, recycle, and e-waste handling communities, we draw on the literature from community resilience in social sciences. Although the dominant literature of community resilience is concerned with disaster crisis, the literature is the entry point for this paper to understand and assess the communities' vulnerability to unprecedented crises and their techniques to adapt to the situation.

Community resilience is the characteristic of a community that determines how a community can survive and thrive in unexpected, sudden, and often hazardous situations [73]. This community feature is not about how individuals of a community cope with a hazardous situation, but the collective capacity of a community to adapt to a crisis situation [73]. Norris et al. present a model for community resilience that provides insights into a community's capacities that help a community bounce back after a disaster [54]. The capacities are economic development, social capital, information and communication, and community competence [54]. A resilient community brings together individuals, groups, and organizations to resist a danger [46]. A resilient community creates a "sense of community" by negotiating mutual concerns and shared values [61]. Through an exchange of accurate and trusted information, a community deals with risks and disasters to mitigate their impact [54]. Besides important economic resources, communities develop social, cultural, human, and political resources and they engage collectively as a community in crises [22, 47].

Essentially these communities leverage informal means of social organization, also referred to as informality [14]. Broadly, informality refers to how power and resources are negotiated by community actors [28], in relation to powerful state actors. In the presence of weak state institutions, trust plays an important role in communities across the Global South, where interpersonal trust and extended social networks, rather organically, becomes the primary means of regulation [62]. In the face of uncertainty and risk, informal market actors around the world fall back upon their informal relationships to both make sense [20] of events and to find community-driven workarounds [18] that lead to stability and resilience.

In HCI and CSCW, community resilience research often comes under the hood of social sustainability [21], which Dillahunt argues is the weakest pillars of sustainability. Within the growing body of scholarships, the dominant literature within HCI and CSCW exploring resilience involves crisis informatics and migration studies (see, for example, [21, 49, 50, 75]). Soden et al. present action research that supports a disaster-prone community in Nepal by helping to build resilience through increased access to geo-spatial data [75]. Mark et al. conduct an ethnographic study with Iraqi citizens and report how they use technology to adapt their changing situation during the wartime [50]. They show how the war affected people build resilience by reconfiguring their social networks, creating self-organizing and robust communities, arranging fault-tolerant infrastructures, and developing trustworthy information-sharing strategies. Mark and Seeman study resilience in collaboration during a prolonged disruption in communication infrastructure [49]. They suggest that the aid of technology in creating a virtual work environment and assisting to keep connected with other community members create safety and independence. Al-Akkad et al. study how people make use of "left-over" technologies to restore the function of a broken infrastructure [12]. Rifat et al. show how e-waste handling communities (also known as "bhangaris") create economic resilience in hazardous working conditions by cutting their healthcare cost [65]. Seeman et al. study veteran's integration to civil society and show how veterans use technologies to adapt to their identity crisis [72]. These and other works [58, 74, 84] within HCI and CSCW demonstrate how individuals and communities use technologies, techniques, tools, innovations, and creativity to build resilience during disruptive moments.

However, the literature is still inadequate to understand the resiliency of repair, recycling, and e-waste handling communities to provide technology and policy support in sustaining their practices and business. The communities run within a complex interactive business and social structure, often depending on one another in multiple ways. For example, many e-waste handlers depend on the repair markets for their products [65]. Repairers also often get repair tools and electronic parts from the e-waste market [9, 37]. Because of such inter-dependencies, the communities develop strong business and social ties among themselves, which is an indicator of strong social resilience. Many resources, skills, materials, and tools are often transferred from one community to another through a stable infrastructure combining communities and technologies. We ask, what happens when such a stable infrastructure breaks down within the communities? How do the communities adapt to disruptions? On top of that, the COVID-19 pandemic has created

an unprecedented situation, where the communities' existing adaptation techniques are not sufficient to help them sustain. Our study contributes by exploring how the COVID-19 pandemic impacts the post-use phases of technology and how users sustaining in this unprecedented situation by building resilience with their limited resources.

3 BACKGROUND AND CONTEXT

The repair-recycle ecosystem in contemporary Bangladesh consists of repair workers, e-waste workers, and end-users. Repair workers operate within a complex ecosystem of practices organized across a spectrum of activities. While there are some "authorized" high end repair shops in general malls, their range of repair activities is often limited to minor replacing or fixing activities within the warranty period. On the other hand, informal and independent repairers, generally occupying a whole market, work on more diverse cases and handle a much larger share of the actual repair activities performed. In contrast to branded, authorized repairers, the issues handled by independent repairers demand a heterogeneous set of expertise, ranging from fixing broken screens, hardware, speakers to mitigating overheating issues to handling software updates of "slow" devices. The entry into any repair professions follows a wide range of paths such as accruing knowledge and skills from abroad, learning under apprenticeship in repair shops, or sometimes formal training in local training programs conducted by senior repairers within the community. In a typical repairer market, there are repair workers, novice apprentices, repair workshop owners, and engineers graduated from three-year polytechnic institutes. They maintain close ties within themselves through actively learning from, working under, and assisting each other with knowledge and parts. In addition to providing repair services, some of these repair shops also sell accessories such as mobile covers, earphones, and protectors as a side business. As suggested in prior work [9], an important requirement for them is to learn how to deal with customers and understand their needs. This independent repair work in Dhaka is primarily based on two hubs: one big underground market with other smaller markets around Gulistan area, a busy commercial zone in the old part of the capital city of Dhaka, and several big repairing markets around Elephant Road – an urban residential and commercial area in the heart of Dhaka.

Apart from repairers, another group playing a key role in the post-use phase of technology is the community of e-waster workers, commonly referred to as "bhangaris" (a Bengali word meaning "those who break"). The word "bhangari" encompasses people who collect discarded electronics from all over the city, test and sort based on perceived value and preference, re-purpose to sell them in local market if possible, and finally dismantle to extract metal. Collectors visit repair shops, households, and offices to buy or collect broken parts and devices at bulk prices or in exchange for grocery items. Some bhangaris start the business with collecting and take this profession temporarily or seasonally, while others make it their permanent profession, eventually owning a permanent workshop. In comparison with repairers, their job mostly does not involve working with end-users – only the collectors directly interact with end-users when they buy from households or offices. Four major e-waste markets in Dhaka are Nimtoli, Elephant Road,

Islambag, and Zinzira. Nimtoli, having aged more than twenty years, remains the oldest and the largest. The Elephant Road e-waste market is close to the repairer markets in that area, thus allowing the e-waste workers there to work closely with the repairers and collecting from them. Islambag and Zinzira are well-known for their plastic and metal processing facilities, respectively. These markets are not located in multi-storied buildings compared to the repair shops. We did not find any female worker in this repair and recycle industry.

COVID-19 in Bangladesh. When the COVID-19 pandemic first hit Bangladesh on March 8, 2020 [60], the country quickly went into lockdown within three weeks[48]. Usual business activities were suspended and markets and offices were shut down in the capital city of Dhaka. At the same time, there was an increase of technology usage to cope with the lockdown and continue meetings, classes, offices, and virtual interactions [26], leading to frequent breakdown of electronic devices due to excessive usage [53]. However, with the repair and e-waste markets closed, the infrastructure was suddenly unavailable, leaving the end-users in a precarious condition. Against these backdrops, we conducted our study to understand how these end-users continued their repair and recycling activities.

4 METHODS

4.1 Recruitment and Procedure

To understand the impact of the infrastructural breakdown of repair, recycle, and e-waste communities due to the coronavirus pandemic, we conducted a four-month long (from April to July, 2020) interview-based study in Dhaka, Bangladesh. Following our research ethics board's guideline, we conducted the interviews remotely over the phone, Skype, and other communication mediums. All authors in this paper are born and raised in Bangladesh. Two authors have been conducting ethnographic studies with repair, recycle, and e-waste processing communities for over five years. The authors regularly communicate with people in the repair and recycle markets. We started our interviews from a pool of already existing connections. However, we did not confine in recruiting participants only from our known connections; rather, we prioritized recruiting new participants by snowball sampling [23].

From April to July 2020, we conducted interviews with 15 repairers, 15 e-waste handling workers, and 21 mobile phone and laptop users. The repairers in our study are running businesses in Motaleb Plaza and Multiplan center, which are two of the biggest hubs for informal repair shops. E-waste handling workers have shops in the Nimtoli market, which is the biggest e-waste market in Bangladesh. In addition to the repairer and e-waste workers, we also conducted interviews with end-users ($N = 21$) of mobile phones and computers who experienced problems and breakdown of their devices and needed repair. This set of interviews complemented our findings from repair and e-waste worker communities. Besides, interviews from end-users give us insights into their resilience practices in a broken repair infrastructural situation when they needed to get their devices fixed. All interviews are semi-structured with some predetermined themes from existing literature on the post-use phase of technology and resilience in HCI. However, we

Table 1: Demographic characteristics of the study participants.

	End-Users (n=21)	Repairers & E-Waste Workers (n=30)
Age	Min: 18 Max: 63 Average: 30	Min: 15 Max: 60 Average: 32
Gender	Female: 8 Male: 13	Female: 0 Male: 30
Highest Edu.	High School: 4 Bachelors: 12 Masters: 5	No Schooling: 7 High School: 15 Bachelors: 6, Masters: 2
Career	Student: 9, Teacher: 2 Homemaker: 2, Job: 4 Business: 2, Retired: 2	Repairer: 15 E-waste worker: 15

were also open to emerging themes and regularly updated our protocol accordingly. On average, each interview lasted 35 minutes. There were some smaller interviews, which we discarded as the interviews were interrupted by our participants' call from their family. The ages of the participants ranged from 18 to 63 years. For detailed demographic information, refer to Table 1. Altogether, we conducted 51 interviews with repair, recycle, e-waste handling communities, and end-users which sum up to 24 hours of interview data. We conducted the interviews in Bengali and then transcribed and translated them to English to guide our analysis.

4.2 Analysis

We followed an inductive approach to analyze our data [83]. The initial analysis started with several rounds of reading of the transcripts. We highlighted the transcripts to discard unnecessary data. We then conducted open coding, followed by axial coding to develop memes and themes. During this analysis, all of the authors regularly met to discuss the predetermined themes as well as emerging themes. The findings we report bellow combine both predetermined as well as emerged themes.

4.3 Research Ethics

The research is approved by the institutional review board of a researcher in-situ. Due to the coronavirus outbreak, we followed the ethics board's instructions of avoiding in-person contacts. The participation of this study was voluntary; participants did not receive any compensation. As we conducted the study remotely, and some of our participants were not tech-savvy, we took their verbal consents. We informed our participants with all possible risks. We discarded any personally identifiable information from the dataset and used pseudonyms throughout the paper. The transcripts were kept in a password protected machine. Only researchers of this study have access to the data.

5 FINDINGS: REPAIRERS AND BHANGARIS

Our study gives insights into the disruption of repairers' and e-waste workers' ('bhangari'[1]) professional life due to the COVID-19 pandemic. This section starts with informing our findings of how the COVID-19 pandemic brought initial shocks and changes in the quotidian work patterns of repair and bhangari profession. We then describe how repairers and bhangaris coped up with the changed situation by leveraging their technological and community resources.

5.1 The Disruption of the Repair & E-Waste Processing Services

5.1.1 ***Reduced Workforce***. The initial lock-down mandated by the government forced many repairers and bhangaris to leave their profession. Around half ($n = 15$) of our participants reported leaving their shop and going back to their home town during this lock-down. Some participants ($n = 8$) waited for a while with the hope of re-opening their shop, but they had to leave as the lock-down was extended later in multiple episodes. When partial reopening was allowed in July 2020, many of the repair ($n = 4$) and bhangari ($n = 3$) workshop owners did not return. The fear of exposing to the virus ($n = 4$) and the uncertainty in their business ($n = 3$) were among the primary reasons for not returning back to the business. Some shop owners hire additional workers when their business grows big. When the pandemic started, it was difficult for the owners to keep their workshops running as their workers left suddenly and often without any notice. This forced the owners to significantly scale their business down. The following case study, constructed from interviews with the owner of an e-waste workshop shows the difficulties they faced during the pandemic,

Case 1: *Mr. Shahid owns one of the biggest bhangari workshops in Nimtoli e-waste market. Typical bhangari shops are small and employ one or two workers. Mr. Shahid's son (18 years of age), three employees (aged 21, 16, and 15 years), and Mr. Shahid himself work in his shop. Within a month of this pandemic, all three of his employees fled one by one to their villages. Later, after four months when he was allowed to open the shop, he called his employees but none of them agreed to come back Dhaka. Mr. Shahid called his employee's parents to persuade them to let their sons come back. He also offered extra benefit to the employees, such as covering their living and medical costs if needed, but they refused. On the other hand, Mr. Shahid could not pay the rent since he was not making enough money. He is still waiting for his employees to come back, while he is trying to do as much as he can with the help of his son and a relative who occasionally help with logistic issues.*

The case above shows that the business owners faced increasing difficulties due to the loss of their workforce. Although the workshops were not getting as many customers as before, the loss of their workforce disturbed their routine works and everyday practices. The informal human and technological infrastructure nevertheless left room for repair and bhangari shops to seek help from their friends and families of the shop owners, who could fit into the repair and bhangari works and help control the damage.

Migrant repair workers, bhangaris, and temporary logistic workers were exposed to increased emotional pressure. The participants

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[1]E-waste workers are known as bhangari in Bangladesh

(n = 5) who left the city from their workshops could not come back due to their own fear of catching COVID-19 (n = 4) as well as the resistance (n = 3) from their families. Participants explained the time as generally depressive, where they had a feeling that the whole repair and bhangari business is collapsing. Some participants (n = 2) described this as Allah's punishment, which will need time to finish; they need to wait till them. The parents (n = 2) of some participants were affected by misinformation and cultural myths. One parent of a participant was describing his belief about the coronavirus,

> "Corona only touches people living in big cities. People in Dhaka are dying. And here, none of us is affected. TV, news showed that these (electronics) are responsible for spreading this thing (virus). How can I let my son go and work into this worst hell (habiya)" [Father of B7, Male, 42 years, Farmer]

In addition to the fear, uncertainty, anxiety, myths, and concerns around the nature of the job, the future economic instability perceived by our participants (n = 3) was another dominant factor the discontinuation of e-waste and repair works. Workshop owners (n = 7) informed us that they sold their possessions over the phone and returned to their rural home because the earning would not be 'enough' had they carried on working. One senior local repairer with nearly 20 years of working experience in repair markets of Dhaka discussed this economic instability:

> "Those who used to earn good amount before Corona did not return. They think they can not regain their market possession, the profit will not be like it was before. Mostly novice, and some mid-level repairers came back." [R4, Male, 50 years, Senior Repairer]

The quote above shows our participants' assumption and insecurity of the future repair market. While young and apprentice participants could not articulate their contingency plan to recover from the future economic hardship, the senior and veteran repairers and bhangaris stressed that their demand for skill-sets and services will still remain the same if not even increase. They described that all will go through an economic hardship, so people will have the less flexibility to buy new phones. As a result, the need for more repair services will hike up that will help them to recover from their economic loss during the pandemic. This hope and vision helped the repairers to partly save help them to refrain from distresses and anxiety.

Overall, the loss of the workforce, fear, distress, anxiety, myths, superstition, and economic insecurity demonstrated a temporal challenge for repair and bhangari businesses, both for big workshop owners and for contract workers. Despite, our participants' hope, willingness to come back to the business, faith in their skill-sets, and a future vision helped absorb the initial shock and wait to come back to the business as soon as they can. During this wait time, they used material and human resources available to them. Their business's flexible and organic structure gave them an additional level of immunity in tweaking their repair and e-waste handling practices so that they can go by in the changed situation.

5.1.2 ***Changes in Tasks and Work Patterns****.* Because of the safety and resource scarcity caused by COVID-19, repair and bhangari

communities were exposed to changes in work patterns and daily tasks. The safety issue disrupted some tasks in the work ecosystem more than others. For example, repairers and e-waste workers who handled e-waste materials directly after receiving them from customers feared to continue their tasks. One senior e-waste handler explains the risks and fear of e-waste collectors,

> "Our collectors do not want to touch, break anymore. They would dismantle part by part first and sell those parts to different workshops. If you sell this way, the profit goes higher. Now, they are not even opening things. They think: 'Even if the profit is 10 taka[2] less than usual, I would not risk myself'. This changes the procedure for us. To get the core metal, we now have to break a lot of plastics, shells first–this is just another burden on us." [B1, Male, 31 years, Owner of an E-waste Workshop]

The senior e-waste worker continues to explain the differential risks of corona virus exposure from collection to dumping in the ecosystem (see Rifat et al. to know more about the ecosystem [65]). The fear of e-waste collectors was partly due to the reason that e-wastes are dumped from the household in Bangladesh. One source of e-wastes for many community bhangaris are the thrown-away e-wastes from their neighbourhoods. Our participants explained (n = 5) the e-wastes are rarely sorted and thrown away separately from Bangladeshi households; rather, they are typically dumped together with other household wastes. They also pointed out that cast-off masks, gloves, clothing, and other forms of protection against COVID-19 thrown in dumpsters made their work risky. The disruption in the e-waste collection slowed down the related tasks in the workflow.

In addition to associating risks with the collection of discarded electronics, participants (n = 10) informed us of the disruption in the supply of necessary raw electronics, parts, tools, and accessories in the market. Raw materials and electronics come through two ways in the repair and e-waste markets: 1) "Chinese" parts import, and 2) extracting functional parts from second-hand or old smartphones from the local market. Due to the COVID-19 pandemic, imports of "Chinese" parts stopped for about eight months. On the other hand, the second-hand electronic-parts market stalled because of negligible customer presence and disruption in the household supply chain. Repairer participants explained (n = 6) that the lack of electronic parts made it difficult to carry out specific repair tasks.

To cope up with this shortage of parts, repairers employed different strategies such as trying alternative repairing techniques (often in trial and error basis), substituting preferred brands of parts, and controlling repair costs. For instance, one repairer shared how they shifted their approach on fixing broken displays when there was no supply from China,

> "Screen related problems of phones are of two types: the issue can be either in the display unit or in the front glass that responds to your touch. When the problem is only with the touch with working display, one solution is to remove the glue between display and touch, and install a new glass over the original display using a small glass-cutting machine. However, this removal often causes harm to the display affecting its longevity. This complex

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[2]Taka is the Bangladeshi Currency. As of July 9, 2021, 1 USD = 85 Taka

procedure also takes around two hours. The other way is to replace the whole display+touch unit for any issues. This method usually takes only 10 minutes and ensures the quality of both touch and display. Before Corona, we only did this replacement and turned away customers wanting to change glass considering the time and safety. However, since January, we could not receive any parts shipment from China. Now for those cases, we are doing this removing-cutting-gluing." [R13, Male, 30 years, Repairer]

Despite the coping mechanisms above, such a scarcity of resources allowed only a subset of regular repair and e-waste handling activities. As reported by our participants ($n = 7$), customer also showed up with only serious problems in their devices. Dead batteries, display breakdown, circuit-board burnt, and speaker issues were among the major repair cases repairers received after the pandemic. For example, Mr. Haider, a 40 years old repairer with a big repair and wholesale parts store, used to have customers in his repair shop with cases ranging from repairing IPhone camera to simply buying screen protector, cheap earphones. This accessories business was one of his major earning sides. However, after COVID-19, there is little to zero sale in these products. He explains: *"These days no one comes to buy only protectors, covers or earphones. They only come to us, when it is must to repair."*

To overcome the shortage of electronic parts, repairers in large markets reached out to community repairers and repair shops in smaller markets. As the neighborhood repair shops had a better connection with people in the community, they received a higher number of discarded electronics during the pandemic. As a result, repairers in smaller markets had a better collection of useful materials and electronics parts during the pandemic. Though it is not uncommon that bigger markets often partner with smaller and neighborhood repair shops, the pandemic increased this collaboration to a significant level. This collaboration did not only benefit the larger repair shops by partly rescuing them from supply shortages, but also helped the neighborhood repairers by helping to grow their business, which the community repairers hope will continue past the pandemic.

5.2 Adaptation and Resilience

The reduced work-forces and broken material and human ecosystem due to COVID-19 have directly affected the lives, works, and security of e-waste workers and bhangaris. Our participants reported their ongoing and future adaptation strategies to continue their limited businesses during the pandemic and recover from the loss after the pandemic. Our analysis shows how the communities planned to use their resources, skills, and techniques to fight against the challenges. Despite, sufferings and struggles still remain when bhangaris and repairers try to adapt.

*5.2.1 **Safety Measures in the Workshop**.* Our interviews with the repairers, recyclers and e-waste handlers demonstrate increased safety measures in their workplaces. Almost all our participants re-opened their workshops after the lockdown reported taking extra safety measures while receiving phones and e-wastes from their customers. Like many other professions, some participants ($n = 7$) informed that after re-opening their workshops they always kept

wearing their masks to assure their customers. Shop owners and senior repair workers reinforced this rule among their co-workers. One such bhangari shares his experience, how he thinks using a mask was a must-do that they had ignored for so long:

> *"Our workshop is just beside busy roads. There is always dust, dirt here. I have been doing this for the last 20 years. My family (wife), always told me to wear a mask for works; I never paid attention. But we are forced now. I can feel the difference when I go home and take a bath or clean my face. (...) We have taken so much harmful chemical, gas, dust inside all these years. From now on, I will always wear a mask during work."* [B2, Male, 45 years, Breaker]

Similar protection measures were also evident in using disinfectants, tissues, gloves, and soaps before and after touching tools and electronic parts. Repairers ($n = 7$) also said they used a hand-sanitizer before touching customers' devices and after taking paper notes from their customers. Most participants embraced the increased safety measures to safeguard themselves and ensure that safety is not resistance in their re-opening of businesses.

However, some participants ($n = 3$) did not appreciate these changes and suggested the extra measures as an additional burden. To show their awareness, our participants put their masks on while breaking, burning, and melting electronics, which often made their job difficult since most of them work in a hot and humid environment. One participant sarcastically showed their frustration by painting the problem of using many one-time safety materials as a mean of producing wastes,

> *"We used to drink tea in glass cups. That tea would cost 5 taka. We used to give life to broken objects, discarded electronics. I fixed so many things that were rejected by big repairers. And here now, we are having tea costing 7 taka at one-time plastic cups, wearing one-time masks, dumping so many things without touching, and breaking. These one-time things are surrounding our lives."* [B9, Male, 25 years, Worker of an W-waste Processing Shop]

This comment from a participant shows a mixed feeling of the adapted situation. While they appreciate that they can take measures for returning to the business, they are also not happy that they have to spend money from their limited income during the pandemic to ensure their safety.

*5.2.2 **Collaboration and Communication**.* Collaboration among community members happens through peer assistance and apprenticeship that keep the bhangaris and repairers connected, well situated within the market and the greater community. These collaborations are often extended through a business relationship of selling spare parts or exchanges of expertise among the communities. The COVID-19 situation has shifted in-person collaboration to online and social media after the pandemic due to two crucial reasons: 1) to avoid physical contacts, 2) keep abreast of a large number of peers who left the profession due to the pandemic. For instance, Mr. Ashraf, owner of a large repair shop as well as a repairer training

center that graduated more than 8000 students maintains a group-chat with his past students. He observed a change in the group chat after the partial opening:

> "My students now interact using this (group). Even most of them never met in person. (...) When one asks, say 'I need this display/ that speaker. Does anybody have it?' Those who have or knows from where to get, responds. They also mention the actual price so that ." [R8, Male, 52 years, Owner of a Repair Training Center]

Repairers also used such groups to discuss about possible openings, uncertainty, coming back after pandemic. Large repairers usually occupy a whole workshop space on rent and pay monthly to the market authority. Some negotiations are further complicated where small repairers rent a portion in a workshop from the tenant and pay the rent not to the market committee but to the large repairer who rented the workshop. Both large and small repairers had to decide whether and how they would pay the monthly rents for the months they had to keep their shops closed due to lock-down. Repairers referred to these social media groups for collectively discussing these terms and conditions to be negotiated with authority. Maintaining such online groups to discuss and reach agreement was necessary as this connected repairers both continuing to work and leaving the market. Small repairers working in Motaleb Plaza by renting small spaces in larger workshop informed us ($n = 2$) that they created a group chat for themselves during this lockdown to discuss about paying rent of the months of lock-down as well as paying less after reopening due to Corona. Another repair who used to connect his suppliers via phone-calls shared such an story where he collaborated with four other workshop owners in an attempting to bring parts from abroad to continue repair activities.

> "Kashef (a repairer) had a supplier in China who said he could make ways for one special shipment of necessary parts in exchange for full advance payment. So, we four sent joint parts requirement list to him. However, two of us did not have the money ready. So, they included Joynal (another repairer) who left the market but could lend us money for. We all discussed parts, price, and transaction through a WeChat group created with that new Chinese supplier." [R12, Male, 24 years, Repairer]

Compared to the repairers–working directly with the end-users to get thing fixed–the whole bhangari ecosystem largely depends on the independent and employee e-waste collectors. Additionally, they receive a variety of electronic and electric devices in a wide range of conditions. So, often the outcome of their work is not as straightforward to that of repairers. Collecting and selling e-waste streams thus needed in-person communication and collaboration among collectors, breakers, testers, and metal extractors.

While a large section of both repairers and bhangaris left their workplace due to COVID-19, we found bhangaris did not keep connected with their working counterparts in the order we observed for repairers. For example, one bhangari shared how he lost connections with all his peers leaving the market after COVID-19 when he lost his feature-phone as well as the contacts. We found only a small section (n=2) of the bhangari participants to own smartphone. This further limited their ability to keep connected with their peers over internet and other digital means.

However, we found two cases where bhangari, e-waste collectors took job under another larger bhangari workshop owners. For instance, Insan used to collect, test and sell e-waste streams to workshops before pandemic. He was trying to take a small workshop of his own. However, during this pandemic, he left this plan as this bhangari business was in decline during COVID-19. He convinced an experienced bhangari having permanent workshop to let him work in his shop in exchange for a monthly salary. This way, they kept collaborating with each other extending their informal relationship,

> I used to sell things to him. But, working as a helping-hand to a bhangari will in turn give me the experience before I start my own. More importantly, a fixed monthly salary is safer when the whole market is in decline. [B12, Male, 21 years, Employee of an E-waste Workshop]

In summary, bhangaris and repairers collaborated and communicated with each others in different ways when usual means were unavailable. They created new ways and opportunities and leveraged existing networks to communicate.

*5.2.3 **Interacting with Customers**.* One natural outcome of the pandemic was the decreased number of customers in the repair and e-waste shops. Our participants reported that this situation of the lack of customers continued even after the pandemic. Participants adopted different strategies to cope up with this situation. We found repairers utilized their social skills, and employed innovative ways to regain their interaction with the customers. One strategy shared by the participants ($n = 4$) was to explicitly asking customers for repairing things other than that they came for. One repairer explained:

> "When a customer comes to me for repairing anything, I try to look at what else can be fixed. I ask them cordially to get that extra issue fixed at a reasonable price. I also suggest them installing screen protector when the protector is broken, new covers when I see an old one." [R9, Male, 30 years, Owner of Two Repair Shops]

Repairers and e-waste workers ($n = 7$) tried to establish remote connections with their customers. For instance, one strategy mentioned by two repairers was to call old customers and ask about their well-being and later about their devices. If the customers mentioned any issues in their devices, the repairers would suggest to come and get those repaired with 'quality parts' at a discounted price. Both repairers argued that their good relationship with returning customers was necessary to convince them. Some shop owners initiated home delivery services during COVID-19 using courier service ($n = 4$) and dedicated employees ($n = 1$) to keep selling parts and accessories. We also found repair shops creating a series of dedicated helpline numbers for online consultation. The owner of a shop describes their effort:

> "We have some responsibility for our regular customers, even when they cannot come to us. (...) Among the calls we received so far, the repair was not necessarily always; we tried to help over the phone as much as possible. For example, one mother called for a speaker problem in the smartphone and shared that his son could not do online

classes. We told her not to come in this risky time and couriered an earphone as a workaround. If you help this way, customers never forget that." [R11, Male, 35 years, Repairer and Accessories Shop Owner]

Conversely, some repairers (*n* = 5) further shared that customers called them asking for help over their personal numbers, messenger, and calling platforms. One repairer mentions:

> *"One of my old customers called and told me that his phone was not turning on after getting wet with rainwater. He was asking me to help over the phone, as he could not come. I thought he was an educated man and could sort that out if I would instruct him over Whatsapp. As I had a spare Samsung phone of a similar model, I showed how to disassemble the set and disconnect the power from the board and clean it before turning the phone on. (...) For me, this was the first time fixing something over the video call."* [R10, Male, 38 years, Repairer with 15 years of Experience]

In summary, repairers made an active effort to continue their business relationship with their customers, even during the pandemic. They capitalized on their expertise, relationships, and available resources to find a seam between them and their customers. With active and strategic actions, they build on a broken infrastructure to engaging with customers and other communities in the ecosystem using available community resources.

5.2.4 **Struggles and Stereotypes**. Participants from both repair and bhangari communities experienced adverse behaviours, discrimination, devaluation, and negative stereotypes by their customers while working during the COVID-19 pandemic. Bhangaris who collect broken and discarded objects from residential areas, experienced such negative stereotypes. One participant explained such an instance:

> *"When we visit from door to door searching for discarded electronics, they [residents] force us to leave, sometimes even without opening the door. Sometimes they treat us as if we were the virus."* [B13, Male, 18 years, E-waste Collector]

Another repairer, Shah, shared a similar story with us where he used a device sanitizer before touching a customer's phone to fixing it. The customer was unhappy with that. He questioned, *"Do you think my phone has corona (virus) ?"*, Shah replied, *"No sir. I did not mean that. I do this with every device I touch just for my own safety."* The customer got agitated and left the shop at once, saying, *"Fakir (beggar)! If you think your customer brings you the virus, keep your shop always shut, never open."*

The above and several other examples demonstrated how repairers were treated in a rude and inconsiderable manner by their customers during the pandemic. Such rude behaviours brought frustration, agitation, and anger among our participants, which exacerbated their already vulnerable mental health. Besides the sufferings described above, our findings reveal cases of exploitation (*n* = 4), where customers and suppliers exploited our participants with an excessively low and high price, respectively. One participant mentioned one such event:

> *"See, we have to buy Savlon (hand sanitizer), masks, and gloves weekly. We need to use those to protect ourselves in the first place regardless of customers coming or not. Our profit margin was always narrow, even without this additional safety overhead. Now we are starving. Even rickshaw pullers get 5 taka extra in Corona, but we get nothing. They (customers) bargain a lot, knowing that we do not have any other option, and we receive a few customers anyway. How do you continue this way?"* [R3, Male, 25 years, Owner of a Repair Shop]

Among five repairers providing remote repair as described in 5.2.3, four reported that they did not receive any payment for their online consultancy. One participant (R10) continues his experience on remote fixing:

> *"If he had brought the phone here for cleaning service, I would do it with my hands, and the cost would definitely be around 200/300 taka. The whole thing took more than 30 minutes, and we were on the call throughout the period. I spent my own MB (mobile data), provided my expertise and time for this. However, he did not say anything about the payment. Should I not get paid?"* [R10, Male, 38 years, Repairer with 15 years of Experience]

The above and many other examples showed the multi-faceted ways the repair, recycle, and e-waste handling communities were exposed to exploitation and mental health issues. Despite this, the communities did not have much room to raise their voices and fight against their sufferings because of their lack of powers and agencies and their fear of losing customers. Nevertheless, our participants found ways to share their sufferings within themselves through Facebook messages, Whatsapp, phone calls, or Facebook messenger groups. The participants also extended help to each other to cope up with their worsened mental health situation.

6 RESILIENCE OF THE END-USERS

In this section, we report our findings from semi-structured interviews with end-users. The lock-down situation due to the COVID-19 pandemic forced technology users in Bangladesh to stay home. During this, all of our participants reported extensive use of their devices. The increased use accompanied increased software and hardware problems in the devices. In a normal situation, the repair market is very accessible to the end-users. The pandemic situation cut their connections off to the repair market. As a result, the end-users came up with novel activities and innovation to get their devices fixed, many times with minimal knowledge and supporting tools.

To describe the general scenario during the pandemic, none of our 21 participants sold any electronic device to e-wasted workers since the beginning of March, the month when COVID-19 hit Bangladesh. Some participants shared that a few bhangaris came to buy waste at home, and only two of our participants sold plastics, old newspapers to them, but not any electronic device. One key concern for not interacting with e-waste workers was around safety as voiced by this participant, *"Who knows from where this bhangari is from? They have been to many houses and places. Better not let them enter into our building."* They also shared a general desire for retaining the devices having issues allowing them to look for better

repairers/experts when they would be able to manage to visit larger repairers or trusted repairers. Dependence on repairers and lack of hands-on experience made it hard for them to assess such devices' future value and usability.

> *"I have shown this to a local repairer, but he can not fix the computer. How do I know that this won't work in future? Someone from Multiplan can surely fix this. Some components might still be working; it will be a fooled idea to sell this whole computer as dead scrap."* [U5, Male, 53 years, Government Employee]

To this end, in the following sections we document different techniques and approaches employed by the end-users to combat partial to complete device failures during this infrastructural breakdown of repair market as appeared in our analysis. First, we report how end-users are self learning repair activities and demonstrate the unique challenges and requirements for self repair to happen. Next, we unpack help and assistance based relationship formation among end-users. We then describe the modes of help observed among end-users and the components embodied in such collaborative efforts. Finally, we sketch how end-users negotiated with their broken devices, adapt to the failure with creative ways in absence of regular repair facilities during this pandemic.

6.1 Repairing by the End-Users

Trying to repair a device by end-users ("small" fixes) is not new in HCI (see [31], for example). Repairing a broken device depends on the skills and knowledge of a user [9]. However, repairing mobile phones by the end-users is not very common in Bangladesh (either because of the easy accessibility of informal repairers and low-cost in fixing devices, lack of access to technical knowledge and devices, fear around digital technologies, or stigma toward repair work). However, we observed that the three-month long nationwide lockdown made some end-users trying out fixing their devices and getting small repair tasks done by themselves. One end-user was explaining their motivation,

> *"We need repairers, but where can we get them now. These days, I think we should see if there is any easy fix possible. Sometimes, there will be, as I have found. Sometimes, you will have hard luck. My experience during this corona tells me not to jump to repairers for everything. At least have an idea about the issue before you decide what to do."* [U19, Male, 32 years, Service Holder]

While some participants showed their interests for fixing their devices, others were not much motivated. There were a variety of factors behind their decision to not/consider repairing their devices. The common reasons are the fear of causing damage to the device, the lack of past experience, unavailability of repair tools, and the lack of technical knowledge about the device. Nevertheless, the lack of repair services increased the cases of fixing mobile phone devices by end-users. Some end-users reported that they will continue to do it even after the pandemic as they have acquired some soft skills of repair.

6.1.1 Device Ownership and Right to Repair. Our findings shows that the ownership of a device often determines who can repair a device in a family. Seven participants had an opinion that repairing is a job for male and women in their family had to hand over their phones to their male family members. One participant said,

> *"I could not connect to the internet using my phone that night ... I called the internet provider to fix it, but got to know they would not help after 3 pm during Covid. It was just an issue with the router so I wanted to try resetting the connection and setting up the router fresh. However, my husband did not let me do that. He insisted on saying 'women should not do these work. This is not their job'. (...) We had to wait till the next morning for ISP workers coming and doing that."* [U10, Female, 35 years, Service Holder]

While most women conform to such norms, a participant reported that her sister did not hand her broken mobile phone to him due to privacy concerns. Similar dynamics existed for other members for the family. Because of such family dynamic and privacy issues, some of our participants reported hiding their device's problems and trying to repair the phone secretly. Such secretes often come up with vulnerabilities, such as, shown by the quote bellow,

> *"If I mess up and anything happens to my phone, I definitely have to answer my brother why I have tried at the first place. I secretly searched in the web and found the fix, but I could not proceed."* [U21, Female, 20 years, Student]

This and other examples show that the willingness of repairing broken devices are entangled with family dynamics and power structures. The dynamics are influenced by the culture, skills, privacy, security, and device ownership. These findings are aligned with the existing body of work on privacy and security in the Global South [1, 2, 4–7, 13, 24, 25, 27, 34, 51, 52, 70, 79–82].

6.1.2 Skills and Knowledge. Repair activities by end-users involve many innovative and creative interventions. These creative skills were not necessarily similar to "expert" repair skills as found in a repair market; rather the skills gleaned from relevant day-to-day experiences and transferable to repair electronic devices. Besides the skills through apprenticeships, some participants brought their knowledge from academic curriculum, which they won't necessarily apply anywhere. One participant explained one such instance,

> *"The charging cable of my laptop tore after being concealed under my chair. I called service center. They demanded exactly double price for a replacement. My family in such a time cannot bear 3600 taka on a charger. (...) During last semester, we worked with micro-controllers and had to solder wire for our semester projects. From there, I got this idea of soldering my laptop charger wire. Even if anything happened wrong during soldering, I would have to buy a new one anyways. The soldering tip cost only 10 taka, and I got a fully functional charger back."* [U3, Female, 23 years, Student]

While some participants reported their contextual knowledge transferable to repair mobile devices, some others (*n* = 5) struggled to find proper information about the device. Hence, they could not

repair their phone after some initial tries. An end-user mentioned his struggle of finding information online, as his Chinese phone only had Chinese texts,

> *"There were all Chinese texts and a few numbers. When I searched online with those numbers, nothing useful came. I just needed to know the correct battery model and could order via online and get that done at home. (...) But I had to visit a repairer to get it fixed."* [U8, Male, 21 years, Student]

Some participants reported trying a repair out even with their limited knowledge and see what happens. Some of them described that they had nothing to loose of they try. One such participant mentioned *"It felt really good when I could open the CPU box, and cleared that power supply cooler. I have always dreaded, and used to spend 500 taka for PC cleanup. I know now how to do it. I never tried it before, did not think I can actually do it. But see? I can!"*

Regardless of successes or failures in repair approaches, our participants showed an increased motivation to try to fix their devices as they had no other alternative options than trying to fix their devices themselves. Such an intention followed innovative ways of conducting "small fixes", which in turn gave our participants a level of confidence to try out more complicated repair cases.

6.1.3 **Compromise and Sacrifice**. One key challenge of learning and practising self repair shared by the participants was the compromise among competing factors. On the one hand, there was an urgency of repairing their devices since they were left with no other options. On the other hand, participants ($n = 4$) knew that they were at risk of damaging their devices permanently if something go wrong. Our participants had to negotiate these competing factors and took their decision for whether they will repair their devices or not. One participant described such an instance,

> *The process demonstrated in videos were complex. While a switch like thing at the bottom opens up the cover and easily remove the battery in other laptops, this model needed removal of the full bottom case. First 10 bottom case screws, then the keyboard, and finally six more under-keyboard screws and then battery removal! I had never done anything like this before and thought quite a few times whether to proceed or not. (...) For the keyboard, the video suggested to use force using a screwdriver. When I tried that, probably I applied extra force than they showed and this broke the keyboard railing there. I did not understand that shiny material was mere plastic. I then replaced screwdriver with a thin steel scale.* [U6, Female, 28 years, Homemaker]

Another participant informed a similar instance,

> *They (repairers) clean the display before installing the protector, so that no dust particle is there and installs in one shot with experienced hand. However, when I tried at home, first time it was not straight, so I had to peel that and try again. The result: a lot of tiny specks of dust trapped under the protector.* [U17, Male, 35 years, Business]

This, along with several other examples from our participants, suggest that the risk of compromising a device or some features of the device is always present among our participants while trying to repair their electronics. Unintended consequences were inevitable in many cases as the participants ($n = 4$) lacked even the basic knowledge about repairing their devices. Despite this, they recovered some of the damaged features while damaging other parts of their phone.

6.2 Help and Collaboration

Our participants informed helping their friends and families by sharing information, tools, and experiences. The sorts of help and the factors influencing collaboration depended upon social and material environment as well as accessibility of social resources during the pandemic. We described the varied forms of collaboration among our participants, along with the factors that impacted their collaborations.

6.2.1 **Seeking and Sharing Repair Suggestions**. Besides applying individual knowledge and skills for restoring technical failures, our participants (n=10) informed relying on the information and experience received from friends, family members, and co-workers. They leveraged social media to ask for information regarding their devices' information, ways of opening the device, and the cost of repairing. One participant posted on a Facebook group asking for nearby 'trusted' shop as his tablet grew very 'slow', the group members instead guided him to a back up followed by a system reset, thus solving his issue. He recalls, *"Everyone was cooperative there. They simplified the process in the comments and asked me to stay home and post again if need be."*

The peers of our participants ($n = 6$) were supportive in repairing their devices. Most wanted to help to their capacity, ranging from experience to tools for repairing, sharing, and lending devices. U2, a school teacher, shares his story:

> *"I did not have any past experience. But my colleague told me that he fixed his 3.5mm earphone ports before, 'Its simple. You just open, and an small press at metal border with a pliers will do.' When I asked him to lend his screwdrivers set, he agreed happily. (...) It was not that difficult as I thought."* [U2, Male, 33 years, Teacher]

Our participants also reported extending help to their friends and families by sharing extra devices (such as mobile phones, keyboards, power cables, etc.) and WiFi passwords. Some participants adopted a collaborative use of their devices when they did not have an extra device. For example, one participant reported us that his brother's keyboard was not functioning during the pandemic. So, he gave his keyboard to his brother till the evening as he does not need to use his computer during the time. He took back the keyboard from evening. This routine continued until they bought a new one.

Participants further reported seeking help from "trusted" friends, "genius" relatives who are known to provide technology suggestions, and people from social media. One participant sought help from his friend because he is *'a genius knowing all technology related stuffs'.* One female participant sought help to get her tablet fixed by posting a help-post on social media. Nobody responded to her post. So, she asked one of her "Facebook celebrity" friend to post on her behalf and she got many suggestions from this posts. In summary, while our participants sought help from diverse sources, they used

their social connections and senses to avail whose suggestions are more credible than others.

6.2.2 Collaborative Fixing.

6.2.2 ***Collaborative Fixing***. Our participants informed repairing their devices collaboratively with their friends and families. The collaborative repairing happened both online and offline. Such collaboration varied from actively helping install a cracked version of software using remote apps (e.g, Teamviewer) to getting all members together to fix complex problems of their devices. The collaboration happened among strong ties (such as family members and tech-savvy relatives) as well as with weak ties (such as with repairers, neighbours, and loosely connected friends). One participant was explaining such an event,

> *"Last week the connection between motherboard and the laptop screen got weak as I dropped it on the floor, but the power was still there. No way to travel 35 kilos from Gazipur to Dhaka, as there was no public transport available. I asked my neighbor with an electric parts and hardware shop, and asked for good local repairer nearby he knew. (...) He himself opened it, checked the connections, and with normal glues for electric devices attached the broken fragment to the board. I did not expect him to know how to fix."* [U13, Female, 22 years, Student]

Our study also revealed varied social challenges in collaborations. Safety was one of the key concerns. Concerns around safety ranged from health safety to device/technological safety. In several cases (n=6), we found potential collaborators backed off considering health and safety issues. For instance, one participant informed us that even after he recovered from COVID-19, his friend was unwilling to meet him to lend one of his extra keyboards. Also people considered compromise to the safety of their instrument, gadgets' safety before deciding on collaboration. This is illustrated in the following case from an interview.

Case 2: *Ricky's PC was affected by Ransomware, and all his files got encrypted. With no repairer around open, he asked one of his techie friends to install a new copy of Windows. His friend agreed to do the setup and later came with his pendrive with Windows in it. Just before beginning, upon hearing the cause of new installation to ransomware, he refused to give the pendrive. He told that inserting the pendrive later in his computer would also destroy his computer.*

Interpersonal trust was also important in successful collaboration to fix a device. Our participants reported that older members in the family did not think that younger members have "enough" knowledge to repair a device. One participant in their fifties said, *"[laugh], my son [16-year-old] is just a kid. How could he fix my mobile phone!"* Even though the participants son were more tech-savvy than other family members.

In summary, while the COVID-19 pandemic has increased family and neighborhood collaboration in fixing broken devices, successful collaboration also depended on the issues of trusts, safety, interpersonal relations, security, and similar cultural factors.

6.2.3 Remote Fixing by Repairers.

6.2.3 ***Remote Fixing by Repairers***. Professional repairers also guided our participants over the phone/video calling platforms (e.g., messenger, whatsapp). The repairers did so for a small amount of money even though the time commitment and labors were even more than an actual repair task in the shop. It was also difficult on the side of end-users since they often did not understand the instruction conveyed by the repairers. However, this sort of collaboration between end-users and repairers got better with time. One participant informed about such a collaboration,

> *" My IMO calls suddenly stopped connecting showing 'no connection'. I had MB, yet could not call my daughter in America. I usually visit Sharafat (a repair mechanic) for issues with phones. He is expert and fixed many of our family phones before. (...) This time I called him, and told this. He asked me to call from another phone while holding my phone with the other hand. He instructed to do something in the net(work) settings and it worked."* [U7, Male, 60 years, Retired person]

The above and other examples informed by our participants show how the existing connections with friends, repairers, families, and neighbours helped to collaborate with them to fix a broken device. On the repairers' end, it partly helped to recover their loss due to the pandemic. On the end-users' end, they were receiving training while also being able to repair their devices through a remote collaboration.

6.3 Adapting with Usage Patterns

Our participants ($n = 6$) reported changing their mobile phone usage behavior during the pandemic. The time of using the device of our participants increased because of attending online meetings, connecting to social media, and getting the pandemic news online. At the same time, our participants were sharing their devices with others, particularly with younger members of their family who already did not own a mobile phone. Consequently, the mobile phone needed more care to withstand this increased usage during this pandemic. Our participants reported taking extra care of their mobile phones to save them from breaking down. They routinely charged their mobile phone, continuously monitored if the phones were getting hot while using, used phone covers if they already had one, and alternatively used mobile devices with other family members' (if other members had) phones so that one mobile phone was not taking the continuous pressure.

> *"My mobile is a bit old and has grown slow. The smartphone my mom uses is a new and updated one. It also has a bigger screen. This is helpful when the teacher uses a whiteboard in his class. For doing those classes, I use my mother's phone. As I am given a reasonable data pack for the online classes on my sim, I have to swap the sim cards in these mobiles before the class. On the nights before those classes, I have to make sure her phone has enough charge."* [U20, Male, 24 years, Student]

However, the end-users who only had one mobile phone in their family had lower flexibility to change their use patterns and take extra care of their phones. In one incident, a twelfth-grader had to take online classes using her father's smartphone. The phone cannot hold the charge for a long time, especially when someone makes a video call. As a result, they could only use the phone while keeping it connected with the charger. This required her to talk and use the phone near the power outlet. So, she used to stack multiple

(a) Torn wire connected via soldering (covered with insulator) using academic knowledge (See 6.1.2)
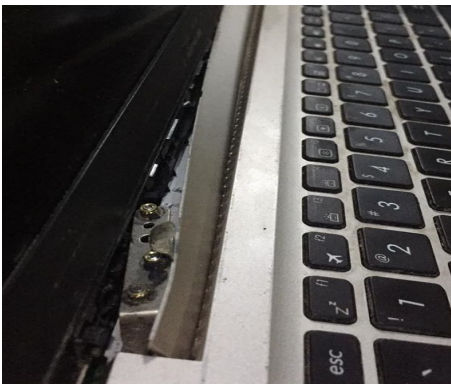
(b) Break that was 'collaboratively' fixed by attaching with glue (See 6.2.2)

Figure 1: Repair attempts by the End-Users

tasks and do them consecutively. She shared her experience: *"I now use this like a land-phone. You will make a way out if you like things."*

The extra care of the end-users' phone often led participants to know their phone better as they were exploring different features of their phone. For instance, one participant had a broken smartphone screen–some parts of the screen were not working with the touch input. She got to know that she can actually rotate the screen that will enable her to better use some video calling app features. This new exploration helped her attend classes, browse social media, manage his part-time online business. She explained the case, *"When I have to touch anything on the upper right corner, I right-rotate the phone, type and rotate back to straight again. When I need to type anything on the upper left, I left rotate and so on.".*

She kept on describing how she felt connected with the phone by using this way.

> *"You need to know the exact angle for holding the phone in the bed so that it does not auto rotate unintentionally. Sometimes, this does not work. You cannot lie on facing either side, you must lie prostate or straight to while using it. (...) Now I know exactly where buttons, icons,*

and boxes are on the screen." [U1, Female, 20 years, Student]

The above and many other cases from our participants demonstrate how mobile phone users in Bangladesh showed extra care, innovation, and adaptation in their mobile phone usage and sharing among family members. The changed use-patterns helped to extend the phone's longevity and exposed end-users to exploring their phone's features.

7 DISCUSSION

In the above sections, we have presented the findings of our study that highlight the disruption in technology repair and e-waste processing ecosystems in Dhaka, Bangladesh. We have also described how the repairers and recyclers are adapting new strategies to tackle the situation. At the same time, our findings highlight how the end-users are showing resilience to respond to this disruption. We have highlighted the changes in their practices with broken electronics and the associated politics. Thus, our findings demonstrate a picture of a sudden disruption in the electronics repair ecosystem, and provides a portrayal of local resistance through adaptation, collaboration, and creativity. This study generates several important lessons for CSCW and related scholarships that we discuss below.

First, our study shows that the informal material practices with broken computing devices is vulnerable to the attack of contagious diseases like COVID-19. As we have seen in the presented cases, many traditional practices of local informal markets (or, 'bazaar'), including touching objects and talking to the customers in a close proximity, have now become risky and most people have avoided them. This incident brings to the question the persistence of such local informal markets. Previous research [19] has shown that the resilience of informal marketplaces is often a consequence of stable socio-material market practices. However, with COVID-19 disrupting existing practices, only those market actors who could integrate themselves to new reconfigured practices were able to survive the exogenous shock. This study thus gives us insight into what makes an informal market stronger. As our study shows, the flexibility in the modality of operation and a deeper level of trust among the buyers and the sellers can provide an informal market with such resistance. While 'market' is an emerging topic within HCI literature, developing this kind of deeper relationship between the buyers and the sellers are seldom discussed there. We believe that existing HCI work on developing friendship [15], empathy [88], and trust[64] could be integrated into the discussion regarding the design on future markets could address this gap.

Second, our findings demonstrate that informal relationships play a vital role in building resistance when infrastructure breakdown takes place. Informal communities have historically been associated with grassroots resilience [59], a consequence of how relationships and practices based on trust are sustained through repeated interactions. We contribute to this discourse on disruption and response by depicting communities as dynamic human systems that remain viable through constant adaptive responses to changes. Our data manifests an active agency of repairers, end-users, and recyclers in response to the changes imposed by COVID-19 in creating community resilience. Our work joins the body of scholarship where resilience is considered around actions taken for building and

leveraging community capitals rather than the collective capacity. We argue that the importance of such informality goes beyond the design of markets, and should be taken seriously in any discussion around sustainability and shocks. Existing works in CSCW and related fields around disaster management and sustainable design have long been emphasizing on "social capital" to overcome the fragility of material arrangements (often in the form of technology). Our paper contributes to those veins of scholarship by demonstrating how informal human relationship contributes in sustaining repair infrastructure in Bangladesh. We show how both end-users and repair-recycle communities thrive through active *'intra-'* and *'inter-'* community collaboration, further strengthening resources and bonds to create an upward spiral for further collaboration even when they are addressing the present disruption. We deepen this argument by focusing on the following two concepts:

(a) Bonding: Bonding social capital represents the close ties that build cohesion *'within'* a community [47]. Our work informs the HCI scholarship around sustainability, resilience, and collaboration about how repairers and bhangaris kept communicating, assisting, and learning with each other in challenging times through newer mediums such as social media and chatting platforms or joining with others. We further showed how end-users seek assistance, including knowledge, information, tools from their peers and employ collaborative fixing within peers to leverage the collective expertise. Our findings highlight the factors facilitating (or complicating) these collaborative efforts such as trust, safety and security, and relationship.

(b) Bridging: Bridging capital represents the ties *'between'* communities [47]. As we have shown, repairers and end-users remained connected with each other through online media to provide remote support and repair when possible. In addition, repairers attempted to convince their customers building on and utilising existing relationships and skills. This way our work brings collective and strategic actions by repairers and end-users to bridge the infrastructural gap that has been created by COVID-19.

Third, as we can see in our data, the informal, improvised, and collaborative mode of resistance to the breakdown of the repair markets is not free from various social and cultural politics. For example, gender remains an important issue in building resilience. As we have seen in our data, women often did not have the right to fix the devices, and they also struggled to get help from the repairers (who are 'stranger men'). So, the disruption is severer for women than men. Women had to rely on the men of their family, and they often had to compromise with situations than men did not have to. Our findings supports a growing body of work in CSCW and related field around the gendered use of technologies, and especially the works around South Asian feminism [8, 29, 42, 43, 55, 69]. Connecting to the existing body of work on nuanced conceptual understanding of ownership of technology in Bangladesh [5], we further contribute to the notion of post-use phase ownership where right and responsibility to take care of repair works is often defined by the family hierarchy and gender. While Houston mentions *"caring for technological things in repair is still largely a male occupation"* [29], we show that fixing intent of female end-users does not always translate into the capacity to attempt repair. Besides the gender issue, we have also seen how the informal connections were

more available for people who were rich and educated. These privileges allowed many to get help with their broken devices while the same task was more challenging for the rests. At the same time, people living in the urban areas found it easier to get tools to fix their devices. Not to mention, such repairing and collaboration were also easier for people with better grip on technology and many older people with less familiarity with their phones or laptops had to suffer more. All these findings demonstrate how the makeshift socio-technical arrangement for repairing broken electronics also hosts various kinds of politics and marginalization that CSCW and related fields are interested in. We believe that the existing scholarship in supporting the marginalized groups in and around such socio-technical systems needs to be integrated with this 'new normal' form of repair markets to make them fairer and more equitable.

Fourth, our study brings to the fore a crucial question around the sustainability of socio-technical infrastructure under "shocks" and "breakdowns". We anchor this discussion on Steve Jackson's 'broken world' thinking [36, 37] and stress on conceptualizing a world that is constantly falling apart (instead of a Utopian view of 'growth' and 'development'). The breakdown of repair market in urban Bangladesh demonstrates that the very basic assumptions around technological infrastructure (for example, expert-mediated service) may not be available all on a sudden, and our existing computing practices are not prepared for this. As Susan Leigh Star famously points out, sociotechnical infrastructure embedded in social structure [76] is revealed upon breakdown and failure [77], it is important to look at the infrastructure in the face of breakdown to understand its core strengths, delicacies, and resources. As our study shows, the breakdown of the repair infrastructure in Bangladesh unveils how the infrastructure actually looked like and what its vulnerabilities were. Our data further demonstrates how the existing skill set and socio-economic status are not enough for most of the repairers and bhangaris to continue despite having worked with a technology that has experienced a significant rise in demand during the pandemic period. Through a portrayal of the impact of COVID-19 on repairers and bhangaris – their fear, uncertainties, departure, and changing nature of their work – we draw attention to the deeper concerns related to informal repair/recycle activities. Synthesized by the shock perceived in low-income setting and their own understanding about the work, our study deepens the ICTD scholarship around infrastructure and shows how this infrastructure built around technology is prone to breakdown despite constantly updating themselves [9].

Finally, our findings contribute to the scholarship of sustainable computing in two ways. First, our study demonstrates that a sustainable repair ecosystem requires care, support, collaboration, and knowledge infrastructure. Second, our study shows how infrastructures that are important for environmental sustainability, such as repair and e-waste processing infrastructure, are poorly built in the Global South and the communities need extra effort to combat an unforeseen challenge. To advance the agenda of social and environmental sustainability further, we need to understand the human infrastructure [71] of the repair, e-waste, and end-user ecosystem and develop technology and policy supports to help the communities build resilience. Our study demonstrates multi-faceted

ways whereby our repair and e-waste processing participants leveraged their strong and weak ties to continue their practices. We have shown how repairers and recyclers reached out to their family members and relatives to help them keep doing their businesses. Even though their relatives had little to no knowledge about repairing and recycling, our participants nevertheless included them by providing short training in small tasks. Repairers and recyclers started Facebook and Whatsapp groups in exchanging expertise and information. Despite a market competition (albeit healthy) among the repairers and recyclers, they chose to be a part of the community to get support for themselves and offer help to whoever needed it. These family and community support did not only help them cope up with their business loss during the pandemic but also helped the communities to hold onto a feeling of "hope".

Beyond the inter-personal and community help-seeking, the communities reached out to their weak connections, such as their regular customers and neighborhood repairers. Even though the business gain of repairers from connecting to the regular customers was insignificant, we have seen an emerging trend of remote repair assistance. Such a trend has broadened the scope of businesses of repairers and e-waste workers in the future. On the other hand, the remote repairing also helped increased repair literacy among the Bangladeshi end-users. This new trend of repair and end-user remote collaboration could be a new avenue of broken computing research for extending appropriate technologies to help both parties [11]. We have further seen how big repair markets depended on the neighborhood repair shops for raw material supplies. Such a dependency highlights the significance of neighborhood repairers and bhangaries to build individual and community resilience of broken computing infrastructure in Bangladesh. As Sambasivan and Smyth suggest [71], exploring this human infrastructure as a network renders new opportunities for ICT4D. The human infrastructure of broken computing device demonstrates how the individual and community level connections support repairers, e-waste workers, and end-users by helping to control temporal damages, make otherwise invisible nodes in the network visible and vital (such as family supports, random repairers connected through social media, neighborhood small repair shops, etc.), and provide access to material resources. Thus, HCI4D communities need to acknowledge and robustly characterize the human infrastructure for design and interventions to support the communities. Our study is the first step towards exploring and characterizing the infrastructure during a pandemic.

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