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Machina ex Deos

Successes and Challenges of Implementing Mobile Computing Technologies for Development. The Experience of Nine Indian Village Health Projects Using a Project-Issued Mobile Application

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Machina ex Deos

Successes and Challenges of Implementing Mobile Computing Technologies for Development. The Experience of Nine Indian Village Health Projects Using a Project-Issued Mobile Application

by

Ariel Schwartz, B. A.; M.PUBLIC.ADMIN.

Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

May 2016

Dedication

To my family

Acknowledgements

Thanks to all study participants including health workers, their families, and clients who invited me into their homes and let me sleep in their offices, who coordinated my field visits, and who put much time and thought into interviews. I am extremely grateful for generous research funds and in-kind support from Microsoft Research India and conference travel funding from The LBJ School and UT Austin. Hearty thanks to Akbar Noman, Joe Stiglitz, Azim Premji U., and Jennifer Bussell, who facilitated my early research trips.

Deepest gratitude to my wonderful committee. Kate, Carolyn, Erin, Melissa, and Peter, I appreciate your excellent guidance and patience! Many other attentive mentors and friends at LBJ include Alvaro, Carlos, Changgui, Eli, Roger, Todd, Bec, Ilse, Jenna, Nisha, Noah, Sasha, Larry, Victoria, Jamie, Jenny, and dear Shama. And at MSRI, Ed, Jonathan, and Melissa, who advised daily, Aditya for clutch translation, Indrani, Bill, Erin, Andrew, John, Pedro, and Spandana. Sheila, Luv, Noor, Ilan, and M. Mehta: a thousand thank yous! for sharing your world with me in India. Thanks to Austin friends Tara, Sri, Joshua, John, and every coffee shop, and to David, Beki, and Alex, who ran it out with me every week. To Joanna, Matt, The ODBs, Thura, Gillian, Menaka, Eva, Heather, and my family: mwah.

I benefited enormously from opportunities that Anya Schiffrin and Angela Newell gave me to present my research. These talks helped me articulate my thoughts and drew constructive feedback. Thanks also to participants of the Advanced Graduate Workshop in Globalization and Development for extremely helpful comments on my research design. The comments of several blind reviewers at ICTD and ITID vastly improved my writing.

Machina ex Deos

Successes and Challenges of Implementing Mobile Computing Technologies for Development. The Experience of Nine Indian Village Health Projects Using a Project-Issued Mobile Application

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The University of Texas at Austin, 2016

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As mobile computing technologies become increasingly functional and affordable, global donor and local development organizations find ways to justify and fund their use in grassroots development work. This dissertation asks two questions: (1) In resource-constrained social sector settings, what project features govern and structure use of work-issued mobile devices? And: (2) How do decision-makers adjust to maximize the benefit of newly-introduced devices while minimizing new burdens to the project and project staff? More simply, what variables under social sector projects' control might promote successful use of information and communication technologies in development (ICTD) projects? This research represents systematic, qualitative comparison of nine extended deployments of a popular mobile health application, CommCare. Each studied project deployed devices loaded with CommCare to health workers in India as a supportive job aid and/or a data collection tool to help monitor beneficiary populations' health status and frontline workers' work. This dissertation examines the conditions under which these health workers were able and willing to use CommCare devices in their jobs, and whether and how they deviated from the use of those devices prescribed by their supervisors.

Primary data for this study come from 62 in-depth, semi-structured interviews, extensive review of project documents, and personal observations from field study in India over six months in 2013. Employing a sociotechnical lens and a principal agent model, my data support expectations that use of CommCare devices would help align community health workers' behavior with their supervisors' organization and mission-related priorities. Use of the devices improved health workers' professional competence and improved communications, data quality, and data access. These improvements facilitated project supervisors' monitoring of health workers and beneficiaries, and funders' monitoring of projects. Contradicting expectations, use of CommCare devices also weakened organizational oversight and control through new data challenges and increased health worker autonomy in their personal and professional lives. These dual benefits and challenges ultimately served the overall projects' missions.

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Chapter 1. Introduction

Priya is at a neighbor's home explaining to her client Sima, a young pregnant woman, the risk factors of pregnancy. Sima's family listens in. Priya uses an application, CommCare, on her mobile phone to facilitate these explanations. CommCare helps her decide what topics to choose, provides substantive information about the topics, and records client data. As Priya finishes each topic with her client, she checks a box and submits the form to register its completion, and the application displays the next discussion point. As Priya explains the importance of delivering one's baby in a medical facility, the application cues Priya to ask, "Will you deliver your baby in a health clinic?" Sima knows the answer, and Priya attempts to select "yes" to complete and submit the form. Then the application "hangs." The screen freezes, and Priya can not complete Sima's counseling session. After restarting her phone, Priya calls Rekha, Priya's supervisor, who drives her motorcycle to Priya's home the next morning. Rekha uses her own device to reinstall CommCare on Priya's phone. Now Priya can get back to work. But instead of returning to Sima's house, to complete her session, Priya decides to visit another client, an hour's walk away, who is typically available only around this time. Priya must complete 10 client visits per day, and, wanting to be sure to include the difficult-to-reach client, goes for the long walk. In the office at the end of the week, Rekha views the data that Priya submitted via her mobile device during each of these visits. Rekha can see that Sima's session was still incomplete. "Priya, did you ask Sima whether she will deliver in a hospital?"

Foreign donors are investing heavily in information and communication technologies (ICT), such as portable computers (including mobile phones, tablets, and laptops) for locally-run social service organizations, to improve efficiency and effectiveness of delivery of services central to holistic development in poor countries. Donors enthusiastically expect project-level ICT investments to directly benefit target populations and improve monitoring and evaluation capabilities and responsiveness to performance challenges. Adopting new technologies often seems an obvious choice for a practitioner. Computers are increasingly functional, portable, and inexpensive, and may enhance efficiency and

effectiveness of work already underway. Some development scholars and practitioners locate ICT "at the heart of recent social and economic transformations" in developing countries (Mansell & When 1998, p. 1). Scholars and practitioners view ICTs as critical means to advance a range of development goals. These goals include poverty eradication (UNDP 1999), women's empowerment and gender equality (UN DESA 2005), conflict prevention (UNDP 2013), and democratic progress. Fraser-Moleketi (2012) identifies ICT in democratic development projects to implement e-governance, and improve information access, transparency, and public control over government. Foreign donors are heavily investing in ICT in expectations that using mobile computing technologies will spur development.[1] As part of this trend, grassroots development practitioners in the health domain are also experimenting with ICTs as a means to improve outcomes in population health.

This dissertation qualitatively compares nine extended deployments of CommCare, a popular mobile health application, in village health work in India. The dissertation asks: (1) In resource-constrained social sector settings, what rules and project features govern and structure use of work-issued mobile devices? And (2) how do decision-makers adjust those rules and features to maximize the benefit of the device to health work's beneficiaries while minimizing new burdens to the project and project staff? Focal projects deployed mobile devices running CommCare to Indian female non-professional health workers as a

[1] At the World Bank, ICT components "are increasingly included in projects across different sectors such as education, health, agriculture, and public sector management. The Bank's portfolio of active projects with ICT components has grown significantly, from about $500 million in 2006 to about $1.7 billion in 2014." The World Bank. "Information and Communication Technologies (ICT) Overview". http://www.worldbank.org/en/topic/ict/overview#2 (Accessed September 29, 2014).

supportive job aid and/or a data collection tool. All focal projects adopted CommCare to help monitor beneficiary populations' health status and frontline workers' work activities.

This exploratory dissertation applies a socio technical lens and a principal agent model to interview, textual, and observational data to identify variables of interest and to obtain a comprehensive picture of ICT use in grassroots development workplaces. A sociotechnical lens illuminates the mechanisms of human-computer interaction in the workplace. A principal agent model, commonly used in studies of foreign aid, helps explain the development task delegation relationships that lead to and emerge from using this dissertation's focal technology.

The design of impact evaluations studying ICT's effects on broader development goals implies that stakeholders give little attention to the mechanisms through which these impacts take place, especially the challenges for social sector organizations to actually use ICT as intended. Instead, these evaluations seem to assume that project participants use adopted technologies as prescribed and in alignment with development goals. While these quantitative, outcome-oriented studies are important, I argue for their contextualization via systematic, direct investigation of how village-level social sector organizations integrate new technologies into their work. Indeed, it is evident that ICT interventions in development settings struggle because *use* is difficult to achieve. Understanding the mechanisms by which using ICT improves or does not improve development outcomes will generate lessons for deepening ICT implementations' success.

Some investigations have described the characteristics of individual users, especially user perceptions about a new ICT, that affect their use of that ICT (Fishbein &

Ajzen, 1975; Davis, 1989; Legris, Ingham, & Collerette, 2003; Venkatesh et al, 2003; Turner et al, 2010). Studies from the ICTD community propose that features of a technology, especially mismatches between its design intent and implementing context, affect use (Lind, 1991; Baark & Heeks, 1999; Heeks, 2002; Heeks, 2006). For example, a tablet developed for entertainment purposes and an industrialized-country consumer market with a culture of paying for unlimited data streaming may present complications for use in a workplace with intermittent or expensive access to electricity, data, or device repair facilities. Less attention has been given to the *project setting*, the organization or workplace that distributes the new ICT and manipulates the interaction between technology and the user. This dissertation explores that setting in nine semi-independent[2] projects implementing a popular mobile health technology, CommCare, to help Indian village-level health workers use ICTs to complete client-based work and reporting.

BACKGROUND AND MOTIVATION: USING COMPUTING TECHNOLOGY TO IMPROVE THE IMPACT OF LOCAL DEVELOPMENT PROJECTS IN THE HEALTH DOMAIN IN INDIA

In 2014, the World Bank alone spent $1.4 billion on information and communications technology (ICT) components for their development projects (World Bank, 2014). Likewise, many foreign aid organizations identify ICT as the single most

[2] Focal projects are independent in the sense that they are unaffiliated with each other. But, because they chose the same application, and the application developer was to some extent involved in each implementation, they can not be considered independent from a research design perspective.

revolutionary investment that foreign aid and international development communities can make in developing countries' social sector projects. Mobile phones and tablets make recordkeeping, organizational management, data accuracy and reporting possible in settings where projects previously lacked the capacity to undertake these activities. Arming far-flung community members with mobile devices can facilitate biometric identification, medical diagnosis, health information delivery, and submission of accurate, real-time reports to health project leaders. The community members studied in this dissertation are community health workers, not doctors or trained medical practitioners, and visit Indian women in their homes. About one million volunteer[3] community health workers in India offer evidence-based World Health Organization-approved advice on, for example, carrying their babies successfully to term and reversing malnourishment in their children. International non-governmental organizations such as CARE, Catholic Relief Services, Real Medicine Foundation, and Save the Children allocate funds and time to ensure these health workers have mobile devices and appropriate opportunities to do their work. Major research institutions such as JPAL and Harvard School of Public Health are studying the effects of these Indian health technology projects on Indian public health. At the time of my study, these projects lacked the baseline data, statistical power, or time to demonstrate effects of ICT use on health.

[3] The vast majority of these million health workers, described below, are incentivized volunteers called ASHAs. *Incentivized volunteer* is a term that health practitioners, non-governmental organization representatives, and government officers frequently described during my interviews with them to indicate that the health workers receive a small commission based on certain healthy behaviors (e.g., delivering a baby in a health facility) taken by those health workers' respective clients. A smaller proportion of community health workers are salaried NGO employees pad a low wage. Payment and incentive structure for health workers is described in more detail throughout the dissertation.

Community Health Workers in India

The role of *community health worker* or village health worker is well-established in many countries. While specific activities may vary, community health workers are generally understood as nonprofessional health promoters embedded in their own communities. As a WHO-designated, globally-recognized health workforce role, understandings of community health workers have evolved since the 1950s, but definitions retain a few core features. One such definition by the WHO Study Group (1989) describes community health workers as "members of the communities where they work, ...selected by the communities, ... answerable to the communities for their activities, ...supported by the health system but not necessarily a part of its organization, and have shorter training than professional workers." Lehman & Sanders (2007, p4) prefer a definition developed by Lewin and colleagues (2005), describing community health workers as "any health worker carrying out functions related to health care delivery; trained in some way in the context of the intervention; and having no formal professional or paraprofessional certification or degreed tertiary education."

Community Health Workers may be government workers or staff of nongovernmental, community-based or faith-based organizations. Community health workers' activities are part of a larger strategy proposed by the World Health Organization (WHO) of 'task-shifting," a practice of assessing a country's health system's tasks and

delegating those tasks to the least specialized person that might successfully perform them.[4] Some community health programs have special focus areas, such as reproductive, maternal, and child health, or prevention and care of malaria, tuberculosis, or HIV/AIDS.

Community health workers currently exist in at least 39 countries by at least 58 names (WHO, 2010; Lehman & Sanders, 2007, citing Bhattacharyya et al., 2001; Gilroy & Winch, 2006). Major programs implemented in China (so-called Barefoot Doctors, 1950s), Bangladesh (by BRAC, 1972) and health ministry-led country-wide programs in Niger (1960s), Ghana (1970s), and Indonesia (1980s) heralded broad use of the community health worker role in developing countries. Early work often promoted, and the Alma Ata Declaration[5] reflected, village health workers' role as community advocate and social change agent, a "liberator," not a "lackey" (Werner, 1981), "a community mouthpiece to fight against inequities and advocate community rights and needs to government structures..." (Lehman & Sanders, 2007, p. 5). Historically, this philosophical focus on self-reliance, poverty eradication, and elimination of social inequities came in large part from decolonization in Tanzania and Zimbabwe, but for ideological or practical reasons, their current role is a technical one, more narrowly supporting community health management.

[4] The Community Health Worker designation generally excludes formally-trained health sector professionals such as medical assistants or nurses' aides. As per Lehman & Sanders (2007), this dissertation also excludes traditional birth attendants, and traditional, faith and complementary healers, all of whom may be included in some local understandings of the community health work role.

[5] The Declaration of Alma-Ata was adopted at the September 1978 International Conference on Primary Health Care (PHC), in Almaty, Kazakhstan. http://www.who.int/publications/almaata_declaration_en.pdf (Accessed January 30, 2015). The Kampala Declaration and the Agenda for Global Action also affirmed the community health worker strategy.

Lehman & Sanders (2007) note that "the fundamental tension between their roles as extension worker and change agent remains" (p. 6).

The World Health Organization cites robust evidence that community health workers *can* implement interventions to effectively improve coverage and uptake of basic health services and improve health outcomes, especially on the Millennium Development Goals that relate to maternal and child mortality, and combating malaria, HIV, and other diseases. The WHO affirms community health workers' potential to mitigate an international "human resource crisis" for health (WHO, 2006, 2010; Lehman & Sanders, 2007), in which "57 countries, from Africa and Asia are facing shortages of health care workforce, and an estimated 4,250,000 workers are needed to fill in the gap" (WHO, 2006).

This dissertation's focal health workers were based in six states in India. As detailed in the subsequent chapters, these community health workers' work aimed to improve basic health and health behaviors, reduce maternal and child mortality, improve child nutrition, promote family planning, and improve disease prevention and care.

Government of India websites describe community health workers as the "first port of call" for health service, especially for women, children, elderly, and disabled individuals. "She is the link between the community and the health care provider." Community health workers are viewed as "change agents" who will reform the health status of oppressed communities of India. "The investment on ASHA[6] will definitely result

[6] ASHA is an Accredited Social Health Activist, a member of a Government of India (GoI) program described in more detail in Chapter 3. All community health workers featured in this dissertation were government ASHAS or other government or non-governmental health workers whose duties were based on GoI guidelines for the ASHA program. I observed that non-governmental community health workers with ASHA-like duties had higher salary, better literacy and more formal education, and slightly more on-the-job

in better health indicators of state and at large the country" (*Ibid*.) Visiting an expected 10 clients per day in their homes, each community health worker mobilizes local health planning and promotes villagers' use of local government services. Government of India prioritizes its national community health worker (ASHA) program in 18 high-focus states, and rural areas and tribal districts across India, especially in places where health facilities are not easily reached. The Indian government also encourages other regions to establish these so-called *link workers*, individuals who connect citizens to government health services.

By design community health workers are not medical professionals, and the majority have insufficient education to find better-paid skilled work. Inserted into positions specifically created to address recognized gaps in the public health system, community health workers in India and globally consistently lack the training, supervision, facilities, and resources to do their jobs as directed (Lehman & Sanders, 2007). Chapter 3 describes in more detail the divergence between planning and implementation of the community health worker role and these challenges in the Indian context.

Using ICT to Enhance Community Health Work

Many Indian community health projects are attempting to adopt information management systems like CommCare to address challenges in community health work.

resources, especially training. The higher salary still kept non-governmental health workers below the lowest poverty line.

CommCare was designed to help ease community health workers' health information knowledge gaps[7] by speaking health information aloud to clients and health workers. Some versions of CommCare also featured decision support, which helped community health workers assess whether a child is sufficiently malnourished to recommend a hospital visit, or which health topic would be most appropriate to discuss at a particular stage in a client's pregnancy.

CommCare also facilitated data collection and retrieval. Imagine a health worker walking door to door, doing her work and recording it by writing in her diary. This information comes to a village health center and supporting organizations infrequently. It is time-consuming and onerous for the health worker to physically bring the diary to a central location that may not be in easy walking distance, and time-consuming and onerous for her supervisors to read and transcribe the diary, and to compile its data electronically with her colleagues' data to get a clear picture of village health status and village health work.

A mobile tool such as CommCare could record retrievable digital client data and transmit it at the moment of recording directly from community health workers in clients' homes to supervisors at a health facility. This real-time, remote data transmission could

[7] It is not accurate to say that CommCare was designed also do address community health workers' low literacy. In interviews, members of implementing organizations expressed having been surprised about community health workers' low average literacy during training on CommCare devices. Though literacy is a required qualification for governmental and non-governmental community health work, generally health workers' literacy had not been fully tested until the CommCare implementation. So, representatives of CommCare's developing organization Dimagi may not have initially developed CommCare for the Indian context with community health workers' low literacy in mind. More on this and other text-based ICT implementation challenges later in the dissertation.

mean knowing which health workers need mentorship or other assistance. These new data could also facilitate remote assessment of village health needs, timely response to them, and timely reporting about those needs and actions taken in response. Given timely information and timely strategic resource shifts in response, resulting organizational performance improvements could then improve critical health outcomes, including the number of beneficiaries with access to community health services, improving their speed of access and thus deepening disease prevention or early treatment, and improving service quality by delivering better and more relevant information and services. An information system such as CommCare could help health practitioners give donors and government agencies timely feedback on the success of their investments and inform future investments. A good information system could facilitate mission fulfillment, and conveyance of the details of that work to partners. Information about improved organizational outputs and outcomes could in turn be transmitted back to the funders, strengthening donors' confidence in their investment choices and better informing a case for future investment.

The conventional wisdom is that these sorts of information and communications technology for development (ICTD) projects are game changers for local development programs. The logic is exciting: instead of flying Americans to India for health service delivery to the poorest of the poor, technology can empower members of those communities to do development work themselves. The international development and foreign aid community, including academics, practitioners, and donors, have many good reasons to focus attention on village-level development organizations. Donors expect that

well-resourced, locally-managed organizations can autonomously accelerate development goals (Uphoff 1993). This line of thinking argues for local social organizations as "leading practitioners of rural development" (Bratton 1989 p. 569) for many reasons. They may be more attentive to particular issues or to under-represented minorities, and facilitate better access to services for those groups (Bratton 1989; Buvinic 1989). They may also be more adept at including those groups in participatory decision-making (Clark 1995). Locally-run social organizations may also be able to intervene in the case of a weak public or private sector, undertaking small projects with minimal resources in neglected places (Bratton 1989), and may be more agile at innovating and experimenting than a large official development agency would be (Clark 1995). They often succeed in the developing world's comparatively large informal sector (Buvinic 1989). Finally, local development institutions, which contribute labor, "ideas, management skills and a sense of social responsibility" (Uphoff 1993 p. 617), precede development, and their maturation is worth supporting.

Further, many in the development community consider ICT projects game-changers because stakeholders expect ICTs will enable *leapfrogging*, defined as "bypassing stages in capacity building or investment through which countries were previously required to pass during the process of economic development" (Steinmueller, 2001, p. 194).

This optimistic outlook for a virtuous circle of improved service, information, and outcomes, and better-directed funding, depends not only on the presence of an information system better than the existing one, but also on its proper use. Use and proper use are

implicit in the sunny predictions of introducing new information into an existing routine.

However, use of a new technology is not overwhelmingly predicted in an organizational or workplace setting. Consider an ideal-form micro-level theory of change, with four chronological stages moving from left to right as in Figure 1.1 below. In the *Readiness* stage, regional infrastructural (i.e., electricity, telecommunications network) and institutional (i.e., rule of law) precursors precede any organizational allocation of inputs to a specific ICT project. These inputs include a decision to adopt a new technology, implicit or explicit adoption goals, and an allocation of time, labor, and funds to enact the adoption.

In the second stage, *Availability*, the focal technology is a physical deliverable, such as a software application and/or a device, which is brought to the site where it will be used. During the *Uptake* stage, an understudied critical juncture, use leads to some results. During the final stage, *Impact*, one may observe outputs including new actions, communication patterns, data, and decisions based on that data. These outputs are expected to lead to benefits that relate to the adopter's short-term goals, or outcomes, such as improved speed and quality of information that a health worker can deliver in an eight-hour period. Finally, these performance improvements should, if noisily, improve development outcomes, some public goal such as reduced maternal mortality.

Figure 1.1. The Information and Communications Technologies and Development (ICTD) Value Chain

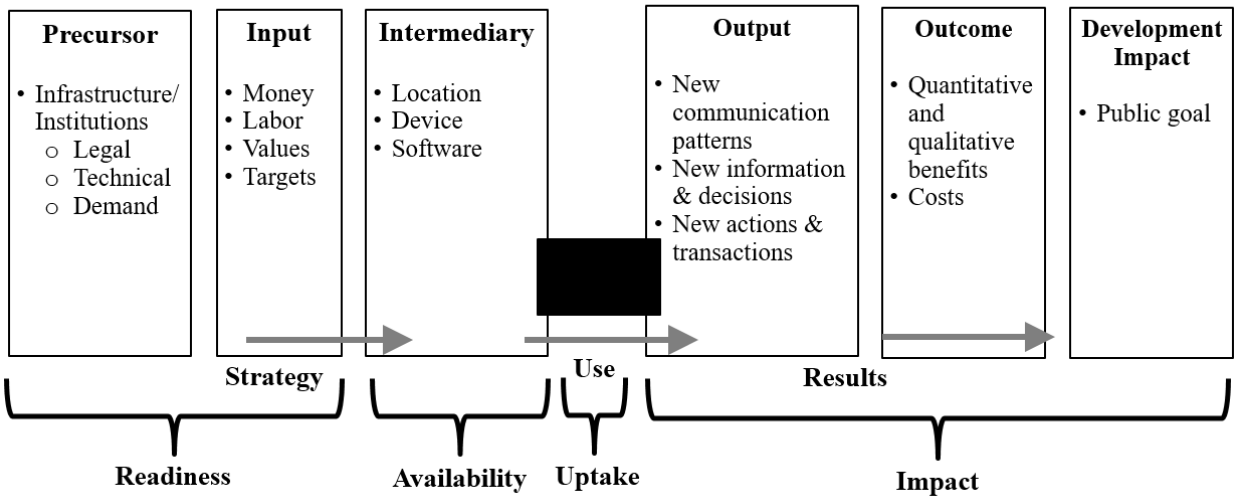

Figure 1.1. *A simple depiction of the assumptions and theory of change by which an information and communication technology might fruitfully support development goals. Source: Adapted from Heeks (2010)*

Unfortunately, many technology adoptions fail, including most health information systems, whose implementations are estimated at 20-25% total failure and 30-60% partial failure (Heeks 2005). These terrible figures should not be surprising. Any technology is difficult to incorporate into existing workplace routines. In a consumer setting, any use including no use is acceptable, and smart phones and tablets are designed specifically to be modified by individual, non-technical users, to enhance their own lives. In a work setting, in contrast, users are expected to use devices in a particular, prescribed way. That way should display a minimum level of skill and consistency across users. This consistent and persistent use among focal users should ultimately lead to outputs and outcomes meaningful for the organization's performance and goal achievement.

Yet community health workers' use of a new technology depends on complementary technologies, relevant prior experiences, and the ability to learn the new skills and organizational capabilities to use the new ICTs. This is a tall order, even in industrialized countries and corporate settings (Steinmueller, 2001, p. 195-6). Especially important is "access to equipment and know-how to make productive use" (Steinmueller, 2001, p. 199) of new ICTs.

> *[W]hen the transferred technology is one that leapfrogs earlier developments, the period of performance improvement and adaptation is likelier to be longer and face greater hazards… An even more conservative attitude is appropriate towards promises of successful performance in developing countries, where there are the additional complexities of technological leapfrogging* (Steinmueller, p. 196-197).

Steinmueller's argument is focused on firm- and sector-level technology transfer, as well as national-level governmental use of new ICTs. I argue that even greater pessimism is warranted for a key organization type: community-level governmental and non-governmental social service delivery organizations in developing countries. These organizations are likely to have especially serious resource constraints. Relevant resource constraints include older or unavailable equipment, poor internet connections, and poor search skills, which may preclude using existing online resources such as manuals and discussion boards where many novices become competent new users of ICTs. Furthermore, important information including reports on health outcomes from community health work

in India, are often not timely, complete, or accurate,[8] hindering good choices about how exactly ICT might facilitate improvement on those outcomes.

Moreover, impact studies in the Information and Communications Technology and Development (ICTD) community have documented that development projects adopting new technologies frequently stall during the uptake stage as modeled in Heeks (2002), failing to fully utilize their new ICTs (Davis et al 1992; Baark & Heeks 1999; Heeks 2006; Warschauer & Ames 2010; Heeks 1999; Madon et al 2007) or to achieve expected productivity gains (Brynjolfsson 1993; Brynjolfsson & Hitt 1998; Arnold 2003; Leclercq & Isaac, 2006). This group of ICTD scholars exhibits serious skepticism that ICT projects in developing country social sector settings can meaningfully influence development outcomes, despite the usefulness and appropriateness of targeting grassroots development actors as catalysts for development.

The above-cited research does not imply that ICTs cannot achieve their expected results, but does imply that research focusing on impact evaluation jumps the gun. In addition to measuring social outcomes, we must also understand project-level organizational processes that might better increase the chances of affecting those outcomes. This dissertation, therefore, reports on that period during which village-level health organizations in India begin to utilize (or squander) a recently adopted ICT CommCare. This study contributes to understanding about how social organizations might use ICTs as tools to advance their development goals and how foreign donors might spend ICT-marked

[8] In interviews, health officials and representatives of local and international non-governmental organizations in both Uttar Pradesh and Rajasthan observed that neither government nor NGOs systematically, accurately, or consistently collected these data.

funds well.

SOCIOTECHNICAL AND PRINCIPAL AGENT UNDERSTANDINGS OF ICT USE AT WORK

This dissertation engages sociotechnical and principal-agent frameworks to understand how focal health project participants used work-issued devices and the project features that supported and constrained that use. To understand the consequences of these explicit and implicit rules, I compare how users were instructed to use their devices with how they actually used them, and perceived effects, on work, skills, morale, device integrity, and the ability to advance personal, professional, and project goals. The next paragraphs summarize the sociotechnical and principal agent lenses' usefulness, and the subsequent sub-sections respectively explain each framework in detail.

This dissertation first applies a sociotechnical framework to identify the characteristics of the social setting, especially the development project and the health worker-client interaction, that surround and shape understandings and use of adopted technologies. The sociotechnical framework also identifies with equal importance the material characteristics of the physical and virtual object that comprise the technology being implemented. Applying a sociotechnical lens, I study how individuals use a new technology at work, where the work environment shapes how staff use the technology and where individual technology users reshape the work setting through their technology use. This recursive reshaping of the human computer interaction and work routines will, if all

goes well, systematically and meaningfully improve organizational outputs and, ultimately, health outcomes.

I supplement the sociotechnical theoretical lens with a principal agent framework to understand how new information and communications technology changes the relationship between health workers and their supervisors, especially patterns of communication and authority. Governmental and non-governmental authorities delegate health work and use of CommCare to health workers. The principal agent framework highlights the delegation chain through which development agents receive mandates for a specific form of health work, community health work, and use of a specific technology, CommCare and its supporting device. These development agents, community health workers, may not fully understand the mandate, and the principals who set the mandate struggle to monitor agents' behavior to know whether the agents faithfully implement the mandate. These information asymmetries characterize all delegation chains.

The long delegation chains found in foreign aid relations generally, and the specific delegation chains that characterize this dissertation's focal projects, feature important information asymmetries that cross many organizational and geographic boundaries. Introducing technology that promotes more and better data about daily development work, more frequently communicated by community health workers to supervisors, funders, and other regional and global stakeholders, could reduce information asymmetries and improve monitoring all along the delegation chain. Mobile devices are inexpensive, useful in a variety of ways, and offer a portal through which information about development work and beneficiaries can flow back to funders. This data flow promises funders more frequent and

more meaningful information, and reduced uncertainty and risk for funders seeking to evaluate their investments.

The following section unpacks and develops these two theoretical frameworks and their application to the empirical study in this dissertation.

A Sociotechnical Lens to Understand Workplace Use of New Technologies

The assemblage of perspectives that constitute a sociotechnical lens, and which are prominently used in organization studies, information studies, and human computer interaction (Zucker, 1977; Weick, 1979; Giddens, 1984; Suchman 1987; Woolgar, 1996; Orlikowski et al., 1995; Orlikowsky, 2000; Orlikowski, 2010; Leonardi, 2012) is well-suited to understand the mechanisms by which development projects might incorporate new technologies into routine work. This section elaborates on how characteristics (1) of the social setting of a focal workplace and (2) of a focal technology interact and contribute understanding ICT use in development projects. Then I describe two relevant models from the sociotechnical framework, the Design-Reality Gap Model and the Technology Acceptance Model, to identify specific variables that might promote or hinder a deployed technology's use.

The sociotechnical lens identifies variables that fall into two broad categories. The first category is *human*, or social, identifying characteristics of individuals and social settings that surround and shape understandings and use of adopted technologies. In the studied projects, the relevant social settings for use are the ICTD project setting and health

workers' residential communities. In this dissertation, a *project* relates to a specific set of objectives, procedures, timelines, activities, and resources surrounding a programmatic decision to introduce CommCare into work. The project's setting relates to the physical and virtual spaces in which project members conduct project work. This constitutes the workplace. This dissertation uses the term *deployment* to mean the strategic distribution of a focal technology among participants of focal project work – in this case, community-level health work.

The second category is *material*, referring to the physical (and virtual) object that constitutes the technology being implemented. *Practice* in the workplace may be understood as a function of a user with agency and the institutional setting in which she operates (Orlikowski, 2000).[9] During *practice*, reflective actors, such as health workers and their supervisors, and social forces, such as workplace norms and routines, recursively

[9] Orlikowski's theoretical grounding is in that of Lucy Suchman, working on *Plans and Situated Actions* (1987), who understands human action as being continually constructed and reconstructed via a dynamic interaction between the material and social worlds, and Anthony Giddens (1984), from whom the idea of structuration originated. This group of scholars makes a strong argument that studying human computer interaction (HCI) is more complicated than studying human behavior using non-computing technologies such as fertilizer or a pen. This argument is based on the a) real-time, b) linguistic c) feedback that happens during human computer interaction that does not happen with non-computing technologies. This real-time linguistic feedback happens on the back-end, between developers and code, and on the front-end, via user interfaces. Suchman (1984) defines *interactive computing* as when "Real-time control over the computing process is placed in the hands of the user, whereby the user can override and modify the operations in progress. This definition contrasts current capabilities with earlier forms of computing, specifically batch processing, where user commands were queued and executed without any intermediate feedback. The greater reactivity of current computers, combined with the fact that, like any machine, the computer's reactions are not random but by design, suggest the character of the computer as a purpose-ful, and, by association, as a social object" (Suchman, 1984, p. 11). Indeed, the social nature of the interaction between humans and computers has been studied for decades. It is no coincidence, then, that designers refer to HCI as a "dialogue" or "conversation," whereby the computer responds to human input with a "dialog box" in many computing interfaces. The distinction between human computer interaction, and human human interaction, this line of thinking goes, is a matter of robustness, especially of "the ability of conversational participants to respond to unanticipated circumstances, and to detect and remedy troubles in communications" (Hayes and Reddy, 1983, as cited in Suchman, 1984, p. 12).

shape social order. In this setting, the interaction between people and technology also recursively shapes technologies-in-practice. The focal physical material in this dissertation is a device (a mobile phone or tablet) deployed to community health workers, and focal virtual material, a software application called CommCare, loaded on those devices. The devices are stable *artifacts* before the deployment begins, but become *enacted technology structures*, or *technologies-in-practice*, as the health workers begin to use the devices. Each of these terms is defined below.

Enactment may be understood as a form of social construction, sense-making, and order-making. Through the process of enactment, organization members modify objective features of an artifact by interacting with those features, creating recursively stable systems of interaction and behavior (Weick, 1979). *Enactment* may be thought of as a "meld[ing of] materiality [for example, a technology artifact] with institutions, norms, discourses, and all other phenomena we typically define as 'social'" (Leonardi, 2012, p. 34). A *socio-technical system* is defined as "a recursive (not simultaneous) shaping of abstract social constructs and a technical infrastructure that includes technology's materiality and people's localized responses to it." (Leonardi, 2012, p. 42)

Enacted technology structures, or *technologies-in-practice,* are analytically distinct from technological *artifacts*, which are relatively durable objects, packages of bundled "hardware, software, and techniques" (Orlikowski 2000, p7). *Technology-in-practice* refers to the

> *specific technology structure we enact every time we use the received machine, technique, appliance, device, and gadget in particular ways in our situated, everyday activities. Some features in the artifact do not exist for us as part of our*

> *technology-in-practice, while other features are rich in detailed possibilities. (Orlikowski 2000, p8).*

For example, this dissertation's focal projects, many health workers who received project-issued devices had previous access to mobile phones, but had only used them for calling primarily family members. The mobile phones as artifacts featured calendars, address books, and Internet portals, but these features did not meaningfully exist for their users, and so these features were not part of the health workers' technologies-in-practice. These same people, community health workers, later received similar devices at work, and used those devices differently than they had used them previously, at home. Community health workers' subsequent at-work use featured use of this broader range of features, including the calendar, address book, and Internet access most often via SMS. Technologies-in-practice are "shaped by people's intentions, interests, interpretations, interactions, inertia, and improvisations. … *[T]echnology structures* are situationally specific, emerging from practice" (Orlikowski 2000, p27, emphasis added). Resulting conditions are not permanently stable because each new use of a technology is a new opportunity to modify it, and new challenges can be opportunities for improvisation that later may become daily practice. "[U]nderstandings of technology are neither fixed or universal," but "emerge from situated and reciprocal processes of interpreting and interacting with particular artifacts over time" (*ibid.*)

Use of technology at work can only be understood as an interaction among the technology, the individual, and the workplace. This is not obvious. In Orlikowski's understanding, a technological artifact (a mobile phone loaded with CommCare) may be

separated from the individual (the health worker) and the social setting (the workplace, in this instance, the health project). However, the meaning of that technology depends on its use by individuals embedded in their social setting. Orlikowski's notion of *emergent technology structure* frames "what users do with technology as a process of enactment" (Orlikowski 2000, p. 6). According to this notion, a particular technology continues to develop after an artifact such as a mobile phone transfers to users' hands. "Technology is here understood as material artifacts that are socially defined and socially produced, and thus as relevant only in relation to the people engaging with them" (Orlikowski 2010, p131). The embodied features of a technology only have meaning if they are "instantiated in activity" (Orlikowski 2000, p4, citing Giddens 1984 and Whittington 1992, p696), that is, existing only through human action. As a device's features are enacted by human use, they become emergent technological structures, rules and resources.

How does this instantiation happen? How do technology structures "emerge" from human interaction with a technology? "[U]sers' knowledge of a technology is also often influenced by the images, descriptions, and demonstrations presented by intermediaries such as vendors, journalists, consultants, champions, trainers, managers, and 'power' users," who comment "'on the product's nature, capacity, use, and value'" (Orlikowski et al., 1995, p. 92, citing Woolgar, 1996). In a focal project, community health workers who were previously unaware of the range of devices' features experienced pressure from their supervisors and each other to explore, learn, and use these previously unused features. Colleagues expressed excitement, helped each other, and modeled misuse, prescribed use, or non-use. Over time, the sociotechnical lens predicts that within a

> *community of users engaged in similar work practices typically enacts similar technologies-in-practice, where through joint training sessions, shared on-the-job experiences, and mutual coordination and story-telling, users come to engage with a technology in similar ways.* (Orlikowski et al., 1995).

Repeated reinforcement by the user community may institutionalize technologies-in-practice (Zucker, 1977), "at which point they become treated as predetermined and firm prescriptions for social action, and as such, will impede change." (Orlikowski 2000, p. 10-11).

The sociotechnical view "makes no assumptions about the stability, predictability, or relative completeness of the technologies" (Orlikowski 2000, p. 5). Instead, particularly interesting are structures that

> *"emerge as people interact with whatever features of the technology are at hand, whether these features were built in, have been added on, or are invented on the fly" ... "[W]hile users can and do use technologies as they were designed, they also can and do circumvent built-in ways of using the technology and invent new ways, which may go beyond or even contradict designers' expectations and built-in features" (Orlikowski 2000, p. 5-6).*

In sum, the outcomes of technological practice range from *social inertia*, whereby the old status quo remains in place, and nothing of relevance in the workplace systematically changes, to some degree of *social change*, which can be understood as the integration of technology into a new status quo. The technology itself is constituted through use in the social setting, and the technology in turn shapes users' interaction with it. We see then, having deployed a given technology, "emergent, unprecedented, and innovative ways in which people engage with new technologies over time" (Orlikowski 2000, pii). Users can and do "assert their agency by ignoring, articulating, altering, or working around the

intended use of technological features" (Orlikowski 2000, p. 9). In other words, the technology artifacts dropped at a location are not stable, and in practice, specific use and salient features may be neither expected nor predicted.

Two sociotechnical models, one that emphasizes characteristics of adopted technologies, and one that emphasizes characteristics of individual users, provide insights about social and technological determinants of technology use in settings relevant to this dissertation.

Two Sociotechnical Understandings of Using ICTs in Social Sector, Resource Constrained Workplace Settings

First, the Design-Reality Gap Model is a techno-centric model that attempts to explain the failure of local-level development project personnel to use new information and communications technologies. This model describes the frequent mismatch between the intended and actual end-users of a particular technology (Baark & Heeks, 1999) in terms of technological, informational, and procedural objectives. The model asserts that the magnitude of the discrepancy between the reality of the implementing context and the original conceptions of the technology's designer will determine actual use in an implementing context (Heeks 2006; Heeks 2002). For example, designers may assume that a device or application will be implemented in a U.S. business environment that values formal information (Lind 1991), instead of a developing country social sector organization that lacks existing methods of systematic or digital data gathering. More generally, mobile

devices such as Smartphones and tablets have been designed as tools for consumption and entertainment, not for productivity (Donner 2015). Because developing country social sector organization workers are not the intended consumers of existing ICTs, and because currently popular and available mobile computing devices were designed to be appropriated by individuals as personal-use entertainment devices, encouraging their proper, work-related use will be an ongoing challenge.

The organizational or implementation policy recommendation implied by this model is that project planners develop appropriate technology designed in an iterative process with the user. This user-centered design principle insures that the end-user has frequent and meaningful input into the design, and is the gold standard methodology by which to design optimal technologies. However, financial constraints often preclude development or purchase of optimal technology (*optimal* defined as based on user-centered design principles). Instead, organizations adopt the technologies they can obtain at low or no cost (Orsin 2013). The task, then, is to implement potentially suboptimal technologies in a way that is useful for the organization. Social sector organizations may lack the in-house expertise or time to properly implement or train employees on a new technology (Wishnie and Bansal, 2013). Further, they may have low capability to enforce staff's proper use in daily work, or to keep up with technical maintenance requirements (Wishnie & Bansal, 2013).

Second, certain human characteristics also predict failure to use new technologies (Correa 2012). Davis (1989) developed the Technology Acceptance Model (TAM), which predicts that the individuals who perceive a new technology as being easy to use and useful

are more likely to use the technology than individuals who perceive it as either not useful or not easy to use. TAM identifies a) *perceived ease of use* (requires low effort to use) and b) *perceived usefulness* (enhances job performance, as per Davis [1989 p.320]), as the heaviest influences on an individual's use of new information technology in the workplace. There is empirical support that perceived usefulness and perceived ease of use predict technology usage (Legris, Ingham, & Collerette, 2003; Turner et al., 2010; Venkatesh et al., 2003). Another important human factor is the "degree to which an individual perceives that important others believe he or she should use the new system" (Fishbein & Ajzen, 1975 p. 451). More simply, peer effects also influence use, and this evidence echoes the peer effects identified by Woolgar and Orlikowski, described above.

There are important benefits to applying a sociotechnical lens to this dissertation. A socio-technical framework affords viewing the project[10] as a mediating factor between the health worker and the work-issued device, observing the immediate influences and impacts of staff technology use. A socio-technical framework offers a way to explore: what happens when a new technology is introduced into a work routine such as community health work? How do staff and supervisory behavior change? What motivates those changes, and to what effect? This dissertation finds that key variables here relate to project staff goals, objectives, understandings, and decisions, which all ultimately shaped, supported, and constrained use. More mundane variables relate to device features such as

[10] It is outside the scope of my dissertation to argue, as in Actor Network Theory (Latour, 1991) for the agency or purposeful action of organizations, technologies, or other inanimate objects or concepts. It is sufficient to note that organizations and technologies can and frequently do influence, shape, and constrain human behavior.

the contact list or calendar, which were available to project participants, but either used or not used. Seemingly mundane variables, such as airtime replenishment (top-up) policies or features of a contract between project supervisors and user, represented ways projects formally mediated the interaction between users and the devices they had been issued. The content and enforcement of these rules had important consequences for use.

Based on the sociotechnical framework, we can derive some theoretical expectations for how health workers might use the CommCare devices they receive as job aids and data collection tools. Generally, these expectations include planned use, unplanned use, and evolving use over time. As noted, "users can and do use technologies as they were designed…" and will "circumvent built-in ways of using the technology and invent new ways" (Orlikowski 2000, p6) to use it. Users ignore, articulate, alter, or work around features' intended use based on their intentions, interests, interpretations, interactions, inertia, and improvisations, whether according to or spite of project plans and documentation.

Finally, we can expect to see evolving routines and behaviors because each new use of a technology is a new opportunity to modify it, and new challenges are opportunities for improvisations that later become daily practice. This expectation incorporates users' evolving perceptions about the usefulness and usability of received technologies, and peer effects. Specifically, the (evolving) perceptions, observable use, directives of others in the social system should, according to the sociotechnical lens, influence focal users' evolving perceptions and observable use of received technologies.

Principal-Agent Relationships in Community Health Work

A principal agent model, which is not explicitly or primarily sociotechnical, offers a complementary way to explore changes in authority structures and communication patterns that take place in a social sector workplace after a new ICT is distributed to workers. Principal agent theory offers insight on the conditions under which delegated use of a technology elicits better compliance, and better supervision of compliance, on other delegated tasks.

Community health projects do not generally operate in a vacuum, but are part of a global network of actors committed to and supportive of their work. A principal agent framework, described in this section, accommodates this embedded view, recognizing that the focal work setting, the health project, is located at the local end of a chain of delegation[11] that extends globally. Community health workers are the agents doing that delegated activity, community health work.

Financial and material support, along with contractual obligations to enact a mandate, come directly and indirectly from an agenda for global public health and community health work set by international institutions such as the World Health Organization (WHO) and the United Nations (UN), and for technology-enhanced community health projects by globally dispersed bilateral and private donors. Those supporters including the WHO, UN, and donors, are the most distal principals in the long

[11] More accurately, though tangentially, community health work is at the bottom rung of multiple, overlapping, and complex delegation chains.

delegation chain that characterizes aid-funded community health work. Thus focal projects adhere to principles and conduct activities according to an agenda that projects did not establish entirely independently, but that instead reflect the ideals and standards of this global network.

Members of the foreign aid and international development community may never personally encounter the health workers they support. However, these two distant groups are connected through a principal-agent relationship. Principal agent relationships may be understood as a dilemma of how an individual or group (*principal*, as depicted in Figure 1.2, or *multiple principal*, as in Figure 1.3) can motivate another (an *agent*) to act on the principal's behalf (Ross, 1973). Restated, a principal delegates her goals to an agent, who agrees to accomplish the principal's goals or mandate. It may not be fully within a given agent's power to implement the principal's wishes, so an agent may appoint another to complete the task, leading to a delegation chain.

This *chain of delegation* (Lake and McCubbins, 2006, in Hawkins et al. eds) refers to the hierarchy created to enact the will of a principal. Actors are linked through chains of authority or delegation, whereby the principal transmits downward to agents goals, tasks, and funds, and agents below transmit reports of the agents' work on the principal's behalf back up the chain of delegation. In the case of foreign aid, delegation chains are longer, and the challenges principals face in monitoring agents' behavior are more difficult than in other typical principal-agent scenarios (Milner, 2006). "[M]ultilateral delegation of aid adds a further link; aid monies then pass through some multilateral organization which, as the donors' agent, makes decisions about the distribution of aid but then passes on to its

agents the actual implementation of these decisions" (Milner 2006, in Hawkins et al. eds, p115-116). See Figure 1.4 for a simplified depiction of this long chain of delegation. The exact delegation relation varies at each level, and some depicted levels may be bypassed or move to join others. For another country or another domain in which foreign donors give directly to developing country governments, US taxpayers, elected officials, and bilateral agencies would feature above the recipient government in the delegation chain. Further, delegation can be conducted formally and informally, with contracts of varying specificity. Contracts may be implicit, as in the case of norms, or explicit as in the case of legislation or memoranda of understanding.

Community health work is lonely work, whereby in India, an unaccompanied woman is responsible for visiting 1,000 of her neighbors. She often walks long distances between homes to deliver health information and potentially life-saving basic care such as oral rehydration tablets. Despite her isolation, her work is underwritten and promoted by her government, foreign donors and taxpayers, bilateral aid organizations, international aid organizations, international financial institutions, and non-governmental organizations. Despite certainly nuanced and heterogeneous desires, this multiple principal believes generally in the importance of global public health as a priority of international development goals, and community health work as a tactic to support that priority. In this dissertation, the community health worker is the lowest-level agent in this principal-agent scenario, and she faces a variety of relevant proximate financial, legislative, and technology principals, depicted simply below in Figures 1.5 and 2.1. The delegation chain's bottom rung, where she does her work, is characterized by overlapping authority shared among

these proximate principals. Who holds ultimate supervisory authority was not always, in my observations, clear to community health workers or their various supervisors.

Figure 1.2. A Simple Principal Agent Model featuring a chain of delegation with three agents

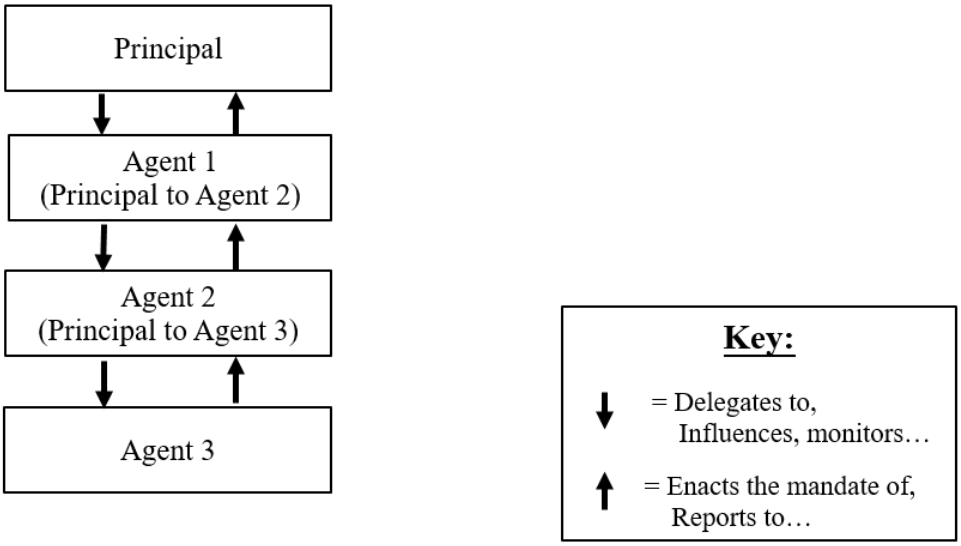

Figure 1.2. *This is a simplified principal agent scenario with a delegation chain featuring three agents, whereby Agent 1 becomes principal to Agent 2, and Agent 2 is principal to Agent 3. Source: Author's elaboration of Hawkins et al, 2006.*

Figure 1.3. A Simple Principal Agent Model featuring multiple principals and a chain of delegation with three agents

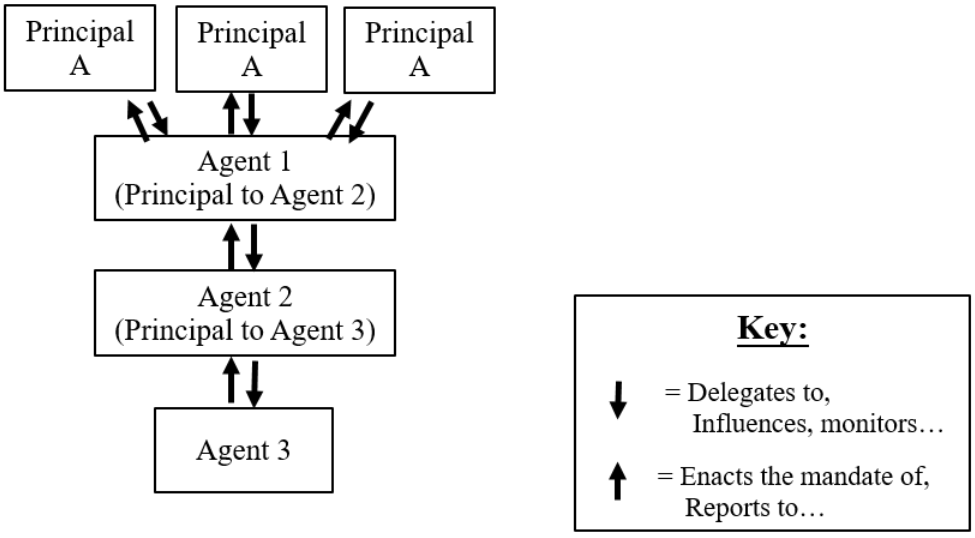

Figure 1.3. *This principal agent scenario features a multiple principal, by which "each principal enters into a separate contract with the same agent" (Hawkins et al, 2006, p. 361). In this case, three principals comprise a multiple principal for Agent 1. Agent 1 remains principal to Agent 2, and Agent 2 remains principal to Agent 3. Source: Author's elaboration of Hawkins et al, 2006.*

Figure 1.4. Village-Level Health Work and the Long Delegation Chain of Foreign Aid

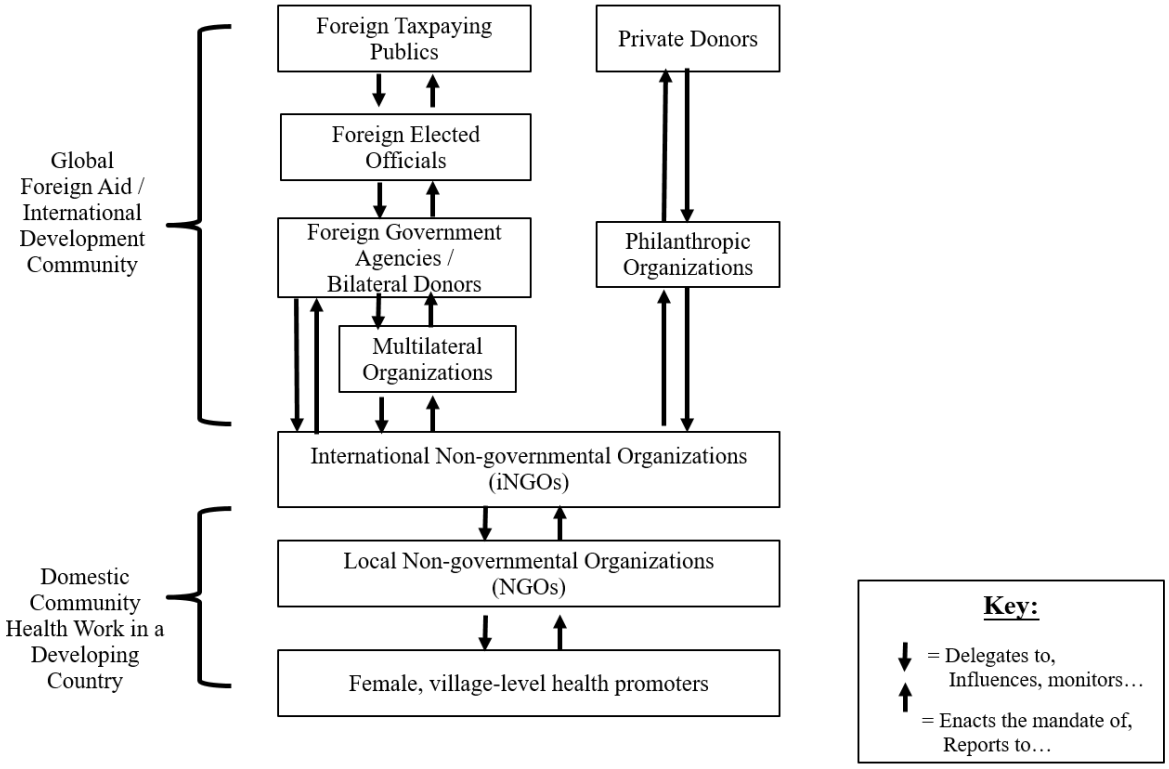

Figure 1.4. *In this simplified model, a multiple principal, the development community, delegates a mission – improve health outcomes – to a local health organization that employs village health workers to implement a program that will deliver impact. Delegation often takes the form of funding and strategic direction, articulated in a contract. Agents report their mandate-oriented work and expenditure back up the chain of delegation, and the principal assess whether to continue to fund the agents' work.*

Figure 1.5. Village Health Workers in India Face Simultaneous Delegation and Multiple Proximate Principals

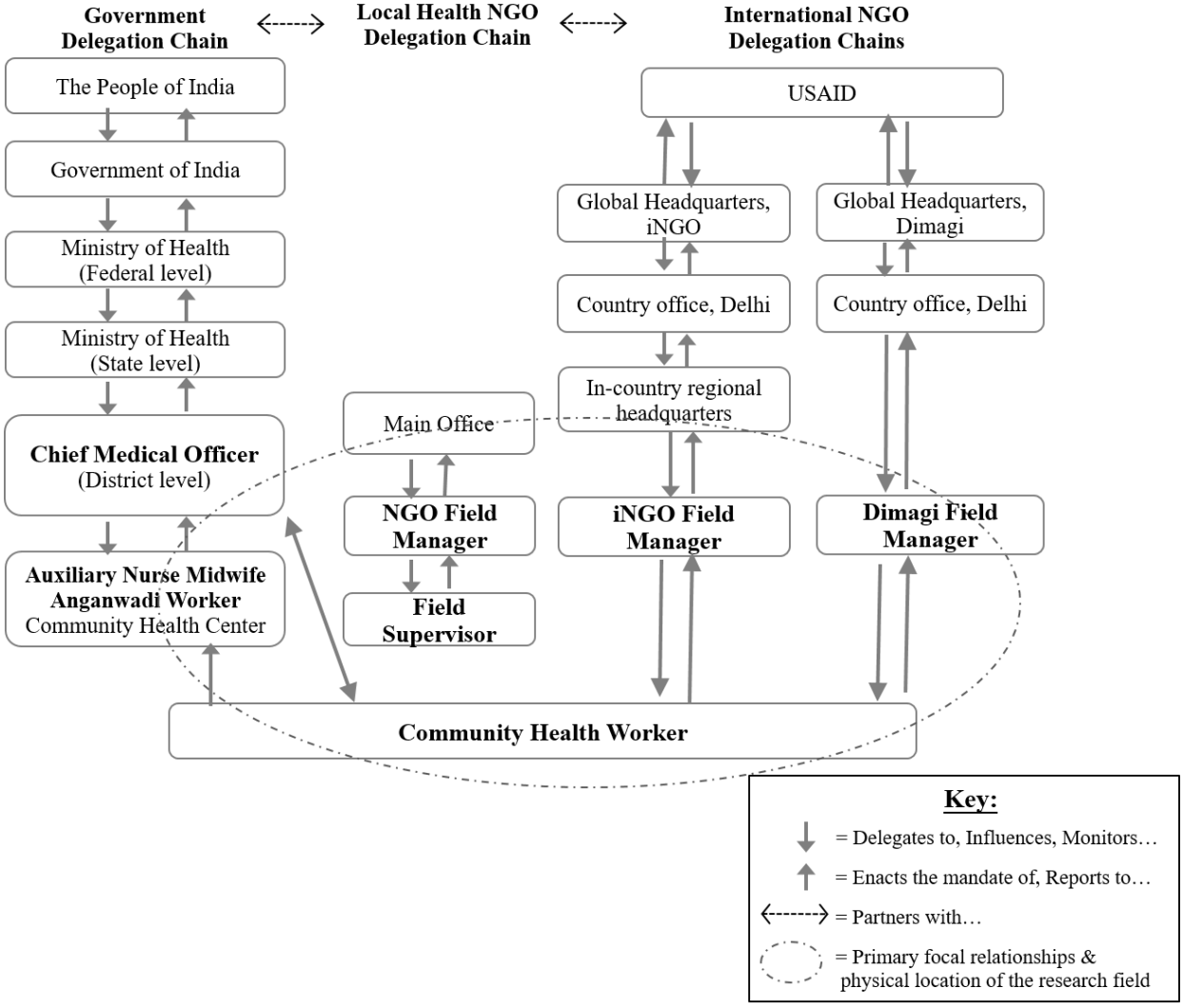

Figure 1.5. *This illustration depicts, in the context of a principal agent relationship, the organizational structure of a typical Indian community health project included in this dissertation research. Source: Author's elaboration of Hawkins et al, 2006.*

In the above figures, downward-pointing arrows depict the flow of mission-oriented task demands, resources, and funds, all proxies for both authority and of

geographic distance between actors. Upward-pointing arrows depict reporting relationships, whereby agents may transmit information about progress on delegated tasks back up the chain to actors who delegated those tasks. All arrows also depict the sequence of communications flows between and among actors. Therefore the illustrations also depict the sequencing, and possible delay, in the movement of critical information about agents' actions on behalf of the principal. "The principal-agent literature focuses on situations where an individual's [agent's] actions can neither be observed nor be perfectly inferred on the basis of observable variables." (Stiglitz, 1987, p1). Even under conditions of agents' faithful intentions and behavior on the principal's behalf, agents will have incomplete information about the principal's preferences, and the principal will have incomplete information about that behavior.

Any delegation is necessarily characterized by information asymmetries, but information asymmetries are exacerbated by the long delegation chains that characterize foreign aid *and* that characterize community health work. Foreign aid relationships feature geographic and political disparities between payers for and beneficiaries of delegated action, and these disparities exacerbate any other information asymmetries (Milner, 2006, citing Martens, et al, 2002). Further, I argue that the relatively remote physical location, distributed status of community health workers, and traditional paper-based reporting exacerbate information asymmetries along the chain of delegation. Community health work in the context of foreign aid features particularly long delegation chains, and thus meaningfully severe monitoring challenges, because of serious communication challenges and geographic distance between community health workers and their most proximate

principals. The community health worker works at her neighbors' home, with often only monthly access to her direct supervisor, a government nurse, who, as elaborated later, may be unaware of the supervisory nature of their relationship. This infrequent interaction contributes to a recognized mentoring gap for community health workers (Lehman and Sanders, 2007, and personal interviews), and also a monitoring gap for even further-flung stakeholders. Introducing ICT in this setting could reduce those monitoring challenges and relieve some tensions associated with information asymmetries.

Figure 1.5 depicts, in the context of a principal agent relationship, a simplified organizational structure of a typical Indian community health project included in this dissertation research. This model may look slightly different for specific projects. For example, for some grassroots health organizations, the field office and the main office may be the same. Further, many projects feature more domestic and international funders than are depicted here. Moreover, the Figure 1.5 does not depict the often overlapping roles that partner organizations take. International NGOs in particular often participate in both funding and in implementation. The right-most relationship in this model depicts the delegation chain of the technology partner, Dimagi, for whom USAID is a major funder. I argue that the focal organizations in this dissertation experience frequent opportunities for slack in the form of shirking and slippage (as per Cortell and Peterson, 2006). I observed neither. The key challenge for principals in the focal principal agent relationships was not about minimizing slack (enforcement) but about verifying whether or not slack was happening (monitoring).

Expectations of Using Computing Technology as a Partial Solution to Asymmetric Information

Health projects adopted this dissertation's focal technology, CommCare, to help health workers become more efficient and effective in their jobs by helping them increase the quality of and reducing the transaction costs of carrying out health care work. In addition to any idiosyncratic project goals that using ICT into work might achieve, a key benefit to introducing a radically better ICT into the context of a principal agent relationship is to improve principals' confidence by improving the quantity, quality, and timeliness of information they receive about the work conducted on the principals' behalf to achieve principals' goals.

Strategic use of inexpensive computers, phones, software, airtime and Internet access could facilitate digitization, better or more frequent communication, and improved data monitoring, aggregation, and reporting. More, better, aggregated and accessible data can be more easily reported all the way up the chain of delegation, in a timelier manner, allowing each intermediary actor to better and more quickly monitor its agents' performance and to do its own reporting. This more and better information would in turn facilitate timelier and better-informed decisions about future investment in community health projects, and easier identification of the field operations that might require additional monitoring or mentorship.[12]

[12] As mentioned in the caption for Figure 1.5, use of these new tools could also facilitate improved enforcement of principals' delegated mandate and reduce agency slack by reducing slippage and shirking. However, these enforcement challenges were not key features of focal projects, whose donors' monitoring challenges were more prevalent.

Previously, I noted sociotechnical expectations about health project organizational throughputs that relate to human behavior using ICT in the workplace. Users may use technologies as instructed, and will also circumvent supervisors' built-in and planned ways of using the technology to invent new ways, develop evolving routines, behaviors, perceptions and observable use of received technologies.

The principal agent model adds a new set of expectations around organizational outputs, especially that surround the new data that should emerge from implementing an ICT like CommCare in a work setting such as foreign aid-funded grassroots health project in India. Use of CommCare should result in important organizational outputs, including new data available to project participants including community health workers and staff, and other stakeholders such as clients, government medical officers, and partner and donor organizations. Given their systematized and digital collection, data quality and transmission frequency should increase.

In Chapter 5, then, I explore how introducing CommCare changed the data and information available to these community health workers and their most proximate principals, communication patterns among them, and relations of authority. Adopting a new ICT such as CommCare should lead to proximate and distal principals' better oversight and control over health projects. Focal relationships include interactions between the health worker and her supervisor(s), between health worker and her clients, and between supervisors and on- and off-site project managers.

I further expect that project participants will have better information based on these data, the analysis of which should help them make better decisions. These improved on-

the-ground understandings should affect supervisors' directives to health workers, health workers' daily selection of clients to visit and messages to deliver during visits, and government medical officers' prioritization of community health tactics in their respective regions. I also expect that project partners and funders will receive more frequent information in the form of reports which will help them evaluate their strategic allocation of health work funds.

Changes in communication patterns are implicit in these changes in access to data. Some communication patterns may disappear, such as keeping hand-written diaries to record client visit and immunization data, and the periodic manual aggregation and submission of these reports to project stakeholders. Other communication patterns may deepen, such as the mode, frequency, and quality communication relationship between donor and project supervisor, project supervisor and community health worker, community health worker and client, and project participants and government stakeholders. If this came to pass, the evidence would be an increase in the number of reports, discussions about the reports, and enforced decisions based on those reports, relative to prior to the CommCare adoption. Local supervisors may also have increased control over projects' influence over health outcomes, based on improved strategic decision making about how to prioritize organizational resources and activities in best service of project goals. Finally, I should observe increased supervisory control over community health workers, and the evidence of this may come in the form of use of CommCare-produced data in hiring, firing, and training decisions, and in more frequent or more effective enforcement of the demands of the job.

In sum, the principal agent model suggests that improvements in data and communication patterns that develop within grassroots health projects due to use of a new ICT will lead to new forms of authority that reflect improved oversight and control by actors over their agents. Indeed, introducing a new ICT such as CommCare could help decrease information asymmetries, and improve monitoring of agent behavior, all along the delegation chain.

ROADMAP TO THE DISSERTATION

Technologies such as the ones used in focal projects promise job assistance, digitization, and improved data monitoring, aggregation, and reporting. The potential of ICTs to enhance development impact is clear and exciting, but it is not yet clear, theoretically or empirically, *how* to unlock that potential. Development actors often behave as though the introduction of a new technology will automatically lead to a positive feedback spiral. Donors hope that providing ICTs will transform social sector performance, enhancing benefit for the populations their grantees serve (Techsoup Global 2013). However, converting access to potentially transformative technologies into organizational performance improvements, and, ultimately, to social improvements, depends on organizational reorientation, staff learning and behavior change. Technology adoption is risky for any organization. The learning process requires temporary diversion of financial and human resources from the organization's primary work. The systematic use that

precedes improvements in performance and reporting are demonstrably difficult even in the best-resourced workplace settings.

This dissertation examines how agents (community health workers) use new mobile technologies to deliver health care services by looking at the use, and the proximate determinants and effects of that use, in nine extended deployments of a popular mobile application, CommCare, in village-level health work in India. An exploratory approach facilitated revelation of additional outcomes that were not the initial focus of the projects studied or of my research, but were nevertheless perceived as deeply meaningful to individual study participants across studied projects, and are also meaningful for the field of development.

The focal health workers, instead of their clients, felt these unpredicted outcomes, especially in the areas of digital inclusion, education, and women's empowerment. I argue that, at least in the short term, use of the new technology changed social relations for health workers in important ways. The devices were a source of prestige for health workers at home and in their clients' homes. Further, they were a source of real power for health workers, who learned from the information contained in CommCare (increasing health workers' knowledge and authoritativeness), and who guided clients' beliefs about the unwavering correctness of the messages contained in CommCare. I discuss these spillover effects of ICT use throughout this dissertation's empirical chapters, and in the concluding chapter.

This dissertation's second chapter, "Sample and Methods: Ways of Understanding ICTD Projects," describes the empirical methods used and the observed health technology

projects. This chapter describes primary data from in-depth, semi-structured interviews and extensive review of project documents, and personal observations from field visits in India in 2013. This chapter explains my sampling and interpretation methods. Chapter 2 concludes with the limitations of my qualitative study and the actions I took to mitigate these limitations.

Chapter 3, titled "Mobile Computing Technology as Bridging the Ideals and Realities of Community Health Work," first describes in more detail the challenges of community health work and the reasons for using ICTs like CommCare to mitigate those challenges. This first section highlights the divergence between the Government of India's guidelines for community health work and how prior research and my observations of community health work diverged from this formal plan. Next, the chapter summarizes the key features each of nine focal projects. This second section describes the critical features and stated goals of each ICTD project, such as the location, number of participants, project objectives, and a briefing of salient ICTD project implementation policies. The section also highlights key commonalities and differences in implementation tactics across projects. The chapter continues with a review of the intended benefits of CommCare in addressing these challenges and describes the actors that comprised the subjects of and participated in this study.

This chapter concludes with an analysis of project outcomes with special attention to previously overlooked unplanned benefits for health workers. I described additional outcomes of health projects' deployment of CommCare that arose from neither my sociotechnical nor the principal agent expectations but were commonly highlighted by

research participants as important. These unexpected outcomes relate to digital inclusion, women's empowerment, and education for the health workers themselves. I give special attention to a sub-population that may be characterized as vulnerable but not the target beneficiaries of the studied projects: frontline workers. Using data from seven projects, this chapter describes the observable and perceived effects of adoption on projects' mobile health workers, who themselves have characteristics often targeted by development projects. Being female, poor, with low education and poor access to ICTs, and living in geographic areas characterized by discrimination against women and girls, the health workers themselves are themselves especially good candidates for other typical development projects prioritizing women's empowerment, education, or digital inclusion. The studied ICTD interventions targeted their neighbor-clients: pregnant women and young children for health effects, but community health workers themselves were also a treated group, who perceived meaningful effects not on their health but on these other important outcomes.

Chapter 4 is titled "Empirical Observation of Uses and Influences on Use". Based on the socio-technical relationship described in Chapter 1, this chapter explores how the project itself mediates the interaction between the focal individuals (community health workers) and a focal technology (a work-issued device loaded with CommCare). This chapter explores project-level characteristics and implementation policies that affect use of work-issued devices, and the rationale behind those policies, to reveal potentially competing priorities, project planners' choices, and exogenous factors that directed technology use in unplanned ways. To understand the consequences of these policies, I

compare how users were instructed to use their devices with how they actually used them, and perceived effects, if any, on work, skills, morale, device integrity, and the ability to advance personal, professional, or project goals.

In this chapter, I describe individual actors' perceptions and official statements about the anticipated purpose of using the adopted technology, perceived threats and tensions over control of devices, and active project intercession in human-computer interaction, via technical selection, implementation policies, and supervisory actions. I also describe my observations of actual use of mobile technology by community health workers, in spite of or according to project rules, and the meaning of such use to project stakeholders. I further explore tensions between projects' objectives and how users appropriated devices beyond projects' scope.

Exploring the contested and negotiated boundaries of expected, ignored, and banned use of mobile devices deployed for a social purpose revealed implicit policies, unintended consequences, and tensions that may face any social sector mobile implementation. The focal deployments overcame these challenges to deploy their mobile devices in a way that met or exceeded many objectives. This dissertation attempts to make explicit these implicit challenges, choices, and consequences, and to extract lessons for others.

Chapter 5, Observational Study of Deepened and Complicated Authority, describes observations directly related to principal agent understandings of the relationship between village-level community health workers and their supervisors. This chapter focuses on observations that relate the introduction of the new technology to changes in power and

control for direct participants in community health work. Some of these changes aligned with established authority as coded on organizational charts and in signed contracts, while were unplanned or unexpected assertions by health workers of authoritativeness and shared power or collaboration. Finally, I report on informational issues, including changes in project data as collected and communicated, new communication patterns, and evolving client, health worker, and supervisors' perceptions about the credibility of CommCare and the data facilitates collecting. Taken together, I find that these new data and communications between community health workers and their proximate principals results in real improvements in principals' ability to monitor community health worker agents. I also find real improvements in principals' ability to increase alignment between agents' behavior and principals' mandates.

Chapter 6 summarizes my findings and interprets the outcomes on the health workers, beyond the scope of health projects' narrowly-defined goals. I make recommendations for organizational policy of technology project implementers and donors, and propose some fruitful extensions of the dissertation for future research.

Chapter 2. Sample and Methods: Ways of Understanding ICTD Projects

This dissertation represents descriptive, exploratory research intended to inform two questions: (1) in resource-constrained social sector settings, what project features affect the use of work-issued mobile devices by workers in the field? And (2) How can decision-makers adjust rules and implementation plans to maximize devices' benefits while minimizing projects' and field workers' burdens of adopting the new technology?

This chapter describes the qualitative empirical methods used in this dissertation research. I construct primary data from field observations, document review, and semi-structured interviews with 62 community health worker, supervisor, funder, government, and technology developer participants in nine health projects in six states in India conducted over six months in 2013.

This dissertation neither claims to demonstrate statistical association or causation, nor employs sampling logic for generalizability. Instead, this study uses the qualitative logic of credibility and validity (Cresswell, 2007, p. 77), which engages a number of techniques to strengthen one's interpretations. First, I employed *triangulation*, studying nine instances of one phenomenon; seeking multiple data sources including interview, document review, and personal observation in order to corroborate or disconfirm my understanding of those instances, and engaging multiple theories to analyze evidence. I also employed *peer review* and *debriefing* of colleagues at Microsoft Research during my data collection period and subsequently in conferences and publications, to help with

ongoing assessment of the research process and interpretation. Further, I employed *negative case analysis,* studying instances that might not support the patterns that I found in my main data. I discuss these informal units I refer to as "Dimagi self-starters," in the limitations section below and in the Appendix. I also *clarify research bias* in the limitations section. Finally, I employed *member checks,* during which I frequently solicited the views of one represented from Dimagi, one project's NGO, and one project's iNGO, to assess the credibility of my interpretations as they unfolded (Cresswell, 2007, also citing Ely et al, 1991; Lincoln & Guba, 1985; and Merriam, 1988) to ensure the credibility and validity of this study. Cresswell (2007, p.202) quotes Lincoln and Guba (1984, p. 314) as asserting that member checks, by which the researcher takes data, interpretations, and conclusions back to study participants for feedback, are "the most critical technique for establishing credibility" in qualitative research.

SELECTION OF FOCAL TECHNOLOGY AND STUDY SETTINGS

Community health work, as described in the previous chapter, is a WHO-recommended strategy. Governments and health NGOs have recognized and implemented the strategy to mitigate the challenge of insufficient health facilities and trained health professionals in low-income rural populations. Focal projects' supervisors and funders initiated ICT projects to support community health work, a strategy that faced its own challenges. The dispersed workforce of mobile community health workers, many of whom are known as *ASHAs,* is generally insufficiently trained, paid, and equipped to complete

their responsibilities. They are tasked with completing more activities than is logistically possible to accomplish in a typical work week. Further, the Government of India, which oversees about 900,000 *ASHAs,*[13] expects local health ministries to support their local ASHAs' work by distributing flipcharts, books that describe, in pictures and in text, symptoms of anemia, advice for avoiding gestational diabetes, and other health topics. These flipcharts are intended to facilitate conversations between health workers and clients, and inform clients about the importance of these health topics and how to adopt healthy behaviors.

In practice, this basic technology is ineffective in facilitating these conversations. Not all ASHAs receive the flipcharts, or they receive them late, as some states and districts issue them more widely and speedily than others[14]. Many ASHAs report leaving the flipcharts at home because they are heavy or because ASHAs can not read them due to poor literacy skills. Other ASHAs lost or damaged the flipcharts, which are not waterproofed and susceptible to monsoon and water crossings, as most village health workers walk from client home to client home.

Dimagi, a US-based for-profit software development firm with a social mission, developed the software application CommCare to help address many drawbacks of the

[13] National Health Mission, Ministry of Health & Family Welfare, Government of India. Data reported from March 31, 2014. http://nrhm.gov.in/communitisation/asha/asha-data.html (Accessed November 12, 2014). The Government of India reports that there are currently nearly 894,525 ASHAs (in some places Link Workers are counted as ASHAs) in India.

[14] Further, research participants reported that the chronic shortage of immunizations, iron tablets, oral rehydration tablets, condoms, and other provisions ASHAs are mandated to dispense, according to the National Health Mission (http://nrhm.gov.in/communitisation/asha/about-asha.html, Accessed November 14, 2014) further undermines ASHAs' credibility when they encourage visits to the health center to receive these items and they are not available.

paper-based flip charts and to provide the skills, resources, and training that community health workers face in developing countries. CommCare, loaded on a mobile device such as a phone or tablet, helps health workers choose the most relevant health messages for individual clients. CommCare also features audio recording of relevant health information, so health workers, who themselves may not fully know the messages they are supposed to deliver, can play the messages during client visits and correctly impart complete, relevant information. Health workers use CommCare via a mobile computing device[15] that can be stored in a health worker's pocket, sari, or purse. It is therefore less burdensome to carry than a flipchart and may be better protected from monsoon weather.

CommCare seemed an appropriate choice of ICTD for in-depth study, as it is increasingly distributed to developing country village-level social sector workers. Reports from pilots of the earliest CommCare adoptions suggested that CommCare delivered on some of its promised performance improvements. For example, a peer-reviewed CommCare study demonstrated "data management gains in terms of data quality, completeness, and timeliness for 836 recorded patient cases" by five health workers over a one-month period in rural Uttar Pradesh (Medhi et al, 2012, p. 1).[16] Medhi et al (2012)

[15] Health workers access CommCare during their client counseling sessions via a mobile device, typically a feature phone, a basic phone with limited Internet and media capabilities, or a smart phone. *Feature phone* and *smart phone* are two commonly-used phrases with incredibly vague definitions. Compare these with basic phones, which have a stable set of features limited to calling and text messaging. Feature phones and smart phones have media and Internet capabilities that basic phones lack: camera, video player, browser, etc. Feature phones and smart phones function more like handheld computers than as phones. The difference between feature phones and smart phones, however, is not technical, and seems to be a know-it-when-you-see-it categorization. For the purposes of this dissertation, feature phones have Internet and media capabilities, and resemble our early Internet- and media-enabled brick phones and flip phones with keypads.

[16] These five health workers were randomly chosen from among the ten health workers participating in the CommCare pilot, for which health workers were purposively selected. The specific data analyzed were a particular type of form (cumulative forms), from a randomly-selected four-week period over the three months

came to these findings via interviews with the health workers and comparing the data input into CommCare against the same data that the health workers had also entered into paper-based forms.

Many of the projects reported in this dissertation represent early attempts to expand the use of CommCare beyond a pilot stage. These transitions typically started with 10 end-user community health workers and expanded to a small scaled adoption by all the community health workers in a locality or grouping, typically a health program in an organization, or all the community health workers in an administrative district. This transition period was a particularly fruitful time to observe use, for a few reasons. First, some research participants could also reflect on the time prior to adoption with clear memories, and could reflect on moments of tension or changes to the implementation plan, especially as the implementation added new end-users. The newer end-users could reflect on their recent experiences learning to use a technology that was brand-new to them. New users' peers and supervisors who had received CommCare devices earlier, especially those who had experienced the initial adoption period, could reflect on the differing experiences of the earliest and most recent learners.

Further, this transition time also reflected a change in the funding structure, and thus the embedded nature of foreign support, for these ICTD projects. The early-stage CommCare projects in India were resourced in large part by CommCare developer Dimagi, which had obtained USAID funding to provide 10 devices to many of these projects, and

of the study. The rationale for this randomization procedure was not explained. It is not clear from reporting how many forms comprise each of the reported 836 cases or how the researchers arbitrated between paper and electronic data submissions to determine which if either were accurate.

provide an on-site Dimagi representative to help with health workers' early transition to CommCare. In contrast, the move from 10 health worker end users to the small scale-up projects reflected the first time the implementing organizations were going it alone. Implementing organizations were forced to test their abilities to manage distribution of CommCare devices to new health workers participating in the project, to train on use of these devices, and to independently troubleshoot technical problems including SIM challenges, memory card and application malfunction, and other issues that had been addressed previously by a Dimagi representative.

All focal deployments faced major financial and other resource constraints to implementation and training, including poor infrastructure, especially roads, electricity, and water, and health workers who reported experiencing low levels of respect from their clients. These staff and their supervisors reported that health workers' low skills explained clients' low respect for them. They referred to both poor technical skills, low knowledge of how to use health flip charts and information and communications devices such as mobile phones and computers, and vocational skills including job-related literacy, numeracy, calculating undernourishment, and knowledge and application of the health topics that constitute their main work. The focal health workers were not medical professionals, and had minimal medical or para-medical training, on average fewer than 30 hours. Nonetheless, they were the face of medicine in their communities.

The remainder of this chapter describes the dissertation's method of observation and analysis, to understand how CommCare devices are used, the immediate influences on, and effects of, that use. I studied how behavior and workplace routines changed after

CommCare's introduction, as well as any subsequent changes in data, communications, and authority.

Data Collection and Analysis

This dissertation uses case study of multiple instances of the same phenomenon: nine semi-independent deployments of CommCare-enabled devices to groups of village-level health workers in India. In this dissertation, the unit of analysis is the ICTD project. The *project* relates to the specific set of objectives, procedures, timelines, activities, and resources surrounding a programmatic decision to introduce CommCare into work. The term *deployment* is generally used synonymously with *project*, and implies the strategic distribution of the focal technology among participants in community-level health work. A deployment or project is illustrated in Figures 1.5 and 2.1. As described in more detail below, for each project, I interviewed as many people as possible who had field experience during each project, to understand patterns of use and surrounding actions undertaken by community health workers and their immediate supervisor.

By studying multiple deployments of the same digital technology, my inductive conclusions are strengthened through the observation of various experiences of the same phenomenon. According to the nested definitions laid out by John Gerring (2004), my dissertation is an exploratory case study of community health projects' deployment of a mobile-device based software application as a job aid and data collection tool to community health workers. Specifically, in 2013 I studied nine community health projects'

2012 or 2013 deployment of CommCare to community health workers in India. The larger class to which this case study belongs includes resource-constrained, village-level health projects anywhere in the world, that deployed to community health workers any mobile application such as CommCare, ClickMedix, mSakhi, MobileMRS, MedicMobile, or FrontlineSMS:Medic, to name a popular few. Within this study of CommCare deployments, I intensively study nine *units*, or instances of my chosen case, purposively selected to study an array of perspectives and experiences of CommCare deployment. The boundaries of my unit are delineated by the Indian community health project that deploy CommCare technology.

The boundaries of the studied units are permeable in the sense that many deployments feature actors with often only brief involvement, and partners from multiple overlapping organizations. Gerring (2004) attributes these challenges to "the complexities of within-unit analysis" (p. 244). In my study, I address the challenge of defining the temporal and membership boundaries of each unit by following CommCare and CommCare devices within each project. Health projects became relevant instances, and potential units of interest for study, well after project managers decided to deploy CommCare. They had already completed an exploration of options, internal negotiation, a purchasing decision, a purchase, receipt of devices and software, set-up devices with CommCare, and had trained their health workers to use the devices in their daily work. They had already also had at least two or three months to observe their health workers' use of CommCare and devices in the field, and modify, if they found appropriate, their approach to the deployment. I addressed the challenge of establishing, within each health

project, who within each organization could reasonably be considered a member of or participant in the unit of interest by identifying who on health projects actually used work-issued devices, the client-interfacing CommCare, the administrative back-end CommCareHQ, and reports of CommCare-collected data (see Figure 2.1 below). I observed these projects on a range of variables inspired by the sociotechnical and principal agent understandings outlined in Chapter 1. I describe procedures for structuring my observations, and the organization and analyzing the resulting data, below.

My study design has been iterative, and I modified my research questions over the course of data collection to "reflect an increased understanding of the problem" (Cresswell 2007, p19). I follow a systematic procedure for this iterative design according to methods outlined in Cresswell (2007), and Stake (1995), framing my work to include the "fundamental characteristics" of a "'good' qualitative study," including "an evolving design, the presentation of multiple realities, the researcher as an instrument of data collection, and a focus on participants' views" (Cresswell 2007, p 20-21). In this endeavor I sacrifice some objectivity for an increased understanding of a new issue that is not yet sufficiently described to undertake a more objective, large *n* study.

Because assertions arise inductively *from* a case study and due to the emergent nature of the research design, specific hypotheses were difficult to develop in advance. However I did have expectations about what I would see, as noted in Chapter 1. First, I expected that CommCare's monitoring and reporting capabilities could improve health project stakeholders' knowledge about health work, by aiding the production of relevant information and timely access to it at all levels. With proper use, efficiency gains should

follow from digitization of records; improved data aggregation and reporting; and better or more frequent communication. These improvements, reported up the chain of delegation, could allow each intermediary agent to improve its own reporting and decision-making. Second, I expected to find evidence that project features influenced whether and how individuals used, the adopted technology. A key research goal was identifying which aspects of the project were, according to project participants, most meaningfully influenced use.

Taking the ICTD *project* as a unit of analysis, this dissertation describes the relationships among members, organizational tasks, rules, and the technology itself, in order to understand the organizational influences on individual project participants' use of a new technology after it had been deployed. This meso-level analysis connects village level workers with the donors and technologists whom they may never meet but who provide resources (i.e., funds) and tools (i.e., technology) that are expected to improve their work. This ecosystem approach to case study analysis affords thinking of the project as an open, dynamic, and emergent sociotechnical system. In this system, many stakeholders may physically be far away or peripheral, but at certain junctures, such as the time of grant award or technology purchase, may meaningfully influence projects' direction and implementation.

Figure 2.1. End Users in Community Health Projects' CommCare Deployments

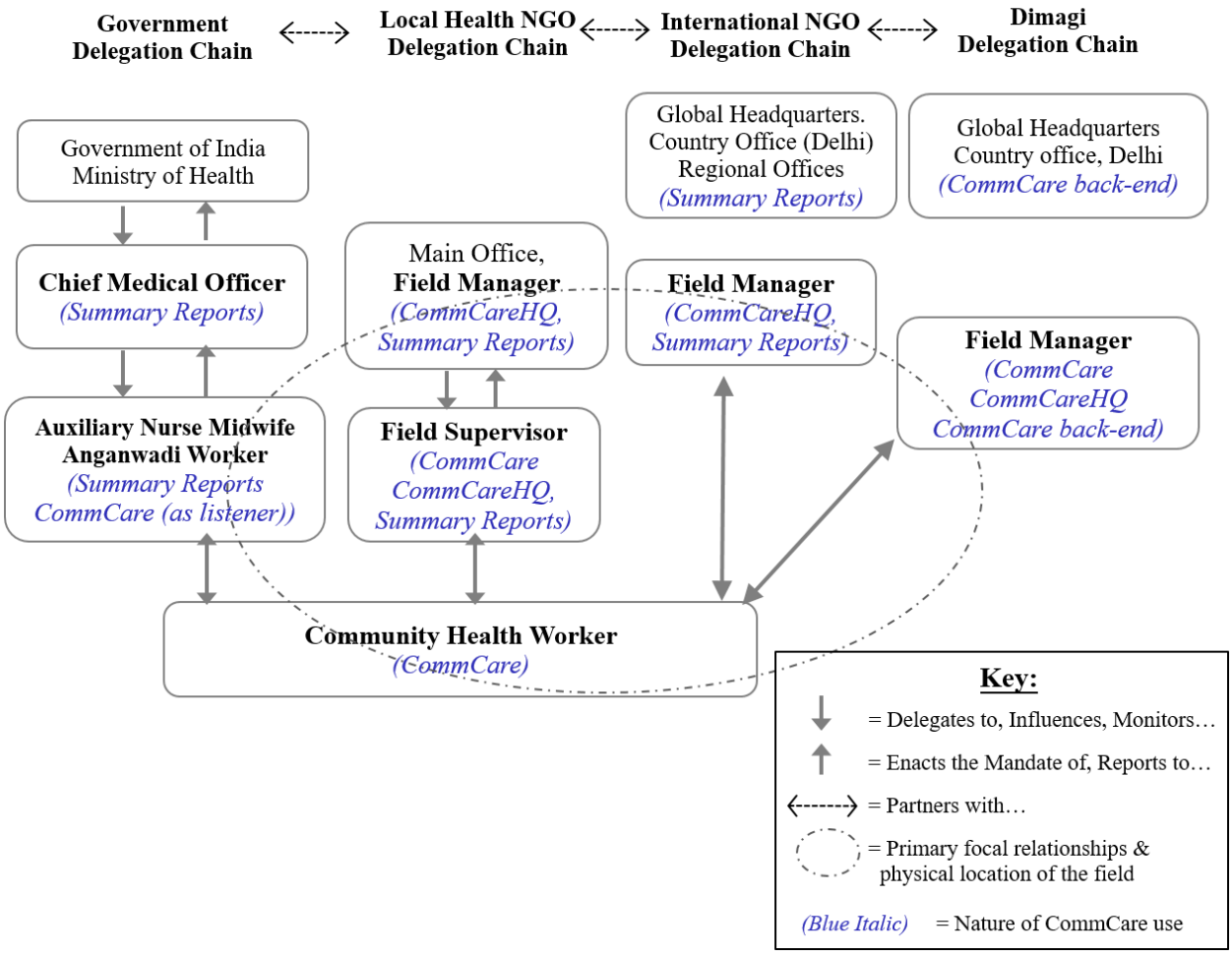

Figure 2.1. *This illustration depicts, in the context of a principal agent relationship, the organizational structure of a typical health project's deployment of CommCare to community health workers in India. Source: Author's elaboration.*

Within each studied project, I sought to interview someone involved in the deployment and use of CommCare, who matched each of the following roles, which I defined before I entered the field and did not know in advance which organization each role applied to. These roles include

- Community health workers, who used CommCare on mobile devices during daily visits to neighbors' homes to deliver health information;
- Health workers' direct supervisors, who, I learned, conducted daily work in a field office but who occasionally accompanied health workers on their client visits largely to monitor and mentor health workers' use of CommCare.
- Project managers, who, I learned, did daily work in a field office but who occasionally visited a (regional) headquarters. Project managers primarily interacted with CommCareHQ, a software application accessed via desktop computer, which facilitated administrative access to data that had been input via CommCare. Project managers also used CommCareHQ to create reports about clients and about health workers, which the project managers distributed (or, in many cases, intended or attempted to distribute) to funders, and government partners. In some CommCare projects, I observed that individuals had both supervisory and managerial duties.
- Project champions, who motivated other planners to choose CommCare. I observed variation in what became these individuals' formal project roles.
- A person typically responsible for end-user training on CommCare and devices, who, I later learned, overlapped heavily with the field supervisors and project managers described above, and
- Technical staff from implementing projects and Dimagi, CommCare's developer.

In practice, there was significant overlap in these roles as they were conceived at the outset of the study. Individual project participants related to CommCare at relevant junctures in a number of ways, including (1) Supervisor or technician, who adapted and distributed devices and software, (2) User of CommCare devices, who produced data, and/or (3) Consumer of the new data using the linked software application, CommCareHQ. Indeed, observation and interviews revealed additional individuals who had agency, or were perceived to have agency, over projects than project planners had counted on. These actors are described in Table 2.1 below, which identifies actors according to their primary role in the CommCare project, and labels and defines each actor as I coded them during analysis. While the *project* is not an animate actor, I distinguish projects (labeled "A1" in Table 2.1) from human project participants (A2-A9) during my data collection activities. As discussed, I sought to identify a specific set of objectives, procedures, timelines, activities, and resources surrounding a programmatic decision to introduce CommCare into work. In the observed deployments, projects were typically implemented as a collaboration among multiple organizations and the government, so statements issued by a *project* do not necessarily fully align with statements issued by the project's partner organizations or by any individual participant. I assessed project expectations and outcome perceptions by reading implementation plans, contracts, grant proposals, annual reports, marketing materials, etc. I attributed the motivations, goals, and perspectives found in these written documents to the project (A1), and attributed the stated opinions of individual members during interviews and written correspondence to the speaker (A2-A9).

Table 2.1. ICTD Project Actors

A1. Project as an entity. This code refers to written statements put out under the name of a project or its implementing organizations. A1 inheres in memoranda of understanding, contracts, job descriptions, marketing materials, websites, etc.	**A9. Government representatives** in this study were most typically members of local Health Ministries. Local Chief Medical Officers and Block Medical Officers often featured prominently in community health projects.
A2, A3. Community Health Workers (CHWs), including Accredited Social Health Activists (ASHAs), government-incentivized volunteers who provide health information to women in their communities. Many ICTD deployments target ASHAs. Other CHWs can be local government- or NGO staff with similar jobs and socio-economic profiles as ASHAs, but often have better literacy or training.	**A10. Clients**. In studied projects, clients were typically rural pregnant women, and by extension, their current and future children. Community health work often targets other family members for particular services.
	A11. Clients' family and neighbors. Consultations took place in clients' homes, often in the presence of family or neighbors, who had much reported influence over interactions between health workers and clients.
A4, A5. On-site ICTD project staff or managers are most typically employed by local or international NGOs, and whose position entails supervising ICTD use or management of an ICTD project.	**A13a. Device or CommCare**. The device and CommCare were frequently referred to by research participants as behaving with real agency – listening, reporting, tricking, etc.
A6. Off-site ICTD implementation partners are members of the same organizations as A4 and A5, but who are physically based away from the ICTD project site, typically in a population center.	**A12, A13b, A13c, A13d. Health workers' family**; **mobile shop owners; strangers and thieves**; and other organizations. Non-participants in the health projects or the specific ICTD interventions studied were frequently referred to by research participants as behaving in ways that meaningfully affected health work due to their influence over or direct action on project devices.
A7. Funding partner refers to the organization that provided funds or material resources; these often maintained a local presence and periodically visited implementation sites	
A8. Dimagi, a for-profit, grant-funded, social interest technology firm that developed CommCare, the software application used in all projects studied.	**A14. Researcher, journalist**, other non-stakeholder observer. These are beyond the scope of the study but often provided secondary documentation that was useful for this research.

This research featured multiple distinct data collection activities[17]. A summary of these activities is captured in Table 2.2 below. First, in-depth studies of CommCare featured

[17] The University of Texas Institutional Review Board (UT IRB) approved my study under Protocol Number 2013-02-0015, and I also received ethical approval for this work at Microsoft Research, Inc.

- Semi-structured interview of two to 26 individuals per project[18], with a total of 96 interview hours across 11 projects,
- Six on-site field visits, with two each in Rajasthan, Maharashtra, and Uttar Pradesh, and
- Document review from all sites, detailed below and in Table 2.7.

These research activities helped me understand context, implementation processes, and decision-making around rules of device use, perceptions about those rules, how explicit and implicit rules affect use and project goals. This work resulted in 456 total coded pages of interview statements, written documents, and field notes. Four additional, smaller-scale studies added variation in project goals, devices deployed, and end-user profile. Finally, I examined data from CommCare deployments referred to by Dimagi as "self-starters," or, projects that implemented CommCare without Dimagi's prior knowledge or help[19]. The text from these activities was aggregated into content that I later coded during analysis.

[18] As discussed above, I sought to interview as many project participants as I could, for each focal project. The range of research participants I spoke with per study site reflects both the size of each focal health project and the access I had to individuals within each health project. I interviewed individuals from 11 projects, and, as elaborated in the main text, nine of these projects are described as formal units in my study. This range of study participants per health project may threaten my internal validity, but I supplemented each study with extensive document review. In the end, I excluded from formal study any units I did not understand at the depth of the others, but discussed anything surprising or puzzling with those I was able to interview from the originating project and from other projects.

[19] CommCare is set up such that anyone can download it and try it out, but active use is logged by Dimagi because all data collected by CommCare are stored in a cloud managed by Dimagi. This way, the activities of anyone who uses CommCare in their work are documented through the application's sent forms. (Incidentally, this is likely to become a critical privacy issue which I discuss in this dissertation's concluding chapter. Dimagi are storing confidential health data without explicit permission, which creates a trove of data to study. All information that I received from Dimagi had been de-identified by Dimagi).

Table 2.2 Summary of Data Collection Activities

Data Source	Detail of Data Collected	Purpose (Project Labels)
In-depth field studies. CommCare projects deployed in India by January, 2013. (n=7 CommCare projects featuring 471 health workers and ~66 mostly web users. Cover ~235,000 population)	• Interviewed 62 on- and off-site decision makers and relevant Dimagi staff • Reviewed 58 primary documents • 456 total coded pages – interview transcripts and primary documents • A, B, K1, K2: field visits, end-user interviews & observation; • A, B: honed interview questions for later studies	In-depth understanding of context, implementation process, decision-making around use policies, their perceptions, and how they affect use and project goals. (A, B, C, D, E, K1, K2)
Additional studies. (n=2 CommCare projects featuring 635 health workers)	• Interviewed 4 Dimagi staff • Reviewed primary documents • 53 total coded pages – interview transcripts and primary documents	Variation in project goals, devices selected, and end-user profile. (G, H)
Informal Units. (n=2 CommCare projects featuring 58 health workers)	• Interviewed 2 Dimagi staff • Reviewed primary documents	Variation in project goals, devices selected, end-user profile, and geographic location. (I, J)
Informal Units. (n=28 projects, including 1,422 health workers and 228 web users. Cover ~204,000 clients)	De-identified detail of CommCare use by all active self-started projects. These projects deployed CommCare without Dimagi's active participation.	Variation in formal partners, to include projects that deploy without the developer's assistance. These data demonstrated that it was possible, and not uncommon, to deploy CommCare and sustain its use without the developer's involvement.

In June 2013, CommCare developer Dimagi provided me with a list of seven (A, B, D, E, G, K1, L) CommCare deployments, six of which met initial selection criteria: deployments that had lasted at least six months, and featured at least 10 individuals who were expected to use a CommCare device in daily client interactions. Of the six, I approached three for intensive study, on the basis of my *a priori* understanding of their use policies and their devices in use. At that point, I understood "use policies" loosely as either *permissive* or *restrictive*, terms that I and my mentors at Microsoft Research India used to

describe the strictness of the rules project managers imposed on health workers' use of their CommCare devices.

Projects that implemented permissive use policies generally allowed those to whom they issued CommCare devices to do what they like with those devices, such as personalizing ringtones and wallpaper, listening to music, browsing the Internet, using Facebook, and watching videos. Projects that implemented restrictive use policies allowed those to whom they issued CommCare devices to use relatively few of deployed devices' functions. Personalization, entertainment, and other non-professional uses of the devices were either explicitly banned by rules often laid out in a contract, or technically proscribed by supervisors who disabled those functions before devices were issued. I planned at the outset to include projects with a range of rules about what staff were allowed to do with project-issued devices, for two reasons. First, the Technology Acceptance Model pointed to the importance of user perceptions about devices as key predictors for use, and I expected that relative permissiveness and restrictiveness would influence morale, excitement, and ideas about the degree to which devices were easy to use. Second, my theoretical framework holds up the project as a key mediator in the interaction between user and technology. I thought that the project's influence would be most apparent in what projects conveyed to staff about how to use the devices.

The two feature phone, permissive deployments (A, B) agreed to participate, as did the restrictive, Android smart phone deployment (K1, and this invitation also led to the study of K2). The other three deployments (E, G, L) were not different enough from the three that accepted to warrant a visit. Instead, I conducted non-field-based interviews either

at my office in Bangalore or over the phone or Skype of two (E, G), which offered additional variety in perspective. Project L declined to participate. The seventh case (D) in the original list did not meet early selection criteria, as it was only a short-term demonstration project, but I later gained useful insights from this project.

In the end, as depicted in Tables 2.2, 2.3, 2.4, and 2.5, I studied nine projects, seven quite deeply and two for additional information, including six on-site visits and in-person interviews with 62 representatives of all seven projects. In two additional deployments G and H, I interviewed the associated Dimagi staff member and read organizational documents (see Table 2.6), but I did not complete an interview with any on-site project representatives. Other useful information came from *informal units* (Gerring, 2004), projects that could have reasonably been included in my study, which I was aware of and learned something about, but which I did not study formally. These informal units, "all other units that are brought into the analysis in a peripheral way" (Gerring 2004, p344), including J and I, are described briefly in the Appendix.

My earliest data collection activities featured on-site study of two projects (A, B) in June-July, 2013. As I conducted this work, additional projects came to light, including one completing six months of use, thereby meeting original selection criteria. This permissive Android smart phone deployment (F) in Mozambique[20] declined to participate. For additional variety in devices and in use policies, I added one short-term, restrictive

[20] Ultimately, I only intensively studied projects in India, but this project in Mozambique was attractive because it was the only permissive smartphone deployment I encountered. Another one in Nigeria provided similar variety, and to include that project as an informal unit, I read documents and interviewed Dimagi representatives.

tablet deployment (C) for comprehensive study, and I interviewed the developer about three ongoing Android deployments of varying levels of strictness. These deployments offer additional variation in (a) objectives, including a health worker job aid or client monitoring tool, (b) device, including Smartphones and tablets, (c) policies affecting device instrumental and non-instrumental use, i.e., technically blocking device features or housing devices in the office each night for safe-keeping, (d) project duration, and (e) project location. Finally, I conducted on-site visits and interviews for projects K1 and K2, two deployments managed by different programs in a non-governmental organization in Maharashtra.

Table 2.3. Deployments under comprehensive study

Label, Location	**A. Uttar Pradesh**	**B. Rajasthan**	**C. Uttar Pradesh**
Deployment Duration by 9/13	28 months	17 months*	1 month
Status 9/13	ongoing	restarted	completed
Formal partners	iNGO + NGO + Government + Dimagi		iNGO
Total # end-users	268	now 74	24
# CommCare users	255	4 during study	20
# CommCareHQ users	15	4	4
FLW profile	ASHAs	ASHAs	Survey Enumerators (NGO staff)
Gender, literacy, prior mobile experience	Female. 40% literate. ~3/10 ASHAs had phones prior to pilot. 1-2 could send SMS. Most could only receive calls.	Female. 95% literate. Many had phones prior to pilot. Many could only receive calls. Few could send SMS.	Female. 100% literate. 100% had phones prior, no prior touch screen or tablet experience
Target beneficiary population	~45,000 pregnant women & infants	Pregnant women & kids age 0-5 in 28 villages in 8	~1,100 households to represent same

		panchayats in 2 blocks covering ~43,000 people	beneficiaries as Case A
Device	Nokia feature phone	Nokia feature phone	Samsung Galaxy Tablet 2
Met selection criteria?	Yes	Yes	No, short
# individual respondents	26	13	4
Total pages, coded interviews	50	32	11
# primary documents	18	10	3
Total coded pages	112	91	20
*Case B deployed in May 2011, the same month as Case A, but paused in December 2012 & restarted August 2013. Field visit in July 2013			

Table 2.4. Deployments under comprehensive study (continued)

Label, Location	**D. Maharashtra**	**E. Madhya Pradesh**
Deployment Duration by 9/13	3 months	26 months
Status 9/13	completed	ongoing
Formal partners	iNGO + Gov't + Dimagi	iNGO + Dimagi
Total # end-users	16	~71
# CommCare users	16	60
# CommCareHQ users	0	~11
FLW profile	Link Workers	Community Nutrition Experts (CNEs, NGO staff)
Gender, literacy, prior mobile experience	Female. 15/16 had personal phones prior to project. Most were only comfortable making/ receiving calls.	Female. 100% literate. Tribal. All pilot CNEs had mobile phones at home owned by husband. 3 had personal phones. All had used a phone for receiving, some making, calls. One had sent SMS, saved contacts.
Target beneficiary population	1,828 pregnant women & 37 live-born children	~85,000 malnourished children in 600 villages

Device	Nokia feature phone	Nokia feature phone
Met selection criteria?	No, short	Yes
# individual respondents	3	2
Total pages, coded interviews	11	8
# primary documents	2	12
Total Coded Pages	16	57

Table 2.5. Deployments under comprehensive study (continued)

Label, Location	**K1. Maharashtra, India**	**K2. Maharashtra, India**
Deployment Duration by 9/13	22 months	22 months
Status 9/13	ongoing	ongoing
Formal partners	NGO	NGO
Total # end-users	56	78
# CommCare users	~50	66
# CommCareHQ users	~6	12 Investigators
FLW profile	Community Organizers	Community Organizers
Gender, literacy, prior mobile experience	Female. 100% literate. 8-10 standard, some 12th or 1 year of college. Understand Marathi and Hindi, a bit English. CommCare is in Hindi. All had had personal mobile phones; touch screens were new.	Female. 100% literate. 10th-12th standard. ~ 70% had had personal mobile phones, none had smartphones. No touch screen experience. Mostly comfortable calling, very little SMS.
Target beneficiary population	>60,000 population in 40 beats of Dharavi. 600 households in each beat	600 households in 40 slum areas of Mumbai
Device	Samsung Galaxy Y Samsung Fit	Samsung Galaxy Y Samsung Fit
Met selection criteria?	Yes	Yes
# individual respondents	8	6

Total pages, coded interviews	34	23
# primary documents	12	1
Total coded pages	137	23

Table 2.6. Additional Deployments

Read documents. Interviewed four Dimagi staff. No contact with end-users

Label, Location	**G. Bihar, India**	**H. Uttar Pradesh, India**
Duration as of 9/13	29 months	9 months
Status 9/13	ongoing	ongoing
FLW end-users (#)	300 ASHAs, 300 ANMs (alongside a 600 non-user control group)	35 enumerators (NGO staff)
FLW profile	Women. ~55% ASHAs had prior mobile phone access; ~80% ANMs had a mobile phone. During project ANMs use CC device for work; ASHAs use it as a personal phone.	Men & Women. 100% literate. Prior to project all had a mobile phone, few had touch screen phones
Target beneficiary population	Eight districts at first	120 health facilities (60 intervention, 60 comparison) in 6 districts. 172,800 live births.
Device	Nokia feature phone	Android smart phone
Met early selection criteria?	Yes	Yes

All above-described deployments, including non-respondents but excluding project C, were undertaken with Dimagi as an active consultant, paid by a third party USAID, in the deployment.[21]

[21] My work to capture all Dimagi-partnered CommCare deployments in India excludes a new set of projects, labeled by Dimagi as *Proof of Concept* projects, funded through Dimagi by USAID, to pilot CommCare in 40 organizations with 10 Dimagi-issued devices each. I excluded these first because they only came into existence in mid-2013, and would continue to exclude them because they are not independent projects. In these deployments, Dimagi is funder, technology partner, and are involved in implementation to such an extent that I do not regard them as real-world projects.

Interviews were semi-structured, and the line of questioning varied slightly depending on respondents' project role.[22] For example, questioning of field staff related to how they used and hoped to use their devices, while project planners were asked about debates surrounding project level decision-making. All respondents were asked their opinions and understandings of the goals of the project and the deployment, about what would constitute optimal use of the project-issued devices, and what rules or other project features seemed to support or hinder that use. Sample questions are in the appendix. Questions were developed based on an early literature review, and were modified based on the findings of the first two in-depth field studies in summer 2013. I obtained informed oral consent before beginning each interview or taking a photograph.

I also sought, with surprising success, a comprehensive set of related project documents, described in Table 2.7 below.

Table 2.7. Primary Documents Collected

Document of Interest	**Justification**
Organizational chart of each implementing partner	To gain a basic understanding of how each project is set up, the reporting structure, and the number of staff at each level, and do background research on each organization
CommCare Project Organization Chart	
Most recent annual report(s)	
Awarded grant proposals for the CommCare deployment	To learn the consensus a priori expectations of each project, and understand the advance implementation plans

[22] For two studies A and B, visits in Uttar Pradesh and Rajasthan featured in-person individual and group interviews, observation in the project office and accompanying staff on client visits. I communicated occasionally through an interpreter appointed by a project-affiliate not known personally by any of the interpreted respondents (in Project A), or by an offsite program director (in Project B). Projects C and D had already completed, so front-end staff were not readily available for interview, but in both cases I spoke with their supervisors and other on-the-ground decision-makers. A manager in Project D unsuccessfully attempted to arrange interviews with some other former participants—link workers and their supervisor, the Chief Medical Health Officer.

Training schedules and manuals on CommCare use	To understand how employees are formally brought into the organization's culture and work setting, as well as the formally-identified expectations of employees.
Contract on CommCare use	
Job descriptions re: CommCare project	
Project reports: • Grant reports • Blog posts, other web announcements • Printed brochures	To learn the retrospective consensus of the projects goals, advancement of those goals, and unexpected successes and challenges.
Blog posts and other available unofficial statements on projects' progress	To surface salient project features not included in *a priori* expectations

Reading documents served many purposes. Early reading offered context and informed interviews with project participants. Later reading provided opportunities to surface or clarify points of disagreement among verbal or written statements. I referred to some documents during interviews. For example many projects entered into a contract with frontline workers (who, as mentioned, were not always employees of the CommCare project implementing organization, thus contract enforcement was complicated), for agreement on device ownership, responsibilities, and contingencies for damage or loss. Job descriptions were an additional source of encoded responsibilities. Training agendas demonstrated the level of attention given to each transmitted message. During interviews, respondents reflected on the priorities that led to the development of these documents, described the circumstances under which they were amended mid-deployment, and described how stakeholders' actions, statements, and sentiments aligned with encoded messages over time.

Using these qualitative data, I undertook hermeneutic analysis[23] as a methodological procedure to understand technology use in the workplace, as per Davis et.

[23] Hermeneutics is a method for clarifying the meaning of a "human action, product, or expression" as text (Diesing, 1991, p.105). "Actions and situations can also be understood and read as texts" (Butler, 1998, p. 291) including, for example, court documents, organization charts, culture, myths, political demonstrations,

Al (1992) and Butler (1998). Defining an information system as "a *social system* [defined as a non-random grouping of people, such as a professional team or a family unit] *that uses information technology,"* and that "[t]here are always social-system elements and information-technology elements to be considered in IS [information system] design, development, and implementation," a hermeneutic procedure facilitates understanding the adoption of a technology in a socio-technical environment (Davis et al 1992, p294). The social and technical dimensions of this environment are depicted in Table 2.8, and each feature four components.

The social components include reactions to the technical system, performance indicators, processes by which the technical system is designed and implemented, and theories-in-use. As an information system develops, each of these social components interacts with each technical component: physical technology such as hardware, user interfaces, information requirements, and organizational fit, and these interactions create a matrix or a framework through which iterative analysis may be conducted. See Table 2.8 below for examples of how these interactions help with interpretation of an information system, by helping to group statements according to relevant themes that have both social and technical dimensions. Ultimately, as my data collection and interpretation progressed,

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and ceremonies, which are "a kind of spoken and acted text" (Diesing, 1991, p.105). The *hermeneutic circle* refers to the back-and-forth process among the hypothesis, which

> *guides the search for and interpretation of details, which in turn revise the hypothesis, which leads to interpretation and further search, and so on. In case of conflict, the circle tends to widen farther and farther into the context on the one side and our foreknowledge on the other side… The goal of interpretation is to produce a reading of the text that fits all important details into a consistent, coherent message, one that fits coherently into the context… The interpreter is not looking for a universal law that is true forever; s/he is looking for the correct interpretation of this text… One should therefore ask, is such a reading of this text correct or valid?* (Diesing, 1991, p. 109-110).

I added themes as it became clear that my observations did not each fall neatly into a space on that particular table. Instead, I allowed relevant themes to arise from the data and I grouped statements according to those themes that emerged. As my field work continued, new themes emerged, and I both revisited data already collected to see if they were relevant to the new themes, and also dug deeper in my field work around those new themes in addition to the original ones.

Table 2.8. Sociotechnical Features of Workplace Technology Use

(adapted from Davis et al, 1992)

	Social system dimension				
Technical system dimension		**reactions to the technical system**	**indicators of technical system performance meaningful to the social system**	**process by which technical system is designed and implemented**	**theories-in-use**
	technology (hardware, software)	*ex. "it doesn't work!"*	*ex. power indicator light is off*	*ex. Staff training on use of new technology*	*ex. Beliefs, ideas, and agendas about the role of technology, of management, etc., that motivate action*
	user interfaces (point of contact with user)	*ex. "it's easy to use"*	*ex. error rate of data input*		
	information requirements	*ex. refusal to input birth date*			
	organizational fit	*ex. "it changed who's in charge"*	*ex. response time of data analysis does not exceed patience of users*		

Generally, I implemented hermeneutic analysis by collecting data each day, classifying that data, noting anomalies in the classified data, interpreting these anomalies, reinterpreting all data, and repeating the entire procedure from the beginning (as per Davis, et al, 1992, p. 304-307). I sought "understanding of a social phenomenon… by a dialectic process of narrowing the scope of generic concepts concerning it, and identifying within the 'whole' the 'hierarchy of topics, or primary and subordinate topics' that constitute it." (Butler, 1998, p. 291).

Specifically, I employed this analysis procedure in my own empirical project as follows. After each day of fieldwork[24] during study of the first two deployments, I grouped the most interesting statements, and the most frequent or surprising respondent-generated topics, into an emailed report that I discussed with three mentors at Microsoft Research and one research participant at Dimagi. I created tentative categories for these groupings, and subsequent interviews featured additional questions related to these topics, to obtain further detail and to better establish whether and how these interesting early topics related to the research question. Early insights from the first two field visits are reported in Schwartz *et al* (2013). The first two field visits and this first blush analysis also informed questions in later data collection, consisting of semi-structured interviews and document review of nine more deployments. During this second phase of data collection, I continued

[24] I audio-recorded interviews. During all interviews, I also took notes primarily on my laptop, recording each question asked and a near-transcript of the response or translated response. In the few instances where using my laptop was impractical, I took written notes and fleshed them out as soon as possible after each interview. I asked clarification questions during each interview and often called interview respondents later for more information especially when subsequent interviews or document review revealed points of disagreement or new topics. Therefore, my notes ultimately diverged from audio recordings to feature additional detail and clarification.

to send email reports to my colleagues, again spurring discussion, tentative interpretation, and adjustment of interview questions. I refer to these email reports and notes from subsequent discussions collectively as the *first round of coding*, the *first code* or the *first interpretation*.

I undertook the second coding and subsequent coding, independently, as follows. Based on the first interpretation, I developed a list of topics relevant to the research questions. Creating a separate spreadsheet in Excel for each deployment, and returning to the original interview transcripts and documents, I copied each recorded statement or document's statement into the cell next to the relevant topic, creating a numbered list of items copied into each topic's cell. Specifically, I assigned a number to each verbal or written statement to mark the sequence in which statements were coded. I also assigned a label to each speaker as per Table 2.1. Coding individual responses thus retained confidentiality while allowing interpretation based on role. After a colon, a statement was summarized or quoted.

For example, in the second code, under the category of "Burdens, and Fear or Threat of Burden", in the cell relating to the topic B1, "Device security / integrity," and the subtopic B1a, "Damage or loss," is:

> *4. A6: • I've had to replace ~7 phones that were lost over 18 months, which is not that bad. For the ~7 lost phones: CNEs* [Community Nutrition Educators, NGO-employed community health workers] *lost it, misplaced during normal work, or gave to a family member. Typical reasons why people lose phones. We did charge half the cost as the contract stipulates… Out of 60 phones—this is around 10% loss of our inventory over 18 months over 600 villages. I'm amazed it hasn't been a bigger problem. The CNEs take very good care of the phones. We didn't provide screen protectors and covers. Many bought both of those things. Take ownership over, protect... Reporting lost phones has happened but hasn't always been timely,*

> *so CNEs may not collect data for a month or so.* [Excerpted from Case E, Second Code].

This refers to the fourth statement included in the cell, and indicates that A6, an off-site implementer, was the speaker. The absence of quotation marks indicates that the statement is not a direct quote. Ellipses indicate that the speaker returned to the same topic during multiple points in the interview. Portions of this statement are also included in the second code under the category "Contractual Rules," in the topic CV1 (or, Contractual Venue 1), "code – formal". They are also in the "Social Rules" category, under topics S2, "Rule Enforcement" and S11, "Culture: feeling of ownership."

As coding progressed, new topics emerged and I created a new line for that topic in an appropriate place in the topic list, and assigned it an appropriate code. The new topic was included in the topic list for all subsequent deployments studied. In the third code, I re-coded my notes and documentation from each deployment for consistency in categorizing statements across projects and to include these additional topics. Where appropriate, I combined or disaggregated topics.

As new data became available, coding restarted, and I expanded the topic list and database according to the above procedure. Eventually, during new entry of data from projects K1 and K2, the most recent studies conducted, the themes and categories were not significantly altered. I considered my database complete when I had completed entry of separate sheets for each deployment, and an additional sheet that aggregates statements and writings that came from the technology developer Dimagi. The interpretation stage was complete when entering new data or comprehensively reviewing previously collected data

added no new information, and surfaced no new themes or required re-categorization of existing themes, I determined that I had reached the point of *saturation* (Cresswell, 2007; Fusch and Ness, 2015).[25]

Because information systems development "in an organization will involve different configurations of social actors, technologies, and objectives," "the development process will be socially constructed," it is important to "capture the world views of relevant social actors," and "several systems development projects will require investigation" (Butler, 1998, p. 293). During interpretation, I compared projects' policies by which devices were entrusted to field staff and stakeholder perceptions of these policies' appropriateness, fairness, and influence on project goals. I also examined differences in understanding within projects, among skilled and semi-skilled users; on- and off-site decision-makers and staff; and among external stakeholders such as decision-makers at Dimagi, project headquarters and donors. Among similar stakeholders, I explored variation in perceptions of the device and CommCare as burden, benefit, or something in between, for the project and for project participants.

Study Limitations

[25] *Data saturation* in qualitative research has multiple definitions. I found two useful when completing this dissertation: (1) "when the ability to abtain additional new information has been attained" and (2) "when further coding is no longer feasible" (Fusch and Ness, 2015, p. 1408 citing Guest, et al., 2006).

Ultimately, this dissertation is a descriptive, exploratory study. The intent of this work is to inform two questions: *in resource-constrained social sector settings, what project features govern use of work-issued mobile devices?* And, *how do decision-makers adjust rules and implementation plans to maximize devices' benefit while minimizing new burdens?* This systematic, qualitative study reveals variables of interest and describes the variety of experience for project planners, implementers, and participants in Indian community health workers' projects to CommCare. This dissertation does not claim to demonstrate statistical association or causation, and does not employ sampling logic for generalizability. Instead, this study uses the qualitative logic of credibility and validity (Cresswell, 2007, p. 77) and techniques including triangulation, peer review, and member checks, as described at the beginning of this chapter, to assess the credibility of my interpretations.

This dissertation is subject to limitations including selection bias, recall bias, and researcher bias. This section describes the challenges these biases presented to the credibility and validity of my research, and the steps I took to minimize and mitigate these biases.

Selection Bias.

Early selection criteria for this dissertation included CommCare deployments that have lasted longer than six months with at least 10 end-users. All identified deployments that met the selection criteria also had an implementation partner in common: Dimagi, CommCare's developer. It is possible that the developer's active early participation in

adapting CommCare to the implementing context, and training the earliest end-users on-site, overshadowed the importance of any other project feature in determining effects on use and goal advancement. It is also possible that the developer's presence is an indicator of or proxy for some other critical determinant of use and mission achievement, such as fungible resources, in-house willingness to experiment, relevant expertise, or good professional contacts. Conversely, the developer's absence in other projects might be indicators of these same things, but more or less of them.

While I was unable to study a directly-comparable counterfactual group, two research activities have helped me gain traction on the magnitude of this form of bias. First, I comprehensively studied Project C, a short-term deployment that ended after one month when its objective, to conduct a baseline survey, was complete. Writes one Dimagi staff member,

> *the cool thing about that project (from Dimagi's perspective) is that we were very minimally involved with it. I happened to be in Kaushambi, so saw the survey in action but was very minimally involved. With a bit of consultation on the technology front, [NGO name] purchased tablets, coded up the app, trained, and executed the data collection* (personal correspondence).

Second, aware that Dimagi's CommCareHQ, a linked application, houses data for all CommCare deployments, even for those that never contacted anyone at Dimagi directly, I requested evidence of any projects that had been undertaken without Dimagi's involvement. Dimagi has limited information about these projects, but a Dimagi staff member provided me with a list of what they refer to as *self-starters* active in the month of October 2013. This information, in which each row represents one independent CommCare

deployment, is summarized in the Appendix. These data lack detail on many relevant project features, but they demonstrate that Dimagi's presence is not necessary for sustainability, a key concern in determining the generalizability of findings to projects that deploy technologies like CommCare without active involvement of the developer. On the other hand, these data do not allow rejection of the hypothesis that the developer's presence is sufficient for, or significantly contributes to, a deployment's success.

Recall Bias.

Retrospective interviews are subject to inaccuracies in memory. This happened twice. First, one respondent reporting on a project conflated the details of that project with a similar one on which he had worked, but that deployed a meaningfully different device to similar or the same health workers. Second, frontline workers and project staff who had been issued devices as part of a deployment occasionally forgot that they had signed a contract with the implementing organization concerning the ownership, use, and maintenance of the device, and only confirmed that they had done so with probing.

After each interview, I cross-checked factual remarks with available documentation and with other interviews. I analyzed the authoritativeness of different sources on a case-by-case basis. For example, in Project A, the number of front-line workers to whom CommCare devices was deployed varied across interviews and documentation. A follow-up conversation with a member of the project team clarified that the plan was to deploy to all frontline workers in a given region, and this number had been estimated in

implementation plans based on the number of positions available. The actual number related to the number of positions were filled at the time of deployment. In reporting, I only report on what 'facts' I can state with confidence; when I can not obtain exact numbers, I mark the number in question with a "~", and in no case does interpretation depend on the precision of that number.

Despite these concerns, interviewing project participants at least six months after deployment had several distinct benefits. The first is that it gave project planners an opportunity to reflect on their decisions after they had had time to see how these decisions affected their deployment and time to adjust their choices based on those effects. This allowed for probing on what project features and choices implementers found most salient in practice, critical junctures that provided opportunity for, or necessitated, shifts in strategy, the relative salience of differing priorities at those critical junctures, and what project goals were prioritized at those times.

Second, waiting at least six months after deployment allowed for better study of strategic and personal deployment of work-issued devices, under the assumption that it would take some time for end-users to become comfortable enough with devices to begin using them creatively, in ways not predicted by project planners. This decision was supported in data collection: one Project D implementer described the end-users he supervised as only having gotten comfortable using CommCare and the devices after two to three months of use in the field. Finally, this time frame allowed respondents sufficient time to get beyond the quick responsiveness needed at the beginning of a deployment period, and to reflect on their experiences with some distance.

Nevertheless, as a check on these assumptions, I developed, with two colleagues at Microsoft Research, three questions for inclusion in a survey that Dimagi administered to more recent projects as they hit three months of deployment. On a rolling basis beginning in August 2013, Dimagi emailed the survey to 40 projects, and by the end of September had received meaningful responses from seven projects. These responses revealed no new topics for which I recoded the primary data. All responses fit into what I had observed during my data collection, and I consider this some support that my sampling, coding, and interpretation methods are sufficient.

Researcher bias.

I am excited about the potential benefits of offering access to communication and information devices to individuals who had not had prior access. I am also not responsible for repairing or replacing devices that are damaged or lost due to personal use. This may bias my interpretation toward minimizing the importance of damage or loss, and/or inflate the importance of development impacts on end-users. Therefore, I asked project planners to quantify their losses and instances of damage, and to assess how meaningful these losses were for the project's budget, and how they affected the project's ability to carry out its mission in a timely way. Forthcoming Dimagi data on devices' impacts on two deployments' frontline workers' literacy, digital literacy, vocational literacy, and personal and professional empowerment, could also allow more objective analysis of this concern.

This chapter has described the details, benefits, and limits of the empirical methods this dissertation employs. This chapter argued that valid hermeneutic interpretations of texts are based on (a) general foreknowledge about the text, (b) specific knowledge about the speaker(s) or producers of the text, and (c) "contextual knowledge of the situation reported in the text" (Diesing, 1991, p. 107). Therefore, Chapter 3 describes what constitutes the dissertation's data as well as the context in which these data are situated. Chapter 3 expands on Chapter 1's description of the context and challenges of community health work globally and in India. Chapter 3 also describes nine health projects in India that have adopted CommCare as a job aid and data collection tool, and the individuals who participate in those projects, that constitute this dissertation's data.

Chapter 3. Mobile Computing Technology as Bridging the Ideals and Realities of Community Health Work

This chapter first describes in more detail the challenges of community health work and the reasons for using ICTs like CommCare to mitigate those challenges. To demonstrate that the challenges that CommCare was developed to mitigate are real and meaningful, I summarize the Government of India guidelines for community health work and then describe how prior research and my observations of community health work diverged from this formal plan. The chapter continues with a review of the intended benefits of CommCare in addressing these challenges. The chapter concludes with a description of the projects and actors that comprised the subjects of and participated in this study.

COMMUNITY HEALTH WORK IN INDIA

India has more than 1.2 billion population, 66% of whom have access to electricity (World Bank, 2014). GDP growth in India was 6.9% in 2011. Yet despite the accumulation of wealth, the country maintains large impoverished populations. The CIA World Factbook (2011) ranks India on per capita GDP as the 165th country in the world with $3,700. Access to improved sanitation facilities is 34% in India; infant mortality rates are 46 deaths per 1,000 live births (ranked #49); and infectious diseases including bacterial diarrhea, hepatitis A, typhoid fever, and malaria represent serious threats.

India has a long history of engaging community health workers to help address many of these concerns. In the 1970s through the late 1980s, India instituted a national scheme by which community health workers provided basic health care and health education to rural populations. Non-governmental organizations and state governments also implemented smaller projects with varying success. For example, in 2002 the new state Chhattisgarh initiated a *Mitanin* program to address inequalities in access to health care.

In 2005, the Government of India (GoI) Ministry of Health and Family Welfare, revived through a new National Rural Health Mission (NRHM) a national strategy by which every 1,000 residents should have access to a community health worker, an *Accredited Social Health Activist* (ASHA), who lives among those residents. Through this strategy, the Mission supports a community-run, decentralized health delivery system, to

ensure simultaneous action on a range of health determinants including water, sanitation, education, nutrition, and social and gender equality. By March 2015, the National Rural Health Mission had selected and installed 907,918 ASHAs across India (Government of India NRHM, 2015). The Indian government allocates 10,000 rupees (~$150) per ASHA per financial year, excluding locally-disbursed performance-based compensation, described below. The federal government issued the following guidelines for states to implement the ASHA program, which focal NGOs also followed when employing their own health workers:[26]

- **Qualifications.** Female 25-45 years-old resident of the village she serves, either married, widowed, or divorced. Health workers should be literate and have 10 standard education.
- **Selection.** The Gram Sabha[27] cooperates with Anganwadi, Block, and District Nodal officers, the Village Health Committee, and community groups to choose health workers.

[26] As mentioned, Indian non-governmental mobile community health workers have responsibilities quite similar to ASHAs', and this dissertation includes projects featuring both governmental and non-governmental community health workers. Non-governmental community health workers with ASHA-like duties have higher salary, better literacy and more formal education, and slightly more on-the-job resources, especially training. The higher salary still keeps health workers below the lowest poverty line. While NGOs are unlikely to have much better access to higher-quality candidates than their government counterparts, the greater resources that NGOs allocate to early training and ongoing mentorship may create a systematic difference in skills and knowledge between ASHAs and non-governmental health workers with ASHA-like duties. Moreover, an urban-rural distinction may be more important in many instances than a governmental-non-governmental health worker distinction. While the ASHA program was developed for rural areas, many ASHAs and other link workers do work in urban areas; for example Orissa State has positioned more than 600 ASHAs in eleven urban slum locations.

[27] The Gram Sabha is a group comprised of the entire adult population, aged 18 years or older, who live in the area covered by a panchayat, or village council.

- **Pay.** ASHAs are referred to as *incentivized volunteers*. This means they are paid a set amount each time a client in their assigned region completes eligible healthy behaviors including delivering a baby in a health facility. They are paid for referring and escorting clients to health centers, constructing home toilets, and client immunizations. ASHAs meeting "expected standards she would earn approximate Rs. 1067 per month," (Government of Rajasthan NRHM, 2015) or about $16.
- **Activities.** Community health workers are expected to survey their villages, identifying pregnant women and newborns, and record villagers' health status, especially of vulnerable groups such as scheduled castes and tribes. They should inform Anganwadi Centers of births, deaths, outbreaks, and unusual health issues, help maintain Village Health Registers, participate in Panchayats' Village Health and Sanitation Committee, and participate in developing a village health plan. Health workers provide villagers basic curative care and make timely referrals to health centers and welfare services. They inform villagers on health determinants such as nutrition and hygiene, and encourage healthy practices. They counsel women on safe pregnancy and delivery, breast-feeding, preventing infections, immunization, contraception, and care of young children. They help organize monthly Village Health and Nutrition Days and meet monthly with other local ASHAs to share experiences, problems, and independently assess the health system.
- **Material Resources.** Community health workers should receive diaries, registers, health cards, immunization cards, and a first-contact kit including a rapid diagnostic

kit, oral rehydration therapy, iron folic acid tablets, soap, oral contraceptives, and condoms.[28]

- **Institutional Resources.** Community health workers are promised (a) Training, including 23 days in five episodes and two-days ongoing retraining every other month; (b) a national ASHA Mentoring Group, composed of researchers and community health experts organized by GoI to conduct on-site supportive supervision. This group bi-annually reviews challenges and innovations across states, identifies emerging priorities, develops training curricula, and proposes improvements in the ASHA strategy to the Ministry of Health & Family Welfare. Finally, GoI tasks (c) local Woman's Health Committees and Gram Panchayat Village Health and Sanitation Committee with ensuring for the health worker a secure, enabling, and congenial local environment.
- **Supervision.** Local health facilities must take prompt action on ASHAs' referrals, and State & District Missions should support ASHAs. As elaborated in Chapter 5, government health workers' immediate supervision is shared among Auxiliary Nurse Midwives, Anganwadi Workers, the Chief Medical Officer, the Block Medical Officer, and others.

[28] Also many receive a flip chart that features colorful images and text that illustrate the lessons that ASHAs are expected to teach their clients. I heard often that this was the case, and saw some flip charts, but found no official references to them.

Challenges to Community Health Work

Health workers' responsibilities as described in the previous section constitute more work than can be accomplished in a reasonable work week, and prior reviews of community health programs in 46 countries corroborate this as a consistant problem (Ofosu-Amaah, 1983; WHO, 1989; WHO, 2006; WHO, 2010). Thus I understand the Government of India Guidelines outlined above as aspirational, and I observed them to be unevenly implemented by states or localities. For instance, Case E deployed CommCare-enabled devices to Community Nutrition Educators (CNEs). The implementing NGO's blog reported relaxing all health worker qualifications:

> *In March 2010,* [Name] *and I were driving around Khandwa district on a motorcycle desperately searching for staff to begin operations of our ambitious "Eradicate Malnutrition" program. In our heads, we had a checklist of criteria for potential new staff, mostly focusing on education levels and any experience in the health, nutrition, or NGO sector. As we drove from hamlet to hamlet, over dried streambeds and through fallow, dusty farmland, the checklist was whittled down to one item: literate.*

Ultimately, community health work is knowledge work, That is, health workers are expected to draw on health information and their personal experiences to convince their neighbors to adopt and maintain healthy behaviors. They are expected to assess, report on, and respond to the needs of their communities, and advocate these needs to the local public health system (Werner, 1981; Lehman & Sanders, 2007; WHO 2010).

Community health workers' role is one of empowerment and agency, but their ability to enact this role is hampered by many challenges. Globally and in India, community health workers have been found to be underpaid, insufficiently trained or supervised, and of low

social status, which might undermine their authority among their neighbors to be knowledge workers and change makers.

An illustration of challenges common to many community health worker programs

There are Mitanins[29] *in almost all places* [in Chhattisgarh]. *Supportive institutional mechanisms have been established at state...* [and local levels with] *a variety of arrangements. However the programme is struggling at the field level on several fronts including Mitanin's demand for drugs, remuneration, training, and referral support; non payment... relative indifference of the health system, and lack of adequate meaningful community participation... The knowledge level of Mitanins, their home visits, provision of primary medical care, referral, cooperation with ANM-AWW* [Auxiliary Nurse Midwife/Anganwadi Worker], *Panchayat connection, gender-rights etc are presently at low levels. Their training, follow-up and support systems need considerable strengthening... Despite good efforts on some fronts like preparation of good training booklets, separate support system for Mitanins, picture-symbols on the tablet-packs, kalajathas* [folk theater depicting life processes] *to generate enthusiasm and community awareness and ensuring a Mitanin everywhere, the programme faces serious challenges* (SOCHARA, 2005, cited by Lehman & Sanders, 2007, p.10-11).

Likewise, the World Health Organization reports that globally, community health workers' service provision is inconsistent and occasionally of poor quality, with critical gaps in health workers' motivation, training, supervision, and supportive material resources. Though the community health strategy demonstrably strengthens underserved populations' access to formal health systems, and is generally a good investment, uneven outcomes relate to expenses and logistical challenges of implementation (WHO, 2010;

[29] *Mitanins* are government community health workers. As stated at the beginning of this chapter, the Mitanin program was a precursor to the Accredited Social Health Activist (ASHA) program in India.

Lehman & Sanders, 2007). Findings from my field work are consistent with that of these reports. Below I describe how my observations complement these prior reports in the areas of unevenly applied guidelines, baseline skills and training, supporting resources, and socioeconomic characteristics of community health workers.

Unevenly Applied Guidelines

The above-described Government of India guidelines for ASHAs are applied unevenly across the states. For example, Rajasthan reduces the minimum age to 21 years, and I met ASHAs older than the 45-year age maximum. The education requirement, already flexible, was now 8th class (roughly equivalent to US middle school), and "in tribal and desert areas the educational qualification may be relaxed if the 8th pass candidate is not available" (Government of Rajasthan NRHM, 2015). Not all state guidelines are more relaxed than the national guidelines. For example, the Government of Rajasthan also requires that disadvantaged population groups are adequately represented among ASHAs, and the Government of Orissa (2015) adds flood situation management to some ASHAs' duties. These local additions improve the relevance of community health services and add to health workers' plates.

Insufficient Supporting Resources

The tool for facilitating community health work that was most frequently-mentioned during my interviews was a government-issued flip chart that illustrated topics

such as risk factors for pregnancy and advice for feeding a newborn baby. Despite the frequency of references to them, these charts were not prominent in daily health work. Some health workers never received the flip charts or received them months after beginning work. Many health workers reported leaving them at home because they were heavy or because they could not read them. Other health workers had lost or damaged their flip charts, which were not waterproofed and susceptible to monsoon and water crossings, as most village health workers walk from client home to client home.

Further, government supervision of health workers was weak. As noted, the National Rural Health Mission appointed multiple overlapping local authorities. Many interviewees reported that in practice, health workers reported weekly to the local Auxiliary Nurse Midwives (ANM) and monthly to the Chief Medical Officer (CMO). However, interviewed ANMs did not recognize their own supervisory responsibility for local ASHAs. Before all focal CommCare projects began, government health workers had experienced low levels of supervision, mentorship, and access to health consultation during their client visits. Performance-based feedback had also been uncommon.

Finally, even when health workers had been taking careful paper-based records, health workers and health centers had poor access to client health histories. The paper diary record system meant that data were not easily retrievable or aggregable. These challenges meant missed opportunities for diagnosis and referral. For example, if a health worker could not determine whether a malnourished child had been undernourished at the time of her last visit, or how long she had been undernourished, the health worker could not fully determine the severity of the child's condition. In this instance, a cautious health worker

may recommend that a relatively healthy child visit a health facility, an unnecessary recommendation that could cost the child's family days of missed work. Alternatively, a health worker might endanger a relatively severe case by neglecting to recommend the health center visit. Moreover, having data that were difficult to retrieve and aggregate meant that projects could not assess village-level health, observe emerging population health challenges, or submit accurate government reports.

Insufficient Training

In interviews, government health workers and their CommCare project supervisors often reported that health workers had not received the full training to which they were entitled. They agreed that with no special education, and often without the required level of literacy, they were not particularly qualified to make decisions and recommendations like those described above or to deliver the health information expected of them.

All interview participants agreed, and listed their low baseline skills including poor literacy, numeracy, digital literacy, and competence assessing malnutrition.[30] Many project supervisors, funder and Dimagi representatives noted that health workers' actual literacy was lower than the level at which they were certified. Some interviewees speculated that applicants had obtained fake documents that misrepresented their skills in order to obtain the health worker position. I suspect that some health workers obtained their literacy

[30] Generally, CommCare supervisors articulated these challenges differently than the health workers did, but agreed despite differences in vocabulary or ability to pinpoint specific challenges.

certifications at the completion of their schooling, but had not used their literacy skills during daily life and were rusty. Many interviewees suspected that local women were highly motivated to be ASHAs in order to benefit society and also to gain respect and social status despite their poverty and low education. One technologist stakeholder agreed, and guessed that "Many ASHAs faked their literacy… expecting that the ASHA position would eventually become a salaried government job, as the Anganwadi and the ANM jobs became." In any case, low skills presented real challenges for focal projects, especially those scaling from a pilot, in which project planners could select qualified health workers to use CommCare, to entire administrative blocks, in which case all health workers in the block now participated in the technology project. One planner noted,

> *We weren't at all prepared for the literacy levels of the ASHAs. They had to be in 8 class, but 30% were not literate, even though they had the certificates. Weren't functionally literate—they couldn't read and write. All CommCare instructions to ASHAs at that point were all in writing. The only recorded* [audio] *messages were for patients.*

Prior reports agree that community health workers' baseline knowledge is universally low. "In virtually all cases in the literature, CHWs… have little or no secondary and no tertiary education" (Lehman & Sanders, 2007, p. 6). Insufficient training is a persistent problem across projects and across countries (Lehman & Sanders, 2007; WHO, 2010).

Moreover, available data indicate that ASHAs began work before their minimum 23 days of training were complete, as recruitment took place locally as needed but specific plans for training new ASHAs were made on a state level. In interviews, health workers

and supervisors reported that 23 days were insufficient to gain the knowledge and skills required to competently carry out the role. Many had not yet received the training in full. Table 3.1 shows that most ASHAs in India have received the first of seven intended training modules, and the numbers drop from there. Still, according to this table, more than 60,000 ASHAs, representing 60 million citizens, are conducting client interactions without having completed even the first module.

Table 3.1. Number of ASHAs Who Have Received Training

Modules	**# ASHAs**	**Modules**	**# ASHAs**
1st module	832,838	6th module & 7th module	
2nd module	803,363	Round 1	613,920
3rd module	800,108	Round 2	455,563
4th module	786,616	Round 3	235,744
5th module	790,425	Round 4	115,015

Data as of 31st March 2014, by which date 894,525 ASHAs had been selected. Source: Government of India National Rural Health Mission. http://nrhm.gov.in/communitisation/asha/ (Accessed January 19, 2015)

A 2011 GoI National Rural Health Mission evaluation of the ASHA program responded to this training gap by recommending a new role, an *ASHA facilitator*, to supervise and mentor ASHAs on an ongoing basis. This role has since been created at the national level. In expectation of this facilitator role, focal NGOs had developed job

descriptions for their own staff that closely resembled this ASHA facilitator role. It was this staff member who often acted as the CommCare field supervisor, and monitored community health workers' CommCare use in focal projects.

Low Pay

A report on the work life of one Rajasthani ASHA noted that "Her work schedule is not limited in hours of service but as she said, it is 24 hours and 7 days duty."[31] (Chandan, 2011, p. 12-13). This ASHA characterized her monthly compensation as unsatisfactory compared with the local Anganwadi worker, who earned more than three times the ASHAs' monthly earnings of about Rs. 1067 (~$16), not a living wage[32]. In addition to being perceived as unfair, this is not sustainable. "There exists virtually no evidence that volunteerism can be sustained for long periods: as a rule, community health workers are poor and expect and require an income" (Lehman & Sanders, 2007, p. vi). Health workers compared themselves to higher-paid government health workers with similar jobs, or to higher-paid urban women with similar qualifications but doing work such as cleaning houses, which further entrenched their low social status. Some interviewees speculated that this poorly-paid health work job has more dignity than others available to women with that

[31] Round-the-clock duty takes place because pregnant women often call their ASHA whenever they go into labor.

[32] Especially since the majority of her income arrives when her pregnant neighbors deliver in health facilities, pay is naturally limited by demographic features. Further, ASHAs' mandate to encourage live births conflict with another mandate, to distribute family planning information and resources. If acted upon, family planning choices to have fewer children will reduce the overall number of pregnancies among ASHAs' neighbors and further undermine their pay.

education level. With limited economic opportunities, community health workers face real tradeoffs among pay, dignity, and social status.

Low Socio-Economic Status

Despite some observed systematic differences between non-government and government health workers, focal health staff generally experienced multidimensional poverty,[33] including poverty in these dimensions: (a) time poverty, which is characterized by unpaid domestic work and excessive paid work, (b) poverty of economic autonomy, characterized by a lack of personal funds, restricted employment opportunities, or less than a living wage, (c) poverty of living conditions, often characterized by poor water and housing quality and overcrowding, (d) education poverty, which may be characterized by low school attendance or a low level of completed schooling, and (e) exclusion, including poor access to education, employment, and health services.

Urban health workers are likely to have more in common with each other, regardless of their governmental affiliation, than with their rural counterparts, on some key characteristics relevant to this study. First, in focal projects, urban health workers had greater access to a personal mobile phone prior to their health projects' deployment. While a negligible few had had prior access to Smartphones or touch screens, urban community health workers consistently had had their own device, whereas rural health workers

[33] See, for example, the Oxford Index of Multidimensional Poverty, which identifies indicators of health, education, and living standards to comprehensively assess poverty.

generally had to borrow from male family members. Further, because of this greater prior presence of mobile devices in urban areas, the subsequently-described status boosts that many studied rural health workers noticed upon receipt of their project-issued devices was not experienced in studied urban areas.

Health workers participating in this study also described their own low social status in their communities, especially among their clients and clients' families. Some interviewees attributed this low status to being less educated than their clients and clients' families. Others noted that in many Indian communities, it is traditional for a woman to live with her husband, so married women were often not living in their home communities and were viewed as outsiders. Because community health workers must be married, some interview participants thought this introduced a systematic challenge to community health work. By introducing the marriage requirement, most community health workers would always be viewed as outsiders by their neighbor-clients.[34]

In combination, these challenges often made it difficult for community health workers to overcome the health advice of clients' mothers-in-law, who were often the family authority in health decisions, and who often preferred the advice of traditional healers over health professionals. For example, health workers reported combating practices of home births, discarding colostrum (early breastmilk, which is rich in antibodies), and feeding honey and water to newborns.

[34] A more optimistic corollary to this interpretation might be that, if community health worker were a role that garnered social respect, then offering married women community health worker positions might be a way to systematically integrate in-migrants into the fabric of their new communities.

One Solution: CommCare-Facilitated Health Knowledge Work

Community health workers in focal projects used devices loaded with CommCare for three general purposes: information delivery, decision support, and monitoring of clients and the health workers themselves. Some projects focused on one or two of these purposes.

Information Delivery

First, CommCare is intended to support health workers' role as knowledge workers who deliver health information to their clients. The application does this by replicating content found in health workers' flip books, displaying colorful images on a device's screen, and projecting accompanying textual information via the speakers. Using CommCare could lead to increased or decreased engagement of the health worker in the health worker-client interaction. In an ideal scenario, the health worker listens actively to the health messages she plays for her client, and uses the messages as prompts for an educational and compelling conversation with the client. When each message completes, the health worker discusses the message, ascertains whether the client understood, and asks the client if she will undertake the behavior suggested. In the worst scenario, the health worker used the application to replace her active participation.

Decision Support

CommCare supports health workers' decisions at critical junctures of the client interaction. For example, the application prompts the health worker to ask her client, "Show me the iron pills you have been taking." If the client cannot find the bottle or shows an empty bottle, CommCare prompts the health worker to recommend that the client visit a health facility for a refill. Some versions of CommCare feature a nutrition calculator that allows health workers to enter a child's height and weight, informs the health worker of the child's nutrition status (normal, severely, or moderately malnourished), and suggests steps to improve the child's nutritional status.

Digital Monitoring

Finally, CommCare allows health workers to record client data digitally. Though it varied by region, some health workers had carried a stack of notebooks to each client visit, in addition to a scale to measure clients' weight. Tracking client histories through these books was difficult or impossible at moments of need. Systematic periodic reporting and evaluation using this system was unevenly administered and incomplete. I asked health organizations if they used these paper-based data for information on their district, and in no district did they use these data. Instead, there was agreement across projects that government health data were low quality and not trustworthy. Digital data collection and client monitoring was intended to replace this onerous paper-based system, and to create a

reliable database that could be used for tracking health data, but by the time of study, the paper system had not been eliminated in any focal projects. On the other hand, district-level government medical offices are reportedly using monthly electronic data.

FOCAL PROJECTS. INDIAN COMMUNITY HEALTH PROJECTS DEPLOYING COMMCARE

I noted that in this dissertation, *project* refers to the specific set of objectives, procedures, timelines, activities, routines, and resources surrounding a programmatic decision to introduce CommCare into work. In the previous chapter, Figure 2.1 depicted, in the context of a principal agent relationship, the organizational structure of a typical health project's deployment of CommCare to community health workers in India. Dimagi was the primary technology partner on all projects. The earliest pilot phases, which took place prior to my study, Dimagi was also funder and implementation partner. Field Managers were decision-makers on CommCare projects. Field Managers primarily used CommCareHQ, an application that affords viewing the data collected via CommCare. Community Health Workers were primary end-users of CommCare. Field Supervisors liaised among health workers and managers, facilitating proper use of CommCare and verifying the data coming through on CommCareHQ.

Local environments added some important differences, especially in language, local practices, and administration of state government. The local environment is less similar across projects, but like the system in which it sits, is also relatively stable over deployment timelines, with a few relevant exceptions noted below. The micro-level

context, on the other hand, emerged (as per Dourish 2004) as a deployment progressed, as decision-makers observed the consequences of their decisions, and as individual and group learning developed. For each project, this emergent context is endogenous, changing (especially, for example, supervisors' expectations of health workers' work behaviors), and central to understanding technology use in those projects.

This section briefly describes each focal project, each project's stated primary objectives for its CommCare deployment, each project's primary users of CommCare devices, beneficiary populations, timelines, and other critical contextual features. This section also describes some key commonalities and differences in implementation tactics across projects.

Slide 3.1. *Dissertation Project Site Locations in India. Source: Author's elaboration and Google Maps.*

255 ASHAs, Uttar Pradesh (A)

This May, 2011 CommCare feature phone deployment in rural Kaushambi District to 10 ASHAs scaled to 111 ASHAs in August, 2012 to total 255 March, 2013, covering two complete administrative blocks and encompassing 45,431 pregnant women and infants. The project was set for a duration of three years, through 2014. The project sought to improve maternal and child survival by strengthening community health workers' (ASHAs') outreach to pregnant and postpartum women, newborns and infants. Recognizing that ASHAs in their target area have limited training and support to carry out effective home visits, the implementing organization, a local health NGO, sought to capture a significant missed opportunity for ASHAs to provide targeted counseling to women and families, and screening and referral for maternal and newborn danger signs during the pregnancy and postpartum periods. I interviewed twenty-six project affiliates, including five ASHAs, 18 on- and off-site staff, and three Dimagi staff members. The deployment was self-funded by the project initiator, an international non-governmental organization (NGO) with a heavy local presence, and was fully implemented by a local NGO.

70 ASHAs, Rajasthan (B)

This May, 2011 CommCare feature phone mobile health deployment in rural/urban Kishangarh District to 10 ASHAs scaled to a full administrative block including 8 panchayats[35] with 70 total ASHAs in January, 2012. Project funds ended in December

[35] A *panchayat* is a village council in India.

2012, and ownership of each device transferred to the ASHA to whom it had been issued. Since then, one panchayat had been funding CommCare use for its four ASHAs. I interviewed those four ASHAs who still used CommCare, the government official who supervised them, the active sarpanch,[36] eight former field- and office-based project staff, and a Dimagi staff member. At the time of data collection, the original project funder (an international NGO) and implementation partner (a local NGO) are independently pursuing scale-up in different districts and at the state level.

Since my field visit to Project B took place, the original implementation partner entered into an agreement with the Block Chief Medical Officer and the sarpanch of the panchayat that had been active during the funding lapse to restart the project in the eight previously covered panchayats. In the new incarnation of the project, the old implementation partner has become the funder, and the lead panchayat distributes the funds to the other panchayats, and supervises device use in collaboration the NGO and the other panchayats. My data collection ended before the initiation of this new iteration of the project began.

Both projects (A, B) were implemented by locally-run NGOs that deployed CommCare in India to Accredited Social Health Activists. Project implementers in both projects reported that the ASHA literacy qualification was commonly relaxed among their ASHAs, for potentially 30% of Project B's ASHAs and 60% in Project A. Local NGO staff also speculated that ASHA applicants obtained fraudulent literacy credentials to qualify

[36] A *sarpanch* is the elected head of the village council, and liaison between government officers and a village community.

for the ASHA position, hoping for improved social status,[37] or that the incentivized government volunteer position would become permanent, full-time salaried work, as had occurred with the Auxiliary Nurse Midwife (ANM) position.

Field supervisors in these deployments (A, B) also used CommCare devices to troubleshoot technical problems and facilitate ASHAs' use. These NGO project staff had no formal authority over ASHAs, who were supervised by local governments' Chief Medical Officer and directly overseen by government-employed Auxiliary Nurse Midwives, though in different settings the relationship between ASHA and ANM was not particularly well- recognized by interviewees including the relevant ASHAs or ANMs.

Both projects (A, B) were led by an international NGO collaborating with the implementing NGO and CommCare's developer, Dimagi. USAID funded Dimagi's on-site presence to ensure that CommCare was well-adapted to the deployment environment, that field supervisors learned to use, troubleshoot, generate and read reports from data collected, and how to train ASHAs to use CommCare. As in many other deployments, a Dimagi staff member remained on-site throughout training, and ASHAs directly reported

[37] Most research participants, in all relevant projects, reported that ASHAs had low social status relative to their clients. This low social status may be mitigated by the social respect that comes from a community volunteer position such as the ASHA role, but I did not investigate this hypothesis. Later in this dissertation, I do report on many accounts of increased social status of community health workers, including ASHAs, in many projects, as perceived by all research participants and attributed to the CommCare deployments. There was variation in the mechanisms attributed to the status improvements. One explanation was that the device signified the health workers' importance; in other words, the device represented the fact that someone in a city thought her job was important enough to give her an expensive device. Another explanation, popular in poorer areas, was that the device itself was a signifier of social status; in other words simply possessing an expensive device conferred status. A third explanation was offered at project sites where health workers used CommCare's information-delivering audio function, whereby the phone spoke aloud to clients; in these instances, the "radio man" or the device was an authority, and accompanying that authority improved health workers' social status. These issues of the new authority of health workers in their clients' eyes, and the misperceptions that health workers often promoted about devices in service of project missions, are discussed in more detail in Chapter 4, titled *Deepened and Subverted Hierarchical Authority.*

problems to that staff member in the pilot stage, calling his or her mobile phone directly and, on one occasion, posting a message to the Dimagi representative on Facebook. Both deployments were implemented by a local NGO with expertise in the locality and in health interventions. The state and local government was an informal but active planning and implementation partner.

Early insights from these first two field visits are collected in Schwartz *et al* (2013). For all stakeholders except Dimagi in both deployments, this was the first mobile health project, and in fact, all studied projects represented their implementers' first mobile health project. Further, except in a few noted instances, the vast majority of community health workers in these projects had had only very limited prior access to, and use of, mobile phones.

20 Enumerators, Uttar Pradesh (C)

In December 2012 - January 2013, 20 female enumerators undertook a baseline survey using Samsung Galaxy 2 Tablets as a survey tool for a health sector project focused on maternal, newborn, and child health in Kaushambi District Uttar Pradesh. The survey covered ~1,100 households over a period of four weeks. All enumerators had some prior health and/or survey experience, but none had experience with digital data collection. All were first-time tablet users and first-time touch screen users. The participants in the implementing organization, an international NGO, had conducted many baseline surveys prior to this deployment, but it was their first paperless survey.

Project C decision makers chose tablets because many survey questions were lengthy, and the tablet had a large display. Testing revealed that it also had sufficient battery life and touch sensitivity, and was locally available. It was purchased out of the project budget, and at the end of the survey were placed into the country program's information technology equipment pool for use across programs, sectors, and regions within India.

The same initiating agency as in Project A initiated this survey and chose an ICT solution because in developing the program for Project A, project planners recognized an opportunity for the project to use the deployed ICT for routine monitoring, baseline, and endline evaluation. These NGO representatives, who were comprised of project supervisors from a local health NGO and project managers from both that NGO and a local satellite of the Indian office of an international NGO, thought that reverting to paper-based tools for project baseline and endline data collections would undermine the mobile health project that became Project A. With the knowledge that the project team had already gained through working with Dimagi developing Project A's mobile application, they independently developed a new CommCare-based application that they used as a survey tool.

I consider Project C a separate deployment from Project A for three reasons. First, the initiating organization undertook the application development and deployment alone, whereas Project A formally partnered with Dimagi for development, and with Dimagi and a local NGO for deployment. Second, the device was meaningfully different, featuring a touch-screen Android tablet in Project C versus a Java feature phone in Project A. The

different device had meaningful ramifications for each project's selection of how to configure distributed devices and the functions accessible by project participants. Third, projects' usage policies were meaningfully different. In Project A, non-prescribed use of the devices was allowed and even informally encouraged, but in Project C, all non-prescribed use was explicitly proscribed, and actively prevented, and the policy strictly enforced. These differences, finally, were also reflected in meaningfully different contracts that health workers had to sign before receiving their work-issued devices.

16 Link Workers, Maharashtra (D)

This May-August 2012 project trained 16 municipal government-employed urban community health outreach workers, called Link Workers, to use mobile phones as a counseling aid and data management tool to demonstrate their feasibility and potential usefulness in helping Link Workers realize their potential to help target beneficiaries. The project deployed the Nokia C-02 phone, a common java-enabled phone with a key configuration that was familiar to many of the Link Workers and that was also deployed in Projects A, B, and E. Prior to the deployment, 15 out of 16 Link Workers had personal mobile phones, but, as in other projects, most had only been comfortable with making and answering phone calls. Despite expressed apprehensions, project planners reported that most were comfortable with the devices by the end of the first week.

The social objective of this deployment was to use CommCare to "improve maternal health by increasing coverage and service utilization through technology assisted

surveillance of mothers and newborns in urban areas." Secondary objectives included surveying eligible women in urban areas, tracking pregnancies, and educating the population about pregnancy and neonatal health. This work was intended to compliment the current Mother Child Tracking System, a Government of India, country-level initiative intended to monitor and improve maternal and infant mortality rates. However, the tracking system was implemented unevenly across Indian states, and often unevenly across districts. The CommCare deployment was intended to make data that Link Workers collected immediately available and consumable to their health facility supervisors. The demonstration project was intended to build evidence for scale-up and takeover by local government health agencies.

After the pilot ended, the phones were taken back from the Link Workers, who, as in Project B, expressed disappointment and a desire to keep the phones and to use CommCare. Unlike Project B, no health workers were allowed to keep their phones, and thus all discontinued their use of CommCare.[38] A project planner reported that when the devices were taken away, the Link Workers returned to their flip charts for counseling tools, and paper registers for monitoring tools.

[38] It is worth noting that all variations of CommCare are available for free download by anyone, and, if these people had their own mobile phones, they could have continued using the application. Data transmission costs were very low, which is an important reason the Rajasthani sarpanch added the cost of his local ASHAs' use to his budget. For a motivated user, the technical and financial barriers to individual use are surmountable, even for the relevant demographic.

60 Community Nutrition Educators, Madhya Pradesh (E)

This project's beneficiaries lived in 600 villages in Madhya Pradesh, where Community Nutrition Experts (CNEs) serve ~85,000 children with acute malnutrition and counsel their caregivers. During July – August, 2011, an international NGO led testing on two mobile technology applications for field-based data collection. After the study's conclusion, Project E chose CommCare and continued to use it for data collection, individual patient tracking, patient referrals, and staff monitoring in Khandwa District. In May 2012, Project E scaled the use of CommCare on Nokia C2-01 feature phones to 60 female, mostly tribal CNEs, and their 10 supervisors. The deployment is ongoing, and is intended to support a community-based child malnutrition treatment and eradication program that targets rural, marginalized tribal communities. In collaboration with Anganwadi workers, who are Government of India Integrated Child Development Services staff, each Community Nutrition Expert surveys 10 villages on a bi-weekly basis to monitor the health of malnourished children and encourage families of severely malnourished children to seek care at a Nutrition Rehabilitation Center. The CommCare application used in Project E is slightly different than others, as its job-aid function is used by CNEs as a decision-making tool, instead of being primarily a checklist of counseling topics.

Project E pursued field testing and scale-up of the mobile application in response to frustration with the inefficiencies of a paper-based reporting system. Prior to the CommCare deployment, one decision-maker recalled, he traveled on a train with 1.2 tons of paper from Delhi to Project E's implementation site in Madhya Pradesh to conduct a baseline survey of ~18,000 households. Data collection took two months. Subsequently,

completed surveys were transported to Rajasthan, where data were manually entered and then translated. The decision-maker estimated that it took a year to get the baseline data in usable form, during which time a third of the program time had already passed. Project implementers worried that, over the course of programming, the NGO wasn't responding to data, but was only recording it, and sought a technology solution.

1200 ASHAs and ANMs, Bihar (G)

This project, a joint initiative among at least seven nongovernmental organizations and the Government of Bihar, tested the effectiveness of CommCare as a health intervention tool in communities with low literacy. Early efforts piloted this project in Sirasa District. Six hundred ASHAs received CommCare-enabled devices; another 600 acted as a control group, in a study that ended December 2013. CommCare was deployed in combination with a set of other technological interventions at the level of the frontline health worker -- these interventions included a call center intended as a resource for the health workers, and another application, a client referral system developed by a different technology organization. As in many other projects, these applications were deployed as multi-media files on the SD card of a Nokia C2-01 feature phone.

Project G emphasized "family planning, pre and post-delivery care for mothers and their newly born infants, immediate and exclusive breastfeeding, care and nutrition for children up to 2-years old, and routine immunization. Coverage for treatment of diarrhea

and pneumonia as well as some neglected diseases and sanitation, is also a part of the plan...in eight districts at first, and then expand to the entire state" (Project document).

One project coordinator worked directly with a Dimagi project manager, and another coordinated the partner organization. Initially, 40 field facilitators liaised among ASHAs, ANMs, and three technology coordinators who were employees of the lead NGO partner. These facilitators were employed by the lead NGO to hand-hold the applications' end-users, the health workers. Three fourths of these facilitators had been phased out by the time of my study. Prior to the deployment, about 80% of the Auxiliary Nurse Midwives, had had a mobile phone. Project implementers were less sure about ASHAs, but guessed that 50-60% had had a personal phone, shared one, or had other access. ANMs used the CommCare devices for work only, but ASHAs came to use them as personal devices as well.

Early in the project, Project G supervisors observed that participating health workers bought media such as music and videos from local mobile shops to load on their CommCare devices. Project G supervisors responded to this experience by locking the memory card and hiding the multi-media folders on CommCare devices so the media files associated with the CommCare application could not be accidentally deleted. Project managers soon realized, however, that when transferred to another phone or computer, password protections they had imposed on SD cards did not hold, and the memory cards could still be easily erased. Project staff here, as in the other sites, recognized the enormous value the phones added to staff's personal and professional lives. Many of these issues had

real salience for many research participants at all sites, and will be discussed in depth throughout this dissertation.

35 Enumerators, Male and Female Uttar Pradesh (H)

This one-year randomized controlled trial using Android touch-screen phones covered 120 health facilities (including 60 intervention and 60 comparison), and 172,800 live births in six regions in Uttar Pradesh, including three in Lucknow, and one each in Agra, Varanasi, and Gorakhpur. After a pilot in May, 2012, this trial ran January, 2014 through January, 2015. The project was implemented through the partnership of an NGO and a western university school of public health, the funder and study coordinator. The implementing NGO sought real-time information about birth registrations in clinics that they were monitoring, and sought an electronic system that connected information to a data center, allowing them to follow up within seven days. They chose CommCare for its case management functionality during home-based client visits, to collect mothers' health data. Primary project objectives focused on data collection, with minimal attention to counseling or clients' behavior change, as local health facility staff conducted these activities. CommCare duplicated the paper-based checklist that birth attendants used during delivery; enumerators watched an attendant deliver a child, and marked via the CommCare application what happened during the birth.

In Project H, using CommCare devices was a critical part of enumerators' job descriptions, as in Projects K1 and K2. Dimagi staff reported very high user motivation to

use devices as prescribed, due to heavy supervision, including daily work monitoring and weekly in-person performance reviews. Tight study guidelines meant that prescription instructions were very detailed, and this deployment of CommCare featured multiple dashboards and customized reports that enabled supervision. Supervision, and the time and other resources devoted to supervision, was heavier than in other observed projects. Despite this relatively heavy supervision, management reported significant trust in end-users about how staff used their devices. While work-related use was closely monitored, non-prescribed use was not monitored, and the project installed no function-blocking software on the phones. Nevertheless, the strict work-related supervision may have deterred personal use.

All Project H enumerators had previously had a mobile phone, though few enumerators had touch screen experience. Typing was a challenge during training, but eventually the enumerators preferred touch-screen typing. Early in the deployment, the project concurrently tested other phones that featured a real keyboard, but the enumerators, having already used their touch-screen phones for some time, reported liking the new phones less, citing that the keys were too small. Ultimately, data collectors competently used their devices as prescribed, and used devices' calling function as needed for work. Talktime balances were regularly prepaid by the implementing organization. Dimagi staff noticed enumeraturs inserting their own SIM cards in the dual-SIM phones, and speculated that enumerators conducted personal communications on their own SIMs, in work-issued devices. Occasionally, enumerators had to leave phones at the office overnight for

charging, updating CommCare software, or syncing data, so the enumerators could not use project devices as their only personal phones.

Project H Managers reported that they had selected a set of phones that were not very reliable; complaints about devices related primarily to battery life, which was needed to last all day. Project H was the only project whose members expressed dissatisfaction with selected devices, though their expectations of a 10% device loss aligned with other projects' expectations. At time of observation, no decisions had yet been made on how to act on this realization.

50 Community Organizers in Maharashtra (K1)

This September, 2011 CommCare Samsung Galaxy Y and Samsung Fit deployment in Dharavi, a major Bombay slum area, to 50 Community Organizers continues through the time of writing. The project sought to reduce wasting -- a form of malnutrition characterized by low weight per height. At the time of data collection, the project covered about 30% of the slum area, monitoring about 8,000 children under three years old, and 2,000 pregnant women. The implementing organization, a Bombay-based local health NGO, used CommCare only for data collection, client monitoring, and real-time analysis of beneficiary populations. Project K1 was the only project studied that made monthly use of its data not only to assess health workers' performance, but also in its primary service delivery. Indeed, such frequent use of collected data represented a critical part of the project's mission; malnourished children who may fluctuate between severely

malnourished (SAM), moderately malnourished (MAM), and in a danger zone, require at least monthly monitoring for quick response time and proper targeting of the most needy clients.

Community Organizers did their work in partnership with the government's Integrated Child Development Services (ICDS). The project was initiated to demonstrate to the local government that it was possible to monitor Dharavi's children with the frequency required to intervene successfully in their nutrition status. In 2014, the implementing organization was attempting to transfer three geographic sections of the monitoring project to ICDS. The Community Organizers were female, 100% literate, and a couple had completed secondary school or one year of college. Understand Marathi and Hindi, a bit English. CommCare is in Hindi. All Community Organizers had personal mobile phones prior to the project, but the deployed devices' touch screens were an unfamiliar new feature.

66 Community Organizers & 12 Investigators in Maharashtra (K2)

This September, 2011 CommCare Samsung Galaxy Y and Samsung Fit deployment also in Dharavi, to 66 so-called Community Organizers, is implemented by a different program of the same organization as Project K1. Project K2 implementers initiated Project K2 after observing the decision making process of implementers in Project K1. Project K2 used CommCare in two ways. First, Community Organizers used it to monitor clients as part of implementing health services offered at community centers. Second, investigators used it for data collection, to assess the success of the health center

interventions. The health center intervention was intended to change health outcomes for women and children. Indicators for this goal included children's immunization and nutrition status, access to contraception, and exclusive breastfeeding. The Community Organizers in this project were female, 100% literate, and most had completed secondary school. Seventy percent of the Community Organizers owned personal mobile phones prior to the project, but, as in K1, the deployed devices' touch screens were an unfamiliar new feature. Previous to the deployment, Community Organizers in Project K2 had only been comfortable with calling and very little SMS.

The following deployments were studied through more limited observation than the above-described projects. For each of the below, I extensively reviewed project documents and interviewed project participants from the implementing technology partner, Dimagi, but did not conduct on-site field visits.

Two additional projects (I, J) represented informal units and are described in the Appendix.

ROLES. ACTORS AND STAKEHOLDERS IN FOCAL PROJECTS

This section responds to the sub-question, what organizational roles participate in, affect, and are affected by health workers' use of CommCare and CommCare devices? This section introduces the key actors of the observed ICTD projects, many of whom were informants of this study. As summarized previously in Table 2.1 and in Table 3.2 below, these actors are grouped by roles as they relate to the development project generally and to

the technology deployment specifically: funder, technology developer, implementer, frontline worker, government partner, and others. Research participants observed these individuals as having agency in the deployment, whether or not that agency was fully autonomous, or even purposefully imbued by a supervising authority. Research participants identified these individuals as actors with influence over the success of the ICTD project.

Table 3.2. Relevant Actors

A1	Project	A10	Clients
A2	Accredited Social Health Activist (ASHA)	A11	Clients' family / community
A3	Frontline Community Health Worker (CHW), non-ASHA	A12	Health workers' and supervisors' families
A4	On-site project staff	A13a	Device or CommCare
A5	On-site project management	A13b	Mobile shop owner
A6	Off-site implementation partner	A13c	Strangers/thieves
A7	Funding partner	A13d	Other organizations
A8	Dimagi, the developer of CommCare	A14	Researcher, journalist, other non-stakeholder observer
A9	Government (often a local Medical Officer)		

Some roles identified were as expected. These include the health worker (A2, A3) who used CommCare devices, and on- or off-site project planners, supervisors, and

partners (A2-A9). As mentioned in the methodology Chapter 2, I distinguished between the opinions of these individuals in my coding and the official stance of the organizations they represented by taking interview statements as inhering to individuals, while documents, websites, and other unattributed statements issued directly by organizations as representing the projects (A1).

Research participants identified additional relevant roles, and were more important to research participants than I would have expected, had I considered them in advance. These roles included health workers' clients (A10), clients' families or community (A11), health workers' own families (A12), the device itself (A13a), mobile shop owners (A13b), and strangers or thieves (A13c). These actors did not necessarily influence the deployments systematically, or even frequently, but all were identified, across deployments, as heavily influencing the project at one point or another.

A more detailed description of each role follows.

Project (A1)

The *project* relates to the specific set of objectives, procedures, timelines, activities, and resources surrounding a programmatic decision to introduce CommCare into work. In the observed deployments, projects were typically implemented as a collaboration among multiple organizations and the government, so statements issued by a *project* do not necessarily fully align with statements issued by its partners. I assessed project expectations

and outcome perceptions by reading documents including implementation plans, contracts, grant proposals, annual reports, and marketing materials.

Frontline Community Health Workers (A2, A3)

Governmental and non-governmental community health workers used CommCare devices in studied projects. These actors were married, literate or semi-literate women who lived in the communities they serve as frontline community health workers. These cealth workers were the first point of contact for their neighbors to the public health system, and advocated to their neighbors to adopt healthy behaviors. For all studied projects that deployed CommCare devices to governmental health workers, a non-governmental organization partnered with the government to distribute devices, maintain control over the distributed devices and over their use, and maintained control over the data produced via CommCare. This introduced a new supervisory authority over the governmental health workers including ASHAs and Link Workers, and non-governmental health workers including Community Nutrition Experts, who received devices, acted as the primary user, and as the individual who input the data into CommCare.

On-site Project Staff (A4, A5)

Supervisory field staff, based in population centers near their community health workers' clients, ensured device and data integrity and monitored use of the devices to ensure adherence to project guidelines. Field supervisors periodically accompanied

community health workers on client visits in clients' homes. Project managers liaised between field supervisors and off-site, supervisory, implementation and funding partners, often in a city center or in Delhi.

Technology Partner, Dimagi (A8)

The company Dimagi developed the software application CommCare to help address some of the deficiencies in knowledge and resources that community health workers face globally, and to address the drawbacks of paper-based flip charts and data collection. Dimagi intended CommCare as a job aid and decision-making assistance tool, helping health workers choose which health messages to deliver to a particular client on a particular visit. Dimagi designed CommCare to be customizable by any implementing organization. For each project, a Dimagi representative helped project planners complete customizations, and participated in on-site training of health workers to use CommCare. That Dimagi representative maintained relationships with project implementers including each site's 10 pilot health workers, keeping in touch via phone, SMS, and occasionally, Facebook.

Government (A9)

Government partners played various roles in observed projects. In deployments where CommCare device users were ASHAs, their Chief Medical Officer approved health workers' participation in the project (and therefore to use CommCare). The Chief Medical

Officer also helped identify the individual ASHAs or the administrative blocks or districts to receive and use devices loaded with CommCare. In such instances, the Chief Medical Officer retained supervisory authority over ASHAs' main health work.

Even in projects in which an NGO deployed CommCare to its own community health staff, the NGO leading the CommCare deployment often solicited and engaged government partners. One typical reason was that the focal NGO intended for the CommCare project as a demonstration project to be ultimately taken over by the government (Projects D, K1, K2). In these instances, project managers took special care to include health ministry officials in planning, and government health workers in implementation. Sometimes, the NGO staff who used CommCare did their work alongside a government health worker.

In Project B, five sarpanches[39] had approved their 70 total ASHAs to use CommCare in a project for which the funding eventually expired. At that time, ownership of the devices, used by ASHAs but owned by the implementing local NGO, reverted to the individual ASHAs who had used them. In four communities, the project was allowed to dissolve. In the fifth community, the sarpanch used panchayat funds to pay fees for its four ASHAs' continued CommCare use. That sarpanch explained in an interview, "The ASHAs approached me. They said, don't stop this because once it's stopped it will be difficult to restart it. So they supported me – the village – and I supported them." That sarpanch also

[39] A *sarpanch* is the elected leader of a *panchayat*, or local government council of a rural community.

later took a leadership role in mobilizing his neighboring panchayats to coordinate on a reinvigorated and differently funded version of the project, expanded to the entire district.

Non-Participants (A10-A12, A13b, A14)

Interview participants identified additional roles that influenced the frequency and quality of health worker-client interactions, and how health workers perceived their own status in their families, communities, and health work. The actions and perceptions of health workers' clients (A10), clients' families or community (A11), health workers' own families (A12), mobile shop owners (A13b), strangers or thieves (A13c), and outside observers including researchers and journalists (A14) often greatly influenced how health workers used the devices during the times when they were not using CommCare. As mentioned, these actors may not have influenced the projects systematically, but all were frequently identified as meaningful to projects.

Device or CommCare (A13a)

Finally, interview participants attributed to devices and CommCare unprecedented power in health workers' client interactions, interactions with their traditional supervisors, and in their personal lives. Chapter 5 describes devices' role in strengthening the authority structures that had existed in community health work prior to projects' initiation, and devices' role in promoting new sources of authority especially for health workers. With the deployed technology considered by health workers and their supervisors as a real source

of personal efficacy, the final section of this chapter describes the technology's role in promoting community health workers' empowerment, education, and digital inclusion.

DISCUSSION

This section briefly describes the effects of CommCare use in the above-described focal projects, on community health workers, community health work. This section previews the subsequent chapters' theory-driven observations.

As described in the subsequent, sociotechnically-oriented Chapter 4, CommCare was used as prescribed in all projects. Having adopted CommCare, focal projects and health workers and their supervisors reported drastic improvements on many of the challenges described in the previous section, including training, knowledge, supporting resources, and social status. As discussed in the principal agent theory-driven Chapter 5, the immediate effects of focal projects included planned improvements in community health workers' delivery of health information to clients, client monitoring, and performance feedback to health workers. Research participants reported that project participation also meaningfully enhanced professional efficacy for health workers. Many benefits of device use accrued directly to project participants, including productivity, new literacies, and ICT access.

Research participants also described important improvements in health workers' and supervisors' confidence, ability to carry out their responsibilities, and feeling of authoritativeness in conducting their work. Their explanations for this improved

professional efficacy included an increase in their ability to communicate with far-flung clients and colleagues, improved job skills and substantive knowledge, on-the-job improvisations of the device, and improved status among clients' and clients' families, who were impressed with deployed devices.

Frontline workers who had been previously unable to visit all of their assigned 10 clients per day were now better positioned to meet this minimum. Research participants offered a few reasons for this improvement. These reasons included the efficiency-enhancing move from paper to digital recordkeeping, which reduced the time necessary to retrieve data. Now, health workers further reported, when medical authorities asked about their work, they could easily switch on their phones and respond to questions about how many clients are registered, and clients' health and pregnancy status. Health workers also cited efficiency gains from their new capacity to use issued devices as phones, and call supervisors and clients, which helped them proactively organize their workday according to clients' availability, and consult with CommCare supervisors, and local doctors and nurses, as soon as they had questions or needed medical consultation.

In addition to efficiency gains, health workers and their supervisors also reported that health workers experienced real gains in their effectiveness doing health work. All projects using CommCare's speaking function reported that community health workers regularly using CommCare during client interactions demonstrated a marked improvement in their knowledge of the health information they were expected to convey to clients. Some reported improved recall, understanding, and ability to articulate key information such as pregnancy danger signs. All projects reported marked improvements in health workers'

literacy and numeracy, both key for accurate recordkeeping, record retrieval, and assessment of low birth weight and malnutrition. Feature phone project planners reported that staff gained English skills, and learned to transliterate clients' names from Hindi or other local languages names into devices that only recognize English characters. Supervisors reported that supervisors' own new technological and vocational literacies for accessing, aggregating, and reporting on data increased their opportunities for professional advancement in implementing and competitors' organizations.

As described in the subsequent chapters, health workers often improvised new mission-oriented device uses such as using the camera to capture alarming client symptoms, which they could transmit to remote health professionals for consultation. When they thought they had successfully encouraged deeper learning or healthy behaviors, health workers shared these new ideas with peers. Further, some reported using the devices to play games during work hours to brighten one's mood, while waiting, or when feeling pressured by work. In this way, non-prescribed device functions were used to refocus health workers on their tasks.

Furthermore, frontline workers felt newly validated in the eyes of their community, clients, and clients' families, which in turn increased health workers' confidence, excitement, and ability to deliver information and spur a decision to adopt healthy behaviors. Introducing devices to the health worker-client interaction changed where and how health worker-client interactions happened within a client's home. Now, clients' family members, with great influence on decisions concerning a client's pregnancy and how children were fed, displayed an interest, and could be drawn in to listen, ask, and

respond to questions. Health workers reported, “Before I wasn’t interested in work, now I’m excited to go to the field because people listen to me.” “I thought I wouldn’t be able to learn. It feels good that I learned.” “It gives ASHAs a sense of authority to be linked to America, to Lucknow.” And, “the mobile phone gives the ASHA an identity.”

Health workers, who had previously experienced immense trouble bending the ear of, teaching, and convincing their clients, let alone other decision makers in clients' homes, repeatedly emphasized how important it was for them to be given new attention and treated with respect and interest.

Chapter 4. Empirical Observation of Uses and Influences on Use

This sociotechnical chapter addresses the research question in its most basic form: how do community health workers in India behave after a technology such as CommCare, loaded onto a mobile device, has been introduced into health work routines? How does use manifest in focal projects? How do individuals' perceptions, project rules, and other project features influence health workers' use of a new ICT? This chapter describes how actors were supposed to use recently-issued technologies, how they actually used recently-issued technologies, and what these actors perceived as the immediate influences on and consequences of these activities.

SOCIOTECHNICAL EXPECTATIONS

Chapter 1 described expectations that users could and would "use technologies as they were designed…" *and* would "circumvent built-in ways of using the technology and invent new ways" (Orlikowski 2000, p6) to use it. Users "assert their agency by ignoring, articulating, altering, or working around the intended use of technological features" (Orlikowski 2000, p9). Further, project participants' use of deployed technologies would depend on their intentions, interests, interpretations, interactions, inertia, and improvisations, whether according to or spite of project plans and documentation. My dissertation research supported these expectations for both planned and unplanned use of work-issued devices. Health workers generally used the devices and CommCare as directed

by the contracts and by their supervisors during training, via verbal messages and training manuals. However, contracts and supervisory messages occasionally contradicted each other, and even when contracts and training messages indicated clearly against health workers' personal use of the devices, most health workers used the devices for personal uses frequently.

Moreover, I expected to see evolving routines and behaviors because each new use of a technology is a new opportunity to modify it, and new challenges are opportunities for improvisations that later become daily practice. This expectation assumes users' evolving perceptions about the usefulness and usability of received technologies, and peer effects. Specifically, the (evolving) perceptions, observable use, directives of others in the social system should, according to the sociotechnical lens, influence focal users' evolving perceptions and observable use of received technologies. My observations supported this expectation as well. While in most projects some health workers briefly resisted adoption, fearing extra work or an inability to use the technology, most ultimately came to incorporate devices and CommCare into their professional and personal lives, and that use continued to deepen into predictable patterns over the course of deployments.

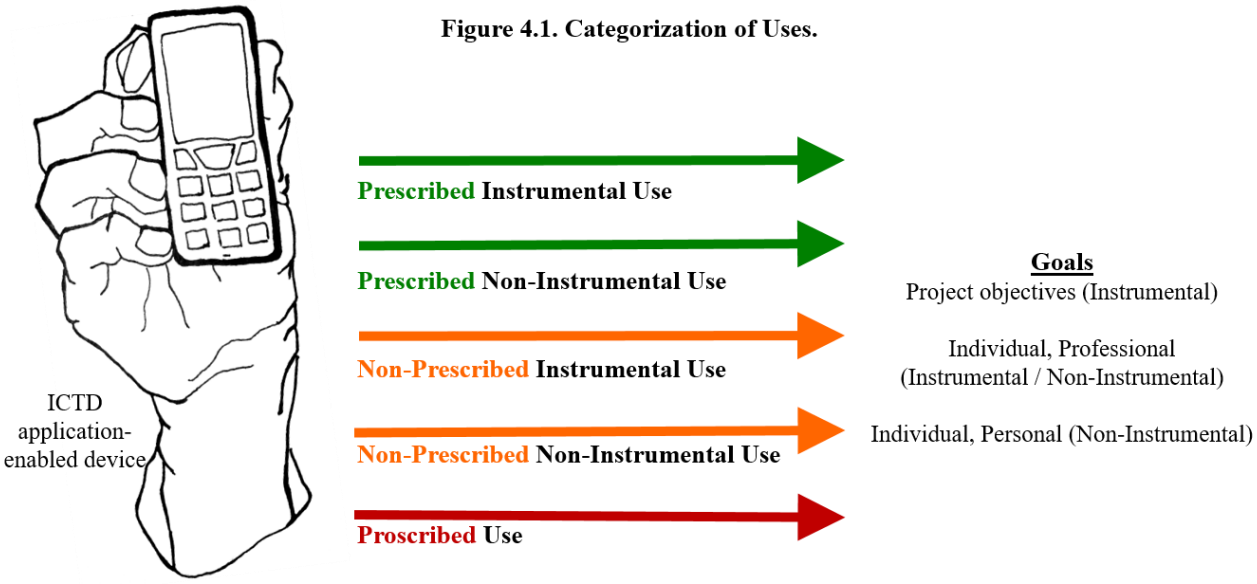
I described these findings in more detail below according to the following structure. First, I describe how health workers, their supervisors, and project managers used CommCare and work-issued devices in the context of focal projects. The first section describes (a) *planned use*, or how community health workers used work-issued devices as project managers had planned. The next section describes health workers' (b) *unplanned use* of work-issued devices, or ways that health workers used the devices both strategically

or instrumentally for work, and non-instrumentally or for personal use at home, outside of project managers' expectations. Then, this chapter elaborates on the results of interviews and observations to identify the project features that supported and constrained use. I group these project features into (a) *goals*, or individuals' understanding of project objectives and benefits, (b) *fears*, including perceived risks and threats associated with the CommCare project, (c) *environmental factors* outside projects' control, and (d) *choices*, or project implementation decisions such as policies on how devices may be used.

USE OF COMMCARE, COMMCAREHQ, DEVICES, DATA, AND REPORTS

This section reports on the uses of CommCare devices and resulting data, as well as on the perceived immediate consequences of this use. These uses include *instrumental* or work-related use, which projects may or not prescribe but which end-users undertake in support of project goals. These uses also include *non-instrumental* or personal use, which may be prescribed or not prescribed but are undertaken in support of personal goals. Restated, project planners can prescribe, not prescribe, or proscribe health workers' uses of work issued devices, and health workers can use devices either instrumentally or non-instrumentally. Figure 4.1 illustrates these combinations into possible types of use.

Figure 4.1. Categorization of Uses.



Health workers may ***use*** device ***functions*** to advance ***project (Instrumental)*** or ***personal (Non-Instrumental)*** goals.
Project planners may ***expect (Prescribe)***, ***ignore (Non-Prescribe)***, or
ban (Proscribe) uses via policy or technological lock.
(adapted from Schwartz et al, 2013).

While individuals retained their health program roles, as pertained to the project, they also developed evolving roles as individual "users" of the technology and its outputs. Recalling Figure 2.1, program managers now created and implemented budgets for using CommCare, planned projects, interacted with donors and Dimagi developers, selected and purchased devices on which to use CommCare, and decided to modify devices and settings. According to these decisions, field supervisors installed CommCare, modified devices and settings, trained health workers on using CommCare and devices, troubleshot technical problems, and installed software updates.

Community health workers input data into CommCare and interacted with beneficiaries and with project-issued mobile devices to input client data and using

CommCare's job aid features. Field supervisors used these data to monitor health workers for competent and quality completion of this work.

Some consumers of CommCare's outputs, such as on-site project supervisors, viewed and interpreted raw data via the linked application, CommCareHQ, while other consumers, including off-site supervisors and funders, viewed reports into which these data fed. As detailed below, these individuals used these data or reports as inputs back into the project, to influence behavior of project staff, or to spur discussion or action on the project by other relevant stakeholders such as local government.

Prescribed or Planned Use

In all projects, project participants generally followed prescribed use, defined as the use of CommCare and enabling features such as the calendar and contact list, as participants' supervisors instructed them to. Community health workers learned to use CommCare and its enabling features of the phones or tablets on which CommCare was installed. Most eventually came to use CommCare consistently and according to supervisors' direction. A small few health workers did not use CommCare properly, and these individuals were dismissed if they were NGO staff or dropped by the implementing NGO from the ICT project if the offending health worker was a government health worker. Field supervisors used data that health workers transmitted via CommCare to monitor health workers' progress. Project managers used these data to create reports for partners, funders, and the government. Dimagi used raw data produced via CommCare in their own

internal analysis.[40] In two projects, a funding partner also accessed the raw data via CommCareHQ. Most project representatives reported acting on these data to give feedback to health workers on their number of client visits per day, amount of time spent with clients, and completion of counseling topics.

None of the projects had experienced the data-enabled strategic decision-making that they expected. They were not yet analyzing data quickly or comprehensively enough to identify and act on emerging neighborhood health concerns. Some still struggled with decisions about what data to collect. Debates among project planners centered on the idea that sparse data would never give a clear enough picture to justify adjustment of health work priorities, but data collection was cumbersome and not the primary work of the health workers. While early use resulted in reportedly overwhelming amounts of data for project supervisors and planners, most projects, at the time of observation, had settled on collecting just what health workers needed in order to do their primary work.

Many benefits of device use accrued directly to project participants, including productivity, new literacies, ICT access, and feelings of personal and professional efficacy, on which I report in Chapter 5.

Non-Prescribed or Unplanned Use

Some health workers' professional uses of deployed devices were not anticipated,

[40] I believe this presents a legal and ethical challenge to patient privacy, discussed further in the concluding chapter.

prescribed, or explicitly allowed by project planners. These uses nonetheless emerged at all sites that did physically not prohibit them either by disabling certain features or by locking devices in the office at night. Female project participants frequently and enthusiastically reported no longer having to ask to borrow their husband's phones to call their supervisors. Health workers often enjoyed games and Facebook to keep their minds fresh and their attitudes positive during a tough work day.

Frontline workers and their families attributed frontline workers' improved social status within their own families and in the community to the deployment, and to frontline workers' conspicuous physical possession of the device. Even in families that already possessed relatively nice phones, husbands and children reported being impressed that their wife and mother had received a phone from work. They perceived that her job was important enough to justify this expense and the training that went along with it. Frontline workers reported that their families expressed pride that they were serving society. One husband reported that expectant mothers now gave preference to what his wife said [implying less competition from mother-in-laws, neighbors, and/or traditional healers, all of whom gave frequent conflicting advice].

One Dimagi representative was very excited to write about an instance in which one health worker adapted CommCare unexpectedly, interacting directly with the multimedia CommCare files stored in her phone.

> *It blew me away when she first told me. After two months of using CommCare, one day during Immunization Day in her village, [name] decided to play the audio files through the media player for small groups of women who were waiting to get immunizations for themselves or their children. The audio played without pause actually sounds like a conversation between two women about antenatal care*

topics. The way we named the files results in the following playlist: 1) a woman says, she does not know about topic xyz; 2) a health worker gives information about this topic; 3) a woman says, yes, she knows about topic xyz. And this flow repeats for 45 antenatal topics! A couple women came up later to ask the ASHA more questions about topics raised in the "radio show".

Health workers did not restrict their inventive instrumental uses of their work-issued devices to inventive instrumental uses of CommCare. Health workers occasionally Googled health information when appropriate. Indeed, health workers often discovered new mission-oriented device uses, and when health workers thought they had successfully encouraged deeper learning or healthy behaviors, shared these new ideas with peers. For example, one innovative use was to photograph clients' clinic-delivered babies to show other pregnant clients how healthy a child could be if its mother decided to deliver in a health center instead of at home. Health workers reported that clients and clients' families often requested to see something new on the phone, and some health workers initiated a practice of taking photos to show pregnant mothers, who did not have mirrors at home, how their bodies had changed with the pregnancy. Health workers also frequently photographed concerning symptoms, such as rashes or swollen feet, to SMS a health professional for remote consultation. Health workers also regularly called their health work supervisors, including government nurses or medical officers, for advice on these and other client health concerns.

Most interesting, project participants reported that health workers fostered, or simply failed to correct, clients' misunderstandings about devices' capabilities when health workers thought those misunderstandings would support healthy behavior changes. Clients

often viewed the device itself as an authority, or as representing a remote authority. As one interviewee explained,

> *We used to say, you have to eat! But pregnant women believed that if they ate too much, the baby would get too big to squeeze out. Now, these superstitions and stigmas are changing. The pregnant mothers know, when the phone speaks, it speaks right.*

Community health workers and project managers understand that phones and other computing devices are not less fallible in their "knowledge" than humans are but, they report, this is not common knowledge in their villages. Clients often forgot or did not understand that a human had to input information into CommCare devices, and so when the phone "speaks," it is only as correct as the human who entered in the information. Community health workers often made use of this perception that technology-mediated expertise – doctors seen on television or, more often, heard on the radio, and now heard through CommCare devices – were correct simply because they were featured on those media. By this analysis, community health workers were able to take advantage of a special moment in time in India, whereby computing technology is visible everywhere, but by no means deeply used or understood by everyone.

In another example, health workers reported that clients and clients' families would tell each other to respond honestly to questions such as, "Have you been taking iron tablets this month?" because someone in Delhi would see and verify the response. Other families thought that CommCare recorded everything said aloud, and shushed each other because "the phone hears everything." Some health workers encouraged this perception by asking clients to speak responses directly into devices, though CommCare lacked a function to

record spoken responses and the health worker had to type in each response afterward.

Multiple projects noted, as this project report did, "Clients perceive audio source to be someone of higher authority than the ASHA, who knows more than her." One project's blog noted, "People find mobile delivered messages more reliable," trusting the CommCare messages "similar to the way they trust television and radio because they feel that broadcasted information is authentic and verified." A different project report stated, clients "now believe that the audio recorded in the application is actually a doctor giving them advice and they tend to follow it." Sitting at her NGO's regional headquarters in a major city, one off-site implementation partner speculated during an interview on how health workers might take advantage of this soft intimidation technique:

> *People seem to perceive that if it's on the computer—I'm not just talking about mobile phones—and I'm talking about all all all of us, not just about ASHAs. If we went to a shop and wanted to bargain, but the shop owner said, the computer says 50 so I have to take 50. It took us a long time for us to understand that a human put it in the computer and we can question that. That message hasn't necessarily gotten through to the rural areas, especially to women. So the ASHAs can take advantage of this to convince each and every woman to have healthy behavior. But they shouldn't do anything unethical. So that challenge will always be there. But like you said. The patients often hold the ASHA's hand and answer directly into the mobile.*

In sum, my data support sociotechnical expectations of community health workers' use of CommCare and CommCare-enabled devices. End user health workers used CommCare as supervisors directed them to, and found many non-prescribed ways to use the devices instrumentally, in service of their health work. The subsequent section describes the key project features that influenced use. I categorize these influences as project participants' goals and fears, environmental features, and organizational choices

that planners made to support and shape use.

RULES. IMPLICIT AND EXPLICIT MEDIATORS OF USE

This section describes how goals, fears, and environmental factors informed and continued to inform project planners' and ultimately, CommCare users' choices. Then, I describe the choices themselves, implementation policies about the use of CommCare, how CommCare devices should or may be used, and procedures for maintaining CommCare's integrity and the integrity of devices on which CommCare was loaded. This section helps address the question: what project features shaped the use of CommCare and the work-issued devices on which CommCare is installed? These project features, including planners' decisions about how deployed CommCare devices should and could be used, are also summarized in Table 4.1 below. Project planners often anticipated many of the challenges reported here, but had little guidance on how to weigh potential benefits with risks when determining their readiness to adopt CommCare. Were the observed projects right to adopt when they did? Should they have waited, or, given their relative success, begun even earlier? Did other similar programs in a similar position, but that decided against implementing a similar technology, make the right choice?

Goals. Written Statements and Expressed Perceptions of ICTD Project Aspirations

First, supervisors' and health workers' interpretations of project goals influenced

their understanding of and behavior with respect to CommCare and CommCare devices. Using mobile computing devices in the workplace was new for all studied projects, and many project implementers expressed wonder about whether the deployed technology could deliver any social benefit. With new technologies intended to reshape existing activities or spur new activities, project implementers had not used a strong evidence base to justify deployment. Instead implementers tried something new, something that they had heard worked in a similar context, or that they thought could radically alter their work and was thus worth risk and expense. Expressed aspirations are grouped below into primary, secondary, and tertiary objectives. All of these objectives shaped supervisors' decisions around how to configure and distribute CommCare devices, and the messages supervisors would offer to health workers about how devices should be used. Commensurately, health workers' own understandings of project goals and the usefulness of CommCare devices in achieving those goals influenced their decisions about whether, how, and when to use this work-issued ICT.

Primary objectives relate to project participants' and their distant principals' most critical development goals: broadly, benefits that accrue to society. These goals include improved health among target beneficiaries, with expected outputs including improved quality of and more timely access to health services and information. Improving government capacity to make good on its health delivery and reporting obligations was also reported as a critical, if long-term, goal. While these objectives are key outcomes from a foreign aid or international development perspective, they were rarely mentioned by project participants, who, at all levels, focused instead on secondary development

objectives, accruing to projects, and tertiary objectives, accruing to individual project participants including supervisors and community health workers.

Secondary objectives were also perceived as important. Project planners often and strongly identified CommCare's use for informing and monitoring beneficiaries, and potential for evaluating projects' impacts. "Networked digital devices such as mobile phones, personal digital assistants (PDAs), tablets and laptops are increasingly being used for improving the efficiency and effectiveness of data collection, as these technologies allow single-point digitization and efficient aggregation of data" (Project E document). This digitization and aggregation of data was intended to reduce delays in data aggregation (E) and provide real-time information (H) that allowed timelier follow-up (E, H) as compared with a paper-based system. Using CommCare also promised to allow frontline workers immediate recall of client data, and remote access to aggregate data by far-flung stakeholders. In practice, data access by anyone not directly responsible for deployments' funder reports, and any project's use of data to strategically shift activities or targets, was rare.[41]

Further, research participants perceived that CommCare promised increased supervision of frontline workers, and this ideal bore out in practice. When CommCare was used on Android devices to monitor a randomized-controlled trial (H), one decision-maker reported high motivation among end-users to use devices for work due to this oversight. Project H supervisors monitored enumerators' work daily, and weekly performance

[41] Except notably, as mentioned, in Project K1, which used the digitized aggregate data weekly to strategically assess clients' needs and reallocate health workers' time according to the most current health needs of their beneficiaries.

reviews and device checks forced users to do what they needed to each day. In many focal projects, new data that CommCare produced allowed for more accessible, more accurate, and more frequent (often weekly or monthly) feedback to frontline workers. Devices' phone and SMS functions also allowed remote check-ins in most deployments studied,[42] which "ensures enhanced connectivity with the ASHAs and leads to saving of time" (Project B, Interview). Many research participants at all levels perceived that deployments also improved overall program efficiency and individual workers' productivity. Project B reported that CommCare gave fast, accurate data in a short time, saving travel time and expenses for staff monitoring and supervision. The principal agent interpretations of this increased monitoring, including details on new forms of communication and data use, are discussed in Chapter 5.

Most deployment decision-makers and project participants also identified tertiary objectives, including opportunities to modernize, experiment, and obtain new project-level literacies including managing digital village-level data. Many interviewees perceived that early progress on these goals led to renewed organizational credibility and supervisors' and health workers' pride to participate. Project B field managers, for example, reported that after receiving new devices, frontline workers actively tried to make a good name for the implementing organization. Likewise, one iNGO field manager supposed that a successful CommCare deployment would improve its organization's credibility, in the eyes of potential funders, in providing grassroots health organizations with technical support.

[42] Two implementations never installed SIMs in deployed tablets, transmitting data in the office instead via WiFi, so increased communication from the field can not be attributed to deployed devices.

Multiple projects were undertaken to demonstrate internally and to funders that scaling-up village health work, which was traditionally paper-based and administratively cumbersome, was possible and sustainable.

Fears. Tensions over Control of Projects, Devices, Finances, and Reputations

Second, supervisors and health workers' fears about CommCare deployments' risks influenced their understanding of and behavior with respect to work-issued devices. Fears combined with the above-described hopes into tensions about maintaining control over devices' use. These fears also shaped the rules imposed by project planners and fueled end-users' self-restraint as they used devices. Supervisors expressed a number of *a priori* and ongoing concerns specifically related to deploying CommCare and its device, especially potential damage, loss, theft, depreciation, application integrity, data security, and proper data transmission.

Some of these fears bore out in participants' experiences. For example, Project A supervisors password-protected memory cards, and during training, explained the logic of locking these cards: CommCare media files resided there, and these media files visually appeared similar to music, games, and other recreational files. The number of CommCare's media files varied by deployment. An image file and an audio file are typically associated with each CommCare form, and any version of CommCare could hold 100 forms, with 300 associated files, or more. Supervisors locked memory cards to prevent unintentional file deletion, which would make the application run improperly. If a user accidentally deleted

a form's image or audio file, its associated form would work, but its accompanying image would not appear or audio would be unavailable. This problem happened frequently, and was fixed when a supervisor brought an uncorrupted version of CommCare to the health worker and reinstalled CommCare on the health worker's device. Further, Project A reported two cracked memory cards, one because an ASHA had been switching out her own card, on which she downloaded and listened to music.

In another example, Project E supervisors "limited training on the phones very specifically to the CommCare application itself," because, a manager reported, he was "very conscious and wanted to avoid use of the phones beyond CommCare," for fear of wear and tear on the phones during personal use, and because he worried about the "mobile shops" in rural India that sell pictures, games, and videos to put on SD cards. In India, he said, "The coverage of these shops is better than basic health care services." He was concerned that shop owners modifying the card would interfere with CommCare's functioning, and that downloaded material would distract from work. During training, he reported, project supervisors stressed that the "phone was a tool, not a toy."

Project H managers agreed, and locked deployed smartphones to prevent access to the Internet or Facebook during work. Indeed, a locking function[43] was the only successful way that projects could prevent health workers from modifying their memory cards. A typical alternative, password protections on feature phones' media cards, was routinely evaded by mobile shop owners, who often erased the media cards completely before

[43] Typically via an application called AppLock, described later in the chapter and only available on smartphones

loading purchased entertainment content.

Despite these evasions, frontline workers were very concerned with meeting obligations and taking responsible care of devices. Project E health staff were "concerned that they might 'break' the devices if not transported with care and that they would be held accountable" (Medhi et al, 2012). And they were held accountable: one ASHA, whose phone was stored in the folds of her sari and fell in a pot of boiling water, had to pay to replace it. Most projects demanded, often in a written contract, that at-fault CommCare users partially or fully paid to repair or replace lost or damaged devices and memory cards. All health workers and supervisors who I interviewed felt this to be a major financial burden, even for projects using basic feature phones.

For this reason, health workers feared using tablets during monsoons, preferring the larger screens compared with mobile phones, but aware of their relative costliness (B). During rainy weather, Project E's frontline workers "used multi-layered plastic packing to protect the phone during transport [crowded city buses; husbands' motorcycles]. But in spite of this, they were concerned that water would seep through and spoil their devices." Multiple deployments reported that health workers had taken it upon themselves to purchase device covers, or had taped or laminated devices themselves. These cautions increased water-resistance, but the home method blocked access to batteries, SIM cards and memory cards, and dampened the speakers, which were critical for the full functioning of CommCare during client visits.

Project participants also anticipated potentially negative social and professional reputational repercussions if they lost or damaged devices. One Project A health worker

who nearly lost her device said, "This phone is my responsibility. Charges [for replacement] are ok, but the feeling of responsibility, that I wasn't able to properly fulfill it is more important than the expenditure part."[44] Device or CommCare malfunctions, even if not directly attributable to health workers, often posed threats to health workers' credibility. For example, in areas with spotty network connectivity, submitted data remained pending. Supervisors who remotely observed a lack of incoming data interpreted the non-transmission as potential shirking by health workers. Though the connectivity problem was relatively frequent in many deployments, supervisors followed up each time, and health workers had to explain that they had been working even if supervisors could not see it, which they had not had to do prior to the ICT deployment.

In two observed projects, when CommCare required reinstallation, all project supervisors agreed that all frontline workers expressed concern, often panic, alongside their urgent requests to reinstall. All supervisors reported that reinstallation caused no financial cost, no annoyance to the supervisor, and no penalty to the health worker. But if CommCare was disabled, the health worker could not work, and malfunctions posed real reputational threats to health workers. For example, participating ASHAs' performance was now announced monthly at government health meetings, and these announcements affected them deeply. ASHAs vocally defended peers if they believed unavoidable circumstances such as a family death prevented ASHAs from working. Further, program staff reported their own and frontline workers' sense of responsibility to protect the devices with which

[44] English translation.

they had been trusted, and their expected feelings of failure in breaching that trust if they were to lose or damage the device. Finally, sometimes CommCare "would not load during registration while a [health worker] was at a patient's house, and this embarrassed [the health worker]. One of the [health workers] managed such situations by saying that the phone had 'run out of battery'" (E).

Some early fears did not bear out. Many frontline workers reported that they had anticipated that the CommCare adoption would mean more work. But after training and a few weeks of use, project planners found their health workers generally convinced that their jobs had become easier. Some health workers, who had previously not had a way to demonstrate that they were working, appreciated the new digital supervision, which in at least three instances reportedly compelled government officials to eschew favoritism and recognize hard-working health workers based on performance-based data, and therefore, merit. Further, one ASHA's mother-in-law enthusiastically reported during a home interview that her daughter-in-law had previously spent each evening recording data about the pregnant women she had visited that day, but now that she used CommCare, her evenings were free for cooking. These positive results, reliefs, and real benefits encouraged and spurred CommCare use.

Other fears arose based on early experiences, and were considered by supervisors and staff to be real burdens of varying importance and occasional but meaningful impediments to prescribed use. I group these burdens into first, new dependencies on technology, technical knowledge, or expertise, and second, threats to project participants' use by non-participants. These challenges contributed to unplanned, real losses in control

over social sector work and over devices.

Technical Dependencies

New technical dependencies came in many forms. For example, health workers also were expected to ensure sufficient battery levels for client visits, regardless of their home electricity supply. Moreover, "Doing daily data quality checks added approximately one hour each night after teams and supervisors had already completed a long day of data collection... about 30 minutes to download the day's data (slow connection) and 30 minutes to review it with the teams" (C). Further, personnel whose primary work had been social sector work needed new technical skills. For example, in all projects, managers and supervisors were now expected to troubleshoot device and application failures, and to access and manipulate more data more quickly than before. "Only when the Dimagi Field Engineer visited were technical problems discovered and dealt with. The absence of such a person [after the pilot period ended] prevented sufficient build-up of local capacity and in the end made it more likely that the project could not be sustained by the NMMC alone" (D).[45]. While most projects developed some local troubleshooting capacity, many shared this experience of an NGO-led deployment that depended on local government to, at least, supervise health staff, and, ultimately, lead the scale-up of a successful pilot. Government partners with already stretched capacity would also have to gain technical expertise for

[45]Project D was a demonstration project that implementers hoped this government entity, the Navi Mumbai Municipal Corporation, would take over if successful.

which there may not be training.

One project planner described the CommCare project as decentralizing the data collection process, and noted that in allowing mobile health workers to do digital data collection, he had to centralize fixing the data collection tools. Adding health workers to a 60-health worker project required more technical management than he had expected based on a 10-person pilot, and he was in the process of hiring technical support staff (E). Complex troubleshooting depended on the presence of Nokia Care Shops, the closest of which, for one project, was 60 km away (A), and on spare devices to use during repair periods. Health workers would not always report lost phones in a timely way, perhaps due to above-described reputational and financial threats, so data collection regularly paused for up to a month (E).

The CommCare adoption also introduced new distractions and obstacles to completing routine client interactions. For example, after each "form is completed, Airtel sends a service reply showing the cost of the data sent. This often shows up midway through the checklist and throws off the ASHA" (B). Supervisors mitigated some confusion via training, but the distracting messages, and extra steps required to get rid of them, remained. "Currently the application is set to automatic submissions upon network availability" (B). CommCare could be set to submit forms in batches, which would reduce the number of service replies, but this could happen only with increased risk of losing pending data. Project planners and Dimagi representatives seemed uncomfortable with keeping unsubmitted data pending on devices for any longer than necessary.

In another example, one health worker observed, "It's cumbersome to go through

all the checklists. Sometimes the software is slow. Sometimes it's easier just to pick up a pen." This could be a real problem: a Project E supervisor noted that a checklist "can take up to 30-40 minutes to complete thoroughly, and if a pregnant woman leaves in between, the answers cannot be saved. One ASHA left the form open for 2 hours when her client had to leave in between and only after the client returned again did the ASHA complete the form." Meanwhile, she could not visit another client, and later, her supervisors demanded explanation for the hours-long completion time. Further, as noted, CommCare occasionally did not load during client visits, embarrassing health workers and precluding counseling sessions.

Control by Non-Participants

Community health workers' use of their mobile devices influenced, and was influenced by, clients' families, strangers including mobile shop owners and thieves, and health workers' families. This subsection elaborates on some of the ways these actors, none of whom were direct participants in studied technology projects or formal participants in daily health work.

Clients' Families. A Dimagi blog post described a story about a woman who was so excited to hear ASHA's message through CommCare, she snuck away from her husband to the Anganwadi center to hear. Her husband did not allow her to follow the practices described, and she was the only woman in the village who gave birth with complications. She was hospitalized with blood loss, and lost her baby four days after birth, which the

Dimagi representative attributed to not following the practices described by CommCare. The Dimagi representative wrote, “I think there’s so much value in filling out the counseling type forms within the home, where there is a higher probability of a (resistant) family member being present and at the very least half-listening. My third takeaway: Encourage ASHAs to complete all counseling forms at the home, instead of at the Anganwadi Center, where household decision makers may also tune in and learn.” This finding highlights a common feeling expressed by those interviewed. New recognition by clients that health workers now had valuable information to share encouraged health workers to carry their work-issued devices and use CommCare during their client interactions.

Strangers. The following examples, from the project planner’s perspective, from the health worker’s perspective, and from the developer’s perspective, illustrate the struggle that project planners and community health workers had introducing the devices into the fabric of their communities.

In one example, representatives of the developer Dimagi actively worked very hard to convey clear rules to community health workers during training about what health workers should do if they happened to damage their devices. Dimagi staff asked health workers to announce damage quickly to project supervisors, and relinquish damaged devices immediately to the implementing organization. Project planners were to bring broken or damaged devices to an authorized, typically Nokia, service center. One project planner stated in an interview, “We do that so they don’t have any random guy fix it.” In practice, health workers had trouble confessing to their supervisors that they had damaged

their device, though they had to in order to secure any warrantee benefits the Nokia service center might offer. Though damaged devices were ultimately serviced through the authorized care centers, health workers routinely waited one to three months before they announced that their devices needed repair.

In a second example, project planners perceived that health work was threatened by mobile shop owners who sold entertainment media content to health workers and, in the process of loading them on the SD card, accidentally deleted CommCare. Projects attempted to preclude these downloads by password-protecting the memory card, or hiding the CommCare multi-media folders so that the media could not be accidentally deleted. But when the SD card was transferred to a computer or to another phone, the password would not be required, and any hidden folders would appear. One interviewee reported hoping that the mobile shop operators would just add, not reformat the cards. But, he stated, the mobile shop operators always reformatted the disk. “They just loved having the full 2GB of space.” A Dimagi staff member noted that most devices’ 2GB memory cards were much larger than CommCare required, but it was difficult to justify purchasing smaller ones at similar cost. Shop owners erased the cards and loaded whatever health workers bought, and in the process, often transferred viruses to the cards.

Many other projects faced similar challenges and concerns. One project planner said, “It’s amazing how good these mobile phone shops are at breaking our hacks. I suspect that they are overloading the memory on the phone, but the CommCare files are on the SD card. Sometimes they delete the SD card, etc. I was concerned at the beginning, and we don’t have control over these things.” That planner eventually “password protected the SD

card. We also verbally reiterated the rules on use." Ultimately, he "never really established a link between the installation of the movies and photos and any errors in the application. We were really concerned about the disappearance of the SD card but no this didn't happen."

In a final example, health workers themselves also experienced direct challenges and threats from strangers. One health worker described an experience in which her phone was stolen and recovered:

> *The gardener stole it. I saw and checked if the phone was where I left it. It wasn't so I chased him. Also my husband and kids chased him. The gardener hid the phone in the mud and kept going. The neighborhood kids ran after him and hit him hard. While the kids were beating him, his uncle was there. He begged his uncle to make the kids stop, and promised he'd give the phone back. They did, and he gave the phone back.* [I asked, before you got the phone back, how did you feel?] *I felt scared I would have to pay 4000-5000 rupees [$65 - $80]. And, how would I do my work. Anxiety. Glad I got the phone back. After, [my supervisor] told me to hide the phone in my dupatta in the future.*

While real losses due to damage or theft were minimal in all focal projects, and all field supervisors reported how little they minded visiting health workers to re-install corrupted CommCare applications, all interviewees took these actors very seriously. Strangers' actions and potential actions weighed as heavy threats on the minds of all project participants. Strangers' actions blocked CommCare use by deleting CommCare files, theft, and encouraged non-CommCare use by adding entertainment media. These mediators of use are not mission-aligned, and take health workers' activities away from prescribed use of their work-issued devices. However, their increased feelings of pride to have a work-

issued device worth stealing, and excitement to provide entertainment to their families, may have motivated health workers to keep their jobs and do them well.

Health Workers' Families. Community health workers' husbands and children often used the devices that health workers had been issued by studied technology projects, often regardless of whether health workers had given permission to their families to use the devices. Family access to the devices both undermined and supported health workers' work-related use of the devices. This section describes how health workers' families undermined health workers' prescribed use of devices, by rendering CommCare wholly or partly inoperable, and supported, through validation and facilitating new learning.

Every interviewee noted that health workers and some supervisors' families used work-issued phones for activities including calling, messaging, taking photos, Internet browsing, playing games, watching movies, and listening to music. Supervisors noted that if families watched a video, children did activities on the phone, or changed the settings, then CommCare was frequently deleted. One health worker reported in an interview, "The kids ask to play games. I say no. They sometimes take my phone and hide in the middle room [of my house] to play games." One on-site implementer noted that gaming in particular "is very dangerous for the mobile application. So we prohibit most gaming from the mobile. They delete [CommCare] application file data, or CommCare was not working properly. Images weren't showing on the mobile phone. Audio was not coming." Health workers did not always allow their family members to use project-issued devices, but often could not prevent it either.

Project planners recognized that health workers may not be able to fully control what happened to work-issued devices when the devices went home with health workers. One project planner stated in an interview, “During the pilot, there were some problems. One time the memory card was locked, and we brought the phone all the way back to the office in [the nearest city, a few hours’ drive away] to address the problem. An ASHA’s son had changed the password on the memory card.” One Project A planner noted, “We wanted to make it clear that [the health worker] was responsible for the phone. But we also knew that typically, women didn’t have their own phones and that typically, kids got access to mom’s phone over dad’s phone.”

On the other hand, project implementers noted that this home use also fostered health workers’ learning of how to use the device, which husbands and children actively supported when the devices were at home. For example, using the keypad was a new experience for many health workers, and they practiced at home often with their families’ help (A, B, E). During interviews, many children and husbands expressed pride of their mother or wife, for doing health work that has been recognized by a well-resourced organization as important. The devices, for them, was a signal of the importance of the work that community health workers did. Health workers’ children also recognized, and expressed pride in, their mothers’ learning that came with the CommCare adoption. One health worker noted, “My younger son says, ‘Mummy has been taught by [two project supervisors].’” Two projects explicitly noted that husbands and children had helped the community health worker in their family practice using the keypads to enter information into the application at night time.

Control over devices themselves was often, or often thought to be, out of the hands of any project participants. Despite actions taken to preclude thieves, mobile shop owners, and end users' families, these non-participants, especially shop owners and family-members, regularly eluded technical barriers and rules restricting use. During one pilot, staff allowed their teenaged children to use the phones to watch Bollywood clips, music videos, and comedy despite password protections to prevent exactly that. Family use of the devices occasionally led to cracked screens, corrupted or damaged memory cards, and very often, compromised CommCare application function, which could only be fixed if a supervisor physically went to the phone and re-installed an uncorrupted version from his or her device. Reinstallation seems a major impediment to scale-up of CommCare use for community health work in India.

Environmental Impediments to Use

Other characteristics of projects' implementation setting, including regional infrastructure and institutions, were exogenous to project tasks and outside projects' immediate action plans or span of control. These forces nevertheless constrained decision making and users' behavior. Many align with the ICTD diffusion model's *Readiness* stage (Heeks and Molla, 2006, and this dissertation, Figure 1.1), featuring infrastructural and institutional precursors to adoption.

CommCare projects in India experienced this stage variously, as the presence of required infrastructural and institutional precursors was promising but spotty, and could

potentially interrupt or entirely preclude use. This made the decision to adopt CommCare risky, as planned workarounds and flexibility to adapt to ongoing challenges may be insufficient to overcome constraints. For example, spotty electricity in deployment areas meant that device batteries were not always charged at critical times. Sometimes supervisors, who visited health workers in the field a few times per month, "found the ASHAs' phone battery status either switched off or at critically low level" (Project A, QPR). Project C's implementation made advanced plans for utilities and double back-ups for electricity and water supply, while Project J documentation reported, "Power still remain [*sic*] our number one problem in the country... though the present government has put in measures to address this issue. Devises [*sic*] were chosen for their long battery life and solar panels where deployed in locations with no access to electricity".

Project E addressed intermittent network connectivity by ensuring that "completed forms were saved locally on the phone and were automatically sent when connectivity was restored. As a result, [health workers] never had to think about network connectivity. This... made data reporting in areas with intermittent connectivity possible" (Medhi et al, 2012, p. 7). Other projects faced greater concern about unsent data associated with network problems. "Though GPRS[46] problems came down from 39.1% to 36.7 % in this quarter, they still remained the largest contributors among all type of tech issues. Project [A] has decided to contact Vodaphone officials and get the strength of network increased in the areas where connectivity is a chronic issue" (Project A, QPR).

[46] GPRS stands for General Packet Radio Service, which is a mobile data service on 2G and 3G networks.

One Dimagi staff member contextualized this problem, noting that without a network (which could be due to either poor network service or to an individual device's zero balance of airtime or data), up to 100 CommCare forms may be entered and stored offline. However, the longer a phone was off-network, the greater risk of corrupted application or a lost phone, which meant lost data. Pending data also created supervisory challenges. In Case B, ASHAs were often out of network area for two or more days, working regularly, but demonstrating via CommCare zero uploaded cases. Each time, as noted above, supervisors asked about the missing work, which health workers disputed. When they returned to a network area, the data came in bulk and it appeared as though they did many days of work in one day. Moreover, poor network connectivity constrained in-office access to existing data, taking 10 minutes (Project B) to 30 minutes (C) to load the data that the health workers had transmitted from the field that day.

Promotional airtime recharge schemes also caused periodic confusion (B). Telecommunications companies often wooed customers on prepaid plans by offering promotions that lasted a week or a month. Taking advantage of such schemes meant, for example, that users could get free talktime with others who used the same plan, or discounted data. Health workers often switched SIM cards to take advantage of these offers, rendering their supervisors unable to communicate with them on the phone number associated with that health worker and unable to match the data they transmitted to the correct health worker. Moreover, these users often experienced GPRS problems when they reinserted their CommCare SIM to do work. Switching SIMs altered data settings which health workers did not know how to adjust, and in these situations submitted data remained

pending until a supervisor could visit and readjust the settings in person. Project A implementers further complained that junk SMS buried project-related messages in inboxes, and health staff often missed important information this way. Moreover**,** networks required a minimum talk-time balance (usually about 20 rupees) in order for data to send. Supervisors could view pending data online, and had to remind frontline workers that personal use of devices was acceptable if required minimum balances were maintained. These schemes also often featured unclear rules such that recharge amounts varied, and not transparently, from month to month, making airtime budgeting challenging because health workers' phones could reach zero balance too early in the month.

SIM card procedural issues also presented barriers to prescribed use. Project D obtained SIMs for Medical Officers and health workers. Most of the SIM cards worked during training but almost all were subsequently cut off by the network provider due to health staff's documentation issues providing including proof of name, address, and birth date. After multiple documentation resubmissions, most connections were restored. This took months, and in the interim, health workers developed a system of sharing functional SIMs. Project C took a different path, asking health workers to purchase prepaid SIM cards themselves through the mobile company of their choice, but faced similar problems. Project managers reported that most of their health workers had trouble producing proof of residence, and were refused SIMs, so supervisors spent much time convincing the mobile companies to issue the SIM cards.

Further, deployed devices presented linguistic challenges. Feature phone keyboards featured Roman script. In Project B, ASHAs often sent messages in a mixture of Hindi and

Roman *Hinglish*. Though they wrote in Hinglish, ASHAs reported difficulty reading received Hinglish responses.

Other ongoing, on-the-ground challenges related to safety concerns, events, and gender norms. For example, one safety concern was the challenge of "locating sufficient, appropriate housing for 20 female data collectors. Due to security concerns in one of the housing locations (lack of door between room where female data collectors slept and unrelated male laborers were staying), [male staff] changed places… with the female data collectors" (Project C documents). Further, harvest times and lifecycle events routinely constrained availability for health workers and supervisors to give or clients to receive services. Moreover, in Project C, male presence during client interactions was considered inappropriate. Few family planning topics were safe or normatively acceptable for a married woman to discuss with, or in the presence of, a male stranger. This challenge made it difficult for male supervisors to observe and advise female data collectors.

A particularly interesting challenge came from within an implementing organization, but outside local project offices. This challenge related to this iNGO's reorientation from an on-the-ground development project implementer to prioritizing government capacitation. As part of this transition, this iNGO moved into what I interpret as a donor role, purchasing the CommCare-related ICT for its implementing partner. Materials purchase orders had to be sent through the country-level headquarters, and **"**there was unanticipated discussion and negotiation that had to happen with headquarter procurement … about the type of tablet [Samsung Galaxy Tab 2] that was proposed for the survey." Further, "[t]he purchase order... just exceeded the threshold that required HQ

approval for purchase. This spurred several days of unanticipated back-and-forth between the India team, HQ procurement and [another office] about the purchase. Costs for tablet purchase were not included in the [project] budget. This required discussion and approval from the Country Representative. Decision was to purchase the tabs out of the [project] budget … and then place them into the country program's IT equipment pool for use across programs and sectors" after baseline data collection was complete (Project C).

Though government did not directly hinder technology use, government neglect of health facilities regularly impeded CommCare project success. For most projects studied, CommCare's messaging included a right to iron tablets and immunizations from government health centers, but these items were often unavailable there or in insufficient quantity. Likewise, CommCare's messages encouraged visiting a health center during pregnancy complications, baby delivery, and children's malnutrition, but some Project E clients reported to implementers "that they fear that there will be nobody to help at the hospital and they feel unsafe to send a woman to the [government health clinic]." Another organization intervened in Project B's CommCare scale-up, feeling competition for resources including facilities and the attention of the district government. Project B was compelled into a smaller contract with authorities in its preferred region, and sought a scale-up location elsewhere.

Project implementers in multiple deployments named local Chief Medical Officers and other specific officials as critical partners despite their limited attention and resources. In Project B, an implementer reported that "everyone in the government sees value in the program but their routine jobs prevent them from persisting in making a scale-up happen…

It's always easiest to pursue what's in hand." Likewise, Project D implementer noted that "the Municipal Corporation was open to the technology, and open to experimenting, as long as its core [health] program was not disturbed. In this district, he thought, if CommCare had come two years earlier, there may have been some policy impact." Moreover, health workers who participated in the client-relations part of Projects A, B, D, G, and J were not employees of the organization deploying the technology, but were government-employed or -incentivized (i.e., ASHAs or Link Workers) to do health work. Issues of fair pay (D), on-time pay (G), and proper administration of incentive schemes (J) weighed heavily on ICTD project managers' minds though these tasks were outside of their control.

Finally, physical distances also posed a problem for device delivery, troubleshooting, application updates, and repair. Between device purchase and implementation, one project "had to rely on individual team members traveling between Delhi and Lucknow to carry the tablets" (C). Project A reported as an important problem that the nearest Nokia Care Repair Center had closed, and that the next available shop was 60km from the project office. One Dimagi staff member noted that while many deployment sites had health workers within 20km of the office, Project L's average distance to a repair shop was 40km, with villages scattered remotely across mountains. Project L's technical support person was located 35-50km from ASHAs. This distance lengthened response time to technical challenges, which were similar to other sites', but became amplified given this distance.

CHOICES AND IMPLEMENTATION DECISIONS. PROJECT-LEVEL INTERCESSION IN THE HEALTH WORKER-DEVICE INTERACTION

Project planners took many implementation policy choices, consciously-taken project-level courses of action that supported or constrained certain staff behaviors, in light of the above-described goals, fears, and environmental factors. Many were taken as cautions to maintain devices' capability to run CommCare, to keep device and application working and memory card uncompromised. Observed choices are described in Schwartz et al (2013), and include a decision about who owned distributed devices. A typical arrangement across deployments featured health workers' ownership of SIM cards and implementing organizations' ownership of devices and memory cards. Other decisions included where the device would reside when not in work use (project office, users' homes); whether to install SIM cards and who (implementing organization, end user) will own them; and how to top up airtime (prepaid or postpaid, with the implementing organization paying carriers directly or reimbursing end users). Project E users were individually responsible for phone maintenance and ensuring battery life for client visits and sufficient credit for data transmission, though the implementing organization recharged balances monthly. Many projects recharged airtime and data balances, and (E) compared submitted data against spent credit, assumed the difference was for private use, and deducted the amount from staff members' monthly incentives.[47]

[47] Project participants who were ASHAs, as in Projects A and B, did not receive salaries but instead received incentives for their clients' completion of healthful tasks, such as getting a child immunized or delivering a baby in a health facility (mothers are also paid for this latter action), so Project E's solution would not work for Projects A and B.

A project may also ban, or *proscribe*, certain uses. The surest proscription method is to select a device that lacks the undesired features, entirely precluding unwanted use and its expected negative effects. Limited-capability devices that can run applications like CommCare are decreasingly available, so this solution is becoming impractical. Multiple projects reported that a preferred device, the Nokia C2-01 feature phone, had by the time of my study been discontinued or was not locally available in quantities needed for replacement or scale-up.

Alternative proscription methods include device modification by password-protecting memory cards, hiding menu items, installing application-blocking software, and explicitly declaring banned uses. Decisions about what uses were proscribed varied among studied projects, as did the strength of the proscription method, and enforcement of rules. All sites recognized the CommCare application's vulnerability as health workers downloaded games, music, and videos, and took or edited photos, but used various strategies to address this vulnerability, including verbal messages, contractual commitments, and technical barriers. Some project implementers followed the advice posted on the Open Data Kit[48] website, "We usually refer to the Android as a PDA instead of a phone because the phone part of it is nothing but a distraction."

Many choices were encoded directly in job descriptions if end-users were employees of the deploying organization and in contracts between the deploying

[48] The application CommCare was developed based on code developed by Open Data Kit (ODK), an open-source application developed for digital data collection. The ODK website provides guidance for training researchers to conduct digital data collection. https://opendatakit.org/help/training-guides/ (Accessed December 1, 2014). A PDA is a Personal Digital Assistant.

organization and individual end-users. Contingencies for damage and loss were most often encoded in these contracts. Two sample contracts are in the Appendix. The contract was typically signed during a training at which CommCare devices were distributed. Health workers' understanding of the contracts was dubious. During my Project A site visit, no health worker or field-level supervisor recalled having signed an agreement, though I had seen these records and, once reminded, these participants agreed that they had. This oversight may be partially attributable to health workers' literacy, which managers estimated as low as 40% at the beginning of the project (though field supervisors, who also forgot, were literate, had at least secondary education, and some were licensed social workers). It is possible that it was participants' first exposure to a contract, and didn't understand its purpose or meaning. Alternatively, superiors' behavior may have downplayed or actively undermined the contract's importance after the day it was signed. One project supervisor's comments aligned with this idea. He said,

> *We only introduce that strictness during the training session. But we don't need to repeat these policies again and again. The trainers are satisfied that the ASHAs understand that the phones are for them to use as they like but they're to protect it from their family members. We can't strictly enforce this. Sometimes the ASHAs must give the phones to their husbands. But the damage clause is followed strictly. ASHAs who break or lose their phones must pay for them, and must fix them at particular service centers (A).*[49]

Projects varied in the resources they allocated to monitoring device use and enforcing rules. Strict or weak monitoring and enforcement of compliance further constituted policies

[49] Lost control over deployed devices to husbands was not unusual. Another planner experienced difficulty coordinating with one ASHA because her husband had traded his phone for her nicer work-issued phone (B).

that support or constrained device use. Encoded rules only directed use to the extent that rules were followed. For example, the second sample contract in the appendix states that users may not allow family to use CommCare devices. Despite this, frontline workers who signed the contract consistently admitted during interviews that family used the devices. The quote above acknowledges this contradiction. When asked why, program staff reaffirmed the seriousness with which frontline workers viewed the responsibility of possessing a device, and the consequences if it were damaged. Because of this, staff did not see fit to closely monitor use, and in fact often actively introduced them to new device functions. Field supervisors noted that they stressed health workers' responsibility for the phones, but that they were also aware that typically, women did not have their own phones. If they did, children would access their mother's phone before they accessed their father's. One implementer hoped that the damage clause would make people feel more responsible, guarded, and protective of the phone, but would never demand the agreed 100% of the phone damage or replacement cost. That project instead only imposed 50% of the damages, which he thought pinched, but did not devastate, health workers.

Many uses of the device were never explicitly prescribed or proscribed during implementation. Project staff who trained end-users on the use of the device and CommCare often showed end-users the range of deployed devices' capabilities. Projects often lacked official policies on using these other device functions, either instrumentally for work or for personal, non-instrumental purposes. This category of uses are *non-prescribed*, uses that were neither explicitly proscribed nor prescribed.

Prior to CommCare projects, participating health workers' general knowledge of

devices' features or how to use them was minimal. During training, staff demonstrated calling, typing and sending SMS, using contact lists, etc. Even during one project in which non-CommCare use was officially discouraged, trainers encouraged frontline workers to use these other functions. Health workers gradually asked supervisors about other uses, including how to take a photograph, share a song, or surf the Web. In most deployments the range of devices' functions were rarely off-limits. Project participants

> *agreed implicitly or explicitly on the import of protecting the devices and on activities that would truly endanger them. Staff and ASHAs also recognized the importance of a) advancing the spirit of the project mission beyond explicit objectives, b) uplifting ASHAs' status in eyes of clients, clients' families, and supervisors, and c) improving ASHAs' lives through a sense of, and actual, independence* (Schwartz et al, 2013 p3).

Project A staff actively promoted a learning and family culture among project participants. As mentioned, many project staff lived together, participated in daily morning prayers, and took turns to lead prayers. Supervisors visited frontline workers they supported in health workers homes, and also cultivated familial ties with them. These close familial relations may have been a result of project planners' proactive choices, culture, or the nature of community health work, which is fundamentally about family choices, conducted in the home, and its mobile nature often forced staff's overnight stays together. Further, all Project A staff expressed the importance of the frontline health worker in a) identifying technical problems with devices or CommCare, b) identifying counseling topics that could be added to CommCare to improve its usefulness, and c) generating ideas based on their field experiences for how to improve service delivery.

Many project staff also reported promoting frontline workers' sense of ownership

over devices, despite their not actually owning devices, by emphasizing the project's importance and frontline workers' role in achieving its mission, and maintaining a relaxed stance to non-prescribed and explicitly proscribed uses. One contract promoted a feeling of obligation toward the project's fortune, and peer responsibility for monitoring device use. These messages that encourage frontline worker independence, responsibility, and agency to enact the project's mission seemed to override much of its strict overall nature and its strict rules. Supervisory choices to encourage community health workers' collaboration and voice supported health workers' feelings of efficacy, professional responsibility, and equality with their managers, and ultimately reinforced their use of CommCare and CommCare-enabled devices.

DISCUSSION

In sum, my data support sociotechnical expectations of community health workers' use of CommCare and CommCare-enabled devices. End user health workers used CommCare as supervisors directed them to, and found many non-prescribed ways to use the devices instrumentally, in service of their health work.

Table 4.1. Project Features that Influenced Use of CommCare and Devices	
Contractual	**Venue:** Written items including contracts, job descriptions, training manuals, memos, signs, objectives, mission statement, performance scorecard, performance indicators **Choices:** Device/SIM ownership, rights, responsibilities, prescribed and proscribed use, top-up policies, device maintenance, contingency for damage and loss
Social	**Venue:** The project setting, interactions among participants and other stakeholders **Choices:** Training; monitoring use; enforcing rules; validation, branding, informal messages; manipulating understandings; expressing hopes, threats, and concerns
Technical	**Venue:** the device itself **Choices:** Password protection, settings, memory card lock, hiding folders, Applock
Physical	**Venue:** The office, clients' homes, the market, users' pockets and homes **Choices:** Device selection, device possession, solar panels, protective device covers
Environmental	**Venue:** Among beneficiaries, donors, government stakeholders **Features:** Infrastructure, topography, stakeholder buy-in, politics, economy, etc.
Environmental factors are features, not choices under a project's control. Each feature or choice has tradeoffs for user capability, user motivation, actual use, device integrity, and client data privacy.	

Table 4.1. Adapted from Schwartz, et al (2013).

This empirical chapter featured an exploration of the sociotechnical features of the studied projects, describing the salient features of both the focal social setting and the focal technology. Table 4.1 above categorizes these features into contractual, social, technical, physical, and environmental supports or constraints to use of the deployed technology. In this social setting, village-level health projects, participants perceived a great number of

actual and potential threats arising from the CommCare deployment, and a great many organization-level features such as contracts, training messages, device modifications, and office practices that shaped individual use of CommCare. As the sociotechnical lens suggested, I observed both planned and unplanned use of CommCare and the devices on which CommCare was installed.

All focal project participants used devices and software in the prescribed manner. Community health workers generally incorporated the application into their client interactions, with some variation that aligned closely with their directives and project mission. Mobile health workers also demonstrated use of resulting new data; they retrieved previously-entered data from the application using their work-issued devices, and could also understand (and refute, if necessary) performance-based information (about their own work) and health-based information (about their clients) that had been aggregated from that data and reported back to them at daily, weekly, and monthly meetings. Project supervisors also used resulting new data in their reporting to their partners, especially local government health officials, and to funders. They reviewed data in order to identify health workers who required additional supervision or training. No studied projects had yet incorporated the new data into their strategic decision-making.

Health workers also used devices in non-prescribed, and sometimes explicitly proscribed, ways, including strategic deployment, instrumentally, for work, and non-instrumental, or personal, use. Many personal and professional non-prescribed uses were neither fully anticipated nor explicitly allowed, but emerged at all sites that did not strongly enforce prohibition. These uses included communicating with supervisors, clients, and

family members via calling or SMS, browsing the Internet, playing games during down time at work, and listening to music and watching movies at home. In these projects, health workers discovered together or with their families features that could be used for pleasure or for their work.

Finally, the sociotechnical lens predicted evolving routines and behaviors, as each new use even throughout a day is a new opportunity to modify it, and improvisations could later become daily practice. This expectation incorporated users' evolving perceptions about the usefulness and usability of received technologies, and peer effects. Especially health workers' field supervisors and families encouraged health workers to learn to transliterate and read at home, introduce the camera into client interactions, and increasingly communicate with clients and supervisors. Many health workers learned to use the camera, calendar, the Internet, and mobile shops as resources, figuring out new ways to do better work, and installing games music and movies to use devices for entertainment.

All actions are situated actions, in the sense that they are "actions taken in the context of particular, concrete circumstances," despite any plan we may have, because "the circumstances of our actions are never fully anticipated and are continuously changing around us. As a consequence our actions, while systematic, are never planned in the strong sense that cognitive science would have it. Rather, plans are best viewed as a weak resource for what is primarily ad hoc activity." (Suchman, 1987 pviii-ix). Anyone may undertake purposeful action, but not all actions have plans.

The key finding of this chapter is that seemingly mundane project- and staff-level

choices had important impacts on health workers' skill acquisition, use, morale, and understandings about the usefulness and attractiveness of adopted devices. Key examples relate to a) SIM card ownership decisions, b) airtime and data top-up procedures, c) device possession rules and usage policies, and d) contingencies for device damage or loss. The sociotechnical lens was a real asset in guiding me to identify these features that might have otherwise remained hidden.

In Chapter 5, I address how the use of deployed technologies changed principal agent relations in focal projects.

Chapter 5. Observational Study of Deepened and Complicated Authority

This chapter describes observations that relate to new instances of control over health work, over the ICTD project, and over health staff. These new situations arose from use of the CommCare application, new communication patterns, and use of newly available data transmitted via CommCare. I report on changes in data availability, data quality, communication patterns, trust of data, how understandings about data influences supervisors' trust of health workers, manipulations, and evolving perceptions about the credibility of information sources.

My observations point to three key findings that derive from a principal agent understanding of CommCare adoptions in Indian community health projects. First, I find that CommCare projects increased the complexity of principal agent relations in health programs that already faced multiple principals. In my observations, principal agent relations became more complex because focal ICT projects by design introduced a **new, most proximate principal**, the ICT project supervisor, into community health work. The ICT supervisor was not meant to replace the health work supervisor, but because CommCare was designed to facilitate health work, and because many health workers experienced ineffective supervision before the CommCare deployment, the ICT supervisor filled that vacuum. Second, I find increased strength of the relationship between principal, the health work supervisor, and agents, the health workers. Principal agent relations improved via **increased ability to monitor** community health workers, the lowest-level

agents on the health work delegation chain, by important principals further up the delegation chain including government medical officers and funding and implementation partners sitting in regional and national offices. **New communication patterns**, and new and timelier **data** and reporting, led to increased information about health work and more active management and mentorship of community health workers. Third, I find additional evidence that using CommCare and CommCare-enabled devices increased health workers' **autonomy** by enhancing health workers' resources, health knowledge, and credibility, and facilitating strategic use of the device for work. Perhaps counterintuitively, this improved autonomy stemming from health workers' use of work-issued devices in turn improved supervisors' control over the primary development task, health work. These benefits motivated supervisors' increased trust in agents' minute-by-minute tactics to conduct health work, and these non-prescribed tactics generally supported the principal's health work mandate.

As noted, the community health worker is the lowest agent in this principal agent scenario featuring multiple principals. As depicted in Figures 1.5 and 2.1, the proximate principals she may face on a daily, weekly, or monthly basis include her employer (in some cases an NGO, and in many cases her state's government, represented ambiguously by her district's Chief Medical Officer, an Auxiliary Nurse Midwife, or an Anganwadi Worker), and one or more funding agencies (possibly the above but also quite likely a different NGO, often an iNGO). In the projects I studied, community health workers also reported to one or more individuals who represented the CommCare project's implementing agency or

agencies (often a local NGO collaborating with an iNGO) on the technology project, and to a representative of Dimagi, the technology company that developed CommCare.

This supervisory situation is characterized by overlapping authority and no clear hierarchy. It is not clear in this situation who would have the final word over all issues, and for specific issues there was a different final authority or shared authority. I find that introduction of CommCare both strengthens existing principal agent relations in large part through better monitoring and reporting, and also complicates it, by introducing new partners including Dimagi and often an additional NGO, who are also new principals and agents. In my observation, project planners resolved this source of potential tension by being intentionally and intensely collaborative. Interview participants from NGOs and iNGOs, who were willing to speak about relevant disputes within their own organizations,[50] explicitly declined to acknowledge disputes with government partners for fear of endangering the relationship. This collaborative spirit is in line with the emphasis on locally-driven development described in Chapter 1. All participating iNGOs were rhetorically aligned with the spirit of locally-driven development, and were actively orienting their activities to support the local-led health technology projects I studied.

Overall, focal ICT projects enabled greater principal oversight and control over agents, by introducing new monitoring personnel and new data into an existing program of lightly monitored health work. This new monitoring standardized much of health workers' daily behavior as they interacted with clients and collected data.

[50] Including disputes over how purchases were approved, what happened to purchased technology after projects' designated end dates, and whether a new program manager had the power to revert to the system of record-keeping prior to the CommCare adoption

For Community Health Workers, the Principal Multiplies

First, all focal CommCare projects introduced new delegation relationships for participating health workers. Community health workers, who are the lowest-level agent delivering on a global mandate of community health work, now faced three new principals. In order of relative proximity, these included (1) a new ICT project field supervisor, who monitored health workers' CommCare use each day, (2) a Dimagi representative, who participated in device distribution and CommCare training, and (3) local representatives of the organization that funded the ICT project, who were typically based in the nearest major city and visited the project monthly. For ASHAs and Link Workers, who are part-time, nonprofessional, government community health workers lightly supervised by government health staff, the CommCare project represented a new device, a new directive, a new way of conducting client interactions, and much more supervision.

As mentioned, governments did not lead the distribution of devices to government community health workers. In all observed projects, a local NGO distributed devices, trained health workers how to use them, and supervised health workers' use of CommCare during client interactions. Field supervisors conducted field observations of health workers, to check both on CommCare use during client interactions, and on the quality of the conversations during which health workers used CommCare to deliver health information. This constituted not only increased monitoring on the use of CommCare, but increased monitoring on health work itself. Similarly, health workers could and did speak with CommCare and health work supervisors for advice on client health challenges during

mobile phone calls that could take place in clients' homes, implying immediate turnaround on customized health advice. Moreover, health workers reported that clients had begun to call the health workers at moments when they had a health concern and when pregnant clients went into labor, which allowed health workers to immediately respond to clients' health needs and give advice.

The NGO that distributed CommCare devices to health workers encoded their new relationship with the health workers in a contract (see Chapter 3 for detail and Appendix for samples) establishing device ownership (distributing NGOs typically retained ownership), responsibilities for proper device use and maintenance, and contingencies for device damage and loss. Device distribution, then, introduced new supervisory authority over community health workers expressed in three key ways, as manifest a) by the existence of contracts, b) by the content of contracts, and c) by additional surveillance of health work.

Manifest by Contracts

NGO implementers asked health workers to sign contracts after one or one-half day's discussion of contracts' contents. After contracts were signed, NGO implementers distributed devices, and initiated training on how to use and maintain devices, and how to properly use CommCare. Project planners did not reportedly intend to impose new supervisory authority on community health workers. Instead, to recognize and uphold the existing system, they designed contracts to be signed by the health workers, the

implementing organization, and health workers' existing supervisor. One planner noted, "The contract is a tripartite rather than a two-person agreement is good because we don't want ASHAs to think that they're [Organization] employees. It is important to reinforce that [Organization] was supporting the government." Nonetheless, as elaborated below, CommCare project officers represented real new sources of authority over community health workers' daily work. Project planners from at least four[51] sites reported that during training, trainers learned that health workers were not all literate as expected, with one project estimating that 40% of its health workers were functionally literate. Further, all participating health workers' experience entering into contracts was generally low. This implies that multiple projects had health workers sign contracts that health workers may not have fully understood, and could not or would likely not refer to later.

Manifest in Contracts

The details of signed contracts introduced new sources of monitoring and control, with two notable examples. One contract introduced the idea of peer surveillance, instructing health workers to observe and report on colleagues' misuse of devices. Further, all contracts described contingencies for lost or damaged devices, which burdened health workers with 50% or 100% of repair or replacement costs. This represented a real,

[51] This number is not exact because multiple interviews, all Dimagi representatives with knowledge of multiple deployments, often spoke in generalizations and referred to each other's projects. Further, health workers' scores on Dimagi's literacy assessments were generally lower than those conducted by the same projects' implementers.

enforced, and meaningful threat to health workers, who, on the few occasions that they did lose or break their devices, required a payment plan in order to pay them back.

Manifest in New Surveillance of Primary Work

CommCare project officers supervised health workers' use of the technology that NGOs distributed to health workers. CommCare project officers also facilitated government supervision of health workers by providing them with monthly performance data. These CommCare project officers also became *de facto* new field supervisors of health workers' health work. On a monthly basis, CommCare supervisors accompanied health workers on health workers' daily client visits to observe health workers' client interactions,[52] and more often if supervisors decided that health workers' advice to clients, or delivery of that advice, was lacking.

CommCare supervisors described the relationship between themselves and community health workers as supervisory *and* supportive. This ambivalence was reflected in the comments of many interviewees. One supervisor noted, "Before, the health department supervised [ASHAs]. Now, with CommCare, we do too." I asked, "How do the ASHAs feel about that?", and the supervisor replied, "ASHAs appreciate the support.

[52] Not all supervision was easy. For example, in one project, "Male supervisors could not access/enter some households during [client visits], making it difficult for them to effectively supervise or provide feedback to data collectors." Another project's field supervision faced serious challenges. Though field supervisors were "employed to hand-hold end-users," the project had phased out three quarters of them by the time of interview because despite multiple refresher trainings the field facilitators did not retain knowledge about using CommCare or troubleshooting.

We're not doing supervision. We're helping the ASHAs. We're seen as helpers." Similarly, another supervisor described his work as in support of ASHAs' work, and of an exciting opportunity for the ASHAs to learn the technology and receive good advising, regardless of their initial interest in those things.

> *Five to ten percent of ASHAs didn't [previously] do their jobs, and they weren't interested [in health work or in CommCare]. The rest were interested in working and those used CommCare without resistance. Now their work has increased and there's increased monitoring of the ASHAs. So the ones who weren't interested do their work now, because of this monitoring, even if they're not interested. Also, these ASHAs have a job aid, which makes even good ASHAs do better.*

Not all interviewees agreed that CommCare supervisors became the *de* facto supervisors of community health work. One planner noted, "We really focused on the job aid. Even if we knew ASHA X wasn't doing her job, we didn't press her that she didn't do XYZ when she was supposed to… [We are] working within a system that's already supposed to be supervising them." Despite this claim, representatives of at least one project recognized that supervision of CommCare use was deeply entangled with supervision of daily health work. One implementer noted, "During the initial pilot, the phone did all the talking. So output 1.1 was re-articulated and, we added a day of training on inter-personal communication," recognizing that CommCare could only be used properly in the context of the existing interaction between health workers and clients.

In interviews and according to supervisors, health workers did not complain or express concern about these new NGO supervisory authorities, but instead often welcomed them. This is contrary to principal agent expectations that agents might resist additional monitoring and supervision. I argue that government community health workers such as

Link Workers and ASHAs generally accepted the new status quo for three reasons. First, health workers recognized that their existing government supervisors would not or could not provide mentorship that the health workers truly needed. Seeing that the new CommCare supervisors could and would provide consistent good advice about how to do their main work, they accepted the performance supervision that came alongside with this mentorship. Second, health workers recognized distributed devices' cost and their usefulness at work and at home. They understood that such a valuable tool, and its use, would be carefully monitored. Third, I believe that any overt or conscious resistance to new supervision was quelled by the often quite intimate personal relationship that developed between NGO supervisors and government health workers during the technology projects. In two separate projects, NGO supervisors brought me to health workers' homes for interviews, explaining and often demonstrating that the supervisors were welcomed like family, and that much work was conducted in this informal setting.[53] I could not ascertain whether these home visits exacerbated an uncomfortable power dynamic, or brightened the presence of a welcome new public health partner. I only

[53] The home is a key space in rural community health work in India. In my observations, the home space and work space often overlapped because distances are far, travel is arduous, and health workers spent more time in their neighbors' homes than in project offices. Health workers did their work in clients' homes. Supervisors, who often used motorcycles and were more mobile than the health workers, met with health workers in health workers' homes and accompanied them on visits to clients' homes to evaluate and mentor health workers. Health workers visited government nurses in nurses' homes. Supervisors roomed together in long-term, semi-permanent living arrangements. On- and off-site project managers slept in the office regularly. Some offices had separate sleeping quarters and others unfolded beds right next to the office desks to pass the night. Meals were taken together when possible, and all food bought or brought from home was shared family-style. During my site visits, I stayed in the office or with a staff-member, which allowed me to observe and participate in morning meetings, prayer session, group meals, and other downtime. The most relevant findings from these rare observations were apparent familiar and quite meaningful relationships that seem to flatten the authority structures between community health workers and their direct supervisors, and their project managers.

observed the positive aspects of this part of the story. This collaborative spirit and familial orientation may have supported the peer effects of CommCare learning and use.

New Data, Communication, Mentorship, and Supervision

The relationship between the Sector Facilitator[54] [SF] *and ASHA is frank, and the ASHA can share information with SF that they can't share with government workers. The hospital is a boss-employee relationship. Only one-way communication. Since the CommCare adoption, two-way communication has started between ASHA-HEO and ANM-ASHAs. Initially there was no coordination between these. It has increased because ASHAs were trained on IPC, Inter-Personal Communication, and guided to share problems with ANMs. This training changed them… SFs encourage ASHAs' interaction with ANMs and HEOs. The communication gap has closed. It has increased the authenticity of the ASHA. She can show she has immunized so many people to the HEOs. ASHAs can prove they are right and have the data to show it.* (Interview. Project Planner)

IMPROVEMENTS MONITORING HEALTH WORKERS VIA NEW DATA

Before introducing CommCare, health work supervisors viewed data about health work, and client-specific health records, with inconsistent frequency and attention. One typical objective of the studied projects was to

> *allow all data collected by the LW* [Link Worker, a community health worker] *to be recorded electronically, giving insight into the daily activities, reinforcing the use of government prescribed protocols, and providing the ability to quantitatively assess and track a worker's performance. Supervisors, including Auxiliary Nurse Midwives (ANMs), will be able to easily access this data in order to better manage and track the daily activities of LWs* (Project D document).

[54] A Sector Facilitator (SF) is a field supervisor of CommCare use. Health Education Officers (HEO) and Auxiliary Nurse Midwives (ANM) are both government professional, health workers above ASHAs in the hierarchy of delegated action on health work.

CommCare projects promised more frequent data, greater volume of data, better quality/more accurate data, aggregated data, and remote access to data. These promises bore out in the sense that CommCare projects generated new data and made that data readily available remotely.

CommCare project supervisors used these new data regularly to assess health worker performance. Each project pointed to real improvements in supervision over daily health work, and new sources of authority over health workers, both in the form of new supervisors as described above, and also in the form of old supervisors empowered with new data. NGO staff working directly on CommCare projects accessed and used the data regularly to give performance feedback to community health workers and reports to donors. Local Chief Medical Officers used reports that NGO staff produced in their monthly public health meetings to access community health worker performance. Other relevant government health officers including Auxiliary Nurse Midwives, Anganwadi Workers, and higher level medical officers did not access the data or make systematic use of the data or reports.

Most studied implementations used at least some new data coming from the field via CommCare. These new data came in at high volume. Each client interaction generated geo-located data including which clients the health worker met and when, basic information about amount of time spent with each client, health behavior topics completed with each client, and clients' basic understanding of those topics.

In line with principal agent expectations, digital monitoring tools allowed planners to view their records at the end of each day and know what the staff had accomplished, who had worked, who had shirked, and who to follow up with. For a project with 20 health workers visiting about ten clients per day, supervisors might see at the end of each day 3,000 new data points, aggregated into spreadsheets available for download off the online aggregation site, CommCareHQ. Project planners emphasized that, being available online, these data were available from anywhere in the world. CommCareHQ could also output these aggregated data into well-formatted reports. This information, previously not viewable on a daily basis and rarely acquired on a monthly or longer regular interval, was seen as providing new insights into grassroots health work. In the context of the principal agent framework, these new data reduced information asymmetries, enabling greater principal oversight and control over health work.

These data and reports formed the basis of new performance assessment tools for project planners and government partners or supervisors. Improved performance assessment resulted in better supervision of community health workers and more frequent and more evidence-based check-ins.

For example, in monthly public health meetings, local government officials including Chief Medical Officers used the new information received from project implementers to assess ASHAs' work during that period. The government health officers now regularly and publicly called out low performing community health workers, and now pressed these volunteers in a more pointed way, to increase the number of clients health

workers visited each day and the frequency with which health workers visited each client. Health workers both appreciated and fretted about the increased supervision.

On one hand, health workers reported that their medical officers now made assessments and staffing decisions based on merit instead of favoritism. One NGO supervisor said, "CommCare has increased the authenticity of the ASHA. She can show she has immunized so many people to the [government health authorities]." ASHAs "can prove they are right and have the data to show it."

On the other hand, the new evidence was somewhat contentious. These data were occasionally incorrect in systematic and unsystematic ways, and often trusted despite known inaccuracies and often mistrusted despite known accuracies. Only one project's implementer referred to a log of systematically recorded errors, although others may also have collected these. In interviews, a number of project implementers wondered whether the new data were accurate or useful. Community health workers felt that low performers were occasionally called out unfairly, and that the data did not always reflect a fair, accurate, or complete picture of what had transpired that month. When an ASHA was unfairly accused, others spoke up at meetings to defend her and explained the circumstances that led her to work less, or why the data did not reflect her work.

Giving health workers performance-based feedback raised a number of concerns, some of which had been addressed and others of which remained unresolved by the time of interview. For example, one indicator of poor performance is when a health worker fails to complete follow-up visits to a client who had been registered as pregnant. In the available data, a supervisor can only see that a pregnant woman has not received critical information

on a timeline that could help promote a healthy pregnancy. Health workers who had skipped these follow-up meetings piqued at the implication that they were shirking their work. Pregnant women commonly return to their home villages to carry out their pregnancy under the care of their mothers, rendering visits by the health worker who registered them impossible.

CommCare Application's Forms Do Not Account for Full Variety of Health Worker and Client Experience

Waiting for my meeting to begin one of the COs sat down with PO [S] *and* [Monitoring & Evaluation lead, who championed CommCare in this project] *to discuss an issue with the application. A few minutes in, PC* [M] *joins the meeting. That issue resolved, a second CO and* [M] *discussed why a SAM kid was followed up as MAM. CO confirmed that the SAM kid had switched to MAM status in the middle of the month. They agreed that things like that can happen, just need to cross-check each time. Then a third CO came to discuss a confusing case. Seems the problem is the CO registered a new client instead of editing an existing client's data when she'd realized she'd gotten his name wrong.* [M&E lead's] *advice: no problems with duplicates, especially if they're caught early. The bigger problem is if you continue entering in data for both. Another issue that arose is that one CO couldn't physically locate a past client. She was unsure whether the patient had migrated. S & M wanted to create a separate category for unknown. They were laughing—should we create a category for child is sleeping, child is crying, child is in the doctor's office.* [M&E Lead] *said it doesn't matter—just say child is unavailable. She tasked S &M with bring the number of categories down to 5* (quoting my notes from Project K1.)

In certain circumstances, health workers' completed work was not accurately reflected in transmitted data. As mentioned, in areas of poor telecommunications network coverage, data were transmitted when and where devices connect with a network, which may not align with when or where health workers logged the data. Lacking network access,

all completed forms remained pending on health workers' devices. If a health worker lost her device or, more likely, experienced an application corruption while her data were still pending, those data were permanently lost. To her supervisor viewing the transmissions remotely it appeared as though she had not been working at all. Supervisors reported that even when supervisors suspected that the health worker's network was unavailable, the supervisor followed up each time. Health workers and supervisors reported that health workers perceived this follow-up as an implicit accusation of shirking that health workers overwhelmingly viewed as unfair. Similarly, incomplete forms will not be transmitted, so if a health worker initiated a form, but her client stepped away, the health worker might wait hours to complete the form. This lag was reflected in transmitted data and implied that a health worker took much longer to counsel a client on a topic than she did.

Moreover, some research participants reported on an attention shift, during group meetings and in individual feedback, to quantifiable or observable factors. While this was often an expected feature of adoptions, some reported on resulting tensions among different groups within their organizations. For example, members of a childhood nutrition unit, for whom a heavy focus on electronic recording of arm circumference measurements represented a clear improvement, reported that their positive results had led to unintended competition with their organization's domestic violence unit, which did not use CommCare and which could not demonstrate its problem or results quantitatively. Members of the nutrition unit felt that the struggle for demonstrable measures changed the relative ease with which they obtained internal and external opportunities for research and funding, despite no change in the importance of their priorities or the quality of their work.

Further, many respondents reported that health workers maintained their paper records even after successfully incorporating CommCare into their routines. The new CommCare data do not reflect why the health workers did this duplicate work, or what was on the paper forms, which health workers clearly found still important, but because of the richness and easy access to the new data source, their supervisors' attention shifted away from paper diaries. We do not yet know whether the above-described challenges are systematic across India or beyond. These challenges to data collection, data quality, and reprioritization of health work for which data are available potentially undermined new insights to community health work, and collected data remain inadequate proxies of key outcomes, such as maternal and child mortality.

Fully using the data takes as much effort as collecting it.

While a large amount of effort in this program went into training and developing a tool for the LWs, [Link Workers] *the ANMs* [Auxiliary Nurse Midwives] *and MOs* [Medical Officers] *who were to be using the data did not receive sufficient training and assistance. While the ANMs and MOs received basic training on how to access data, the availability of computer time, network access, and capacity to comfortably use a computer limited actual use of the captured data. The focus was on development of the mobile tool and not on development of an overall system with people that had capacity to fully utilize the data coming from the LWs. Recommendation: projects need to invest more time and effort early on at how the data will be used, and need to treat those users as equal participants in the project.* (Project Report)

This section described how new data, collected in CommCare and accessed in CommCare and CommCareHQ, affected the supervision of health work in studied projects. In the end, introducing a new technology like CommCare was intended to reinforce the

power structures already in place. Research participants unequivocally reported that this new information did improve supervisory capabilities. Moreover, despite reporting on many substantiated concerns about data accuracy and fairness of the new data collection system, health workers and their supervisors reported satisfaction that supervisors had more control over health staff. All reported increased control over the quality, aggregation, and use of the data. Research participants agreed that data collected via CommCare are overall much more trustworthy, systematically collected, and accessible than before, present opportunities to gain real new insights into village health work and village health status across a vast country with an enormous dispersed population. Governmental and non-governmental strategic decision-making procedures based on those data did not change, and specific decisions for targeting beneficiaries only changed for two child malnutrition projects. In each project, there remain unrealized opportunities to use the new data to better prioritize health projects' interventions in village level health. Further, with so many projects using one application such as CommCare, there also remain unrealized opportunities of aggregating data from unrelated health projects.

Even as new data gave health supervisors the tools for stronger, more active, and more informed supervision, health workers described corresponding important increases in their own professional autonomy, credibility, and capability to accomplish the health work with which they were tasked. The following section describes how the introduction of CommCare also strengthened the autonomy and authority of these lowest level agents, community health workers.

New Competence and Autonomy at the Bottom of the Delegation Chain

Health workers and their NGO supervisors reported that overall, health workers experienced improvements in confidence, ability to carry out responsibilities, and feelings of authoritativeness in conducting daily work. They reported that introducing CommCare strengthened health worker autonomy and competence in their professional and personal domains. They attributed these new benefits to the information contained in CommCare and the devices on which CommCare was installed.

This chapter already described performance feedback that health workers received based on CommCare data. This increase in evidence-based attention is one explanation for improvements in health workers' professional competence. Additional explanations for improved professional efficacy included: (a) an increase in health workers' resources available to communicate with far-flung clients, colleagues, supervisors, and health professionals, (b) improved job skills and substantive knowledge, (c) experimentation and innovative on-the-job uses of devices, (d) improved status among clients' and clients' families, who were impressed with deployed devices, and gave health workers and their messages more serious attention, and (e) new authority that health workers asserted in interactions with supervisors. These five explanations are described in more detail below.

Improved Communications and Remote Availability

In all focal projects for which CommCare was deployed at least partly as a job aid or a performance management tool, the overwhelming majority of community health

workers had not previously possessed a mobile phone. In the remaining studied projects, for which CommCare was deployed primarily as a data collection tool, a smaller but still important proportion of community health workers had previously lacked a personal mobile phone. For most community health workers participating in studied projects, then, their work-issued CommCare device was also the first mobile computing device that they regularly carried on their person. Previously, one project planner stated during in an interview, supervisors and clients had to rely on health workers' husbands to communicate with health workers, and that often, the husband would respond that he was not with his wife. One health worker noted that prior to the CommCare deployment, if she wanted to contact a client, she had to walk to the client's home or visit the Anganwadi center to place a call.

The new communication that corresponded with CommCare deployments facilitated increased efficiency, coordination and mentorship. With the technology project, clients and supervisors could speak with community health workers directly, remotely, and without delay using work-issued devices. Community health workers reported that clients were now better able to reach health workers at critical moments, such as when pregnant women went into labor. Health workers now called medical professionals including nurses and doctors for timelier consultation about clients' health concerns. Further, health workers called their NGO and government supervisors for additional consultation and help developing plans to accomplish daily goals. Generally, in all projects with the technical possibility, health workers consistently and frequently engaged in calling, text messaging, and photo-sharing to support main health work.

The benefits that came from using the work-issued devices as communication devices had not been fully articulated or understood in advance of deployments. Improved communications was not an explicitly-stated *a priori* primary goal of any project, and in few instances was an explicitly stated secondary goal. Nevertheless, improved remote communication was a key component of overall project benefits, and bore real fruit in many projects. Better communications improved relations with, and added real value to, clients, and improved health workers' relations with, and mentorship from, supervisors.

New Professional Knowledge and Skills

All projects reported marked improvements in health workers' literacy and numeracy, both key for accurate recordkeeping, record retrieval, and assessment of low birth weight and malnutrition. Health workers gained English skills learning to transliterate names in Hindi or other languages onto keypads and devices that only supported English characters. All research participants on projects using CommCare's speaking function,[55] a function that provides health information aloud to clients, reported that health workers who used CommCare during client interactions demonstrated a marked improvement in their knowledge of the health information they were expected to convey to clients. Research participants including health workers, supervisors, and project planners, were pleased, and

[55] Two urban Bombay projects did not use audio messaging because the health workers believed that their clients were too sophisticated to be interested in a talking phone. Health workers there may have received a status boost based on the device as a signal of their social status. However, they would not have experienced the knowledge increases that health workers elsewhere received by repeatedly listening to CommCare's audio messages during client visits. Further, those health workers did not boost their efficacy based on clients' families' increased attention during client visits.

expressed some surprise, about this new knowledge.

Experimentation and Strategic Deployment

As mentioned, health workers used CommCare devices as supervisors directed. They also found many non-prescribed ways to use the devices instrumentally, in service of their health work. Many of these non-prescribed uses had important implications for principal agent understandings of agents' autonomy, principals' control over agents' behavior, and the alignment of agents' behavior with principal's mandate. Indeed, these were positive effects of increased agent autonomy. As described, without direction, health workers (a) played CommCare's audio files to large audiences to simulate a radio show, (b) Googled health information to increase the quality of their advice to clients, (c) called or text messaged supervisors, government nurses, and government medical officers for consultation on a client's health issue, often transmitting photographs to facilitate these consultations, (d) took and showed photographs during client interactions to delight clients and to convince them to make good health behavior choices, and (e) misrepresented devices as authorities to compel healthy client behaviors.

These behaviors offer evidence of increased agents' ability to enact their health work mandate according to tactics the health workers improvised and found most useful. These behaviors also generally increased alignment between agents' activities and their mandate, while simultaneously relinquishing some principal control over the details of implementation and health workers' actions in the field.

Validation from and New Leverage over Clients

Community health workers noted in interviews that devices, and photos and graphics on devices, grabbed the attention of clients and clients' whole families. One project planner noted that health workers' carrying mobile devices made the health workers appear to their neighbors as "techno-savvy." With the CommCare adoption, one community health worker stated in an interview,

> *Now, clients perceive me well in society. The phone is important for my work in the community because the phone speaks, which has a huge impact on the minds of expectant moms. They see, listen and learn. They are excited and curious, and memorize the information.*

One project report stated that with CommCare, there was "no chance in [community health workers'] leaving out information due to lapses in human memory," and that "ASHAs are more confident in delivering health messages." Participating frontline workers reported feeling newly validated in the eyes of their community, clients, and clients' families, which in turn increased health workers' confidence and feelings of ability to do their main work, to deliver health information and spur decisions to engage in healthy behaviors. For example, health workers reported that introducing devices changed important aspects of how the health worker-client interaction took place. Previously, health workers counseled clients privately, quietly speaking in a corner of clients' homes. Now, the men, women, and children in clients' households became interested and began sitting near and participating in these interactions, as in the photograph below.

Slide 5.1. Community Health Counseling Session Using CommCare, Rajasthan. Above, an ASHA (center) in Rajasthan counsels a pregnant woman (right), while client's mother in law (center top) sits with a young boy and listens. Other female members of the household (left corners) also listen nearby. Photo credit:[56] *Ariel Schwartz*

One research paper found that nine out of ten questioned Community Nutrition Educators (CNEs) in one studied project

> *agreed that the CommCare system had helped them [the CNEs] earn social respect and recognition from the community. One CNE remarked: 'Earlier [a client's] dad used to be drunk whenever I went to their house for counselling. Now after knowing that someone in Delhi is viewing his daughter's information, he stays away from drinking before my visit and also carefully listens to what I say.' Another family*

[56] I obtained permission for all photographs as per my approved ethical protocols. Briefly, I (1) obtained oral consent to take each photograph from all parties prior to taking each photo, (2) composed each photo so that individuals could not be identified, and (3) showed each photo using my digital camera display to photo subjects to re-confirm consent.

> *thought that they would receive medical help from the headquarters in New Delhi when the 'government' officials saw the health status of their child.* (Medhi et al, 2012).

Another project's annual report recounted a similar experience, to illustrate a common experience among its health workers: "Before we only used to speak to the woman quietly and not talk to the elders… not sit with them. We'd go in and do our work and leave the house. We used to say, 'We only need you [client]'. Now we talk to the elders in the house too. And now our work is going better." In that annual report, the project recommended, then, a

> *Best Practice: Gaining support from elderly women in the village, who are often the decision makers for antenatal practices adopted by their daughters or daughter-in-laws* [sic], *can be strategic for behavior change and adoption of better antenatal care practices. Demonstrating the* [CommCare] *app to other members of the community can help create demand for the mobile application and push the ASHA to show the antenatal checklist to all the pregnant women in her village more frequently.*

One community health worker stated in an interview that now,

> *The women surround me and ask me about the phone. [The women ask,] 'What are the facilities in the mobile? What is the mobile telling you?' I respond: 'The mobile is giving good information.' The clients ask to see preparations for delivery and images about diet. The phone is important for my work in the community because the phone speaks, which has a huge impact on the minds of expectant moms. They see, listen and learn. They are excited and curious, and memorize the information.*

One project planner confirmed that health workers' relationships with clients have become friendlier. Previously, he observed, pregnant mothers rarely paid attention or took health workers seriously, but became interested after the introduction of CommCare. Project planners viewed health workers as operating in their communities from a credibility

deficit that came with their position. The government created the ASHA role after citizens had already met their Anganwadi Worker and Auxiliary Nurse Midwife as community health workers *with* health training. ASHAs were new *and* untrained, so they lacked credibility. Similarly, focal Link Workers and NGO-employed community health workers in Bombay had similar qualifications as ASHAs, and received a much lower salary than a typical low-status, low-pay job in that area such as house cleaning or laundry work. CommCare gave them all a credibility boost, partly because CommCare's repeated playing of messages spurred ASHAs' learning critical health information.

Further, one project planner speculated that being conspicuously linked to a major Indian city, or to the US, gave health workers authority. The mobile device was a more impressive signal to the community than health workers' usual flipcharts. "The mobile phone gives the ASHA an identity," because she felt sure that her message was correct, and because members of their villages took notice that the health workers have their own mobile devices, which was unusual for women, and indicated that an outside authority perceived her as trustworthy and serving a valuable community function. One project planner noted, the communities in which the projects operated featured many NGOs and activists. Using the application as a prompt for an interactive conversation, instead of only a data collection tool, set the focal community health workers apart and garnered both curiosity and respect.

Not all positive client perceptions validated the health workers' authority as knowledge workers. Instead, many believed that credibility accrued directly to devices, attributing clients' newfound attention, learning, and behavior change to mobile devices'

explanations. One project reported a

> *great increase in discontinuing the wrong practices that were earlier practiced by the elders of the family, such as giving prelacteal feed (ghutti) ... The beneficiaries now know what should the child be fed, when should the child and mother be vaccinated and other important things such as only feeding mother's milk to the child during the first six months. Their experience says that 'The mobile explains better than the ASHA herself'.*

For community health workers themselves, feelings of validation, improved, confidence, knowledge, and professional efficacy also came with feelings that credibility accrued to devices. When I asked one health worker, "So how do patients now view you?" she responded, "Some authorization is there. Before, we were less believable. It's better now that someone else is speaking." A project report clarified,

> *Clients perceive audio source to be someone of higher authority than the ASHA, who knows more than her. According to the ASHAs, because of this misperception, pregnant women are paying more attention to the audio messages. The audio clips are giving them more credibility when they elaborate on topics.*

This perception may be reinforced in projects in which the application is designed to speak directly to the client specifically about that client's condition. In one such project that focuses on child malnutrition, the application says, "your child's condition is improving" or "getting worse." Especially in rural areas,[57] in which CommCare's audio function spoke health messages directly, listeners including clients' families and neighbors treated health messages with the authority of a doctor and the interest they would devote

[57] Audio is not used in two urban Bombay projects because the health workers believed that their clients were too sophisticated to be interested in a talking phone. So, while health workers there may have received a status boost based on the device as a signal, they did not necessarily get an efficacy boosed based on increased attention from clients' families to content.

to a radio show.

It cannot be overstated how important it was for health workers, who had previously experienced immense trouble bending the ear of, teaching, and convincing their clients, to now be given attention, treated with respect and interest, and have their messages heard. Though their job was to influence client behavior, clients' mothers-in-law were often the primary decision makers concerning a client's pregnancy and how children were fed. For the first time, mothers in law now displayed an interest. They were drawn in to listen to the health workers messages, and asked and responded to questions. This advancement was thrilling for community health workers and project planners, perceiving a win for public health. Health workers often reported, "Now they call me *Didi*," meaning that clients looked up to heath workers more, and referred to her as *Sister*.

Validation from and New Leverage over Supervisors

Health workers' perceptions of increased professional efficacy were matched by instances of real leverage exerted by health workers in project areas. For example, when Project B, led in Rajasthan by a grassroots NGO, targeting 70 ASHAs whose government supervisors relatively passively participated, ended due to expired funds, four of those ASHAs asserted new power in their community. As described in Chapter 3, with the project's end, these four ASHAs found themselves owners of issued devices but with discontinued supervision or funding to support their use of the devices. The four ASHAs convinced their *Sarpanch*, their elected village leader, of the health importance of

continuing to use CommCare. The Sarpanch agreed to pay from village funds for the ASHAs' CommCare-related data and airtime. In interviews, the ASHAs themselves did not interpret this as an increase in their own power. I asked, "What did you think about the fact that you were only four of 70 ASHAs whose phones were recharged during the funding break?" They responded that "the Sarpanch said the work would not stop. We didn't have to pay much ourselves, maybe 1 rupee. So we didn't stop." However, in an interview the Sarpanch directly attributed his village's decision to adopt the cost to recharge the phones to those four ASHAs having exerted pressure on him. The credit the Sarpanch gave to the four ASHAs for spurring his active involvement in the project, and for spurring his leadership over the project's expansion, represents an unusual demonstration of ASHAs' power in their community.

In another example of new assertions of authority by government health workers over traditional authority, in two projects, planners reported that ASHAs now had specialized knowledge relative to Auxiliary Nurse Midwives (ANMs), ASHAs' superiors and sometimes-supervisors. In one, project planners stated that "ANMs are frequently not able to answer questions that the ASHAs now can. This has changed a bit who is the authority." One ASHA understood the outcome of ASHAs' new knowledge slightly differently, observing that her status increase has led "to a friendlier relationship with the ANM. Now we take tea together. She takes me to her farm," because ANM sees that ASHA is working hard and is dedicated. Indeed, another project planner noted that previously, ANMs could not verify that ASHAs were visiting their clients, but CommCare project facilitators showed monthly reports to ANMs to verify this activity, and ANMs recognized

ASHAs' work.

Another planner on that project noted that, from a technical standpoint, the ANMs still had more knowledge, but that everyone now recognized that ASHAs knew the community better and coordinated with the community better than ANMs could. This reportedly fostered collaboration between ASHAs and ANMs, who complemented each other's work to promote community health. One government official saw it differently. He observed that giving ASHAs in his area new devices "definitely" introduced competition among ASHAs and ANMs. The government official speculated that ASHAs felt,

> *'We are special, especially in comparison with the ANM. We were selected for this mobile application, not the ANM.' So [ASHAs] thought their work was important, more important than the ANM. ANM asked, 'Why did you not give us this mobile phone? You are giving this phone to ASHAs, why not us? We are more literate, qualified?'*

In some instances, ASHAs exerted real leverage over salaried government health workers. One research article noted that community health workers have successfully threatened to use CommCare phones' camera and audio recorder to document interactions with Anganwadi Workers (AWW) who refused a malnourished child for treatment at a Nutrition Resource Center (NRC).

> *This made the AWW[58] very nervous and she immediately agreed to take up the referral at the NRC. On a similar occasion where another AWW was reluctant to take up a SAM referral case, the CNE threatened to audio record the conversation using the CommCare phone and report it to the senior government officials. Three of the ten CNEs agreed that the CommCare system gave them the power to hold AWWs accountable with respect to referral activities in the field, unlike the paper-*

[58] An Anganwadi Worker (AWW) is a government salaried nurse. Malnourished clients visit Nutrition Resource Centers (NRC) for advice and help. A Community Nutrition Educator (CNE) is a type of community health worker that uses CommCare in this study. Severe Acute Malnutrition (SAM) is a medical term.

based system. (Medhi, et al, 2012).

New professional autonomy sometimes arose within a power vacuum further up the hierarchy. One project report highlighted a challenge that the local Chief Medical Officer did "not take much interest in the project," and attempted to spur interest by briefing him twice per quarter, and "roping in some of the higher officials." In these instances, community health workers could consider their new CommCare supervisor as a health work supervisor or mentor without negative consequences. In these instances, CommCare supervisors offered health workers guidance for how to conduct client interactions and strongly advocated for health workers when, for example, health workers' incentive pay from the government was late.

Health workers also asserted autonomy in small ways, which did not necessarily imply their supervisors' concession of project control, but which supported health workers' feelings of professional pride and efficacy. For example, one Dimagi representative speculated that by personalizing devices that health workers had been issued for work, by purchasing covers, laminating devices, and changing the wallpaper, the health workers asserted a psychological ownership over devices even if the distributing organizations retained legal ownership. Other project planners supported this thinking as well, including an off-site implementation partner who emphasized in an interview that community health workers *should* feel some ownership over work-issued devices, just as he does with his work-issued laptop.

Overall, supervisors had consistent information that health workers' behavior was

increasingly aligned with their goals via active monitoring and mentoring. Supervisors' enforcement of, and health workers' adherence to, the new data-driven aspects of health work were also accompanied by increased trust by supervisors in health workers to decide how to accomplish this work. So, that which increased monitoring and control also meant a real if sometimes small ceding of autonomy to health workers and sharing authority with them.

DISCUSSION. TECHNOLOGY PROJECTS' EFFECTS ON PRINCIPAL AGENT RELATIONSHIPS

The observations described thus far point to three key findings that derive from a principal agent understanding of CommCare adoptions in Indian community health projects. First, I described how CommCare projects increased the complexity of principal agent relations in health projects that had already faced multiple principles. In this finding, authority is further shared among additional multiple principals, I observed new tensions over who is in charge of health work and new accusations by the new supervisors of health worker shirking. Second, I described increased strength of principal agent relations. In line with principal agent expectations, improved data and communications that came after CommCare deployments absolutely improved principals' monitoring and control over agents' behavior. That monitoring and control was, in all instances, partly or wholly delegated to new supervisor, the field supervisor of health workers' ICT use. Third, I find additional evidence that health workers' unplanned uses of CommCare devices increased

health workers' autonomy by creating additional technical and mentoring resources for health workers, allowing health workers' strategic use of the device for work purposes, and improving health workers' credibility in the eyes of clients and colleagues. These changes increased health workers' confidence, professional efficacy, and independence in meaningful ways. This autonomy increased the alignment of health workers' behavior with the multiple principals' mandate to do good health work, but sometimes in ways that the principals might disapprove of, and sometimes in ways that sacrificed the integrity of CommCare or devices.

Shared Authority

First, this chapter described increased complexity of principal agent relations in the context of community health work. Initially, CommCare project planners' intended only to introduce health workers to a new technology, CommCare, and introduced a supervisory authority, the field supervisor, to monitor only the health workers' use of that technology. However, project goals and intended use of CommCare was so intertwined with health workers' main health work that the strong effect was that the health workers came to face additional principals for the primary health projects' mandate. Further, CommCare supervisors monitored health workers' CommCare use on a daily basis, while health workers reported to government medical officials monthly.

Therefore, in monitoring and shaping health workers' CommCare use, CommCare supervisors effectively became supervisors of health workers' entire work routine. These

CommCare project supervisors' goals were mission-aligned with those of the health workers' original supervisors, and those original supervisors either readily welcomed or genially tolerated this new sharing of authority. CommCare project supervisors diverged from health supervisors on tactics for community health work, advocating in most instances that the health supervisors demand that all health workers adopt CommCare for health information delivery and data collection. All interviewees emphasized these shared goals, and strived to make clear that resolution of these potential tensions would feature equal voice, mutual benefit and collaboration.

From government health workers' perspectives, introducing a new authority, the CommCare field supervisor, was a generally positive but more confusing experience. This confusion was partly an extension of an existing lack of clarity even before CommCare projects began, during which time health workers may have already been not fully clear about who their supervisors really were. For instance, in one project in which I conducted a field visit, the Auxiliary Nurse Midwife who had been identified by a CommCare project manager as that CommCare project's ASHAs' supervisor seemed surprised and confused that she might hold this supervisory role. In a second round of questioning, the ASHAs and CommCare supervisor stated that the ANM's response was typical.

Indeed, as described in the previous chapter, the Government of India offers vague guidance about how the health workers should be supervised. Perhaps because the government considers these health workers volunteers, greater emphasis is placed on institutional support and mentoring than supervision, and disperses mentoring responsibilities among "women's committees," the "village Health & Sanitation

Committee of the Gram Panchayat, peripheral health workers especially ANMs and Anganwadi workers," (GoI NRHM, 2015) a State Health System Resource Center supported by the National Rural Health Mission, a District Nodal Officer nominated by a Civil Surgeon, a Block Nodal Officer nominated by the Block Medical Officer, and the Primary Health Center (PHC), which administers pay to health workers. These guidelines note that "the guidelines do not provide for additional human resources, it is expected that [the District Nodal Officer] would be doing the work with the existing human and financial resources. However… managing the various aspects of the functioning of more than 1,000 ASHAs will not be a simple task without adequate human and financial resources." Further, "There would be considerable workload at PHC level as many of the bills for payment to ASHA would be processed in that office, [but] no additional manpower is provided at this level" (GoI, NHRM, 2015).

CommCare project managers and field supervisors stepped into this vacuum of under-funded, under-staffed, under-supervised health work. Government-employed health workers came to report more often to their NGO-hired field supervisors of their CommCare use than they reported to their government supervisors of their health work. Further, CommCare project field supervisors now gave monthly performance reports to government Chief Medical Officers. In some instances, these reports became the basis upon which Chief Medical Officers reviewed government health workers, so field supervisors necessarily became more authoritative than project planners had initially intended them or perhaps government partners had expected. Moreover, CommCare project supervisors required health workers to sign a contract before they received a CommCare device, but

many health workers may not have understood the meaning of these contracts, implying some ambiguity in the power relationship between health workers and supervisors.

For non-governmental health workers too, introducing a new authority, the CommCare field supervisor, who was in turn supervised by a monitoring and evaluation specialist, also led to some confusion and tension. In these organizations, interviewees at all levels recognized the increasing primacy of quantitative data in their tactical and strategic discussions, over unobservable or qualitative indicators of health, which these same interviewees (including the monitoring and evaluation specialist) believed to be more important.

Finally, low network connectivity across project sites frequently prevented health workers' transmitting evidence of having completed their work fully and on time. Health workers and their supervisors were acutely aware that they depended on imperfect infrastructure to assess performance, and that the new performance assessment method could not distinguish between non- transmission due to poor network and non-transmission due to shirking. Health workers were held accountable to transmitted performance data, even when all participants knew that the information supplied was incomplete. Therefore health workers across projects now periodically explained to NGO and government supervisors that they had worked even when they could not prove it.

CommCare projects increased the stakes for health workers in many ways. Projects increased health workers' visibility (conspicuously using expensive computing devices that spoke aloud), and introduced more extensive monitoring by new supervisors. New threats to reputation and job were real, and fear of repercussions for accused shirking

imposed burdens on health workers and elicited empathy from CommCare supervisors. Therefore while health workers often on one hand welcomed their new proximate principal, and the improved mentorship, training, and status that accompanied that new authority, on the other hand the new proximate principal and its new tools also further entrenched and complicated an already entrenched and complicated confusion about who was in charge of health workers and how health workers' performance was assessed.

Monitoring Improves Alignment between Principal's Mandate and Agent Activities

Second, this chapter described how CommCare deployments improved health projects' data and communications, which in turn improved principals' monitoring and control of agent behavior. Overall, all proximate principals now had access to more data, of better quality, more quickly, and more often than prior to CommCare deployments. In line with principal agent expectations, supervisors used data transmitted via CommCare to monitor and mentor health workers to increase the alignment between these agents' behavior and the mandate of these proximate principals. Field supervisors tracked health workers' progress on key organizational outputs including the number of clients visited per day, the duration of client visits, and health workers' completion of appropriate counseling topics during client visits. According to projects' theory of change, and according to my observation, using CommCare as directed was an important throughput improving these outputs.

According to projects' theory of change, improvement on these outputs should subsequently improve key health outcomes including maternal mortality, child mortality, health promotion, and disease prevention. By the time of my observation, neither project planners nor their funders or government partners had used the new data for major strategic decisions such as re-prioritizing organizational activities to support population health. Rather, they used data most often to help with daily and monthly decision making for how best to mentor and direct community health workers. Ultimately, then, while I observed improved alignment of principals' expectations and agents' behavior, I could not say whether this improved alignment of processes led to improved mission fulfillment of health goals.

Health Workers' Instrumental and Non-Instrumental Device Use

Many health workers used work-issued devices in ways that project planners had not anticipated, but which I argue, and supervisors agree, unambiguously aligned with principals' goals. Examples of this strategic instrumental use included using the camera to photograph pregnant women's concerning health symptoms to send to medical practitioners for immediate advice, and photographing healthy clinic-delivered babies to convince other pregnant women to deliver in a clinic. In another example described in this chapter, health worker innovatively and successfully used CommCare's audio messages to make it sound as though two women were having a conversation about maternal health on a radio show. These non-prescribed uses by health workers of CommCare and the devices

on CommCare was loaded arose not from supervisors' training of health workers but from health workers' daily use of their devices in the field. These strategic actions demonstrate that focal health workers were not merely instruments of health policy and organizational plans, but that health workers were thoughtful knowledge workers increasingly able to teach their clients about health topics and convince their clients to adopt healthier behaviors.

On the other hand, much innovative use by health workers of CommCare and CommCare devices depended on clients' misunderstandings about devices' technical capabilities. This chapter described families' consistently-expressed concerns that their words would be heard and fact-checked by officials in Delhi or the US, and that there would be serious consequences for lying. Instead of correcting these entirely false beliefs, health workers reported leveraging these misunderstandings to softly intimate clients and clients' families into giving honest responses and undertaking healthy behaviors. According to health workers and their supervisors, these manipulations increased the attentiveness of many clients' family members to health workers' messages, and may have improved the veracity of collected data. Ultimately, these manipulations may also improve health outcomes by helping health workers to convince clients and their families to adopt healthier behaviors.

On questioning, heath workers and their supervisors expressed little concern about this mode of compelling clients' behavior change, but I suspect that principals may have eschewed these methods for ethical reasons if they had considered them during projects'

planning stages. To the contrary, interviewed supervisors seemed pleased that frontline workers had new tools to strategically decide how to do their jobs better.

This chapter described how health workers conducted daily work after the introduction of a new technology, with close attention to changes in power dynamics between them and their most proximate principals. As expected, as use of the new tool became embedded in daily routines, the quantity and quality of information about clients increased, and with that increase, traditional supervisory authority increased as well. New sources of authority, efficacy, autonomy, and trusted information emerged from the lowest link in the delegation chain. Though study participants rarely used the word 'hierarchy' or explicitly referred to authority structures, each deployment described frequent, important, and nuanced understandings, misunderstandings, and subversions of who or what controlled or constrained particular decisions and behaviors that relate to the CommCare project. Quantitative assessment may demonstrate more conclusively whether traditional authorities in net retained or relinquished control. My qualitative interpretation is that the mandate of health promotion was faithfully adhered to with equal or less deviance than took place prior to each CommCare project. All along the delegation chain, actors' overall ability to achieve goals increased, while day-to-day autonomy at the bottom increased as well, and health workers engaged without conflict in friendly deceptions, which health workers enthusiastically embraced in service of their mission.

Chapter 6. Findings and Recommendations for *Machina ex Deos*: Mobile Computing Technology for Development

Mobile communications are being rapidly deployed to leverage technology for social services in the developing world (World Bank, 2014; Steinmueller, 2001). Many projects adopt mobile devices such as smart phones and tablets to reap the benefits of improved information delivery, improved staff supervision, improved data, minimized data loss, and reduced data collection costs (Baark and Heeks, 1999; Brynjolfsson 1993; Davis et al, 1992). The conventional wisdom among aid makers and development scholars is that mobile technologies will revolutionize village-level social service delivery, and based on this bold assumption, evaluation of such projects focuses heavily on social outcomes. However, whether and how radically new technologies will be used properly and systematically by project staff is understudied.

This dissertation asked two questions. First, in resource-constrained social sector settings, what project features govern and structure use of work-issued mobile devices? Second, how can decision-makers adjust to maximize the benefit of newly-introduced devices while minimizing new burdens to the project? More simply, what variables under social sector projects' control might promote successful use of information and communication technologies in development (ICTD) projects? This research represents systematic, qualitative comparison of nine extended deployments of a popular mobile application, CommCare.

This dissertation took the ICTD project as the unit of analysis, and employed a qualitative, exploratory approach to reporting on project experiences from nine implementations across India, in Uttar Pradesh, Maharashtra, Rajasthan, Madhya Pradesh, Bihar, and Delhi. Research featured extensive document review of all projects, 96 hours of interviews of project stakeholders including health workers, staff supervisors, funders, and Dimagi's representative on each project. Research also featured six site visits, including two each in Rajasthan, Uttar Pradesh, and Maharashtra, and direct observation of health workers' client interactions at two of these sites.

Each focal project deployed devices loaded with CommCare to primarily female health workers in India as a supportive job aid and/or a data collection tool to help monitor beneficiary populations' health status and frontline workers themselves. This dissertation examined how project participants used work-issued devices, and the project features that supported and constrained that use. To understand the consequences of these explicit and implicit rules, I compared how users were instructed to use their devices with how they actually used them, and the perceived effects on work, skills, morale, device integrity, and the ability to advance personal, professional, and project goals.

This dissertation applied a sociotechnical framework to research that featured primarily semi-structured interview and document review, with additional observations during site visits over six months in India. As the modifier sociotechincal implies, this framework identifies first the characteristics of the social setting (especially the development project and the health worker-client interaction) that surround and shape understandings and use of adopted technologies. Second, this framework identifies the

material characteristics of the physical and virtual object that is the technology being implemented. The sociotechnical lens allows for understanding how individuals use a new technology at work, whereby the distributor of the technology is interested not only in use of distributed devices, but in use that systematically and meaningfully improves organizational outputs and, ultimately, health outcomes.

This dissertation explores actual use, in spite of or according to project rules, and the meaning of such use for project stakeholders. I reported on changes in communication patterns and authority attributed to the deployment. These changes in communication and control over the development project were important for individual actors doing the work of global public health. These changes also had meaning beyond the narrow bounds of projects, whose work, while often isolated and narrowly defined, was embedded in and shaped by a much larger network of institutional actors devoted to global public health. Therefore, I supplemented the sociotechnical theoretical lens with a principal agent model to understand how the new information and communications technology changes the relationship between health workers and their supervisors, especially their changed patterns of communication and monitoring.

Governmental and non-governmental authorities delegated health work and use of CommCare to health workers. The principal agent framework highlights the delegation chain through which mandates for a specific form of health work, community health work, and a specific type of technology, CommCare and other similar applications, arrived in the hands of focal health workers and to community health workers across the developing world. Any act of delegation is characterized by some degree of asymmetric information.

The long delegation chains that characterize foreign aid in general, and the focal projects in particular, feature even greater information asymmetries. Introducing technology that promotes more and better project-related data, more frequently communicated, could reduce information asymmetries by improving monitoring all along the delegation chain. Mobile devices are inexpensive, useful in a variety of ways, and offer a portal through which information about development work and beneficiaries can flow back to funders, promising a reduction in information asymmetries, uncertainty, and risk for donors who must justify their investments to far-flung stakeholders. Therefore, the Principal Agent framework also helps provide an explanation for those peripheral actors' heavy investments in mobile technologies to support community health work.

This dissertation examined nine Indian health projects that installed an application called *CommCare* on a feature phone, smartphone, or tablet, to address some of these challenges. The intent of these projects was, broadly, to facilitate the health facilitators, by distributing to them a CommCare-enabled mobile device as a job aid and a monitoring tool to community health workers.

Dimagi designed the focal application CommCare for three purposes, the first of which was to help health workers by delivering information and encouraging behavior change. The information contained in the application was similar to that found in paper flip charts that health workers often used. Audio features were included to help health workers use their devices more productively than the flip charts, to give their clients complete and accurate information about health topics. When the application was used during a health worker's interaction with a client, the phone spoke each topic, such as importance of taking

iron tablets, out loud. It then asked, “Will you take our iron tablets?” The health worker recorded responses in a form on the application, which then transmitted the completed form via data connection to a central server, and moved on to another appropriate topic. Built-in decision-making and logic features helped health workers choose appropriate topics for each client and each visit. Second, the application was used to monitor clients, providing forms to enter client data, and search functions to retrieve it. Digital recordkeeping made client data easier to retrieve and aggregate, as compared to recordkeeping using traditional pen-and-paper diaries. Therefore, third, project supervisors used the application to supervise health workers, and hoped to use it to monitor the health status of a massive, disperse rural population and the work of a mobile health workforce.

Ultimately, these nine projects were situated in a global development challenge with an existing, imperfect but exciting global solution to the human resource challenges of administering public health services to a large, disperse, and poor rural population. Community health work was that solution, but faced its own systematic challenges. The focal technology was developed to radically deepen the benefits of community health work.

In the focal settings, the organization or project mediated between technology and user in the human computer interaction. Even when a supervisor did not hover over an individual health worker, the decisions, cultures, routines, directives, and action plans that permeated the organization or project interceded, constrained, and shaped her interactions with the tool. Employer-issued technology use is well-described in private sector, resource-rich, workplace settings, and shows that the behavior change and organizational reorientation required to systematically adopt any new technology is incredibly difficult,

due to the path dependence of existing routines, mindsets, and action plans. Technology in workplace settings in developing countries is less well-studied, but generally, grassroots development organizations have fewer resources to train and supervise use. Relative to corporate work settings, they feature fewer supporting technologies, systems, labor capacity, and existing knowledge and skills that would ease adoption. All focal projects represented attempts to adopt a technology that was meaningfully new for users, who were not switching, for instance, from a Blackberry to a Smartphone, but were instead learning new a tool that required real learning and behavior change.

Further, mobility, decentralization, and a village context, all central features of focal health projects' work, exacerbated these obstacles to use. Because staff spent their days in their neighbors' homes, managers could not directly observe daily work. A traditional office environment could have provided more opportunities for staff to learn from peers and supervisors, via more frequent directives, quicker responses to questions, and reinforcement through socialization and observing peers' use. Further, focal health workers had extremely limited prior experience on similar technology, though prior experience on similar technology is a key variable in determining whether individuals will use a new technology.

DISCUSSION OF FINDINGS

This dissertation reports three sets of findings. First, a sociotechnical lens illuminated projects' use of work-issued technology. Community health workers

incorporated the application into their client interactions, with some variation that aligned closely with their directives and project mission. Chapter 4 reported on use, the influences on, and effects of that use. Second, Chapter 5 described how projects' new communication patterns and use of new data influenced health projects' patterns of authority and control. The CommCare application aggregated these new data, and supervisors reported these aggregations back to health workers at daily, weekly, and monthly meetings. As the principal agent model suggested, the new data improved monitoring capabilities by supervisors of health workers, and by funders of health projects. Supervisors' use of the new data also better aligned health workers' actions with their most proximate principals' expectations.

Health workers also used devices in non-prescribed, and sometimes explicitly proscribed, ways, including strategic deployment, instrumentally, for work, and non-instrumental, or personal, use. Many personal and professional non-prescribed uses were neither fully anticipated nor explicitly allowed, but emerged at all sites that did not strongly enforce prohibition. These uses included communicating with supervisors, clients, and family members, browsing the Internet, playing games during down time at work, and listening to music and watching movies at home. Health workers discovered together or with their families features that could be used for pleasure or for their work. This section reviews sociotechnical and principal agent findings, and interprets this third set of findings: technology projects' effects on health workers' personal lives.

Sociotechnical Findings: Seemingly mundane project- and staff-level choices had important impacts on project success

A sociotechnical approach revealed rulemaking variables, including verbal rulemaking, password protecting memory cards, and installing function-blocking software, that were more important, across focal projects, than the website restrictions emphasized by existing literature. Further, the exploratory approach revealed how each of those variables interacts with the enforcement continuum. Seemingly mundane project- and staff-level choices had important impacts on projects' success. These findings highlight that interventions are complex in meaningful ways, featuring a device, software, and a set of binding or non-binding rules about how to use it. Key examples relate to SIM card ownership decisions, airtime and data top-up procedures, device possession rules and usage policies, and contingencies for device damage or loss. Here, I briefly review these examples.

Projects had to decide how to obtain a SIM card for each device. Two competing considerations influenced this choice. On one hand, India's terrorism security procedures ban anonymously- or group-owned SIM cards, so SIMs had to be registered to individual users. However, health workers' consistent lack of documentation including proof of identity and residence precluded timely SIM registration. For months, one project's health workers shared a few working SIMs, seriously undermining security and limiting the usefulness of the technology.

Implementers also had to decide whether to directly top up staff phones or to reimburse airtime and data expenses, at what amount, and whether to use pre-or post-paid

plans. Projects with post-paid plans overran their budgets when health workers indiscriminately made personal calls. Those with pre-paid plans could minimize personal use of project funds, but ran the danger of leaving devices with insufficient balance to transmit job-related recorded data. Further, their health workers often replaced work SIMs with their own to make personal calls, rendering themselves unavailable to their colleagues and clients.

Implementers also made a set of choices around how staff should use work-issued devices and how best to maintain devices' capacity to properly run CommCare. All projects explicitly expected or prescribed using CommCare and supportive features. Projects also proscribed or banned uses, explicitly by rule-making or implicitly by creating technical barriers. Supervisors implicitly allowed ignored or non-prescribed uses. Supervisors' monitoring of use and enforcement of rule-following moderated health workers' actual use use, and supervisors' behavior often contradicted explicit project rules. Many supervisors were glad to teach eager staff to use devices' full range of features, and this constituted soft encouragement of broad use regardless of rules. One critical decision was where devices reside when not in work use. Office storage ensured batteries would be recharged nightly, but decreased work time or infringed on personal time for health workers who may not have otherwise visited the office each morning and evening. Office storage also precluded non-workday device access, thus diminishing opportunities for morale- and skill-building, and for clients to contact health workers during nighttime health emergencies.

Lastly, by contract, written policy, or precedent, implementers established procedures to reinstall corrupted applications, to repair or replace damaged or lost devices,

and for financing the same. Most contracts stipulated that health workers would pay replacement and repair fees. Loss occurred infrequently, but managers enforced the rules, and health workers perceived the financial ramifications as a major financial burden. Their entire monthly income could not replace even a feature phone. Furthermore, a reputational threat weighed heavily on participating health workers: in their view, losing or damaging devices, by their own mistake or outside forces such as theft or monsoon, would be a major blow to their professional integrity. Each research participant reported that this concern weighed even more heavily on their minds than the already heavy financial stakes.

Principal Agent Findings: New data and communications improve monitoring of agents

Second, this study revealed that, as use of work-issued devices, and use of new data stemming from CommCare became part of daily routines, new sources of authority, efficacy, autonomy, and trusted information emerged. This dissertation supported expectations of strengthened authority structures given new use of a technology that facilitates information creation and dissemination. As expected, new data created though use of CommCare improved the ability of stakeholders along the delegation chain, especially those without direct, daily access to health workers, to understand details of daily health work that had previously been unavailable. Donors in regional or national headquarters not only reported new access to data, but also analyzed and posted briefings about these data, and about health work they funded, online and in reports.

This improved transparency about the conduct of health work also improved the frequency and fairness of performance evaluation, and health workers reported better feedback from supervisors and new efficacy in doing their jobs. Through this new tool, and the improved monitoring that it facilitated, outputs related to health work certainly improved.

I argue that, while the new technologies were ultimately an overall positive force for projects, their emergence was also a source of new tensions. For example, while on one hand, health workers perceived that their supervisors now made decisions based on merit instead of favoritism, on the other hand, health workers often felt that low performers were called out unfairly. They reported that the data did not reflect a fair or complete picture of what transpired each month. Indeed, in certain circumstances, health workers' actual work was not accurately reflected in transmitted data. Even when supervisors suspected this, he followed up each time, an implicit accusation that health workers overwhelmingly viewed as unfair. Challenges to data collection and data quality potentially undermine new insights to community health work, and ultimately, collected data remain only proxies the key outcomes of interest, such as maternal and child mortality.

The possibility of aggregating multiple projects' data, which are overall much more trustworthy, systematically collected, and accessible than before digital data collection, present opportunities to gain real new insights into village health work across a vast country with an enormous, decentralized workforce. But, we do not yet know whether these shadowy problems about data accuracy and completeness are systematic across India or across countries. "Code, or architecture, sets the terms on which life in cyberspace is

experienced... It affects who sees what, or what is monitored" (Lessig, 2000). We must further contextualize these data in order to gain meaning from their inevitable analysis.

Further, health workers also experienced new capacity to make autonomous decisions. Focal projects improved health workers' standing as agents competent to complete their duties. Health workers also began to exercise strategic behavior, instrumental and non-instrumental uses of work-issued devices, and made decisions about whether, when, and how to assert new authority over clients and supervisors. Ultimately, community health workers are knowledge workers and, better supported, newly informed, and newly marked with a status symbol, they were newly empowered.

Inductive Findings: Digital Inclusion, Education, and Empowerment for Women

The exploratory approach illuminated focal projects' additional effects, which were not generally a focus or goal of each project. In receiving a mobile computing device in the context of health work, health workers experienced important improvements in personal and professional efficacy. These effects on health workers stemming from use of the new tool were incidental to population health priorities, but related directly to other key development goals, especially women's empowerment by means of education and digital inclusion.

All projects reported that community health workers who had not had a personal phone prior to the deployment (most users) adopted the deployed device as their personal phone. For many health workers, the CommCare phone became the only phone in the

health worker's household or a well-used second device. Most health workers reported they used their work-issued devices to place calls to and receive calls from relatives. In all projects, health workers reported receiving missed calls, especially from their clients, children, and sisters, and the health worker called them back. Community health workers also placed missed calls to family members, including husbands, sisters, and mothers. Some also sent SMS messages to relatives. One health worker explained, before the technology project, "I wasn't able to use a mobile at all. My husband went to Karari, and before I couldn't order sugar. Now I call for sugar delivery."

Community health workers in all focal projects used their work-issued devices to the fullest extent possible, for work, communication, to facilitate their domestic labor, and as an entertainment device. Health workers and their families obtained new media from mobile shops or from their friends' devices via Bluetooth connection. The features they used included the camera, the media player for songs, videos, and games, and Internet, for accessing Facebook and young relatives' school test scores. Many health workers used their devices at home as a camera, photographing their children and using the camera to capture events such as weddings.

Access to a mobile information and communication device improved health workers' literacy in reading, numbers, and computing technology. Health workers and their supervisors reported that health workers experienced improved confidence, ability to carry out responsibilities, and feelings of authority in conducting work, and an increased ability to do independent work independently.

Their explanations for these feelings of improved efficacy included a) an increase

in their ability to communicate with far-flung clients and colleagues, b) improved job skills and substantive knowledge, c) innovative on-the-job uses of the device, and d) improved status among clients and clients' families, who were impressed with deployed devices. Health workers perceived, and their families and supervisors agreed, that their social status had risen at home and at work. Family members and neighbors viewed their work with more respect, as they learned that someone in the city had given them a mobile device to do it. Health workers thought that their children were impressed that they were learning. Health workers' expansive uses of mobile devices, fully predicted by the sociotechnical framework, had the unpredicted effects of strengthening health workers' messages and convincing clients in instances when they otherwise could not. Health workers found real power in the improved perception that clients and their governmental supervisors had of them and their work, and leveraged these perceptions into increased confidence and improved negotiating power in these relationships and in their personal relationships too.

In sum, health workers who participated in CommCare deployments felt the most important direct effects of focal technology projects, especially in the areas of digital inclusion, education, and women's empowerment. Receiving and conspicuously using mobile devices changed social relations for health workers in important ways. Research participants agreed that devices were a source of prestige for health workers at home and in their clients' homes, reporting dramatic increases in families and clients' respect for health workers and health work. Further, the devices were a source of real power for health workers who learned CommCare's health information, increasing health workers' authoritativeness on the subject of health issues, and who guided clients' beliefs about the

unwavering correctness of the messages contained in CommCare.

Will these effects will persist in the long term, especially as mobile phones become more widely distributed among and understood by client populations? In my study, urban health workers, whose prior access to mobile devices was better than that of rural health workers, did experience less improvement in digital literacy. However, urban health workers did experience their rural counterparts' improvements in prestige, as devices still signaled to their families and clients that their jobs were important. Urban health workers also learned information contained in the application, and experienced increased authoritativeness in client interactions. As long as community health workers continue to be medical non-professionals, and undertrained on the health information they are expected to deliver, their knowledge and job prestige will remain sufficiently low such that I expect these knowledge and prestige gains to persist in the long term, even after the period where mobile phones are more generally available. Moreover, projects' practice of purchasing the most powerful devices they can afford, though limited-use devices would suffice, suggests that participating field workers will continue to receive generally newer devices than those of their neighbors.

These unplanned effects warrant additional attention. As noted in this dissertation's introduction, scholars and practitioners generally view ICTs as critical means to advance a range of development goals including women's empowerment and gender equality (UN DESA 2005). The focal projects specifically contributed to health workers' education and digital inclusion. These two outcomes are important contributors to women's empowerment as understood by Sen (1999) in *Development as Freedom.* Understanding

poverty as lacking "the capability to realize one's potential as a human being," (Banerjee and Duflo, p. 6, citing Sen, 1999), Sen helps us view woman as an "agent" not only in the principal-agent sense but as in the "'grander' sense as someone who acts and brings about change, and whose achievements can be judged in terms of her own values and objectives, whether or not we assess them in terms of some external criteria as well." (Sen, 1999, p. 18-19). In Sen's view, the agency role of the individual is one as "a member of the public and as a participant in economic, social, and political actions" (*ibid).*

Sen observes that social facilities, economic opportunities, and political freedoms are interconnected, and together strengthen each other. He notes that "women's earning power, economic role outside the family, literacy and education" increase the general "respect and regard for women's well-being" and sharply decrease their survival disadvantage (Sen, 1999, p. 191). Further, education increases a woman's decision power in families by increasing her social standing, independence, ability to articulate her opinions, knowledge of the outside world, and skill in influencing group decisions (p. 218). Sen observes, "the denial of the right to work outside the home is a rather momentous violation of women's liberty" (Sen, 1999, p. 115, citing Sen in Tinker, ed., 1990). He notes, "outside work is also causally important in making women have a better 'deal' in intrahousehold distributions" (Sen, 1999, p. 115, citing many). Women's agency also promotes the well-being of all people in a region or society. Increasing women's agency specifically in the form of women's literacy and women's labor force participation statistically significantly reduces regional child mortality and fertility (Sen, 1999, p. 218).

There is an important overlap between agency and well-being, and only through

achieving both agency and well-being will women achieve full personhood (Sen, 1999, p. 190). Therefore, I understand *empowerment* as the process by which a person accrues agency and well-being.

This view helps women escape narrowly defined self-ascribed and societally-ascribed identities (Sen, 1999). I find that via the focal projects, health workers took themselves more seriously, and her neighbors did too. I argue that focal projects indeed empowered women and improved fundamental freedoms as described by Sen (1999) by increasing the social value of health workers' economic roles outside their families, and in the area of social facilities, economic opportunities, and political freedoms. I directly observed, and health workers and their supervisors reported on,

- Increased ability to communicate via calling and SMS with colleagues, clients, friends, and family,
- Increased access to online social networking sites such as Facebook,
- Decreased social stigma and improved social standing among their own household, clients' households, and in their communities through conspicuous use of work-issued devices,
- Improved skills including literacy, numeracy, English, and health information knowledge
- Improved access to information for work and personal use,
- Better integration into the government health system, through more frequent, more substantive, and often friendlier interaction with government health professionals, and

- Improved leverage over government health workers and other government officials.

Moreover, “in line with the importance [Sen] attach[es] to the role of public discussion as a vehicle of social change and economic progress,” (Sen, 1999, p. xiii) health workers also had new opportunities to access and take political action on sites such as Facebook, Twitter, CGNetSwara, and IPaidaBribe.com, though I did not observe health workers’ political participation on these sites.

In light of this evidence, I argue that most focal projects achieved important development goals, well beyond projects’ original stated scope, with a new beneficiary group and new outcomes as compared with community health projects that do not feature device-enabled health work. Community health workers, as described extensively in Chapters 1 and 3, are individuals who, for other projects development practitioners routinely target as beneficiaries as rural women with low education and relatively few economic opportunities. According to my conservative estimates, at least one million Indian women in this category stand to gain personally and professionally by introducing a technology component to itinerant health work.

This is an exciting prospect, but requires at least two important caveats. First, technology adoption at scale is not easily achieved. Indeed, my motivation for this study, as described in the introductory chapter, stemmed from terrible statistics about the success rate of social sector workplace technology adoption. In interviews, I asked two relevant questions of project planners and health workers: What would you do differently if you were to lead a state-wide scale-up? and What would you suggest be done differently if the

government were to lead scale-up? Project supervisors, managers, and funders took these questions very seriously, and responded extensively. In general, they speculated that distributing CommCare-enabled devices to all heath workers in their home states would be a terribly complex task, and few expressed strong confidence in the success of a publicly- or privately-run state-wide program. This dissertation does not report on responses to this line of inquiry, but the responses are worth detailed attention.

This dissertation is titled *Machina Ex Deos,* or, translated from the Greek, *Machine from the Gods.* It is a play on the plot device, *deus ex machina,* or, *god from a machine,* by which a god figuratively (in the case of a literary device) or literally (as a theatrical device, whereby a god is wheeled onstage via a mechanical contraption) swoops in at the end of a story to save the characters from tragedy. This dissertation borrows from the term's mirror, *Machina Ex Deos,* to mean that the gods (donors, or the foreign aid community) save village-level development by sending a machine in the form of a mobile device and application. This title optimistically acknowledges mobile computing technologies' potential, if well-used, to vastly improve outcomes. The title also cynically recognizes the techno-fetishism and technological determinism with which foreign investments in mobile computing technologies for development work is often made. Given these gifts that seem to fall from the sky, is it sufficient to be satisfied with the immediate and strongly positive development effects of these gifts, especially if we have no solid evidence that the development effects that we set out to improve have already or will ever improve?

This challenge points to the second caveat: health projects to focus on improvements for health workers could require an unacceptable degree of mission creep,

away from primary development targets such as improving population health, in favor of secondary or tertiary goals, from the perspective of the implementing organization. As this dissertation acknowledges, many project planners explicitly recognized a tradeoff between benefits for health workers versus for health projects. Many project choices influenced the depth at which health workers could experience education, digital inclusion and personal empowerment outcomes. For example, many focal projects initially deployed devices incompatible with Hindi script. As reported, projects met this challenge by having health workers learn to read and type English script, entering Hindi names into CommCare using an English transliteration. By the time of my study, at least one project had found a way for health workers to enter client data in Hindi. Planners viewed this as a major improvement for health work, but halted an activity that health worker viewed to have real personal benefit, and convey learning that was previously unattainable:

> *Earlier, we had to register new patients by writing their names in English. But we now have the capability to enter the names in Hindi, which is easier. But English is better because we were learning it—we would be rocket scientists by now if we still had to enter names in English!* (Community health worker).

In another example of how project choices influenced the effects of health workers' empowerment, projects that held devices in the office overnight precluded via this ICTD project implementation policy opportunities for health workers to develop new skills, use devices as they pleased, and use devices conspicuously among their families and neighbors. Restricting health workers' device use during personal time was intended to protect devices and application integrity, and to ensure nightly electricity for charging. Project planners' technical methods to protect devices such as password-protecting memory cards and

installing function-blocking software rendered devices into single-function CommCare machines, squelching both personal use and strategic, health work-related improvisations. Additional research could help quantify the tradeoffs of prioritizing device integrity versus encouraging comfort with and motivation to use the devices. How might projects, and funders, whose primary mission is to improve health outcomes, account for, prioritize, or at least not undermine, these important incidental impacts?

IMPLICATIONS AND EXTENSIONS

These tensions highlight the need for practical implementation advice to prioritize the yet-untested health impacts of this work, while not undermining the organizational and incidental benefits that clearly arise in the shorter term. Projects must balance instincts to control behavior that stem from concerns about device security by recognizing and embracing the potential gains that can accrue from its unrestricted and unplanned appropriation of devices by frontline workers. This work recommends that projects enable end-users to understand the range of devices' functions, the risks associated with irresponsible use, and how to undertake basic troubleshooting. Teaching the principles of one's project mission and professional ethics will guide users as they navigate novel situations and experiment with non-prescribed solutions. Health workers' understanding of projects' importance, their responsibilities, and the real consequences of shirking can serve as a basis to trust them to be the knowledge workers they are expected to be.

Specifically, projects should a) teach users projects' principles and adoptions' theory of change, connecting specific device uses to specific goals implementers hope to

achieve, b) teach project staff and frontline workers a range of device functions for professional or personal use, c) encourage exploration of mission-oriented device use beyond explicitly prescribed uses, and d) teach professional ethics to guide individual decision-making as participants discover new uses of issued devices. These activities will encourage frontline workers' sense of agency to do one's job and accomplish personal goals, and increase their sense of professional responsibility and personal ownership over their work-issued devices.

Ultimately, in the spirit of Dani Rodrik (1999, 2000), development projects should be localized and look "messy." Successful projects look like local experiments that are continuously learning lessons from each other. It is not necessary or even desirable for them to implement identical technology in identical ways, even if they intend to use the same application for the comparable purposes. The context-specificity, dynamism, and variability of implementation settings precludes a formulaic implementation, and implementations will therefore continue to appear idiosyncratic and produce similar data that do not mean the same thing in all contexts and therefore, resistant to randomized controlled assignment.

This dissertation has important implications for evaluations including randomized controlled trials of projects that feature an ICT component to their development project interventions. Interview participants including project planners, funders, and technologists identified projects evaluating how using CommCare and similar applications effects population health in India. At the time of study, these evaluations lacked the baseline data or statistical power to demonstrate the effect of health workers' ICT use on outcomes such

as anemia in pregnant women and mortality in infants and mothers. In these evaluations, ICT use is a proxy for health.

My research redresses the conflation between ICT use and its effects by studying organizational throughputs (including use and content of contracts, policies about SIM ownership, airtime top-up, device possession, and use, contingencies for damage or loss, and enforcement of these rules) and outputs (including how field staff use the new technology, and any resulting new data and communication patterns) that emerge before health outcomes are observable. There are important consequences to ignoring these factors, especially for those who seek to replicate positive effects of ICT use. Even the best-designed trial that confidently demonstrates the health benefits of projects' ICT use, without tracking the organizational processes by which use became routine, will struggle to properly attribute benefits.

Moreover, my findings suggest that increasing attention to organizational throughputs and outputs will three benefits for implementations. First, attention will decrease the sociotechnical barriers to use by increasing the likelihood that field staff will use distributed technologies according to the implementing organization's theory of change. Second, throughputs and outputs offer specific leverage points to increase the quantity and usefulness of new data and communications about health work, beneficially increasing principal oversight and control over health workers. Finally, attention to these details allows implementing organizations to allow any spillover benefits that may come with flexible enforcement of use policies.

Perhaps counterintuitively, careful policies combined with flexible enforcement of

how health workers' use work-issued devices promoted health workers' faithful use in service of health goals, and autonomous advancement of professional and personal goals. With loose control over device use, supervisors improved their control over the primary development task, health work. As distribution scales to greater numbers of health workers, and as devices' technical capacity to preclude improvisational use improves, it is tempting to treat the distribution of an application-enabled device as a simple intervention. Careful control over device use, however, does not demonstrably improve control over health work. Careful attention to the organizational setting in which devices are distributed might.

Further, my observations raise important legal and ethical questions about patient data privacy in the context of grassroots development projects' move from paper-based to digital data collection. As mentioned earlier in this dissertation, CommCare functions such that anyone can download and use it. The activities of anyone who uses CommCare in their work are documented through the application's sent forms. All data collected via CommCare are stored in a cloud managed and fully accessible by Dimagi. Planners of two projects noted that they learned the implications of Dimagi's data storage policies after it was feasible for those projects to switch to a different technology. In interviews, project planners reported that after learning and expressing concern that a) Dimagi employees would have access to their clients' data, and b) Dimagi retained the right to use these data in internal evaluations and for peer-reviewed research, Dimagi staff worked faithfully to mitigate perceived risks. In addition to risk of unauthorized access to client data stored in the cloud, all projects reported that thieves, mobile shop owners, and health workers' family members had frequent access to the devices, and therefore to any unsent client data

pending on them.

As grassroots development projects move from analog to digital data collection, they must give more systematic and proactive attention to client data privacy. As depicted in Figures 1.2, 1.3, and 1.5, and in Chapter 5, Dimagi members are simultaneously principals, directing community health workers' CommCare use in health work, and agents to donors such as USAID, which delegated to Dimagi the task of developing a technology to facilitate community health work. Dimagi's dual role as principal and agent offers an opportunity for the funders of Dimagi and other similar ventures to incentivize data privacy practices. An important policy recommendation for organizations considering funding the development and implementation of applications to digitize client data collection should make funding conditional on serious data privacy measures. These measures should address the risks associated with cloud storage, unauthorized physical access to devices, and with the fact that most of those with legitimate direct access to the data, including community health workers, development project planners, and technology staff members, are not medical professionals extensively trained in patient privacy principles or practices.

This dissertation research directly applies to a targeted 4.250,000 community health workers in 57 countries (WHO, 2010; WHO, 2006). Globally, community health workers work to improve three Millennium Development Goals, including reducing maternal and child mortality and combating diseases including HIV, tuberculosis, and malaria (WHO, 2010). Community health workers are already using CommCare on a mobile phone or tablet to advance these goals in more than 500 organizations in 50 countries (Dimagi.org, 2016). Moreover, Dimagi faces at least 70 competitors who developed applications that,

like CommCare, are based on the open-source technology Open Data Kit for field worker data collection and recall (OpenDataKit.org, 2016). I argue that it is worth exploring the extent to which my findings apply to domains beyond community health work, in which grassroots development agents enact their daily development tasks autonomously, outside the context of a central office.

In time, I would extend this dissertation into to three areas that are ripe for future research.

First, I might expand my current research project to include representatives of funding organizations that did not directly participate in the studied projects, but who do routinely make decisions to fund development projects with significant ICT components. During my research, I asked funders and project implementers how they knew that a technology would radically improve health work, how a radically-new technology be usable by the particular staff who would use it, and how they decided that it would be worth the time, funds, and effort. This dissertation does not report on these questions, as findings would be more robust were they supplemented with responses to similar questions posed to a wider group of funders. Comparing donor, technologist, and project planner reports on projects' capacity to use ICTD, and project-level obstacles to that use will reveal key differences in understandings of how implementations happen on the ground. I wonder how donors assess the competence of organizations to adapt technologies that would be radically new for users, or that are intended to catalyze systematic, radical behavior changes among those workers.

For example, I would question the World Bank's Senior Innovation Specialist, who

oversees mHealth initiatives, and the USAID Mobile Solutions Data Lead. I would also question corporate and donor organization program officers who have previously funded projects similar to those I studied, including for example at Mahindra and 3ie, and at the Nokia, Dell, HP, and Rockefeller, Gates Foundations. Moreover, the United States State Department narrative budget request justifications, which document a key donor agency's understandings of funding priorities and requests, are one example of policy documents that may fruitfully complement these perception-based interviews.

Second, I would compare mobile health initiatives in India with those in the United States, exploring the boundaries of usefulness of the concepts *developing* versus *resource constrained* settings. My motivation for this work would be to formally explore a hunch I maintained during my dissertation research: that certain resource constraints, such as the mobile character of health work, that post additional obstacles to technology-driven organizational learning and routine change, transcend a "development" designation to and present similar obstacles regardless of whether they take place in a developing or developed country setting. Both the US Center for Disease Control and Prevention and the National Institutes of Health, as well as some US state governments, recognize and employ the community health worker strategy to address health disparities. The federalist nature of the system of government in India and the United States facilitates case-study comparison on understanding, use, and limits of the community health worker role nationally and in Texas.

Finally, I would compare problems posed in mobile health ICTD projects with those in the mobile education movement. Here, I would explore research extensions to technology-for-education projects in three arenas, including online models for teaching

many (i.e., massive open online courses, or MOOCs); one-device-per-student models (i.e., One Laptop Per Child, or OLPC); and models of in-person, group learning on shared devices (i.e., in-classroom multi-touch tables). These examples would suggest extensions into two different arenas, including into the education domain, as well as into the domain of direct-to-client development technologies. Research participants in the education domain more comparable to the current work might be in-country teachers using tools to facilitate their work (i.e., One Mobile Projector Per Trainer, or OMPT).

CONCLUSION

Overall, my findings and these extensions reinforce understanding village health workers' role as a social change agent (Werner, 1981) and "a community mouthpiece to fight against inequities and advocate community rights and needs to government structures..." (Lehman & Sanders, 2007, p. 5). The historical role of community health workers was established during a global decolonization event. This role, which promoted self-reliance, poverty eradication, and elimination of social inequities, revealed itself over and over in my work, even when research participants emphasized a technical role that more narrowly supported community health management. Lehman & Sanders (2007) observe this ongoing "fundamental tension between their roles as extension worker and change agent" (p. 6). Theory and practice predicted that technology project would improve health projects' organizational efficiency and the alignment between health workers' responsibilities and actions to competently deliver health information to their neighbors.

Research participants were proud to report on their improvements in the area of efficiency and effectiveness of health information delivery. Health workers also proudly contradicted my expectations that they would conceal their non-prescribed use of their devices, which in the very contracts they signed could be interpreted as shirking. Instead, they fully embraced the devices into their personal and professional lives, taking ownership over their productive deployment. In doing this they also embraced and better embodied their role as change agent, in their clients' lives and in their own.

Appendix A. Sample Interview Questions[59]

(Prompts Indented)

1. What was your role in the CommCare deployment?

2. What was the purpose of adopting CommCare?
    - What, if any, were the stated objectives?

3. Who initiated this project?

4. Who uses CommCare devices?
    - # end users
    - # program staff
    - # managers
    - # technical staff
    - # M&E staff

5. Profile of FLW?
    - ASHA/CHW/other
    - Project staff?
    - Who is her supervisor? CommCare facilitator?
    - Literacy rate?
    - Prior access to mobile phone?
    - Prior use of mobile phone?
    - (Prior exposure to smartphone, tablet?)

6. How was the particular device chosen over others?

7. Once acquired, were devices modified in any way?
    - to restrict use?

8. What rules were imposed on use of the device?
    - What rationale?
    - Any debates?
    - How are rules enforced?
    - What adjustments were made to these rules during scale-up?

[59] Selection and wording of semi-structured interview questions for each interview varied depending on interview participants' status as health worker, field supervisor, manager, technologist, donor, etc., and depending on the flow of each conversation.
FLW = Frontline worker, a broad term and commonly-used in India to describe anyone who interacts with clients, including community health workers and their field supervisors.

9. Did CommCare ever need reinstallation?
    - If so, what consequences to FLW? (Policy v. actual)

10. Did devices ever need repair or replacement?
    - If so, what consequences to FLW? (Policy v. actual)

11. On what non-CommCare tasks were FLWs trained? Encouraged? Asked and shown?

12. Do FLWs ever use CC in ways you didn't expect?

13. Any unexpected evidence of FLWs using the device strategically for work?
    - Call/SMS/missed call project staff, supervisors, or clients?
    - Camera
    - Practice using CommCare at home?
    - Show clients how to use the device?

14. Any personal use of device?
    - Place missed calls?
    - Receive/make calls or SMS?
    - Email/Facebook/Photos/Videos/Games?
    - Family use?

15. Are there any ways in which FLWs would like to use their devices, but can't?

16. What meaning did the device have in FLWs' lives?
    - Mechanisms?
    - How did this meaning change over time?
    - Device itself?
    - How did project messages or rules affect this meaning?

17. If intimidation, do these conflict in any way with transparency objectives?

18. How has deploying CommCare devices changed your project participants or organization?
    - Daily work patterns?
    - Ability to carry out the organization's mission?
    - Communication patterns?
    - New authorities?
    - New obligations? (FLWs to clients, project staff to each other)
    - Unanticipated problems or costs?

19. What would you do differently if you were to lead a state-wide scale-up?

20. What would you suggest be done differently if the government were to lead scale-up?

21. Was there any early resistance to the adoption?

22. How do you assess staff competence on CommCare or the phone?

23. How has the adoption changed participants' professional opportunities?

24. How has the adoption changed the way you think about mobile phones or computers?

25. How has the adoption of CommCare changed the way you think about health services?

26. What is the frequency of staff turnover?
    - at the CHW/ASHA level?
    - The field supervisor level?
    - Program manager/director?
    - What explains this frequency?

Appendix B. Coding Scheme and Documentation of Coding Activities

CODING SCHEME

Case Quick Description
Prescribed, non-Prescribed Instrumental Use
CommCare, including strategic non-prescribed uses
scheduling
Phone, SMS, Contact List
camera
Share media
Music player, Games, Download media, Internet
Email
Facebook
Video recorder
Money transfer
Ringtones
Wallpaper
Battery
Calculator
Non-instrumental Uses
CommCare
scheduling
Phone, SMS, Contact List
camera
Share media, Music player, Games, Download media, Internet, Email, Facebook, video recorder
Money transfer
Ringtones
Wallpaper
Battery
Project Rules/ Features
Device Selection
Cost
Usability
Functionality
Purpose of Deployment
Duration of Deployment
User
Tablet v. Anroid v. smartish v. feature
Device Posession

Modifications including Password Protection
Device
SIM Card
CommCare
Memory Card Modification
Hide Menu Items
Lockdown incl. AppLock
Settings (including GPRS)
Creating shortcuts
Code - formal
Code - informal
Device ownership
SIM Ownership
Responsibilities
Prescribed Use
Proscribed Use
Top-Up Policies
Device maintenance
Contingencies for damage, loss
Monitoring by-the-rules Use
Rule Enforcement
Branding
Informal Messages: spirit, norms, interactions i.e., during training or troubleshooting
Culture: learning
Culture: family
Culture: values diverse experience
Objectives / Benefits that Accrue to Society
Social Benefit: Improved Health or similar.
Social Benefit: digital literacy
Access to Services
Information
Government Capacitization
Timeliness
Objectives / Benefits that Accrue to Project
Monitoring and Evaluation
Monitoring, beneficiary population
Evaluation of improvements in project performance or social outcomes
Monitoring of FLW, and giving FLW

feedback	**Entertainment**
Device Security	Information
Productivity	**Access to Device/Internet**
Paperless/Portable	
Availability / Communication - work	**Burdens, and Fear or Threat of Burden**
Timeliness	**Device security /integrity**
Use technology	**Damage or loss**
Scale-Up/ Demonstration / Sustainability	**CC app integrity**
Scale-up / sustainability considerations	**Battery life**
Policy considerations	**New dependencies**
Device selection	**Financial threat/burden**
Objective	**Reputational threat**
Control over project, FLW, device	**Fear/threat/anxiety**
Implementation ideas / challenges	**Project staff fear**
New literacies	**FLW fear**
Project level credibility/ validation/pride	**Client fear**
	More work
Objectives / Benefits that Accrue to Individual - Professional (ToC: Prof --> Project --> Social. Always works?)	**Data security, transmission**
	Infrastructure problems/ Exogenous threats
Exercise professional agency; experience pride/ confidence:	SIM ownership
in current job	Stakeholder lack of interest/fatigue
opportunities for future professional advancement	Language / context barriers
Professional responsibility	**Supervision**
Vocational Literacy	**Distraction from work**
Productivity / efficiency	**Lack of (digital) literacy**
Paperless/Portable	
Availability / Communication - work	**Power. Authority Structure, Status, Spans of Control**
Validation	**Hierarchy**
Information	Take advantage of misconception
New literacies	Project of FLW
	Contracts will be enforced
Objectives / Benefits that Accrue to Individual - Personal	FLW of client
	Affordances
Personal Independence / empowerment / pride	Change rank order of credibility of information source: MIL, mother, midwife, FLW, flip charts
Literacy	Change power dynamics even when formal authority structures are unchanged:
Digital Literacy	ASHA over ANM/ government
Productivity	Government over ASHA
Availability / Communication - personal	FLW gets guidance in absence of supervisor
Validation	**Importance of mobility / spatial distance**
	As burden creating more work

Allowing communication /monitoring /influence from anywhere (benefit)	Contact list/address book
Other, including rep of faraway authority	Camera
New communication channels	Share media
Power share: collaboration, control tensions	Video player
Control of project/ device by stakeholders:	Music player
FLW control	Games
Implementation power share	Download media
Implementation power mine	Internet
(should-be) like-minded, not formal partners	Email
Control by non-participants. (Expression of what the device wants?)	Facebook
FLWs' family	Video recorder
Device or CC	Money transfer
Mobile shop owner	Ringtones
Strangers/thieves	Wallpaper
Other organizations	Battery
Introduce new power even though formal authority structures are unchanged:	**prescribed - non prescribed**
project in relation to FLW	digital literacy, vocational literacy, and literacy, language
tech over FLW	**Device or CC?**
Assertion of FLW or CC over (client, MiL, traditional knowledge, etc)	**Device/CC or FLW?**
Project in relation to government	Blurred roles
Trust	government v. government
Client trust of FLW	**Benefit v burden**
Trust of device/CC	
Project trust of FLW	**Uncategorized Issues**
FLW trust of project staff	Project learning processes different than in typical consumer setting
Government trust of FLW	Excitement, novelty
Partner of Partner	Exploration, taking initiative. Probably this overlaps with agency
Project trust of device/CC	Equity
	Motivating FLWs
Blurring	FLW capacity to adopt
Structured flexibility; flexibility as blessing and curse	NGO capacity to adopt
instrumental – non-instrumental	Changes over time
Focal application: CommCare	
Calendar	**Roles**
Phone	Project
SMS	ASHA
	FLW non-ASHA
	On-site project staff
	On-site project management
	Off-site implementation partner

Funding partner
Dimagi
Government
Clients
Clients' family / community
Researcher

DOCUMENTATION OF CODING ACTIVITIES

Third code. Goal: consistency across cases by improving on 2nd code.

Examining second code:

- Deleted: Rule categories (Social, physical, contractual, technical); recoded to "features"
- 2. Deleted: Ph1 Technological Frontier; L1 Organizations: rules, roles, structures, objectives; L2 Affordances; L3 Blurring.
- Reshuffled objectives:

Objectives/Benefits that Accrue to Society

O1 Social Benefit: Improved Health or similar.
O22 Access to Services
O11 Information
O2 Government Capacitization
O19 Timeliness

Objectives/Benefits that Accrue to Project

O3 Monitoring and Evaluation
O3a Monitoring, beneficiary population
O3b Evaluation of improvements in project performance or social outcomes
O3c Monitoring of FLW, and giving FLW feedback
O12 Device Security
O17 Paperless/Portable
O18 Use technology
O19 Timeliness
O20 Scale-Up/ Demonstration / Sustainability
O20a (X5) Scale-up / sustainability considerations

Objectives/Benefits that Accrue to individual - professional

O14 Professional agency
O6 Vocational Literacy
O7 Productivity
O8 Availability / Communication - work
O9 Validation
O11 Information
O15 Professional responsibility
O17 Paperless/Portable
O21 New literacies

Objectives/Benefits that Accrue to individual - personal

O16 Personal Independence/individual empowerment
O4 Literacy
O5 Digital Literacy
O7 Productivity
O8 Availability / Communication - work
O9 Validation
O10 Entertainment
O11 Information
O13 Access to Device/Internet
O11 Information

- Moved R1, R2, and R3 contents to Blur6; deleted Roles
- Moved X7 contents to Blur1; deleted X7
- Moved B5M1a to B5M2A; deleted B5M1a (dup)
- Moved S7 contents to B5; Deleted S7
- Moved S4 contents to O9/P1; deleted S4
- S1: should be projects' monitoring FLWs' device use. All other monitoring (including FLW performance) goes in O3.

IUF1 includes strategic uses of CommCare.
IUF includes strategic use of device
O14 Separated: - a. Increased agency in current job
- b. increased opportunities for professional advancement
Blur6 Separated: - a. Control /power share of project by project participants:
- a1. implementer + decision-maker (strategic use, distract from work)
- a2. Government informal partner; NGO seeks government support/scale up
- b. Control over device by non-participants: family, mobile shop owner
O5 -> B17 Moved relevant O5 content to newly created lack of digital literacy as burden
O14, O16 Includes feelings of pride
O16 Individual empowerment
O22 Added access to services (mostly from O1 – O22 becomes O1a)
Blur2, Blur4 Combine into Blur2; delete Blur4
O12 Device security as objective (mostly pulling content from B1)
O20 Scale-up / Pilot / Demonstration / Sustainability relates to goals only.
X5 → O20a Moved X5 as subcategory of O20; content features ideas on how to implement scale-up

Fourth code. Goal: completeness within topics by rereading original data.

Reading interview notes and documents, for statements relating to:

A11, O11, O9 Family/community listens in now too
S10 Culture: values diverse experience
S11 Culture: feeling of ownership
O17 Paperless / portable
O18 Use technology
O19 Timeliness
O21 New literacies
B5 Taking advantage of misconception
B8 Fear
B10 Data transmission problems
B11 Infrastructure problems / exogenous threats
B15 Supervision (of government, of FLW)
B16 Distraction from work
B17 Lack of digital literacy
P7 Hierarchy
Trust Tensions
X8 FLW adoption capacity
X9 NGO adoption capacity
X10 Change in perceptions/use or over time, i.e., with learning
Blur5 Which literacy?
Blur6 Power share
Blur9 Blurred roles
Blur10 Benefit/burden tradeoffs
A13 Includes guy at the mobile shop.

Fifth code. Goal: consistency across cases by improving on 4th code.

Examining fourth code:

- Name change Blur6: Power share + agents
- Delete P1; T6; P4c; P4d
- Better distinguish between: O3 Monitoring and B15 Supervision
- Content from P4 → Blur6
- Content from S11 → Blur6; delete S11
- Made all Ps a subset of P7 (hierarchy/structure)
- Made Blur6 a subset of P7 and separated:
    - FLW control
    - Implementation power share
    - Implementation power grab
    - like-minded, or should-be like-minded, direct stakeholders not formally partners

- Moved functions to Blur2 (instrumental/non-)
- Moved A12 and A13 to subsets under Blur6b
- Separated A13 into device and mobile shop owner
- Moved O17 (Paperless), Communication (O8), and O19 (Timely) under O7 (Productivity)
- Moved Spatial under P7
- Separated spatial
    - As burden that creates more work
    - Allowing monitoring from anywhere
    - Deleted P5a-P5f
- Moved all Trust → P7g
- Moved B3, B4, B5 → P7

Sixth code. Goal: consistency across cases by improving on 5th code.

Examining 5th code:

- Added a subtopic of Ph2, Ph2g = Tablet v. Android v. smartish v. feature
- Separated B8: client/FLW/project
- Broke X5 into subtopics:
    a. Policy considerations
    b. Device selection
    c. Objective
    d. Control over project, FLW, device
    e. Implementation ideas / challenges
- Considered breaking O18 and P7 into subtopics but decided not to
- Considered necessity of Functions, (Non)instrumental Uses, Trust; made no changes
- Assessed the accuracy of these impressions:
    - Developer frames outcomes formally as only accruing to project and informally as also accruing to individual FLWs (personally and professionally)
    - Project frames outcomes formally as accruing to society and to project, and occasionally to individual FLWs, and informally to all three.
    - FLWs frame outcomes as mostly accruing to society and individual FLWs, and less to project.
- Consider: digital literacy accrues to personal or professional? Or, another blur?
- Consider: X9 (NGO capacity) goes near O21 (new literacies)?
- No changes made to code on above 3 considerations, to be dealt with during analysis

Appendix C. Informal Units.

COMMCARE SELF-STARTERS

Table AC.1. CommCare Self-Starters

CommCare Self-Starters. Data source: Dimagi, Inc.												
	Project Country	First Form Submit	Last Form Submit	# Users	# Active Users	# Cases, last 60 Days	# Active Cases	# Inactive Cases	# Cases	# Form Submits	# Web Users	Notes
1	Togo	2013/09/07	2013/09/21	28	3	7	7	0	7	15	6	Counsel & support HIV patients, on ARVs, general health, family planning, OVC support, etc.
2	-	2012/04/20	2013/09/24	6	2	-	-	-	-	1,697	8	
3	India	2012/10/26	2013/09/26	7	7	4,572	5,554	5,061	10,976	20,454	1	Household monitoring
4	Malawi	2012/06/10	2013/09/26	49	47	305	308	7	332	705	2	A basic data collection app at health centers. Discovered CC & made/deployed app with very limited support.
5	Wales	2013/06/07	2013/09/19	6	1	2	64	-	64	864	1	Pilot for delivery & management of a meals service to vulnerable groups including elderly, drug addicts, alcoholics & ex-prisoners
6	Malawi	2012/09/28	2013/09/26	107	36	207	441	342	984	2,650	7	
7	Malawi	2012/03/17	2013/09/23	22	5	12	32	96	388	3,074	25	Tracking incidents of abuse
8	-	2012/10/11	2013/09/25	176	66	916	921	966	2,007	2,936	1	
9	Guatema	2013/08/09	2013/08/28	39	1	93	93	-	93	1,802	4	IT Infrastructure Analysis
10	Guatema	2013/08/12	2013/09/26	44	34	1,445	1,445	-	1,482	2,904	6	IT Infrastucture analysis
11	Malawi	2013/02/07	2013/09/25	45	25	263	901	101	1,118	2,593	9	
12	Guatema	2012/11/22	2013/09/25	31	2	8	442	731	1,513	4,344	8	Pilot to track clinical historical records (nutrition, immunization, etc.). Hope app becomes primary channel to capture nationwide clinical patient data
13	Lesotho	2012/12/05	2013/09/26	18	7	150	178	4	396	994	3	
14	Tanzania	2011/06/03	2013/09/26	185	162	2,414	5,450	8,334	17,725	45,415	21	
15	-	2013/07/28	2013/09/26	21	15	1,291	1,342	-	1,342	19,311	3	
16	-	2013/08/05	2013/09/25	40	37	79,796	79,796	5	79,801	79,831	3	
17	Nigeria	2013/05/24	2013/09/20	30	3	42	625	224	854	1,624	8	
18	Ethiopia	2012/10/24	2013/09/26	158	69	6,466	7,642	16,048	26,993	63,135	17	MCH app tracking children under 5, pregnant women, & households. Deployed to community health workers
19	Tanzania	4/10/2013	2013/09/26	62	51	8,610	10,199	748	11,299	25,323	11	
20	Malawi	2013/01/29	2013/09/26	39	34	7,381	8,660	8,194	18,489	26,812	13	
21	Nigeria	2013/07/09	2013/09/26	35	8	1,219	11,837	53	12,055	12,886	10	
22	Uganda	2012/11/06	2013/09/26	69	69	17,701	18,799	802	31,605	144,801	12	
23	Ghana	2013/04/11	2013/09/26	45	42	6,187	9,282	2,713	12,676	42,659	28	
24	Malawi	2013/07/15	2013/09/26	108	136	34,688	35,160	-	35,087	107,134	9	
25	Malawi	2013/02/07	2013/09/26	20	4	211	1,642	205	4,071	13,856	6	Completely self started project, zero help from Dimagi
26	India	2013/02/05	2013/09/26	21	21	456	478	45	581	3,943	1	Small scale data collection for a nutrition study
27	Kenya	2012/04/23	2013/09/26	12	2	-	-	44	44	9,549	1	
28	Malawi	2012/12/13	2013/09/26	27	26	1,596	2,676	606	3,644	5,485	4	
Total				**1,422**	**915**	**176,031**	**203,967**	**45,329**	**275,619**	**646,781**	**228**	
Mean				**51**	**33**	**6,287**	**7,285**	**1,619**	**9,844**	**23,099**	**8**	
Standard deviation				**50**	**39**	**16,080**	**16,052**	**3,622**	**16,961**	**35,439**	**7**	

A Dimagi staff member provided me with a list of what they refer to as *self-starters* active in October 2013. This information is summarized in Table A3.1 above. In this table, each row represents one ICTD project. Of the 28 active self-starters, 16 projects had

sustained beyond six months with the longest running at 27 months as of October 2013, with 162 active users (the remaining 12 were younger projects). Of these 16, 10 had gone beyond six months and they had at least 10 active CommCare users, and so were already as successful as the projects under comprehensive study, using this loose definition of success. Of the 12 projects that had not yet hit the six month mark, six had deployments of at least 10 active users, so could meet selection criteria in the future. Of these, the project with the greatest number of users has 136 active CommCare users. See Table 3A.1 above, in which each row represents a different independent CommCare deployment, for a depiction of this information.

These data lack detail on many relevant project features, rules, and device use, but they demonstrate that Dimagi's presence is not necessary for sustainability, a key concern in determining the generalizability of findings to projects that deploy without active involvement of the developer. On the other hand, these data do not allow rejection of the hypothesis that the developer's presence is sufficient for, or significantly contributes to, a deployment's success.

I also considered the following two informal units, which, unlike those described in the table above but like the units I formally studied for this dissertation, had been initiated and implemented with Dimagi's active involvement.

20 MALE FIELD INVESTIGATORS, DELHI (I)

This September, 2013 project was an intended demonstration for a planned Government of India volunteer designation, Urban Social Health Activists (USHAs, whose

work would parallel ASHAs') with tasks directly oriented to promoting health urban areas. This project, only one month old at time of study, is intended to run for two years. At the time of study, a pilot with 20 Field Investigators, whose job description replicates the planned USHA role, covers two clusters of Delhi slums, and will eventually cover 40 clusters totaling 16,000 households. The implementing organization, an Indian NGO, deployed CommCare to conduct a study to demonstrate that a mobile health project would improve health outcomes. Android phones delivered to the Field Investigators had not been locked down by the project; field supervisors reported confidence that the Field Investigators would not delete the application. Project I Field Investigators had generally, at most, completed secondary school or a pre-university equivalent. At night, they took the phones home. This project is notable in that it is the only studied project whose end-users were all male.

38 COMMUNITY HEALTH EDUCATION WORKERS, ABUJA & NASARAWA, NIGERIA (J)

This project formally launched in February, 2013 to more than 150 community health extension workers and midwives. This project deployed CommCare on Nokia feature phones and Android tablets. to empower lower-level health workers in 20 hard to reach health facilities in Abuja and Nasarawa, Nigeria. They use CommCare to collect data, manage clients, and prompt health workers to make decisions on treatment or referral for complications experienced during pregnancy.

The implementing organization, an iNGO, installed AppLock on the CommCare devices to block all non-CommCare use, including text messaging. At night, field workers

take phones home with them, but office-based workers leave them at the facility, though they could also choose to take them home.

Project objectives include encouraging health workers to follow antenatal care protocols in support of the Nigerian government's Saving One Million Lives Initiative; improve health workers' capacity via “clinical decision support during antenatal service delivery in the Primary Health Centers; and improve client health outcomes by helping the health workers identify complications early in pregnancy and make informed decision.” Community health workers "use multimedia audio counseling clips during group health talks that prompt them to have continued conversations about health behaviors." Collected data facilitates disease surveillance and drug use tracking, screening for pregnancy danger signs, and promotion of safe pregnancy and delivery. The implementing iNGO developed an online data dashboard to view data in real-time, and sends reports to the local government office.

Appendix D. Two sample contracts.

Reproduced from Schwartz et al (2013), including:

Figure AD.1. Sample Contract #1. Between implementing NGO and an employee of that NGO

Figure AD.2. Sample Contract #2. Among implementing NGO, a government-incentivized volunteer (ASHA), and that volunteer's supervisor (Medical Officer).

Figure AD.1. Sample Contract #1.

Sample Contract #1 (SC1). Words in [brackets] imply redacted identifying content

Tablet Handover Contact

Name of Receiver…….
ID Proof Type/ID Proof No. of
Receiver……/…….
Tablet No……

Date of receiving……

I receive the Samsung Galaxy along with the charger for the use of protocols on the field and will return it back after completion of the [Project] baseline survey. I take the responsibility of the proper use of the tablet and charger for the time period of the pilot. I understand that I will only receive full compensation for my work as a data collector upon return of the tablet and charger in good working condition.

Ownership

Tough clause. Encoded threat of burden

……
Signature of Receiver

……
Signature of [iNGO] India Team member

Signatories: employee (device recipient) and employer

Figure AD.2. Sample Contract #2.

Sample Contract #2 (SC2). Words in [brackets] imply redacted identifying content

Contract with ASHAs regarding Mobile Phones issued under the [Name] Project

Organization – [NGO, Address] hereby issued 1 (one) Mobile Phone (Model - Nokia C2-01, IMEI No_____ and ID No._____), charger, battery, and 1 (one) 4GB memory card to (ASHA name) _____ address _____.

Rules on the ownership, usage and maintenance of the Mobile Phone:

The Mobile Phone and its accessories are issued to ASHA for use as a job aid in the [Name] Project. Hence, the safekeeping of the same shall be the sole responsibility of the concerned ASHA.

Spirit

Spirit

It will be the responsibility of each ASHA to safeguard the mobile phone issued to her and also advise their fellow ASHAs to exercise all caution regarding the safeguarding the phone because any loss of the phone or any kind of damage to the phone will be a unfortunate for the entire project. Hence it shall not only be the responsibility of each ASHA to safeguard her phone and accessories but also encourage other ASHAs to exercise the same care and caution. If an ASHA observes any instance of misuse of these phones she may report the same to her respective ANM or a staff member of [NGO].

Spirit

Spirit

Spirit

Tough clause. Encoded threat

1. **Ownership:** The following guidelines will be effective regarding the ownership of the mobile phones-
   a. The mobile phone shall be the property of [NGO]
   b. At the time of issue of the mobile phone each ASHA shall have to submit a copy of a self-attested proof of identity.
   c. At the end of the project duration, a final decision will be taken by senior managements of [NGO] and other stakeholder organizations involved in the project, whether the ownership of the phone will remain with [NGO] or it may be transferred to the respective ASHA.

Ownership

Carrot clause. Encoded potential benefi

2. **Usage:** The following guidelines will be effective regarding the usage of the mobile phones-
   a. The mobile phone shall be used as a job-aid under the [Name] Project implemented by [NGO].
   b. The use of the mobile phone is exclusively for the ASHAs on the [Name] Project. Use of the mobile phone by any other person like a family members and or any person/s of the community/village is expressly prohibited. The sole responsibility regarding the use of the phone shall rest with the ASHA.

Rules on Use

Proscription

Top-up policy

c. The organization ([NGO]) shall be responsible for recharging data pack required for sending information under the [Name] project.

3. **Maintenance:** The following guidelines will be effective regarding the maintenance of the mobile phones-

   a. The ASHA shall exercise due caution while using the mobile phone.

   b. It will be the sole responsibility of the ASHA to safeguard the phone and the other accessories issued along with (charger, battery, and 1 (one) 4GB memory card).

   c. In case of any instance of damage occurring to the mobile phone due to improper/incorrect use of the mobile phone, the same shall be immediately reported to [NGO].

   d. In case of a fault with the mobile phone, please DO NOT approach a non-authorized/local technician for repairs. The repairs shall be carried out through [NGO] at an authorized service centre but the costs for such repairs shall be borne by the ASHA.

   e. The ASHA shall be fully responsible for damage/breakage if any to the mobile phone.

   f. The ASHA shall be solely responsible for loss/theft of the mobile phone. In case of loss/theft of the mobile phone the ASHA shall be responsible for reimbursing the organization the market value of the phone or a new Nokia C2-01 back to the [Name] Project.

Reputational threat

Tough clauses. Encoded threat of burden

Signature	**Signature**	**Signature (With name and Address)**
Chief Functionary [NGO], [Location]	**Medical Officer In-charge Block_____**	**Receiving ASHA**

Signatories include project staff and informal government partner who has some formal authority over device recipient

Date:

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