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ORIGINAL ARTICLE

The design and evaluation of a photograph-sharing application for rural and urban Kenyan families

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Abstract Family members in Kenya rely on technology to connect between rural and urban regions, yet little is known about the specific communication challenges they face and how to overcome them through new communication technology design. To explore this topic, we conducted two studies along with design work. First, we conducted an interview-based study that explores how families in Kenya currently used communication technology and the social and technical challenges that they faced in doing so. Our findings showed that family communication focuses on economic support, well-being, and the everyday coordination of activities, yet infrastructure challenges, reduced access to technology, and social situations created communication challenges. Second, we used these results to inform the design and deployment of a system called TumaPicha that supports the sharing of photographs between families who live in rural and low-income urban areas via intermediaries. The goal of the system was to support communication around economic activities while easing issues around connectivity and technology literacy. Third, TumaPicha was deployed over a period of 5 weeks with families in Kenya whose members inhabited both rural and low-income urban areas. Deployment results reveal that families used photographs to share knowledge related to subsistence awareness, village awareness, and health and well-being awareness. This suggests promise for simple media sharing applications in developing countries like Kenya that rely on a mixture of technology and social processes; however, our study also raises challenging questions around privacy and power consumption with new devices and applications.

Keywords ICT4D · Family communication · Awareness · Mobile devices · TumaPicha · Rural Kenya · Low-income urban Kenya

1 Introduction

Research on communication practices in developing countries has focused on challenges such as poverty, lack of electricity, and IT illiteracy that are prevalent in these regions [22, 28, 40, 43, 49]. Other studies have investigated how gender and rural access of technology for women affect the patterns of cellphone use in developing countries [10, 22, 28]. Specifically, explorations have been conducted on how Kenyans living abroad (e.g., in the United States) use technology to communicate with their families who are 'back home' [51], and how Kenyans living in Australia use technology to maintain their cultural heritage [20]. For our area of focus, we see little work on how technology supports family communication especially among the low-income populations in Kenya.

To bridge this gap, we conducted an exploratory study involving in-depth interviews with 24 participants living in rural, suburban, and urban areas of Kenya to understand why and when they used technology to communicate with each other. The results uncover social practices that created pressure for the eldest children in families to be nearly constantly available and led to an imbalance in terms of

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access to technology. The latter relates to finances and literacy. Together, these results outline the challenges that future communication technologies should try to overcome along with lessons for how to begin to approach such design challenges. Detailed results of this study have been previously published [30, 31]; here, we summarize them in a reflective manner in order to inform our design work.

Building on our first study, we designed a system called TumaPicha ("send photographs" in Swahili) that supports the sharing of photographs between rural and urban family members in Kenya. The goal of the system was to enhance existing communication routines with new ways to share information about economic activities while trying to overcome the issues found in our first study, which included connectivity, electricity, and technology literacy challenges. With TumaPicha, family members in a rural location of Kenya use a mobile phone to capture photographs of their surroundings and activities. Intermediaries, in the form of a motorcycle taxi driver and a cyber café attendant, are then involved in the transfer process of the photographs. The system is deliberately simple, uses technology that is presently available to Kenyans, and relies on intermediaries as service providers.

We deployed TumaPicha with families as part of their everyday routines. Here, two pairs of family members (four families in total) shared photographs between rural village areas and low-income urban locations over 5 weeks. Our results illustrate how rural and low-income urban families shared information to provide subsistence awareness, a broader awareness of the village that families lived in, and also health and well-being awareness. We found that technology mediation by non-family members, such as the motorcycle taxi driver and cyber café attendant, worked remarkably well despite potential privacy concerns. Moreover, by providing a simple interface and varying degrees of access to it—sometimes even restricting access for certain people (rural family members)—people could learn about technology at an individualized rate. By this, we mean that they could experience new technology that was only slightly more advanced than they were used to, rather than being overwhelmed by technology that was new and clearly outside their scope of understanding and learning. We discuss these findings and reflect on both the successes and challenges that they pose for future technology design and research in Kenya.

Next, we detail the related research around technology design and deployment in developing countries along with studies of Kenyan family communication and technology usage. Following this, we describe each research stage in turn: our requirements analysis study of family communication routines, our design work of TumaPicha, and then our field deployment. We conclude with discussion of the implications from our research.

2 Related work

2.1 Appropriating technology in developing countries

Extensive research highlights the importance of designing technology that meets local needs in developing countries to enhance adoption [14, 16, 36, 40, 50, 54]. Such needs could revolve around single or collective ownership and of the use of technology [40], or even the roles of women in slums and how they influence the way technology is accessed via intermediated interactions [40]. The desire to accomplish tasks has also been reported as a large incentive toward the adoption of technology in many developing countries [36, 41, 42, 48]. Many communities in Africa have also been reported to adopt technology for various needs. In Uganda, Africa, segregation of space coupled with economic dependence on husbands is reported to influence women's cellphone usage [7]. In South Africa, populations in rural communities have also been reported to prefer the use of voice communication [2], while in Liberia, mobile phones have been used as sources of personal security [1]. In Namibia, Facebook was not only used to share religious and political views, but also to share posts about funerals [34]. Therefore, gaining insight into people's ways of life can linguistically and culturally bridge the gap between local and nonlocal understandings of everyday practices that are important for adoption [4].

2.2 Designing for developing countries

Designers are encouraged to evaluate the notion of "Digital Divide" by paying attention to the adoption of technology that amplifies existing practices [12, 14, 15, 47] in addition to infrastructural challenges that exist in rural and low-income communities [2, 13, 51]. Newly developed systems [12] should also aim to provide opportunities for operation by illiterate users [23, 35] through mediated assistance [32, 40]. Therefore, the use of desktop computers and the support of technology-savvy individuals should certainly be explored in such situations [36]. Exposure to technology and one's cultural background does not limit users from being willing to create and present different forms of content when presented with the necessary tools that resonate with their daily routines in familiar contexts [24]. For instance, studies with users who did not have access to technology revealed that rural communities were enthusiastic about recording local stories when provided with a meaningful platform [4].

HCI research that engages local communities should aim to reciprocate their involvement with future design

explorations so as to promote the sustainability of any technology solutions that aim to be developed [5].

2.3 Technology deployment in developing countries

In the past, attempts have been made to implement significantly simplified interfaces for use by illiterate users [35]. Testing such systems revealed that the challenges faced by illiterate users might not be identified when testing with literate users. For example, first time mobile Internet users in South Africa ran into problems since the error codes on their phones directed them to desktop computers, something they had never used [13]. Other studies have shown that family-sharing practices can also be extended outside the home to build communication networks with relatives and the broader community [36]. Therefore, designers should consider technology deployments that build on available hardware, resource infrastructure, and stakeholder relationships [47], while real-life social status of people should be reflected in system designs [21, 32].

Research on the adoption of technology by rural communities has been ongoing. In India, an audiovisual social network application called KrishiPustak was tested with low literate farmers. Some farmers used the system to share family and community issues in addition to sharing farming-centered information [26]. Other investigations with digital media on mobile phones revealed that low-income users were interested in the sharing of videos of more common activities such as local music between their peers [25]. An investigation of how members of a rural community in South Africa used an information-sharing platform highlighted the ability to effectively share stories with various groups within the community [33]. Generally for effective results, technology deployment in rural communities should involve the local population so as to benefit from opportunities for sustainability that such involvement would bring [3]. This is necessary since implementing solutions that are set outside of these communities can often lead to failure in adoption as a result of ignoring local practices and routines [8].

2.4 Kenyan technology needs and use

In Kenya, studies have reported how expatriates who live in Nairobi creatively navigate limited connectivity by preplanning and engaging in meaningful offline preparation before accessing the Internet [53]. Wyche et al. [50, 54] investigated the Facebook experience of Kenyans from different social, economic, and technical context backgrounds that frequently used rural cyber cafes. They found that Kenyans navigated technological challenges via

workarounds such as multitasking browsing activities while accessing Facebook to connect with friends and find jobs [50, 54].

Other research studies report on how Kenyans living abroad have used technology to keep in touch with their relatives "left behind" in Kenya. An investigation on how Kenyans living in the United States communicated with their relatives back home show that family members in Kenya received a large degree of technology support from those living in the United States [51]. Elsewhere, Kagonya et al. [20] investigated how calling, the use of mobile chat applications, and video conferencing technologies supported Kenyans living in Melbourne, Australia, to obtain cultural knowledge while abroad. The results showed that technologies such as Facebook and the WhatsApp chat messenger were used alongside meetings with people from the same tribes living in Australia, and groups were organized to cook traditional meals together so as to maintain a connection with their ancestral homes while sharing "Indigenous Knowledge" [20].

A prototype that allows users to create digital stories in rural Kenya showed that individuals created stories attached to specific objects or places that were well known within their community [38]. The participants used still images and annotated audio recordings on lower end mobile phones to create and explore digital stories from their communities [37].

Overall, the related work presented in this section provides a foundation for understanding technology usage in Kenya and also gives insight into the challenges that need to be addressed when thinking about deploying appropriate technology for marginalized communities. Our work builds on past research by focusing on how people within Kenya connect with family members who are distributed across the country in a mixture of rural, suburban, and urban settings. We specifically explore family communication practices where we identify how and why technology is used and what social factors affect this communication. We then explore system and service design directly be creating and studying a new communication technology specifically designed for Kenyan families.

3 Family communication routines in Kenya

The goal of our first study was to uncover family communication practices that were technology-based and understand how families adopted the use of technology in rural, suburban, and urban areas of Kenya when faced with infrastructure limitations. We explored when technology was used and why, and what social factors affected this usage. This moves beyond infrastructure-related issues such as a lack of connectivity or electricity, which have

already been reported (e.g., Wyche and Grinter [51], Wyche et al. [53], Wyche et al. [50, 54]).

3.1 Recruitment

A community leader assisted the first author in identifying rural interviewees while other participants were recruited through word-of-mouth and notices that were displayed at the local village chief's office. The participant selection was conducted iteratively where the first author reached out to people of different occupations as he continuously learned about family practices while conducting studies with those who had already signed up. It is necessary to also point that our participant selection was intentionally non-homogeneous as we wanted to capture the communication practices of a cross section of families from rural, suburban and urban areas of Kenya.

3.2 Participants

We were interested in a wide range of ages, different study locations, and a variety of occupations so as to gain a representation of typical rural and low-income Kenyans.

Table 1 shows our participant demographics. A total of 24 participants between 19 and 59 years of age were recruited across three study sites in Kenya:

1. *Migori (rural)*—Eleven participants (six women) were from rural Migori, Our participants from this setting lived in Awendo, a rural part of the larger Migori District that lies 360 km from Nairobi with a population of ∼47,000. Figure 1 shows a typical home in the rural part of Migori consisting two or more huts built within the same compound and enclosed by a fence. Families in this region cultivate tobacco and plant sugarcane as cash crops while families that do not own large parcels of land engage in subsistence farming of maize, beans, coffee, groundnuts, and vegetables. Polygamy is also practiced in this region. Education levels of our participants varied from no schooling to high school graduates.

2. *Kisumu (suburban)*—Four participants (two women) were from suburban Kisumu. Kisumu is a port city in western Kenya with a population of ∼400,000. Kisumu is the major commercial center in Western Kenya. Fishing, agriculture (both large scale and subsistence sugar and rice cultivation), textile, and

Table 1 Participant details

#	Participants	Participant description and technology ownership			
P	Name	Gender	Age	Occupation	Location
PI	Waithera	Female	56	Owns rental houses in Githurai	Urban
P2	Patrick	Male	44	Acrobat and gymnast	Urban
P3	Obango	Male	42	Aspiring local politician	Urban
P4	Joel	Male	52	Civil servant and tailor in Githurai	Urban
P5	Okayo	Male	50	Businessman in Kisumu	Suburban
P6	Opondo	Male	58	Retired teacher in the village	Urban
P7	Jagem	Male	59	Consultant	Urban
P8	Abdul	Male	49	Civil servant	Suburban
P9	Peace	Female	29	Graduate	Suburban
P10	Robina	Female	34	Works at immigration office	Urban
Pll	Mama Baron	Female	26	Small-scale kiosk vendor	Urban
P12	David	Male	29	Subsistence farmer	Rural
P13	John	Male	25	Motorbike taxi	Rural
P14	Jeremiah	Male	22	Subsistence farmer	Rural
P15	Lavendar	Female	23	Tailor and housewife	Rural
P16	Min Onyango	Female	46	Widow and farmer	Rural
P17	Nyakambare	Female	56	Community leader	Rural
P18	Akinyi	Female	24	Graduate	Suburban
P19	Rashidi	Male	29	Graphic designer—freelance	Urban
P20	Alice	Female	41	Food vendor	Urban
P21	Jane	Female	28	Nursery teacher	Urban
P22	Margaret	Female	23	Rural chemist	Rural
P23	Godana	Female	31	Roadside vendor	Rural
P24	Shiru	Female	22	Waitress	Urban

Fig. 1 Migori: a rural home surrounded by land for subsistence cultivation

fish processing industries are located in this city. Several offices of NGOs and commercial banks servicing the entire western Kenya region are also found here. Our participants from Kisumu included a businessman, a senior civil servant, and two recent university graduates.

3. *Githurai (urban)*—Nine participants (five women) were from Githurai, a multilingual mixture of slums and suburbs that lies in the eastern part of Nairobi with a population of over 300,000. According to a World Bank report on Kenya, 47 % of the population lives below the poverty line characterized by lack of proper housing, poor infrastructure, poor access to health care facilities and lack of quality education. Figures 2 and 3 show the range of homes of our participants in Githurai. On one hand, Fig. 2 shows a home of a participant who was selling fish by the roadside to make ends meet. Figure 3 shows the living and dining room in the home of a senior civil servant in a suburban area. People living in Githurai engage in merchandise sales in small retail shops, open-air cloth stores, welding, carpentry, formal employment in the nearby Kenyatta University, and low-level administrative duties in government offices.

Across all three regions, technology usage by our participants varied. Seventeen participants (10 rural out of 10, 5 urban out of 10, and 2 suburban out of 4) owned a single mobile phone. On the other hand, seven participants (2 rural, 2 suburban, and 3 urban) reported the ownership of

Fig. 2 Githurai: a low-income home

Fig. 3 Githurai: a sitting room in a suburban setting

more than one mobile phone where each phone was used for a different purpose. Five participants from the urban and suburban areas reported the ownership of a laptop.

3.3 Methods

We conducted an interview-based study [18] to discern the social factors that affected family communication. We used semi-structured interviews to gain more insight into the use of technology by the participants. We conducted two interviews lasting between 45 and 60 min with the participants. Participants were provided with a plain A4 size paper for drawing their family communication networks [17, 29, 44, 45]. Together with the participants (sometimes using the local Luo language) [46], we filled in the type of technology and kind of information that was exchanged with their kin as illustrated in Fig. 4. This was necessary because some of the rural participants were reluctant to draw the communication maps for fear of messing up the diagrams. We then asked a series of questions about participant communication routines with the listed family members. The second visit happened approximately 1 week after the initial study where first author mainly discussed findings from the first interview and asked follow-up questions to gain clarity on aspects of communication using technology.

Rural participants were mainly interviewed within their homes while urban and suburban participants were interviewed either at their workplace or homes. Participants spoke in a range of dialects and languages that included Luo, Kiswahili, and English that the primary investigator understood and later translated. Overall, the participant selection gave insight into the family communication practices of five different tribes in the city and two tribes in the rural settings.

3.4 Data collection and analysis

All interviews were audio-recorded while handwritten notes described the types of technology participants used to

Fig. 4 Participant relationship map
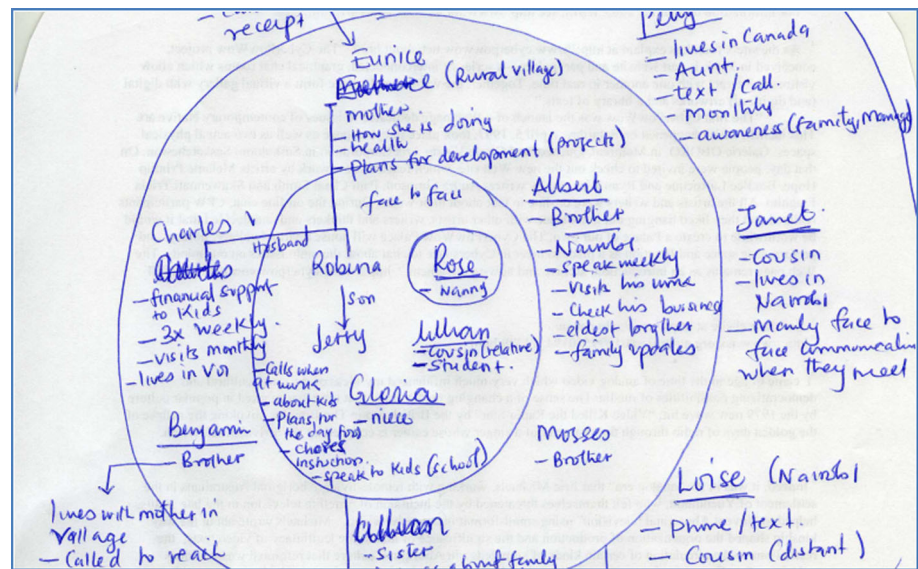
support family connection as well as the type of information that was shared and any challenges that were experienced during the process. Our findings are based on 24 transcribed interviews, 69 photographs (depicting participants' homes and areas of communication), and 92 pages of field notes. We analyzed our interview transcriptions and notes using open, axial, and selective coding [44] to reveal key themes.

The next section highlights the main results that informed our subsequent design work. As mentioned, full results are reported in Oduor et al. [31]. All participant names have been anonymized.

4 Results

This study revealed that family communication in the rural areas was focused around in-person exchanges and technology was used only occasionally to communicate with the people that one lived with. While out working in places such as the farms, most participants did not communicate with their family members unless there was an important message to discuss. Mobile phones would then be used to coordinate urgent matters. In the suburban and urban regions, family members had more frequent opportunities for exchanges of information throughout the day through the use of technology.

4.1 Reasons for technology-based communication

Across the three regions of Kenya that we studied, we found that technology-based communication generally focused on one or more of four areas, depending on the family and their life situation:

1. *Economic activities*—Like findings from previous studies (e.g., Mimbi et al. [27], Wyche and Grinter [51]), our participants reported that the most important reason for communication with technology was for economic support. This occurred frequently where people living in rural areas would communicate with their suburban and urban family members. This included situations such as parents receiving financial assistance through MPESA [19] from their adult children who were working away from home.

2. *Life advice*—Communication between rural and urban family members also focused on parents providing advice to children and siblings and close friends encouraging each other about the challenges of life. This was especially the case for parents of adult children who had moved away from home.

3. *Well-being*—We also found that family members used technology to communicate about the well-being of others. For example, two rural participants reported calling their children in urban areas of Kenya as well as in other countries abroad with a focus on understanding their well-being, e.g., troubling times and health issues.

4. *Family coordination of activities*—For households containing multiple individuals, it was important to coordinate the daily activities of family members. In rural settings, technology was not widely used for family coordination because it was too costly or simply not needed (since family members would see each other in person in the morning and evening). Instead, only people who had specific jobs that required them to use a mobile phone for work would do so. Suburban and urban participants who lived with other family members used technology more often for coordinating

family activities in comparison with the rural participants. Parents reported using technology to get in touch with their children for shopping, dinner planning, and household chores.

Together, these findings suggest that family communication technologies should be targeted at one or more of the information areas discussed above. While designs that focus on supporting information sharing around economic activities may be most valued initially by families, over time they may also be valued for other sharing purposes such as life advice or well-being.

4.2 Technology usage

We found that rural participants shared phones within family structures because of a lack of ownership, loss of service network, and a lack of battery power (also found by Smyth et al. [43], Wyche and Murphy [52]). Face-to-face interaction was the most widely used mode of communication between rural families. While rarer, there were specific cases where technology was used for coordination purposes. For example, people who had specific jobs (such as motorbike taxi operators) that required them to use a mobile phone for work would do so. Technology use in the rural areas related to whether or not someone had a mobile phone, when people were available for calls and how they would time them, and the social pressures of having to stay in contact with others or initiate calls. In the absence of mobile phones, especially in the village, people would routinely walk to meet with their family members in person in case they had something to discuss. Rural participants would also call people and ask them to pass on information to those who would not be located on their mobile devices. In this way, they relied on other people to pass on messages as intermediaries. This suggests the importance of future communication technology designs that *support shared access to technology resources* such as mobile phones and also *the importance of intermediaries who can pass on information* to those who cannot afford a mobile device or do not know how to use one because of technology illiteracy.

All participants from urban areas owned mobile phones and could easily communicate with them. A section of the urban participants reported to have used e-mails and social media either in their home or workplace to communicate with family living outside of Kenya. While mobile phones were certainly the most popular communication tool, some urban participants also used computers, social media, and video conferencing to communicate with remote family members who lived abroad. This meant that computer-based communication did not occur between urban and rural areas because those in rural regions could often not

afford computer technology, while infrastructure issues and a lack of electricity would create usage problems. While attempting to call rural families, urban participants would also begin by calling immediate family including siblings and then progressively move out to cousins and other relatives until a person of interest was reached.

4.3 Social situations and challenges

We also found that a variety of social situations affected how families communicated using technology. First, we found that additional pressures are placed on the eldest sibling or those who were in a stronger economic situation. In these situations, the family members tasked with sharing information were socially and culturally obligated to stay aware of the activities of additional family members and coordinate the exchange of information. This suggests *future communication technology designs could better support the sharing information between larger groups of family members* to ease the need for a single family member to share information with many individuals.

Second, we found that access to technology and usage will differ between those with different literacy rates and computer experience, and those with different levels of technology access due to connectivity and finances. Computer literacy varied among rural and urban families with all the rural family members reporting that they did not use other forms of technology beyond the mobile phone for communication. This was expected because the rural family members had little experience with using computers and lacked Internet access unless they went to a cyber café located away from the village. Our results also revealed that younger rural participants indicated an interest in using social media and planned to use it at some point once they were able to access the Internet and learn how to set it up. On the other hand, older rural family members did not express an interest in learning about new technology, as they were more interested in meeting the economic needs of their families. This suggests that *future communication technology designs should provide varied options for using and accessing the technology* depending on family members' interests in using or learning different types of technology.

5 The design of TumaPicha

Building on our first study, we wanted to design a family communication system for Kenyans that would focus on supporting their economic activities and communication around them. We decided to explore the design of a rich media-based communication technology that might allow rural family members to *visually show* what their economic

activities looked like to remote family members who were helping fund the activities from the urban centers. We also wondered whether a system focused around economic activities might begin to be used by families for other purposes found in our first study such as sharing information to support well-being and a sense of social connection. Such media-rich applications are typically not used in Kenya currently because of connectivity issues, a lack of access to computers, and a lack of technical knowledge to use them. As such, our design efforts focused on providing a very simple user interface that could be accessed by a variety of means depending on a person's technology literacy where intermediaries could play a key role in using the technology.

We designed TumaPicha as a web application and physical service to support the sharing of activity information in the form of photographs between rural and low-income urban Kenyan families. It consists of a web interface that supports the uploading of photographs from a mobile phone or computer along with optional annotations including a title and description (Fig. 5, left). Uploaded photographs are viewed on a separate web page (Fig. 5, right). The TumaPicha interface is accessible on web browsers that are widely used in Kenya such as Internet Explorer, Firefox, and Chrome. The interface has only the most basic options, which provide a high probability that a user with basic computer literacy would be able to use it.

While the application may seem simple, if not already available using other existing technologies, the manner in which we designed it and anticipated it would be used is premised on the needs and routines of rural and low-income urban Kenyan families found in our first study. However, we return to a comparison of TumaPicha to other technologies later in this section. Next, we describe the design by exploring the interactions and usage, which follows four main steps:

1. *Photograph capture by family members in rural areas* First, family members living in rural areas use a mobile phone to capture photographs of things they want to share with family members in the urban centers. This might include photographs captured by multiple family members within the same village area—extended relatives often live together within a single village. We anticipated that photographs would, at least initially, relate to the subsistence farming activities of rural family members since they are often supported by remittances from urban family members. Once rural family members are ready to share their photographs, they hand over their phones to a motorcycle taxi driver, described next.

2. *Physical transfer by a motorcycle taxi driver* In our first study, we found that motorcycle taxi drivers transport people and commodities to different locations. Given that they already travel between rural areas and towns containing cyber cafés, we decided to incorporate them in TumaPicha as intermediaries who could perform a *physical transfer* of the photographs/phones to locations containing Internet connectivity. Thus, a motorcycle taxi driver collects the phones from rural family members (with the photographs on them) and delivers them to a cyber café in the local town. This also serves a second purpose: Family members in rural areas often lack electricity so they cannot easily charge their mobile phones. As such, the taxi driver also brings the phones to the café for charging.

3. *Data transfer by a cyber café attendant* At the cyber café, an attendant uses the TumaPicha web interface (Fig. 4, left) to upload photographs from the mobile phone to a server. There is no special login or access ID for families as we wanted to remove the complexity that might come with login accounts and the remembering of passwords.
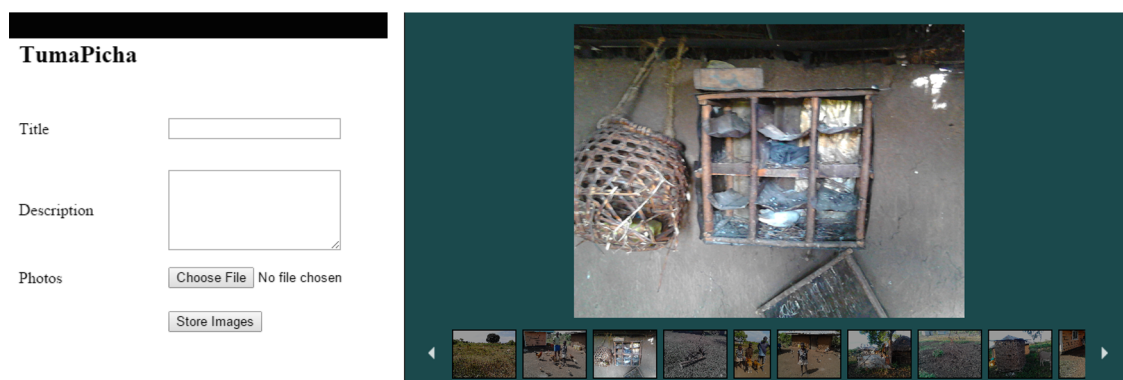

Fig. 5 TumaPicha: image uploading (*left*), photograph viewing (*right*)

Data bandwidth is still relatively limited with a dial-up connection of 100 Kbps and below. For this reason, we chose to use photographs and not video clips. The act of handing the phones to a cyber attendant to upload photographs while charging the mobile phones is akin to having customers take their phones to local charging booths in rural areas (again seen in our first study). The system design also incorporates the use of the cyber attendant's computer knowledge to upload the photographs to the server. Once done, the attendant returns the phone to the motorcycle taxi driver who delivers it back to the rural family members.

4. *Viewing by an urban family member* Urban family members view the shared photographs using a desktop computer. The display page (Fig. 4, right) provides thumbnails for browsing. When a thumbnail is clicked, the selected image is displayed in a larger screen that also provides an arrow on either side for browsing stored images. Given the lack of access permissions, urban family members can view all photographs being sent from rural families using the system. This, again, reflects the simplicity that was built into the system. We explore the effects of this in our deployment.

5.1 Design rationale

As can been seen, the cyber attendant has access to view the photographs and is an integral component in the data transfer. While many in Western culture may feel this would create privacy sensitive situations, we hypothesized this act would likely be a socially acceptable practice in Kenya because the cyber attendant is helping out rural families and the photographs (e.g., of farming activities) would likely not be privacy sensitive. That said, we explore the above situation and privacy in our deployment.

The cyber café attendant and the motorcycle taxi driver are intermediaries in the photograph transfer process. The use of intermediaries for technology sharing and information exchange was found in our first study (e.g., phones are often shared and messages are relayed between people). We explore the extension of this aspect outside the family unit to include other service providers.

We did not intend for *rural* family members to use the TumaPicha web application to upload photographs themselves because they do not typically have access to computers and Internet connectivity and lack the IT knowledge required to use many application. Even though they are able to purchase data to use with their existing mobile phones in rural areas, it is with a cellular carrier and very expensive. Cheaper options involve walking to a cyber café, which might take about 2.5 h to get to. We also recognized that rural family members often face problems

with learning how to use even simple technology interfaces. Thus, TumaPicha tries to solve two problems. First, it overcomes the lack of technology understanding by having the cyber café attendant transfer the photographs rather than the rural family members who may easily not understand the upload interface. Second, it overcomes high cellular phone data rates by having the motorcycle taxi driver transport the phones to a place that provides Internet access. Within our service setup, rural family members would only need to pay for using the computer while uploading the photographs at an approximate cost of Kshs 120 (∼$1.30 USD) to submit an average of 18 photographs over a period of about 2 h per visit. These costs are less than the amount of money rural Kenyans would typically spend in using phone credits to call their family members living in urban centers in order to describe their economic activities. This suggests that systems such as TumaPicha could be beneficial to low-income families that are prevalent in our study settings.

We envisioned that rural and urban family members would want to talk about the photographs after they were viewed and felt that existing communication routines using phone calls would suffice. We focused on rural family members sending photographs to urban family members— and not bidirectional sharing—because urban family members are more interested in following the progress of projects going on in the village since they occasionally remit money to their rural families to support various projects using money transfer services such as MPESA [11, 19]. While the system could be used for bidirectional photograph exchange, we felt that photograph viewing by the rural family members may be too technically challenging. Instead, we wanted to start with a base case that we could learn about and understand first, and then consider bidirectional sharing as a part of future systems or deployments. That said, our field deployment does gather reactions from participants about the potential value of bidirectional sharing of photographs.

5.2 Design iterations

TumaPicha was designed over the course of a year and included sketching, design scenarios, and discussions between collaborators. As part of this process, the lead researcher who is a native Kenyan discussed viewpoints from a local perspective gained while living in Kenya.

As part of our design iterations, we considered two main avenues for transferring media between devices and people. The first was an automated approach where images would automatically transfer from a rural family member's phone to a device carried by the motorcycle taxi driver when in close proximity with the rural family member (e.g., within Bluetooth range). A similar transfer could

occur between the taxi driver and the cyber café attendant's computer. The second approach was the manual transfer process that was described earlier and selected. We decided to not pursue the automated transfer, even though it required less user interaction, because we felt it was important for people themselves to perform the transfers. Cyber attendants in Kenya already act as a form of intermediary of technology appropriation, so we felt that continuing with this trend was important to create meaning for the technology within the rural communities.

5.3 Comparison to other technologies

As said, TumaPicha is similar to other existing technologies, yet we feel there are important differences. Existing photograph sharing applications (e.g., Facebook, Picasa, Instagram) provide both website and application interfaces that facilitate the upload and display of images. These applications are designed to provide thumbnails and slideshows, the ability to organize photographs into albums, and allow users to add comments to uploaded photographs. These applications typically require user profiles to be able to share images (e.g., Facebook, Instagram). TumaPicha is different than these applications because it provides family members with a one-step process to access uploaded photos via a dedicated link. A local technology intermediary (cyber attendant) and urban family members are the ones who access this link. Most photograph sharing applications also focus on sharing photos via large social networks (e.g., Instagram). In contrast, TumaPicha focuses on a small set of individuals for photograph sharing. We feel this is important when people are still new to using communication technologies.

TumaPicha is also similar to other research prototypes designed for developing countries that focus on digital story telling [39]. During the testing of MXShare (see [4]), researchers found that technology adoption did not occur very strongly because users were only interested in certain aspects of the technology [4]. The study results showed that regardless of the complexity of using tools for sharing media asynchronously within rural communities, it is necessary to work with information that the local communities consider to be relevant [4] while designing systems for their adoption. TumaPicha provides an avenue for family members to connect remotely through mobile phones that are already accessible to family members in addition to adding a digital platform to share images with remote family who are dispersed across the country and even abroad. TumaPicha is different than these applications since it provides a platform for sharing family activities of interest to immediate family and close neighbors without the need to use plugins for sharing on social media with a wider audience.

6 Field deployment

We investigated how families in rural and low-income urban areas of Kenya appropriated and used the prototype through a field deployment. Our goal was to understand how, when, and why families would use the system, and gain insight into the challenges they might face, if any, when doing so. We describe our participants next where names have been anonymized.

6.1 Study settings and participants

We deployed the design to two families in rural Migori and two families in the low-income Githurai area of Nairobi (urban) where they connected as pairs between the rural and urban areas. Recruitment was done through word-of-mouth and by contacting participants in prior studies. Participants in this study had previously participated in our first study.

Household Pair 1 (HP1)—Jekonia and Ben Jekonia (25 years old) is a married peasant farmer and caretaker of a rural home in Migori. He also works as a fisherman in the evenings. Jekonia is married and has two children and lives with his family and nine other relatives. Jekonia already used an Iplus i110 Chinese-made phone purchased for Kshs 1499 ($17). The phone had a dual SIM card and a 0.3-MP camera. He used TumaPicha with one of his three brothers, Ben, because he felt closest to him in terms of information exchange.

Ben (39 years old) is a freehand graphic designer who lives in a low-income urban area of Nairobi with his wife and three children (6, 10, 15 years old). He mainly communicates with Jekonia and two other siblings. He uses his mobile phone and also accesses e-mail and other Internet services at a cyber café that is a 10-min walk from his house. Ben pays Jekonia a monthly salary for managing activities in the home.

Household Pair 2 (HP2)—Consolata and Maurice Consolata (53 years old) is the first wife of a polygamous primary school teacher with eight children, four of whom live away from home. She is on the board of a local primary school. She mainly shares information with her eldest son, Maurice, who lives in Nairobi. Consolata engages with local women's group activities, coordinates church activities, and is also a peasant farmer in addition to managing a small-scale business. She regularly uses her mobile phone, which is the Vodafone 150 that offers basic voice and SMS facilities along with support for mobile payment services.

Maurice (28 years) is an IT technician, who is married, with a two-year-old daughter and lives in the low-income

area of our study settings. He reported using e-mail, Facebook, Instagram, Skype, and general Internet browsing on the computer. He used his smartphone to access Facebook, WhatsApp, and Instagram.

Overall, our participants represented a relatively young demographic (25, 28, 39, and 53 years old). This was because our previous study showed that younger adults in Kenya tend to be more interested in trying out new technologies. We also specifically chose to work with only a small number of families so that we could monitor their usage of TumaPicha closely.

Intermediaries We recruited a motorcycle taxi driver, Ondiek, to deliver the mobile phones between the village and the cyber café as part of TumaPicha. Ondiek was 32 years old and had been working in the area for the past 2 years. We paid him a small amount of money (Kshs 240 = ∼$2.40) for his work throughout the study. Typically, Ondiek charged Kshs 80 to ferry a customer from the rural village to the local town. That said, Ondiek explained to us that he was willing to do the task on an ongoing basis for no fee because he was already making the trip between the village area and the cyber café when ferrying his regular customers. Transporting the phones did not require any extra work. Moreover, because Ondiek was from the same village area as the rural participants, he knew them well and simply liked to help out his friends. Whether this generosity would translate to other motorcycle taxi drivers is unknown.

The cyber café attendant, Akinyi (29 years old), was a communications major and taking a 1-year break from university studies. She was familiar with technology and able to use the computer and Internet at the café to upload photographs using TumaPicha.

6.2 Interviews and home visits

We conducted an initial visit with families to describe the study and show how TumaPicha worked. Participants were told the goal of the system was for them to be able to share photographs of locations and activities that they felt the remote family would like to see. Semi-structured interviews were conducted with participants during this initial visit for 45–60 min. We asked about their communication routines and how they communicated with distributed relatives. Example questions included: why do you choose a particular technology for communication? What challenges do you face with the technologies you currently use for communication?

Rural participants were given a Huawei Android version 4.2.2 phone for the duration of the study. Thus, they did not have to purchase the phone themselves. Huawei phones are available for sale in Nairobi and one of the options selected by some Kenyans as a basic smartphone. Some people in rural areas of Kenya use them, but would not typically have data plans for them because of the high cost.

Second, we met with the motorcycle taxi driver and cyber café attendant and explained the study to them and how they would be involved. This included us showing them how to use the TumaPicha prototype.

Following this, participants took part in the field trials. They were told to use the system as they saw fit throughout a five-week period. During this time, they kept handwritten notes in a diary. We met with them on a weekly basis to discuss their diary entries and the usage of TumaPicha. For example, we asked questions such as: how did TumaPicha support you in sharing your activities over the past week? What challenges, if any, did you face?

Once the 5 weeks were over, we waited one further week and then conducted a final interview with all participants, including the taxi driver and cyber café attendant. Our goal was to give them some additional time to reflect on their usage and see what their experience was like after withdrawing the prototype for a week.

As compensation for the family members' participation, we paid for the fees at the cyber café to upload the participant's photographs. These fees are quite small (∼$2 USD per phone upload) and, thus, we did not feel they largely impacted how many photographs participants shared. Moreover, this amount is similar to what urban family members often already transfer to their rural family members in order for them get air time for their phones. They do this so they can communicate with rural family members about the farming activities that other remittances support. At the end of the study, we gave the mobile phones to each rural participant as a way of saying thank you; however, they did not know we were going to do this at the start of the study so it did not motivate them in any way to participate.

6.3 Data collection and analysis

All interviews were audio-recorded, and handwritten notes were kept. Our findings are based on transcribed interviews, over 300 photographs depicting participants' homes and areas of activity, and field notes. We analyzed our interview transcriptions and notes using open, axial, and selective coding [44] to draw out the main themes in the data. We coupled this with a review of participants' diaries and the photographs we captured. Our themes included a list of the ways that TumaPicha was used (e.g., the types of photographs captured), the reasons behind this usage, and a categorization of social situations and practices that emerged. We describe these results next.

7 Rural usage and reactions

Our rural participants used the study phones throughout the deployment to capture photographs and found TumaPicha beneficial for sharing their environments and activities in a new way with their urban-based family members. Across both family pairs, 86 photographs were shared with roughly equal participation. Despite their lack of technical knowledge, they began using features of the phones beyond just TumaPicha. Within these practices, each used the system and phone in a somewhat different way.

First, Jekonia (HP1) carried the phone nearly everywhere he went because he used it as a communication device for phone calls and text messaging, in addition to using it for TumaPicha photographs. In this way, it replaced his existing phone. He would carry it to the farm, to the beach during the day, and even to the local shopping center when going to run errands. However, he left the phone at home during the night when he would go fishing. Jekonia was careful to not let his children near the phone because he was worried it might get damaged since it was new. Jekonia felt he had improved his technical literacy during the study by learning how to type messages using two fingers on the large phone screen. At the end of each day, Jekonia would often play around with the phone while resting at home. He wanted to try and test its capabilities and see what else he could learn. This included capturing videos and even viewing videos on YouTube—for this he used his own cellular credits, which he did not realize was very expensive for data usage. This was a surprising learning for him after the fact.

On the other hand, Consolata (HP2) used the phone in addition to her usual phone. This was because she was not comfortable in using the study phone without direction from her husband and sons since she wanted to make sure that she was doing the "right things" with the phone. This reflected her unfamiliarity with "newer" technologies and the fact that she was most comfortable with her existing phone.

> These new phones are not easy for me to use. However, my husband has used cheap touchscreen phones made in China. I therefore use my phone in his presence in case I get stuck while using the study phone and require his help. - Consolata (HP2)

Consolata would use the TumaPicha phone right after meal times or when the family had just completed reading the bible together. During these times, her husband and children would be around to provide help with the phone. In addition to capturing photographs, she used the phone for MPESA transactions during the day when accompanied by one of her kids or husband.

Both rural participants found that the phone consumed a lot of power, more so than their existing phones. This caused them to need to charge them frequently and turn them on only when needed. Jekonia (HP1) talked about having to charge the phone at a local charging station every few days. Sometimes, Jekonia's younger brother would take the phone to the charging station for him. This was an unanticipated challenge with the system and meant that our planned service for TumaPicha's charging (at the cyber café) did not actually work in practice as planned. That said, the family's existing routine for charging phones sufficed and this meant that TumaPicha was able to fit reasonably well within their normal phone charging activities.

Once the deployment ended and we took back the phones for the week, our rural participants found it more challenging to describe what was happening in their village because they could no longer rely on photographs to show the situation to their remote family members. They told us that they missed using the new technology due to its clearer audio when compared to their old phones, and trying to learn what other features the phones supported.

8 Urban usage and reactions

Both urban participants accessed TumaPicha at cyber cafes. This was because they did not have computers with Internet connections at home. For example, Ben (HP1) used TumaPicha from a cyber café that was located in Githurai. He would access the system while visiting the cyber to check on his e-mails or to download and print documents related to his work. He always went to the same cyber since he had established a good relationship with the owners. Ben and Jekonia would talk about the photographs on the phone after Ben saw them. Ben would also refer to photographs during phone conversations that he had with his other brother who lived in London. Thus, the photographs became a conversational artifact beyond just discussions with Jekonia. Overall, Ben felt that TumaPicha was a valuable system and felt its usage should be extended to other people in the village to spread an awareness of technology.

> People should be educated about technology use in the rural villages to understand how the whole TumaPicha process works. I believe that people should overcome fear of using technology to enjoy the benefits it brings to sharing information. – Ben (HP1)

In the other household pair, Maurice (HP2) accessed TumaPicha from a number of different cyber cafés since he was in the IT field and needed to check his e-mail often.

Even though he frequently accessed Facebook, Instagram, and WhatsApp from his mobile phone, he still frequented cyber cafes to send e-mails and look for freelance IT jobs.

Maurice (HP2) valued the photographs he received but said that it would have been a good idea to add video uploads to the system. This would be more similar to what he was used to seeing on social media sites. He also thought that it would be a good idea to have bidirectional sharing within TumaPicha; thus, he wanted to also share pictures of his activities with Consolata in the village. He wanted his mother to be able to see his family and children occasionally since it was a while since his whole family had returned to the village home. This was a clear limitation with TumaPicha, in Maurice's opinion.

Both urban participants were able to see all of the photographs shared using TumaPicha, since, as mentioned, we did not use access controls or user accounts to associate the pictures with a particular recipient. Ben (HP1) and Maurice (HP2) did not have any issues with having access to all of the pictures in the system. They were quickly able to know which ones were sent specifically for them, and tended to focus on these over the other photographs.

During the week following TumaPicha's deployment, our urban participants, Ben and Maurice, both told us that they missed using the system. The field deployment had built up the expectation that they could see photographs of what was happening at their family's village. The awareness that the photographs brought was harder to achieve through phone conversations with the rural family members.

9 Intermediaries and privacy

To facilitate TumaPicha's usage, we used the services of the motorcycle taxi driver, Ondiek, to deliver phones from the rural homes to the cyber café. At the cyber café, the attendant, Akinyi, would upload the photographs to TumaPicha.

Ondiek came by the village homes and was given the phones roughly once per week. He would ride his motorbike along footpaths passing through the village to pick up or drop off his customers and would be stopped when needed by the rural participants. This was the usual time period in which the rural families would update the urban families about what was happening back in the village. This was also because many photographs were about work activities and situations only changed every few days.

Ondiek would hang around the cyber café after handing over the phone to Akinyi and was able to see the photographs being uploaded. He purposely stayed around to see this happen because it was a new experience for him. He told us he was "fascinated to see the photographs uploaded from the phone to the web" within a very short time. He had never been to a cyber café before, and so he was able to see a computer in use for the first time. At times, he would be forced to keep checking whether the Internet could support photograph uploads. Whenever there were power blackouts, he would need to come back at a later time. For example, in the third week of our study, there was a power outage that began at 8 am and lasted until 6 pm. On that day, he would keep checking the cyber to see whether the lights were back on every time he brought a customer to the town.

The cyber café attendant, Akinyi, found TumaPicha to be simple and straightforward for uploading and accessing the photographs. She said that our prototype was an interesting perspective that could be used to share photographs to a wider audience unlike Bluetooth that shared photographs just between two phones. However, she told us that power interruptions were frequent during the rainy season and this would hamper photograph uploads. Slow Internet connections delayed photograph uploads at times requiring the purchase of expensive data bundles for USB powered Internet. Akinyi was also able to add a title for each photograph that was uploaded and she used this to write a short description of what was shown in the picture, e.g., "Cow and calf in good health." Such content did not add a lot of additional knowledge to the photographs though.

As mentioned, both Ondiek and Akinyi saw the photographs that were being uploaded. Rural participants told us that they understood that others would be able to see the photographs they shared. Yet they were generally not concerned with this and potential issues of privacy since the photographs they captured were mostly updates about their life and area, which was not deemed to be private. There was a sense of trust in the sharing process and the remote family members, such that they did not worry about photographs being seen by others outside of the small group using TumaPicha.

> I do not worry about sending photos to Ben since he is already waiting to receive them. Once I send them to him, he is in charge of the photos at his disposal and can share them with anyone that he likes to. – Jekonia (HP1)

Jekonia and Consolata told us that private matters about financial issues or other topics would be discussed over the phone and such details were not present in the photographs they shared. Jekonia and Consolata would even briefly browse the photographs with Ondiek when he arrived to pick up the phones to ensure that photographs had actually been saved on the phones. This further shows that they were not concerned that he could see them. Akinyi, the cyber café attendant, similarly felt that the photographs did not contain anything sensitive that others should be concerned with her seeing.

I do not think that the photos I uploaded onto the system and labeled were that private. Most of them showed the farm, home, animals and people. In any case, Ondiek would not have been given a phone with private information to bring over here to me. I think the photos are meant to inform their relatives in the city of things that are happening these sides. – Akinyi, Cyber Café Attendant

10 Reasons for using TumaPicha

Within the aforementioned usage patterns, we found that TumaPicha was used by family members to share three main types of photographs resulting in three main uses for the system: subsistence awareness, village awareness, and health or well-being awareness. These reflect the ways in which participants found value in the system.

10.1 Subsistence awareness: farms, farming, animals

As mentioned, our participant families that lived in the rural villages engaged in subsistence farming, fishing, and domestication of animals. These activities were often supported by remittances from family members living in the city. As a result, the primary use of TumaPicha was indeed to share photographs of these activities and provide an *awareness* of one's *subsistence* activities.

For example, Jekonia (HP1) shared photographs describing the different stages of recovery of a calf that had been suffering from foot-and-mouth disease. He also shared photographs of his home in addition to a cultivated maize plantation and uncultivated farmlands. Other pictures shared along the lines of farming included that of a plow that needed to be repaired. Generally Ben (HP1) was interested in these photographs because he would send finances to ensure that the home was maintained in a good condition, that the sick cow was treated, and that farming activities (including repairs to the plow) were going well.

Consolata (HP2) shared photographs related to subsistence farming that were similar to those already described for Jekonia (HP1). For example, she shared photographs of a granary, chicken, and goats grazing in a field. As a result, Maurice (HP2) received an awareness of joint farming and chicken rearing activities that he was doing with his mother and younger siblings.

Sometimes it is important to show the people in the city that we are actually using money that they are sending our way for development purposes. For example Maurice sent money for his siblings to use in

this chicken project and that is why I shared photos of the chicken. - Consolata (HP2)

10.2 Village awareness: personal activities and outings

Rural participants also provided remote family members with a sense of *village awareness*. This was knowledge of what the person did as part of their personal activities beyond subsistence. These acts occurred in a broader area outside of just one's home quarters and showed the remote family members areas of the broader village. As a consequence, remote family members also saw other people in the photographs beyond the main participants and their immediate family members. In some cases, these photographs were of little interest to the urban family members, but still, they provided additional awareness of the general happenings in the village. Even though urban participants felt they would not have asked their rural family members to share such information, they still perceived it to be valuable.

For instance, Jekonia (HP1) shared photographs of the local beach where he kept his boat and fishing nets during the day. Jekonia also shared photographs of a welding shop and a local furniture store. These photographs were taken around the places where he would be going to take care of various assignments that did not directly relate to taking care of the home. Of these shared photographs, Ben (HP1) was interested in knowing the costs of welding a window and obtaining the prices of furniture for a house that he was planning to build soon. Even though Jekonia took the fishing photographs out his own interest, Ben was happy to see the areas surrounding the lake and so it did not bother him that Jekonia had sent photographs that were unrelated to the jobs he was to complete.

The photos provided me with an awareness of the village by seeing farms, funeral procession, cattle, the beach and the local shopping center. I was also able to tell photos that were meant for me. – Ben (HP1)

Consolata (HP2) shared photographs of a school board meeting that she had attended, mattresses at a local shop, and women at a local church. She wanted to give her son, Maurice, a better understanding of the things she did away from her home. Maurice (HP2) generally enjoyed the photographs shared by Consolata since they provided a visual component to discussions about new information that happened in the village over the previous week. Maurice was also interested in purchasing a mattress during his next visit home hence the interest in seeing the options available at the local shop.

TumaPicha provided photos of the village to complement my conversation with the rural family. I was able to see that my younger siblings were still doing a

poultry project that we have been doing together and school related discussions. – Maurice (HP2)

Rural family members were happy that their family members in the city would refer to the TumaPicha photographs during phone conversations. The shared photographs enabled the participants to actually visualize the situations being discussed to enrich the already short discussions that would be conducted over the phone.

10.3 Health and well-being awareness

Lastly, rural participants shared photographs that focused on the health of others, including information about deaths. In this way, TumaPicha provided urban family members with a sense of *health and well-being awareness.* Coupled with this knowledge, however, was also sometimes a hidden motivation of suggesting that remote family members send some additional funds to support health issues, or the photographs served as a 'thank you' for such remittances. Thus, even awareness of health or well-being sometimes ended up focusing on finances.

For example, Consolata (HP2) shared photographs of a dispensary (pharmacy) that she went to in order to get a prescription for her younger son. Maurice (HP2) was not particularly interested in the contents of these photographs but seeing them sparked a conversation with his mother over the phone where he asked who needed medicine from the dispensary. He was glad to hear that his younger brother was now feeling better after the treatment. From Consolata's perspective, the photographs also served as a suggestion to send them additional remittances.

> I took my youngest son to the dispensary and needed help in settling the bills. I took the photo of the hospital because I wanted Maurice to think about sending us some money for use in purchasing medication. - Consolata (HP2)

In the case of Jekonia (HP1), he captured and shared photographs of a funeral procession and burial ceremony so that Ben could see it and know about the details surrounding the passing of their relative. In this case, the photographs were socially significant as a form of 'thank you.' Ben had sent money to Jekonia so that he could provide a financial contribution to the bereaved family while attending the funeral ceremony. Ben had actually used money given to him from his elder brother in London so he further described the situation to the elder brother after seeing the pictures uploaded from the village. The elder brother was also able to view the photos via the TumaPicha web page.

> Before this system, I had to physically travel to the village to capture photos, scan and then email them to him. TumaPicha helps me save on transport and time

while also availing information to anyone who can view our link on the web. – Ben (HP1)

Overall, TumaPicha allowed rural participants to share knowledge of their situation with their urban family members where the photographs augmented existing phone conversations.

11 Discussion

We now reflect on our findings and discuss the implications of our work and opportunities for designs moving forward.

11.1 The appropriations of TumaPicha

First, we found that rural families shared photographs related to a number of themes and activities providing three main types of awareness: subsistence, village, and health/well-being awareness. We had anticipated the first type of shared knowledge since this is the main focus of family communication in Kenya using technology. The additional uses show that Kenyan families are also interested in sharing photographs about other relevant situations. Sometimes, this further ties to economic support, and other times, it is more simply about having knowledge of what is happening. This suggests that designers of communication technology for connecting rural and urban family members should think about ways to support the sharing of information about livelihood sustenance as well as other social situations that may arise. This validates our first study on family communication routines where we build on it to show that such needs extend to actual technology usage when media sharing is available. Along this thread, we found that TumaPicha provided the distributed families with a visual dimension to augment their existing phone conversations. The technology was not a replacement for such calls; instead, it enhanced them. Families in the village were glad that their family members in the city would refer to the photographs during conversations. Rural users were now able to provide more complete descriptions of their activities with short phone conversations that go beyond beeping [9]. These involved making quick phone calls to alert remote family members to monitor the progress of an activity online.

Applications like TumaPicha could further be integrated into exploratory research on how technology could support Kenyan immigrants living abroad who are interested in learning and sharing indigenous knowledge [20]. Already, exploratory investigations have shown that new technologies such as Facebook, WhatsApp, and YouTube allow people to share indigenous knowledge in transnational communities [20]. Our study results suggest that TumaPicha could be used in a similar manner to such systems.

Of course, TumaPicha was not without its issues. We designed the technology and service to try and help address problems related to a lack of Internet connectivity, technology literacy, and power/electricity. We were reasonably successful at the first two, discussed more later, yet electricity was still an issue as phones needed to be charged more frequently than the phone delivery service was slated to occur. This was largely a result of the high level of power consumption needed by the smartphones to fulfill rich media capture. This is an opportunity for further research into ways through which people living in rural communities of developing countries could influence the design of lower end smartphones to address energy saving challenges that come with the type of technology we used for our testing.

11.2 Technology education and learning

Rural family members also used the mobile phones from our study in other ways beyond the usage of TumaPicha. This included capturing videos and watching YouTube, which were new activities for them. This shows that rural families can adopt meaningful technologies into their practices, explore their capabilities, and even extend their anticipated usage. Thus, while designers may be focused on providing one particular type of new technology, it can be valuable to think about how the presence of a new device may spawn additional uses. In this way, the new system can act as a catalyst for learning and exploration in rural contexts. These results mirror findings that there exists opportunities for hybrid approaches to designing social spaces for dispersed families, such as using voice based technologies and online platforms together to support awareness between dispersed family members [6].

Our study also revealed how the use of intermediaries can act as "vehicles" for technology learning. Each person involved in the use of TumaPicha played an important role and interacted with someone who knew more about the technology than him or herself. For example, the design focused on family members capturing pictures, the most basic of interactions in the system. They interacted with the motorcycle taxi driver who experienced the actual uploading of the photographs and could describe this process to them, as he understood it. In turn, the motorcycle taxi driver interacted with the cyber café attendant who knew the most about computers and could share this knowledge with the taxi driver. Thus, the taxi driver was exposed to technology in a new way that was not already familiar to him. Each person in this process expanded his or her skills in working with technology as a result of interacting with another person. Together, this shows that one way to help the act of learning and provide increased technology exposure in developing areas of the world could involve a carefully worked out chain of actions (and

people) as part of a system's design. We paid particular attention to the types of roles that people already play in Kenyan family routines. In this case, it was that of motorcycle taxi drivers ferrying people or items between locations and cyber café attendants helping people use computers. Along these lines, we feel that designers should think about developing systems that do not disrupt already existing routines but rather enunciate the existing way of life in creative ways.

11.3 Privacy

In terms of privacy, our study revealed that both rural and urban participants were generally not concerned with potential privacy risks with sharing their photographs more broadly—with intermediaries and other families—since they would capture activities that were deemed to be fairly mundane and not sensitive. The private aspects related to these photographs were shared during phone conversations. Discussions with participants revealed that their lack of privacy concerns was not because they did not understand the potential privacy issues; there simply was not an issue presently. What is not clear, however, is how far this level of comfort would extend. There were only two family pairs in our study and two intermediaries. In only one case did a participant tell others (his eldest brother) to also look at the TumaPicha photographs. Overall, this limited the potential privacy threats to a small number of individuals. If a system like TumaPicha was expanded to include more users, one could reasonably expect that privacy concerns might begin to arise since there would certainly be more families using the system and more intermediaries may easily be needed. Such expansion is likely since it was clear from our study that the families found the system beneficial. Both of our urban participants also felt strongly that the system should support bidirectional sharing, which would mean even more photographs would be stored in the system and accessible for people to see. Thus, the open question is: At what point do people begin to get concerned about the privacy of their photographs?

Further studies will need to be conducted to address this question, yet we feel our study results point to one way of considering privacy models for developing areas like the one we studied. Unlike systems designed for Western culture, which typically use single user access credentials, it may be possible in rural areas of countries like Kenya to have access restrictions at a group level containing multiple families. This might eliminate the challenge that passwords need to be remembered and entered for every single user and, instead, they could be shared by groups of people since we know that families are typically okay with others in a small group (like our study) seeing their media. This idea should be further tested in actual practice, however.

Our study revealed a general preference by urban participants for creating technology awareness in rural areas of the country; that is, they tended to feel that technologies, even with their flaws, were important to introduce into rural regions of the country such that people would begin to be more exposed to technology. On one level, this may suggest that even if privacy concerns are present among users, the desire to present a greater awareness of technology may supersede such concerns. This may be another reason our participants generally did not describe privacy issues with TumaPicha. This finding also points to the fact that technology awareness is a general user need that designers should consider fulfilling in addition to their system's normal functionality.

11.4 Extensions of the system

Lastly, we reflect on how TumaPicha would need to be expanded if it were to be used by people outside of the four-family context that we studied. If TumaPicha were more widely available to Kenyans, we would anticipate that additional intermediaries in the form of motorcycle taxi drivers would be needed. Given our observations, it would be reasonable to expect that one motorcycle taxi driver could support the transfer of roughly a dozen or so phones to a cyber café. This matches their existing pattern of picking up and transporting commodities for rural families between the villages and the local towns that are close to the village. Cyber attendants would likely be able to handle transfers from multiple taxi drivers but this would ultimately depend on when and how long power is available (in case of power blackouts).

Expanding TumaPicha for use with more families would also require addressing issues of privacy, which would be likely to emerge with larger social groups sharing photographs. Urban families who have knowledge on how to use technology could be provided with an option to select photographs that they would want to keep private. Providing the ability to select and reorganize photographs would provide urban family members with the opportunity to even share the selected photographs with other family members in closed groups using other social media. For example, photographs of a family function could be saved in a single folder, which could then be shared with specific people in a closed group such as a Facebook group.

12 Conclusion

This paper has presented the study of family communication routines in rural, suburban, and urban Kenya and the design and field deployment of TumaPicha, a system and

service for sharing photographs between urban and rural areas of Kenya. Our initial study showed that technology-based family communication focuses on economic support, well-being, and sometimes the everyday coordination of activities. These communication patterns were affected by infrastructure challenges such as reduced access to technology. Our study of TumaPicha revealed how a system designed specifically for family communication in Kenya was used by participants for gaining a sense of subsistence awareness, village awareness, and health/well-being awareness. Our design focused on overcoming issues related to a lack of Internet connectivity, education, and electricity. Through the use of intermediaries, we found participants were able to share photographs between rural and urban areas yet additional power was needed to support the media-rich application. Furthermore, we learned that families did not have privacy concerns because media was shared within small groups, yet there is a chance this could change with continued usage and additional families using the system. Further studies are needed to test out these ideas with larger groups of participants over extended periods of time.

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