The Struggle for Digital Inclusion: Phones, Healthcare, and Marginalisation in Rural India

Marco J. Haenssgen [a, b, c, d, e, *]

[a.] Centre for Tropical Medicine and Global Health, Nuffield Department of Clinical Medicine, University of Oxford, Old Road Campus, Roosevelt Drive, Oxford OX3 7FZ, UK

[b.] CABDyN Complexity Centre, Saïd Business School, University of Oxford, Park End Street, Oxford OX1 1HP, Oxford, UK

[c.] Green Templeton College, 43 Woodstock Road, Oxford OX2 6HG, UK

[d.] Mahidol Oxford Tropical Medicine Research Unit (MORU), Faculty of Tropical Medicine, Mahidol University, 3/F, 60th Anniversary Chalermprakiat Building, 420/6 Rajvithi Road, Bangkok, Thailand

[e.] email: marco.haenssgen@ndm.ox.ac.uk, phone: +44 (0) 7771805068

[*.] Corresponding author

The Struggle for Digital Inclusion: Phones, Healthcare, and Marginalisation in Rural India

Abstract

The gains from digital technology diffusion are deemed essential for international development, but they are also distributed unevenly. Does the uneven distribution mean that not everyone benefits from new technologies to the same extent, or do some people experience an absolute disadvantage during this process? I explore this question through the case study of curative healthcare access in the context of rapid mobile phone uptake in rural India, contributing thus to an important yet surprisingly under-researched aspect of the social implications of (mobile) technology diffusion.

Inspired by a previous analysis of cross-sectional data from rural India, I hypothesise that health systems increasingly adapt to mobile phone users where phones have diffused widely. This adaptation will leave poor non-adopters worse off than before and increases healthcare inequities. I use a panel of 12,003 rural households with an illness in 2005 and 2012 from the Indian Human Development Survey to test this hypothesis. Based on village-cluster robust fixed-effects linear probability models, I find that (a) mobile phone diffusion is significantly and negatively linked to various forms of rural healthcare access, suggesting that health systems increasingly adapt to phone use and discriminate against non-users; that (b) poor rural households without mobile phones experience more adverse effects compared to more affluent households, which indicates a struggle and competition for healthcare access among marginalised groups; and that (c) no effects emerge for access to public doctors, which implies that some healthcare providers are less responsive to mobile phone use than others.

Overall, my findings indicate that the rural Indian healthcare system gradually adapts to increasing mobile phone use at the expense of non-users. I conclude that rapid mobile phone diffusion creates an opportunity to improve people's access to healthcare in rural India, but it also creates new forms of marginalisation among poor rural households.

Keywords

Digital inclusion, mobile phones, healthcare, Asia, India, panel data

The Struggle for Digital Inclusion: Phones, Healthcare, and Marginalisation in Rural India

Highlights

- This study relates to the social implications of (mobile) technology diffusion
- I hypothesise that phone diffusion undermines non-adopters' healthcare access
- I use a panel of 12,003 sick households across rural India in 2005 and 2012
- Poor non-adopters' access to private healthcare worsens during fast diffusion
- Wealthier households and public healthcare access are insulated from this trend

The Struggle for Digital Inclusion: Phones, Healthcare, and Marginalisation in Rural India

Acknowledgements

I thank Proochista Ariana, Felix Reed-Tsochas, Xiaolan Fu, Gari Clifford, Juan F. Castro, Andreas Georgiadis, and participants of the TMCD Research Workshop at the Oxford Department of International Development and the Development Studies Association 2016 Conference in Oxford for helpful discussions and feedback.

The Struggle for Digital Inclusion: Phones, Healthcare, and Marginalisation in Rural India

1 Introduction

It is a common stance that the diffusion of information and communication technology (ICT) is essential for development (Aker & Mbiti, 2010:229; Donner, 2015:14; Heeks, 2008:26), but what if the process of digital inclusion is a struggle that leaves excluded groups *worse off* than before? I investigate this question through the case study of phone-aided curative healthcare access in rural India between 2005 and 2012, demonstrating that the increased availability of mobile phones intensifies competition for scarce healthcare services among poor rural households. While poor phone owners enjoy more access to private doctors in contexts of rapid mobile phone diffusion, the slow-growing supply of healthcare and a system that caters increasingly to phone users mean that poor households without mobile phones see their access to healthcare diminish. Left to their own devices, mobile phone adopters thus outcompete non-adopters in the struggle for scarce rural healthcare services.[1] All the while, more affluent households with a broader range of options to access healthcare are insulated from these developments.

This research was motivated by the literature on "digital divides" and "information and communication technologies and development" (ICTD), which has begun to examine the inequalities of technology adoption (Donner, 2015:137-154; Graham *et al.*, 2014:758-759; Napoli & Obar, 2014; Schroeder, 2015:2828-2830; van Dijk, 2005:22), but which tends to assume that diffusion itself is desirable and that nobody experiences an absolute disadvantage through it. Contrary to this position, an earlier mixed-methods research project on healthcare-related mobile phone use in rural India and rural China suggested that widespread mobile phone use can lead to an adverse over-utilisation of resource-constrained rural healthcare systems, which can leave digitally excluded groups at a growing disadvantage (Haenssgen & Ariana, 2017b). Because the cross-sectional study was not designed to capture long-term and systemic effects of mobile phone diffusion, the present paper uses India-wide panel data from the Indian Human Development Survey (IHDS; Desai *et al.*, 2010b; Desai *et al.*, 2016).

Adopting a process perspective of mobile-phone-aided healthcare access, I hypothesise that the increasing spread of mobile phones in rural India worsens healthcare access for digitally excluded households.

This paper contributes to the interdisciplinary study of the social implications of technology diffusion in general, and to the study of digital divides and inclusive innovation in the field of ICTD in particular. It advances the conceptualisation of digital inclusion through an empirically grounded process framework of technology adoption that appreciates dynamic and systemic effects of mobile phone diffusion on healthcare access in rural, resource-constrained areas. Empirically, it provides the first quantitative evidence that the healthcare access of digitally excluded groups deteriorates with increasing mobile phone diffusion, which challenges the framing of mobile phones as an inclusive innovation and of digital inclusion as an unproblematic process. The tools and findings of this paper offer space for further research in other areas of digital development, like employment, government service access, or social interaction.

The remainder of this paper situates the study in the fields of technology adoption and ICTD, followed by a detailed description of the analytical framework (Section 2). Section 3 explains the empirical model to analyse the household panel data from the IHDS, using fixed-effects linear probability models with village-cluster robust standard errors to estimate households' probability to access healthcare as a function of mobile phone adoption and district-level phone diffusion. The results are described in Section 4, showing that households who failed to acquire a mobile phone between 2005 and 2012 are on average poorer, and that poor households without mobile phones are less likely to gain access to "responsive" private healthcare providers if mobile phones have otherwise diffused widely in their district. Section 5 will argue that the results correspond to the analytical framework. On the demand side, diffusion drives competition and creates divides between poor phone users and non-users. On the supply side, healthcare providers who are more responsive to patients' mobile phone use will increasingly cater to this group at the expense of non-users. That public healthcare access is

yet unaffected by these trends should only offer momentary respite, given that my previous cross-sectional study in 2013-2014 indicated that public providers in rural India have begun to adapt to patients' mobile phone use, too. Section 6 concludes.

2 Literature and Framework

2.1 Technology Diffusion, ICTD, and Digital Divides in the Context of Mobile Phones

This paper speaks to the literature on digital divides and "information and communication technologies and development" (ICTD) as part of the broader, interdisciplinary study of the social implications of technology diffusion. Two key insights from the broader field—comprising anthropological, sociological, and economic research—are that (a) technology diffusion has both positive and negative consequences for social, economic, and political development; and that (b) these implications are not evenly distributed (Bédoucha, 2002:104; Miller, 2010:53; Munn, 1992:109; Pedersen & Bunkenborg, 2012:565; Thompson, 1967:81-86). Given the commonly understood dialectic relationship between technology and society, it seems indeed improbable that technology diffusion invariably leads to desired development outcomes like improved economic security, education, or political participation (consider e.g. the human development index by the United Nations Development Programme, consisting of income, education, and longevity; UNDP, 2014:160-163). That not all technical change processes are "pro-poor" has been shown for instance by Gudeman (1992:145), who illustrates how continuing innovation and technical change helps Guatemalan households to generate savings and—potentially—profits in the local markets, but their lacking bargaining power means that more competitive merchants absorb the surplus. And although the broader economic literature of technology diffusion tends to be more enthusiastic about its potential benefits (Bandiera & Rasul, 2006:869; Besley & Case, 1993:396; Foster & Rosenzweig, 2010:421), it, too, is occasionally cognizant of nuances and absences of development outcomes (Stewart, 1978:74).

Within this field, ICTD research focuses on a subset of (typically digital) technologies and their potential applications to support "development" (variously defined) in low- and middle-income contexts (Díaz Andrade & Urquhart, 2012:289; Duncombe, 2012:2; Flor, 2015; Heeks, 2014:2; Unwin, 2009:1). As a result, most research in the area of ICTD has focused on ICT readiness and availability, the factors that drive diffusion and acceptance of technologies, and the positive development potential of technological change (Andersson & Hatakka, 2013:293; Dodson *et al.*, 2012; Heeks, 2014:12; Qureshi, 2015:516; Roztocki & Weistroffer, 2014:351). This involves for example the development and delivery of phone-based interventions in areas like personal finance (Jack & Suri, 2014:220), agricultural marketing (Rashid & Elder, 2009:5-8), or learning (Aker *et al.*, 2012:118).

The techno-centric focus in ICTD has been criticised for its insufficient emphasis on the social embeddedness of technology, user behaviour and different forms of use, unintended negative and positive effects of ICT diffusion, the equity implications of technological change, and the broad spectrum of consequences surrounding digital inclusion and exclusion (Ayanso *et al.*, 2013:63; Graham, 2011; Heeks, 2014:12; Sæbø & Furuholt, 2013:128-130; Wyche, 2015:2). The field is only now experiencing a gradual transition towards broader research of technological and social development, a growing theoretical base, and more interdisciplinary and mixed-method research that permits locally grounded conclusions—beginning thus to reflect concerns of the broader study of technology diffusion (Andersson & Hatakka, 2013; Burrell & Toyama, 2009; Chib, 2015; Donner, 2015; Gagliardone, 2015; Heeks, 2009:27; Kleine, 2013; Walsham, 2013:50).

The sub-field of "digital divides" has made a similar transition. The digital divide literature focuses on the uneven adoption of technology, which tends to reproduce or even reinforce inter-personal and inter-societal inequities. Originally framed in terms of ownership of ICT—the "haves" vs. the "have nots" (Barzilai-Nahon, 2006:270; Dewan & Frederick, 2005:299-300; Qureshi, 2014:215; Stump *et al.*, 2008)—the concept would eventually develop into "higher-order" forms of actual engagement with ICTs together with the skills required for their operation (Barzilai-Nahon,

2006:274-275; Helsper, 2012:411-414; May & Diga, 2015:100; Pearce, 2013:78; Robinson *et al.*, 2015; van Dijk, 2006:224). Donner (2015:137-154), Graham *et al.* (2014:758-759), and Schroeder (2015:2828-2830) go yet further and analyse digital divides between social groups and across countries in terms of technology-aided media content creation and consumption.

While the potentially problematic equity outcomes of technology diffusion are increasingly acknowledged (Mbiti & Weil, 2011:16-17), the process of inclusion is regarded as unproblematic and adoption as generally desirable. For example, Donner, though critical of the distributional implications of global mobile Internet diffusion, argues that, "When we assess the spread of informational production via mobile devices we should not let the (absent) perfect be the enemy of the (nearly ubiquitous) good" (Donner, 2015:153-154). It is thus assumed that diffusion processes benefit various groups differently, but that no party involved in the process will see its living conditions worsen.

Beyond digital divides, this paper also speaks to the related field of "inclusive innovation" in ICTD, which considers innovation and inclusion typically from a descriptive and prescriptive angle in an attempt to overcome the patterns of inequity often found in mainstream innovations originating from firms (Heeks *et al.*, 2014; Papaioannou, 2014). Different forms, or "levels," of inclusiveness are defined, for example, by Heeks *et al.* (2013:6), ranging from inclusion by intention via inclusion through adoption and impact to inclusion by inclusive design processes and innovation in an inclusive discourse. The broader inclusive innovation literature tends to focus on deliberate innovative activity rather than general diffusion patterns of technology as in the present case (Foster & Heeks, 2014; Fressoli *et al.*, 2014),[2] but it is conscious of the potential inequities that can result from the innovation and diffusion process across and within excluded groups (Heeks *et al.*, 2013:5-6; Papaioannou, 2014:11). In the present case, the diffusion of mobile phones as an innovation could be considered as "inclusive" for instance if its adoption and impacts are distributed equitably or in a pro-poor fashion (Foster & Heeks, 2013:335).I investigate in this paper whether a positive process approach to digital inclusion is defensible and whether mobile phones emerge as an "inclusive innovation." In contrast to

previous studies in the field of technology adoption and ICTD, my focus is in particular on population groups who are excluded from the process of mobile phone diffusion. I consider the case of healthcare access in resource-constrained contexts (health being an important domain of development; Sen, 1999), specifically curative healthcare access in rural India between 2005 and 2012. I derive my hypotheses from an analytical framework that is grounded in previous qualitative and quantitative research in rural India and rural China (Haenssgen, 2015b; Haenssgen & Ariana, 2015, 2017b).

2.2 Analytical Framework

2.2.1 Summary

In short, my framework explores the process of digital inclusion and suggests that, as mobile phones diffuse, an already marginalised part of the rural population will be unable to incorporate phones into their health behaviour. Those individuals who are able to do so will for example call a doctor for a home visit or an appointment, have a family member arrange a taxi, or ask friends about sensible treatment options. Within my framework, I expect that such activities entail a shift in patients' healthcare access towards providers who are more capable of accommodating phone-aided behaviour as part of their service delivery—in rural India, these "responsive" providers more are likely to be private than public doctors as they are not bound to their clinic to carry out a home visit, for example. If an increasing number of patients uses mobile phones to access healthcare providers, then this will not only increase healthcare demand (disregarding here as to whether such demand would constitute an improvement, which it need not necessarily), but the health system will also progressively adapt and cater to this behaviour (e.g. local doctors being only "on call"). Based on this framework, I hypothesise that an adapting health system will discriminate increasingly against marginalised and digitally excluded groups.

2.2.2 Incorporating Phones Into Health Behaviour

The process of healthcare-related mobile phone use is depicted as a flow chart in Fig. 1. It shows that, when a patient is ill and requires healthcare access, she will incorporate mobile phones into her healthcare-seeking behaviour if these are generally available, if they are accessible for a health-related purpose, and if they are a suitable solution for the problem at hand. Should these three conditions not hold, the patient will engage in conventional health action without mobile phones. This process is described in detail below.

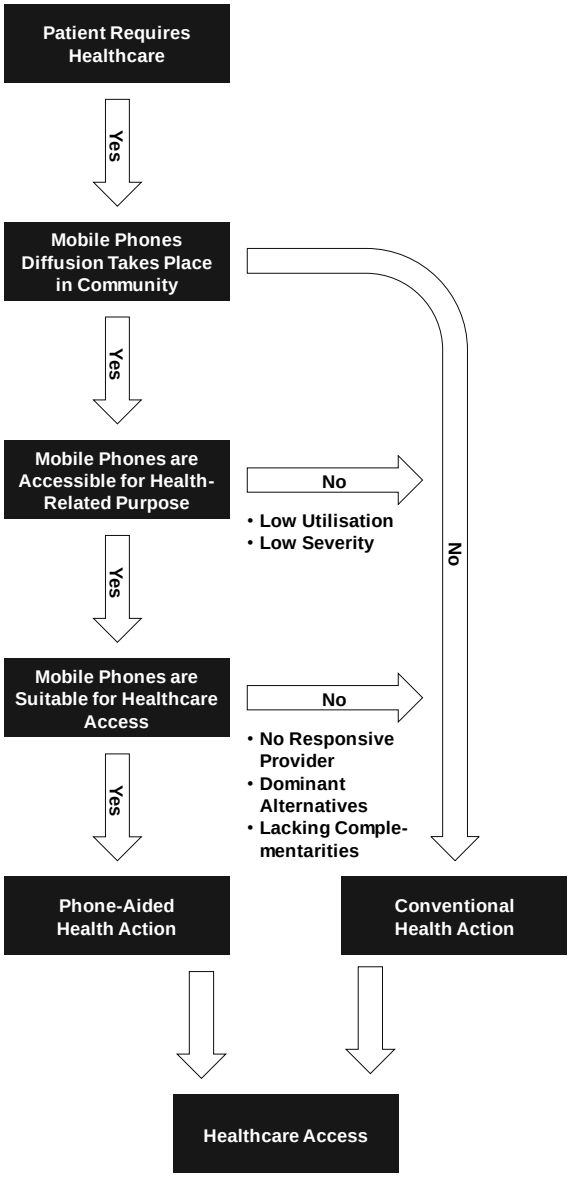


Fig. 1. Stylised Description of Phone-Aided Health Action Decision-Making Process

Source: Author.

Even in contexts where mobile phones diffuse rapidly among individuals, households, and communities, people will continue to exhibit diverse arrangements for accessing mobile devices, which means that difficulties in utilising the technology are likely to remain (Burrell, 2010; Chipchase, 2006; Hampshire *et al.*, 2015:97-98; Hampshire *et al.*, 2011:707; Helsper, 2012:411; Karnowski *et al.*, 2011; Katz, 2008:10-11; Reisdorf *et al.*, 2012:15-16; Steenson & Donner, 2009). For example, to "borrow" a mobile phone requires the explicit permission of the owner of the phone and may come

with explicit or implicit costs and obligations for the borrower. In this context, Hahn and Kibora (2008) show that it is customary in Burkina Faso to summon remote family members for funeral arrangements when a villager dies. Phones are borrowed for this purpose from teachers (among others) who live in the village, but the teachers would in return "expect the young men from the village to weed their field" (Hahn & Kibora, 2008:99). Similarly, differences in personal characteristics, technical features, technological context, social environment, and local cultures influence how people engage with mobile devices. For example, different mobile phone types and specially designed devices for older users (audio aides, high-contrast displays, simplified navigation) can remedy some of the challenges arising from age-related sensorial impairment (Kurniawan, 2008:893-895; Ziefle & Bay, 2005:381-382).

Whether a phone is indeed accessible for health-related uses also depends on the severity of the patient's health condition. Difficult access can rule out mobile phone use for what are perceived "trivial" health reasons; common and mild conditions like colds or headaches may neither convince lenders nor justify the social obligations for borrowers to ask for others' mobile phones. Less pressing health issues, indirect and non-personal access, and less intensive and extensive usage can therefore create a disjunction between mobile phone diffusion and phone-aided health action.

Aside from being accessible for a health-related purpose, mobile phones also need to be a suitable solution from the patients' perspective. My notion of suitability has three interlinked elements. Firstly, the actors and solutions within the health system need to be responsive to phone use, which means that they can be accessed through the phone and provide desirable solutions from the perspective of the patient. If actors in the patient's surrounding health system are not responsive, accessing them via mobile phones may be futile and the patient has to find other solutions. For example, Pitt and Pusponegoro (2005:145) report the need for emergency ambulance services following a terrorist attack in Jakarta. As an ambulance called for an injured diplomat failed to arrive in good time, "the casualty was taken to hospital in the nearest available form of transport—a rubbish truck" (Pitt & Pusponegoro, 2005:146). While health system actors as in this case may be unable to

respond to mobile phone use, others may actively oppose it. This can have many reasons, including a loss of income sources, concerns about workload, circumvention of institutionalised referral systems, privacy, accountability, and personal safety during home visits (Mechael, 2006:169-170). And although access to such unresponsive providers can also be coordinated without having to interact with them directly (Nakahara *et al.*, 2010:323-325), we may expect that healthcare seeking through the phone is more likely to be practised *along the lines of responsive actors in the health system*.

Secondly, where the health system can be navigated through viable alternatives to a phone-aided solution, mobile phones are superfluous. Patients are arguably less likely to use a phone if they have preferred health facilities in their immediate vicinity. The World Health Organization (WHO) illustrates such substitutability through emergency care in Ghana, where ambulance services can be accessed "by calling the dedicated emergency line (193) from landlines and mobile phones. However, people can also walk to the ambulance station or make a radio announcement through local FM stations" (WHO, 2010:9). Whether access is unproblematic is then partly a result of availability and location of healthcare providers relative to the patient. Other factors contributing to the substitutability between phone-aided and conventional healthcare access are personal characteristics (e.g. ability to walk or cycle, immediate access to vehicles and caregivers in one's household) and contextual conditions (e.g. safe roads in good condition, efficient and affordable public transport), which can undermine the instrumental value of a mobile phone during an illness. Besides, patients may choose courses of action that are less likely to involve mobile phones, for example self-treatment with medicines at home.

Thirdly, while some individual, contextual, and behavioural factors provide an alternative to health-related phone use, others constitute complementarities that facilitate the realisation of certain types of phone-aided healthcare seeking, for example proper road infrastructure enabling home calls.[3] Some authors for instance suggest that complementary service networks such as taxis need to be present to enable phone use for emergency transportation (Horst & Miller, 2006:140; Mechael,

2006:121-122; Miller, 2010:128). Likewise, favourable location, public transportation links, and personal vehicle ownership described above as alternatives to home calls can also be facilitators to other activities such as making appointments. While the local interplay of alternative solutions and complementarities shapes the visible spectrum of phone-aided healthcare solutions, it is not clear *a priori* whether the presence or absence of specific assets like vehicles facilitates or discourages phone-aided health action on average.

This process framework suggests that certain parties are possibly excluded from phone-aided health action despite the apparent diffusion of these devices. Digital exclusion of this form is therefore partly a matter of choice (if alternative solutions are dominant), but also of constraint (no phone diffusion, no alignment between phone utilisation and health condition, no responsive provider). Pre-existing patterns of economic, social, and spatial marginalisation can contribute to people falling into the group of "constrained non-users."

2.2.3 Equity Implications of Phone-Aided Health Action

Fig. 2 considers the implications of the process framework for rural healthcare access. Overall, if patients used to refrain from seeking care or relied on local yet unqualified healthcare professionals *for want of better options*, then mobile phones might enable them to tap into a broader range of solutions, provided that other actors are responsive. The responsiveness of the health system is arguably a function of the diffusion of mobile phones and the associated use of phones among patients for health-related purposes. The light-grey-shaded arrows in Fig. 2 illustrate this: The greater the extent of mobile phone diffusion, the easier it is to use a mobile phone to gain direct access to responsive healthcare providers. Even if a provider does not respond directly to mobile phone use, facilitated logistical arrangements (e.g. taxis) can still increase access, albeit to a lesser extent.

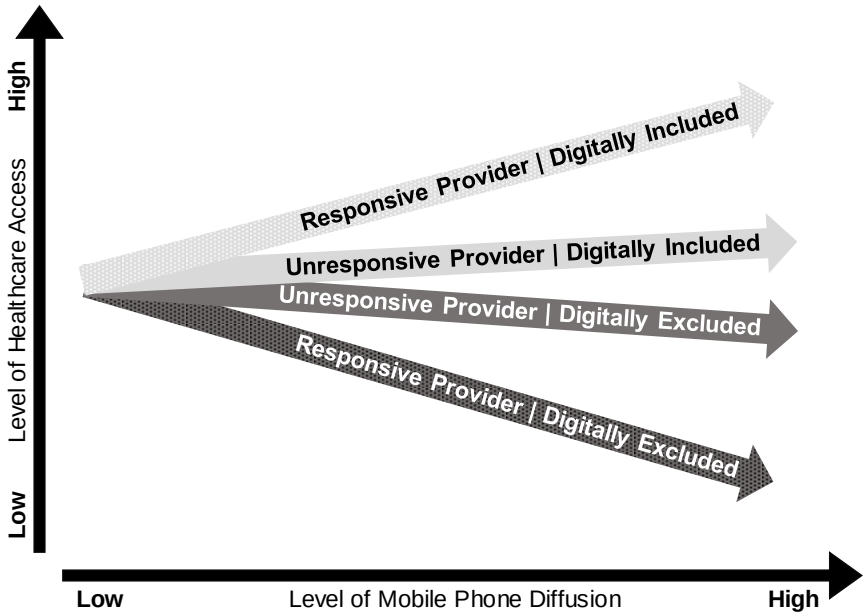


Fig. 2. Hypothesised Relationship Between Healthcare, Mobile Phone Diffusion, Health Provider Responsiveness, and Digital Inclusion of Patient

Source: Author.

An important implication of this framework is that dynamic health system adaptation in response to increasing health-related phone use can leave non-users worse off than before, as illustrated by the dark-grey-shaded arrows in Fig. 2. Imagine that more patients call responsive doctors to their homes for treatment (e.g. Mechael, 2006:169-170; 2008:98). These healthcare providers would then spend more time out of station, making it necessary for other patients to make appointments prior to visiting the clinic. Non-users would consequently experience greater difficulty in navigating the health system, finding "responsive" healthcare providers busy catering to phone users or indeed out of station when they arrive at the clinic. Such developments need not be problematic for individuals who previously had not used mobile phones because of dominant alternatives. As the framework suggests, this group could incorporate phones because their relative value for healthcare seeking rises. However, such developments would be problematic for those people who cannot use mobile phones because of social, economic, or spatial marginalisation, thereby raising the barriers to accessing healthcare. The

ensuing depression of digitally excluded patients' access to responsive healthcare providers is depicted in the bottom arrow in Fig. 2. To a lesser extent, this "crowding-out" effect would also occur among digitally excluded patients accessing non-responsive providers. This framework suggests that the process of digital inclusion creates an unequal struggle between those patients who can use mobile phones to facilitate their healthcare access and those who cannot.

In summary, my theoretical framework problematizes the process of digital inclusion, pointing at positive and negative healthcare access patterns associated with mobile phone use and at risks of exacerbating the marginalisation of some groups. This contradicts existing digital inclusion narratives, which, even if the outcomes of complete diffusion are understood to be unequally distributed, assume that the process itself is painless and unproblematic. Should it turn out that diffusion instead undermines service access among the rural poor, then we could consider mobile phones as an "exclusive" innovation in the healthcare sphere and the mainstream narratives might require revision.

3 Materials and Methods

I base my analysis on recently published panel data from the nationwide Indian Human Development Survey (IHDS; Desai *et al.*, 2010b; Desai *et al.*, 2016), which was carried out in two waves in 2004-2005 and 2011-2012. Wave I included 41,554 households with 215,754 individuals; Wave II surveyed 42,152 households with 204,569 individuals. The panel data structure in the IHDS allows for the matching of households over the two survey periods, yet not of individuals. The analysis therefore involves only those rural households that reported an illness in both survey periods to trace healthcare choices over time; that is, 12,003 households per period across 22 Indian states.[4]

I estimate fixed-effects linear probability models with village-cluster robust standard errors. If healthcare access Y_{kit} is defined as household i's probability of accessing healthcare provider k at time t, the empirical specification of the time-demeaned fixed-effects model (with $t_1 = 2005$ and $t_2 = 2012$) is

330

331 $$\ddot{Y}_{kit} = \beta_m \ddot{MOB}_{it} + \beta_d \ddot{DIST}_{it} + \beta_x \ddot{MOBxDIST}_{it} + \beta \ddot{CONTROLS}_{it} + \ddot{YEAR}_t + \ddot{u}_{it}, \quad (1)$$

332

333 Where $\ddot{Y}_{kit} = Y_{kit} - \bar{Y}_{ki}$ etc. are time-demeaned variables; MOB_{it} is household-level mobile
334 ownership; $DIST_{it}$ is district-level mobile phone diffusion (as a proxy for health system adaptation to
335 mobile phone use); $MOBxDIST_{it}$ is an interaction term; $CONTROLS_{it}$ are other household-level, time-
336 variant variables controlling for healthcare access; $YEAR_t$ is a trend variable; and u_{it} is an idiosyncratic
337 error term. Because of time-demeaning (see below), household-specific and time-invariant
338 characteristics drop from the analysis (akin to differencing between the survey periods in a two-period
339 case). The dependent and independent variables in this model are summarised in Table 1.

340 *Table 1. Variables in Regression Models and Expected Relationship to Healthcare Access*

	Variable	Description
Y_{kit} (Dependent Variables)	Any Healthcare	[1] if any ill household member visited any kind of formal or informal healthcare provider; [0] otherwise
	Public Care	[1] if any ill household member visited a public doctor; [0] otherwise
	Private Care	[1] if any ill household member visited a private doctor; [0] otherwise
	Pharmacists	[1] if any ill household member visited a pharmacist; [0] otherwise
	Traditional / Other Care	[1] if any ill household member visited a traditional healer or other healthcare provider; [0] otherwise
Independent Variables of Interest	MOB_{it} (HH Mobile Phone)	[1] if household owns at least one mobile phone; [0] otherwise
	$DIST_{it}$ (District Phone Diffusion)	District-level weighted average share of phone-owning households
	$MOBxDIST_{it}$ (Interaction Term)	Interaction term between household-level mobile phone ownership and district-level mobile phone diffusion rate
Other Control Variables	HH Landline Phone	[1] if household owns at least one landline phone; [0] otherwise
	HH Highest Education	Highest completed grade of formal education of any household member; [0] if illiterate, [1] if uncompleted primary education, [2] if completed primary education (5th class), [3] if completed middle school (8th class), [4] if completed secondary education (10th class), [5] if completed higher secondary education (12th class).
	HH Average Sex	Percentage of women in household; [1] if 100% women
	HH Size	Number of members in household
	HH Average Age	Unweighted average age of all household members
	HH Below Poverty Line	[1] if per capita household expenditure < poverty line (which varies by state; 2005 poverty line adjusted by village-wise deflator); [0] otherwise
	HH Asset Index[a]	Unweighted sum of 33 household assets, using the same household asset categories in 2005 and 2012. Stratification of sample by household wealth will categorise households as "poor" if their average assets between 2005 and 2012 were below the unweighted sample median, and as "affluent" otherwise.
	Major Illness	[1] if any household member experienced a "major" disease in last 12 months (e.g. cataracts, tuberculosis, hypertension); [0] otherwise
	Mild Illness	[1] if any household member experienced a "minor" disease in last 12 months (e.g. fever, cough/cold, diarrhoea); [0] otherwise
	No. of Public Health Facilities	Village-level count of public clinics (e.g. sub-centre, primary health centre, community health centre), as recorded in medical facility questionnaire
	No. of Private Health Facilities	Village-level count of private, as recorded in medical facility questionnaire
	No. of Other Health Facilities	Village-level count of other health facilities (e.g. family planning clinic), as recorded in medical facility questionnaire
	Year Dummy	Trend variable, capturing developments e.g. in local infrastructure and overall health service provision

341 Sources: Author, based on Beals (1976); Colson (1971); Gulliford *et al.* (2002); Kroeger (1983); Lieber *et al.* (2006); Meessen *et al.*
342 (2011); Nyamongo (2002); Shaikh *et al.* (2008); Shaikh and Hatcher (2005); Storla *et al.* (2008); van Egeren and Fabrega (1976); Ward
343 *et al.* (1997).
344 *Notes*: HH is household; defined as "people living under one roof and sharing the same kitchen" (Desai *et al.*, 2010a:222).
345 [a.] Wealth index includes mobile phones. Robustness checks excluding phones from index confirmed main results. Robustness checks
346 separating vehicles from wealth index have reproduced the model results without notable differences, while the vehicle coefficient was
347 statistically insignificant for all estimated models. The reported models therefore only include the wealth index.

This analysis involves the estimation of a healthcare access model, which includes mobile phone adoption and diffusion among other determinants of access. Healthcare access takes place in a broader health system, which I define in line with the WHO as a system that incorporates "all organizations, people and actions whose primary intent is to promote, restore or maintain health" (WHO, 2007:2). Access to public and private medical care providers are therefore not the only forms of healthcare utilisation. Informal caregivers and traditional healers should also be considered in healthcare access models, given that they account for up to 90% of all healthcare providers in the health systems of some low- and middle-income countries (Sudhinaraset *et al.*, 2013:3). In order to appreciate the multi-actor (or "pluralistic") nature of the rural Indian health system, the dependent variables include access to public doctors and nurses, private clinics, pharmacists, and "traditional and other" healthcare providers, together with overall access to any of these providers. In the empirical models, these are dummy variables that indicate whether any member of the household with a "minor" or "major" illness accessed the respective type of healthcare (conditional on an illness in the household during the twelve months preceding each survey round).[5] Different types of access can take place for the same household at the same time.

As I hypothesise that a health system that adapts to mobile phones will discriminate increasingly against individuals who do not adopt mobile technology, the independent variables of interest relate to household-level mobile phone adoption and health system adaptation to phone diffusion. I use district-level mobile phone diffusion to approximate the health system's expectation that people use mobile phones to a greater or lesser extent. This variable is calculated as the population-weighted percentage of households who own a mobile phone. In addition, the IDHS data does not include patients' healthcare-related mobile phone use, but previous research has found that the absence of household mobile phones predicts the absence of phone-aided healthcare-seeking better than the absence personal phone ownership (Haenssgen, 2015a). I therefore use household-level mobile phone ownership to approximate the likelihood of household members to engage in health-related phone use.

Household phone use and health system adaptation may interact insofar as a person using a mobile phone to access a doctor may be more successful in a system that expects such phone use (e.g. by calling taxis, by doctors being ready to accept calls on their mobiles). The interaction term $MOBxDIST_{it}$ captures this relationship.

A positive evaluation of the hypothesis follows if (a) healthcare-related mobile phone use contributes to better access to healthcare, (b) increasing health system adaptation has a negative effect on healthcare access, and (c) the coefficient of the interaction between health-related phone use and system adaptation is positive, meaning that mobile phone ownership becomes increasingly useful and compensates for the otherwise adverse effects of system adaptation. However, the analytical framework points at space for heterogeneity because adverse effects may be particularly pronounced for poor households who do not have alternative means of accessing healthcare. In addition, we may expect heterogeneity across different types of healthcare providers, with smaller effects for public providers such as regional hospitals that are bound by institutionalised referral systems and guidelines that prevent phone-based service delivery (Mechael, 2006:169-170).

The empirical model controls for other determinants of access, based on the literature on healthcare seeking and therapeutic itineraries. Important determinants of healthcare access in this literature are the nature, severity, and stage of the specific health condition; the patient's education, economic situation, age, sex, and decision-making autonomy; personal predispositions and belief systems (e.g. accepting pain as part of lifestyle); societal perceptions of the health condition; availability, accessibility, and awareness about providers (e.g. location); trust in and perceptions of the providers' quality of care; and the compatibility of provider competences with the patient's condition (Beals, 1976:184-185; Colson, 1971:234-236; Kroeger, 1983:149; Lieber *et al.*, 2006:469; Nyamongo, 2002:381; Shaikh *et al.*, 2008:749-753; Shaikh & Hatcher, 2005:50-52; van Egeren & Fabrega, 1976:537-538; Ward *et al.*, 1997:21-23).

This long list of determinants suggests that an empirical analysis of healthcare access should be cognisant not only of mobile phone diffusion but also of the patient's characteristics, her or his social networks and cultural environment, the nature of the illness, and health system attributes. Table 1 displays and describes the control variables that approximate these factors within the IHDS data set. However, it is plausible that unobserved characteristics like health provider preferences are not captured with the IHDS data. In such a case, the error term ε_{it} in an empirical model could be specified with an idiosyncratic and a household-specific, time-invariant component: $\varepsilon_{it} = a_i + u_{it}$. If the unobserved household characteristics were correlated with other predictor variables, then this would constitute an omitted variable problem.

I choose fixed-effects models to deal with this problem because, through time-demeaning, the unobservable (assumed static) household characteristics $\ddot{a}_i = a_i - \bar{a}_i$ drop from the model, leaving only the idiosyncratic error term $\ddot{u}_{it} = u_{it} - \bar{u}_i$. Hausman and generalised Hausman tests were statistically significant at the 0.1-percent level for all but two of the estimated models (two affluent sub-sample estimations were statistically significant at the one-percent level), indicating that the fixed-effects specification is preferable to random effects panel models that treat unobserved variables as uncorrelated with other independent variables.

Because the dependent variable is not normally distributed, logistic regression models are typically preferable to model binary access to healthcare. However, the fixed-effects estimator in a panel logit regression model is inconsistent in a two-time-period case (Greene, 2008:801). I therefore report only linear probability models with village-cluster robust standard errors (estimations with serial-correlation- and heteroscedasticity-robust standard errors yielded less conservative results and will be omitted here). Robustness checks using fixed-effects logit models reproduced the general direction of the results, although significance levels are weakly sensitive to functional form.

Furthermore, it could be argued that the panel containing ill households introduces a sample selection bias. However, the estimation sample containing only sick households in 2005 and 2012 is

remarkably similar to the complete panel of rural Indian households, for example in terms of household size (it is on average by 0.3 members smaller in 2005; by 0.2 in 2012) and wealth (on average by 0.10 index units wealthier on a scale from 0 to 33 in 2005; by 0.17 in 2012).[6] In addition, it is plausible to assume that any unobserved household characteristics leading to inclusion into the estimation sample are controlled for by the fixed-effects estimator. I carried out the analysis using Stata 13 (StataCorp, 2013).

4 Results

4.1 Case Study Context

4.1.1 Indian Health System Context

The study period from 2004 to 2012 was shaped by the introduction of the National Rural Health Mission (NRHM) in 2005, established to improve the health status of the Indian population in general, but also to integrate the hitherto fragmented health programmes landscape in India under a common umbrella (MoHFW, 2002: §2.3.2.1; Prasad & Sathyamala, 2006:13). This section describes the India healthcare system, the changes associated with the introduction of the NRHM, and the continuing challenges for healthcare in India.[7]

The NHRM envisages an ideal delivery system for rural areas with multiple levels of healthcare (MoHFW, 2006:4). On the village level, community health workers such as accredited social health activists (ASHAs) provide the first point of contact with the health system through health education and social mobilisation. Sub-centres staffed with a nurse and a male multi-purpose health worker (i.e., male nurse) are the first point of contact with the health infrastructure and cover five to six villages. The first contact point with a medical doctor is the primary health centre, which caters to roughly 40,000 people. The first referral unit are community health centres (30-bed hospitals with specialist

445 doctors). At the tertiary level are district hospitals, accommodating 31 to 750 beds and serving a
446 population between 100,000 and 1 million.[8]

447 Between 2005 and 2013, the NRHM provided ₹1tn (approximately £12bn) to support rural
448 healthcare in India, which involved among others the construction of nearly 15,000 rural health
449 facilities and the recruitment of 890,000 ASHAs (MoHFW, 2014:1-2). These investments coincided
450 with (and arguably contributed to) a larger trend of healthcare improvements and socioeconomic
451 development in India during the study period (Table 2). Between 2000 and 2015, under-five mortality
452 almost halved from 91.2 to 47.7 deaths per 1,000 live births, maternal mortality fell from 374 to 174
453 deaths per 100,000 live births, and life expectancy at birth increased from 62.6 to 68.0 years (Table 2).
454 Despite such improvements, the absolute level of health in India remains worrying. For example, in
455 2014, India ranked 142 out of 199 countries and territories in terms of life expectancy (World Bank,
456 2017), and its health system has continued to exhibit disparities and deficiencies with respect to
457 financing, infrastructure, and human resources.

458

459

460 *Table 2. Selected Health and Development Trends in India, 2000-2015.*

	Indicator	Unit	Year			
			2000	2005	2010	2015
Health Indicators	Life Expectancy at Birth	Years	62.6	64.5	66.5	68.0 (2014)
	Under-5 Mortality Rate	Deaths per 1,000 Live Births	91.2	74.6	59.9	47.7
	Maternal Mortality Ratio	Deaths per 100,000 Live Births	374.0	280.0	215.0	174.0
	Prevalence of Undernourishment	% of Total Population	17.0	21.2	15.7	15.2
	DPT Immunisation Coverage	% of Children 12-23 Months	58.0	65.0	79.0	87.0
	Physician Density	Physicians per 1,000 People	0.5	0.6	0.7	0.7 (2012)
	Nurse Density	Nurses and Midwives per 1,000 People	1.2	1.3	1.6	..
	Public Health Expenditure	% of Gross Domestic Product (GDP)	1.1	1.1	1.2	1.4 (2014)
		% of Total Government Expenditure	4.4	4.5	4.3	5.0 (2014)
		Constant 2011 US$ in Purchasing Power Parity (PPP)	22.2	32.4	50.7	80.3 (2014)
	Out-of-Pocket Health Expenditure	% of Total Expenditure on Health	67.9	65.9	63.4	62.4 (2014)
Other Development Indicators	GDP per Capita	Constant 2011 US$, PPP	2521.3	3213.1	4404.5	5729.8
	Poverty Headcount Ratio	% of Population Below US$1.90/Day (PPP, 2011 US$)	..	38.2 (2004)	21.2 (2011)	..
	Rural Population	% of Total Population	72.3	70.8	69.1	67.3
	Adult Literacy Rate	% of Total Population Aged 15+	61.0 (2001)	62.8 (2006)	69.3 (2011)	72.2
	Access to Electricity	% of Total Population	62.3	..	75.0	78.7 (2012)
		% of Rural Population	48.4	..	66.9	69.7 (2012)
	Access to Improved Sanitation Facilities	% of Total Population	25.6	30.6	35.5	39.6
		% of Rural Population	14.5	19.5	24.5	28.5
	Access to Improved Water Sources	% of Total Population	80.6	85.5	90.3	94.1
		% of Rural Population	76.1	82.0	87.9	92.6
	Fixed Telephone Subscriptions	Subscriptions per 100 People	3.1	4.5	2.9	2.0
	Mobile Phone Subscriptions	Subscriptions per 100 People	0.3	8.0	62.4	78.8

461 Source: World Bank (2017).
462 *Notes:* Deviations from reported year in parentheses. ".." indicates that no data was available for respective period.

The Indian health sector has long been underfinanced, and the NRHM has only been a partial remedy for this problem. For example, the 2002 National Health Policy stressed the need to increase financial resources for health, envisaging 7% of state spending and 2% of the Indian Gross Domestic Product (GDP) to be spent on health by 2010 (MoHFW, 2002: Box IV). Despite expenditure growth under the NRHM, even latest data from 2014 indicate that government health spending just reached 5% of total government spending or 1.4% of GDP. For comparison, the UK spent 7.6% of its GDP on health in 2014, and India's per capita public health expenditure (adjusted for purchasing power) was approximately 2.9% of the UK in 2014 (World Bank, 2017).

As public spending falls short of its targets, households have remained the principal source of healthcare finance. According to India's national health accounts, household out-of-pocket expenditures especially for private healthcare contribute for the majority of healthcare financing (71% in 2004-2005 and 69% in 2013-2014), and four-fifth of healthcare expenditure are directed at curative care as Fig. 3 indicates (especially medicine expenses; MoHFW, 2016:29, 39; WHO, 2009:xx). Not only are the high out-of-pocket expenditures a persistent burden for households despite the introduction of the NRHM, but the reliance on curative care mirrors broader healthcare-seeking challenges in low- and middle-income countries (Dupas, 2011).

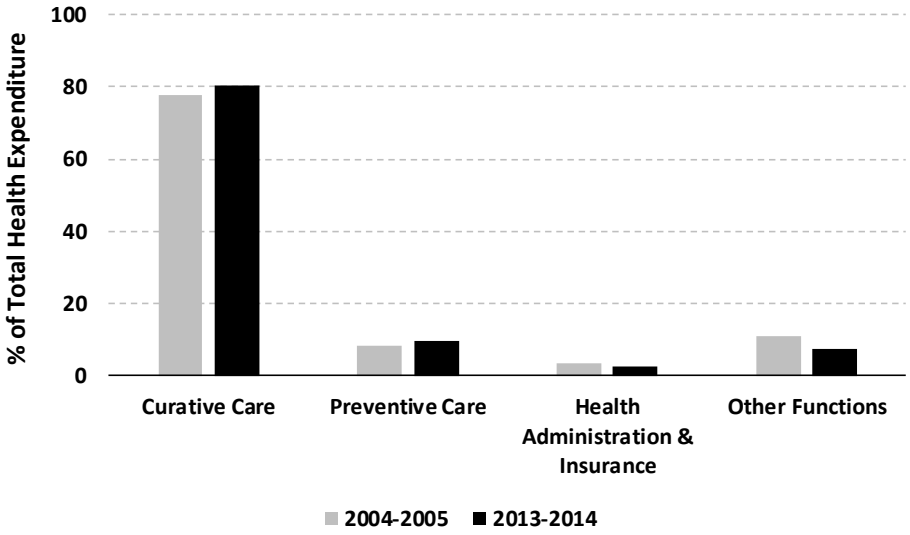


Fig. 3. Health Expenditure by Healthcare Function, National Level

Source: Author, derived from WHO (2009:39) and MoHFW (2016:xx).
Notes: Values for fiscal year 2013-2014 are estimates.

The continuing financing challenges reflect the still problematic healthcare provision in India. For example, the Indian Planning Commission reported data for rural areas in 2008, indicating a nationwide shortage of 12.9% of sub-centres, 17.2% of primary health centres, and 36% of community health centres (Planning Commission, 2011:149), and only 54% of the planned rural healthcare facilities under the NRHM had been completed by 2013 (MoHFW, 2014). Even where infrastructure is provided, healthcare workforce provision and attendance remains variable (Chaudhury *et al.*, 2006; Rao *et al.*, 2011; Sathyamala, 2006:143). For instance, the Indian Chief Nursing Officer reported a shortage of 2.4 million in India by 2012 (Senior, 2010) and Rao *et al.* (2008:25) estimate that the nurse-to-doctor ratio in India is at a low 0.8, which suggests that the division of labour in health centres is not optimal. For comparison, the U.K. nurse-doctor ratio is currently at 2.8 (Organisation for Economic Co-operation and Development, 2017) and the World Bank considers between two and four nurses per doctor "adequate" (World Bank, 1993:133).

In summary, India expanded rural health system financing, infrastructure, and workforce coupled with a restructuring of national health programmes and a broader development trend during

499 the study period. Nevertheless, health system challenges remain and continue to characterise the study
500 context as resource constrained with a strong reliance on household out-of-pocket healthcare
501 expenditure for private and public curative treatment. These conditions resonate with the study focus
502 on curative health action involving public and private allopathic healthcare providers.

503 **4.1.2 Descriptive Statistics**

504 The household sample in this study is characterised by rapid yet heterogeneous uptake of
505 mobile phones in a context of improving socio-economic indicators, and high healthcare demand and
506 constant supply. Summary statistics are presented in Table 3.

507 Table 3 indicates that mobile phones spread rapidly across rural India between 2005 and 2012.
508 The average share of households owning a phone in the sample increased from 3% to 75%. An average
509 district in the study sample experienced an increase of 70 percentage points in the absolute proportion
510 of rural households owning a mobile phone, with an inter-quartile range of 62-81% (a histogram
511 depicting the increase is shown in Fig. 4). The share of households owning a landline phone dropped
512 from 11% to 5%.

513 *Table 3. Summary Statistics of Survey Sample: 2005, 2012, and First Difference*

		Round I: 2005					Round II: 2012					First Difference 2005-2012				
		n	Mean	Std. Dev	Min	Max	*n*	Mean	Std. Dev	Min	Max	*n*	Mean Diff.	Std. Dev	Min Diff.	Max Diff.
HH Mobile Phone		12,003	0.03	0.17	0	1	12,003	0.75	0.43	0	1	12,003	+ 0.72	0.45	– 1	+ 1
District Phone Diffusion[a]		264	0.03	0.05	0.00	0.33	264	0.73	0.18	0.00	0.99	12,003	+ 0.70	0.16	0.00	+ 0.95
HH Landline Phone		12,003	0.11	0.31	0	1	12,003	0.05	0.22	0	1	12,003	– 0.06	0.30	– 1	+ 1
HH Size		12,003	6.38	3.25	1	33	12,003	5.14	2.52	1	33	12,003	– 1.24	3.27	– 24	+ 26
HH Highest Education[b]		12,003	1.97	1.53	0	5	12,003	2.15	1.56	0	5	12,003	+ 0.18	1.30	– 5	+ 5
HH Average Sex (1=Female)		12,003	0.49	0.16	0.00	1.00	12,003	0.51	0.18	0.00	1.00	12,003	+ 0.02	0.16	– 0.75	+ 1.00
HH Average Age		12,003	28.23	10.89	8.00	90.00	12,003	31.95	13.79	6.80	99.00	12,003	+ 3.72	11.15	– 59.40	+ 58.00
HH Below Poverty Line[c]		12,003	0.22	0.41	0	1	12,003	0.19	0.39	0	1	12,003	– 0.03	0.50	– 1	+ 1
HH Asset Index[d]		12,003	9.68	5.14	0	27	12,003	12.49	5.73	0	28	12,003	2.81	3.68	– 15	+ 21
Any HH Member, for Any Illness	Experienced Any Illness	12,003	1.00	0.00	1	1	12,003	1.00	0.00	1	1	12,003	+ 0.00	0.00	0	0
	Accessed Any Healthcare	12,003	0.96	0.19	0	1	12,003	0.97	0.16	0	1	12,003	+ 0.01	0.25	– 1	+ 1
	Accessed Public Care	12,003	0.31	0.46	0	1	12,003	0.34	0.47	0	1	12,003	+ 0.04	0.58	– 1	+ 1
	Accessed Private Care	12,003	0.69	0.46	0	1	12,003	0.72	0.45	0	1	12,003	+ 0.03	0.58	– 1	+ 1
	Accessed Pharmacist	12,003	0.06	0.23	0	1	12,003	0.08	0.28	0	1	12,003	+ 0.03	0.36	– 1	+ 1
	Accessed Traditional/Other Care	12,003	0.03	0.16	0	1	12,003	0.04	0.19	0	1	12,003	+ 0.01	0.24	– 1	+ 1
Minor Illness in Past 12 Months		12,003	0.83	0.38	0	1	12,003	0.80	0.40	0	1	12,003	– 0.03	0.51	– 1	+ 1
Major Illness in Past 12 Months		12,003	0.43	0.50	0	1	12,003	0.56	0.50	0	1	12,003	0.13	0.65	– 1	+ 1
No. of Public Clinics[e]		1266	0.89	0.35	0	2	1325	0.90	0.32	0	2	1266	0.01	0.44	– 2	+ 1
No. of Private Clinics[e]		1266	0.93	0.33	0	3	1325	0.86	0.35	0	2	1266	– 0.06	0.45	– 2	+ 1
No. of Other Clinics[e]		1266	0.09	0.30	0	2	1325	0.07	0.26	0	2	1266	– 0.02	0.39	– 2	+ 2

514 *Notes:* Unweighted statistics. First difference morbidity statistics for households who experienced a minor/major illness in both survey rounds. HH is household.
515 [a.] District-level data (rural areas only), calculated as weighted average share of phone-owning households in districts, using complete survey sample and village sampling weights.
516 [b.] 0="illiterate," 1="uncompleted primary education," 2="completed primary education (5th class)," 3="completed middle school (8th class)," 4="completed secondary education (10th class)," 5=
517 "completed higher secondary education (12th class)."
518 [c.] 1 = per capita household expenditure < poverty line (which varies by state; 2005 poverty line adjusted by village-wise deflator).
519 [d.] Unweighted sum of 33 household assets, using the same household asset categories in 2005 and 2012.
520 [e.] Village-level data, as recorded in medical facility questionnaire.

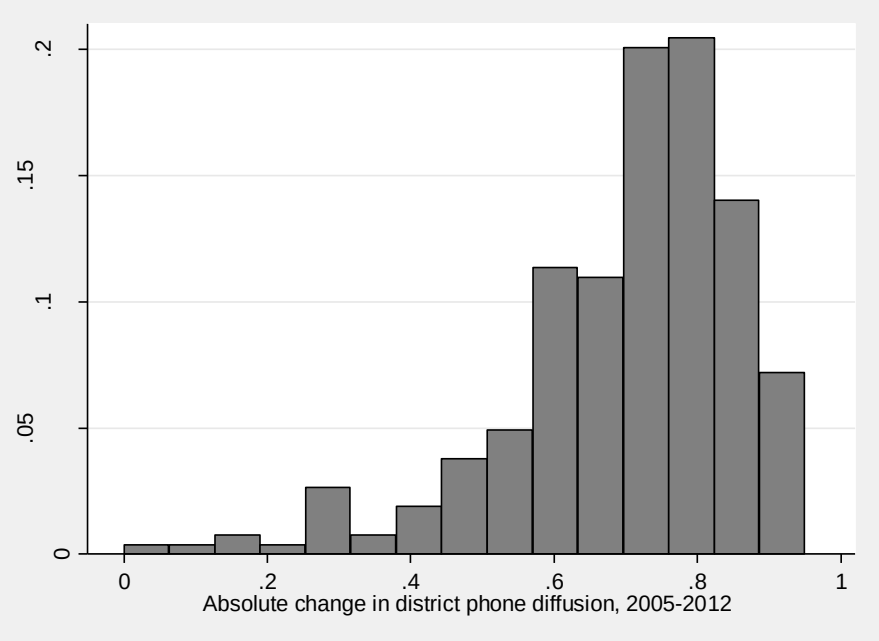


Fig. 4. Change in District-Level Mobile Phone Diffusion in Survey Sample, 2005-2012

Source: Author, derived from Desai *et al.* (2010b, 2016).
Notes: Based on 264 districts represented in estimation sample.

Other socioeconomic indicators also indicate notable change over time. For example, the average survey household became smaller and was 3.7 years older in the second survey round. Wealth increased by 29% from 9.7 to 12.5 common household items, and the share of households below the poverty line fell 3 percentage points (based on inflation-adjusted state-level poverty lines and per-capita household expenditure).

In terms of healthcare, overall utilisation rates of informal and formal healthcare providers were very high with 97% in 2012, up 1% from 2005. Private healthcare was with 71% in 2012 the most commonly accessed type, while traditional and other forms of healthcare provision only accounted for 4% of the sample in 2012. Access to all categories of healthcare providers increased between 1 (traditional healers) and 4 (public doctors) percentage points

over the two study periods. As far as the supply of health facilities is concerned, village-level facility survey data from the IHDS indicate that the provision of public clinics increased slightly from an average of 0.89 to 0.90 facilities per village (corresponding to a decrease from 12.0% to 10.6% of villages without any public clinic). Private facilities were commonly found in the survey villages as well but their average number (together with "other" clinics e.g. for family planning) fell marginally over the same period. Overall, households in the sample experienced a notable increase in socio-economic indicators and an environment of high healthcare demand and constant supply.

The analysis in the remainder of this paper will argue that mobile phone diffusion has undermined healthcare access for marginalised groups at the expense of more affluent households. In order to establish that phone-owning households are better off than their "disconnected" peers, Table 4 presents the levels and changes of household assets and poverty status, depending on whether a household owned a mobile phone in 2005 and 2012. The table shows that households who did not own a phone in either period had the highest poverty incidence and the lowest wealth, the latter of which expanded slower than the sample average. In contrast, households who acquired a phone between 2005 and 2012 developed their asset wealth by 3.7 units (2.7 if adjusted for mobile phones as index component), notably above the sample average of 2.8 (2.1). In light of these patterns, we can establish that households who had not acquired a mobile phone by 2012 were economically more marginalised than those who did.[9]

Table 4. Wealth and Poverty Trends by Household Mobile Phone Ownership

Phone in 2005	Phone in 2012	Number of Households in Panel	Average Household Asset Index			% of Households < Poverty Line		
			2005 (adjusted)[a]	2012 (adjusted)[a]	Difference (adjusted)[a]	2005	2012	Difference
Yes	No	22 (0.2%)	16.5 (15.5)	11.9	– 4.6 (– 3.6)	0.0%	18.2%	+ 18.2%
No	No	2,987 (24.9%)	6.6	7.2	+ 0.6	33.8%	33.1%	– 0.7%

Yes	Yes	340 (2.8%)	19.7 (18.7)	20.6 (19.6)	+ 0.9	1.5%	4.4%	+ 2.9%
No	Yes	8,654 (72.1%)	10.3	14.0 (13.0)	+ 3.7 (+2.7)	18.9%	14.3%	– 4.6%
Total		12,003	9.7 (9.7)	12.5 (11.7)	+ 2.8 (+2.1)	22.1 %	18.7%	– 3.3%

Notes: Unweighted statistics.

[a.] Household mobile phone ownership is a component of the household asset index. Acquiring the first household phone corresponds to a one-unit increase in the index.

4.2 Regression Results

This section presents the results of the fixed-effects linear probability models. As indicated in Section 3, I estimate 15 models, five each for the general rural population of India, for rural households below median income ("poor"), and for rural households above median income ("affluent"). For each group, I estimate a model of overall access to any healthcare provider, and provider-specific models for access to public doctors, private doctors, pharmacists, and to traditional and other healthcare providers. The main independent variables are household-level mobile phone ownership, district-level mobile phone diffusion, and an interaction term between these two variables. The linear probability model results are shown in Table 5, all of which are significant at the 0.1-percent level. I focus the examination of the results on overall access to healthcare and access to public and private providers among poor households, which represent the most common forms of healthcare utilisation.

574 *Table 5. Fixed-Effects Linear Probability Regression Results: Factors Influencing Change in Rural Healthcare Access*

	All Rural Households					Poor Households (<Median Wealth)[a]					Affluent Households (>Median Wealth)[a]				
	Any Healthcare	Public Care	Private Care	Pharmacists	Traditional / Other Care	Any Healthcare	Public Care	Private Care	Pharmacists	Traditional / Other Care	Any Healthcare	Public Care	Private Care	Pharmacists	Traditional / Other Care
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13	(14)	(15)
HH Mobile Phone	-0.02	0.05	-0.05	0.01	0.02	-0.07	0.07	**-0.16***	-0.02	0.05	-0.01	0.03	-0.02	0.03	0.00
District Phone Diffusion	**-0.10****	0.06	-0.12	**-0.13****	-0.03	**-0.15***	0.05	**-0.19***	**-0.13****	-0.03	-0.05	0.16	-0.05	**-0.15***	-0.03
MOBxDIST Interaction	0.03	-0.09	**0.11***	-0.02	-0.04	0.10	-0.10	**0.28****	0.01	-0.07	0.00	-0.09	0.07	-0.01	**-0.05***
HH Landline Phone	0.00	**0.05****	-0.04	-0.02	-0.01	-0.03	0.04	-0.05	0.05	-0.03	0.00	**0.05***	-0.04	-0.01	-0.01
HH Highest Education	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	-0.01	0.00	0.00
HH Size	0.00	0.00	0.00	0.00	**-0.00****	0.00	0.00	**0.01***	0.00	**-0.00****	0.00	**0.01***	0.00	0.00	0.00
HH Average Sex (% Female)	**-0.04***	-0.02	**-0.08***	**0.05****	0.02	-0.03	-0.05	-0.05	**0.06***	0.02	**-0.04***	0.02	**-0.11***	0.05	0.01
HH Average Age	0.00	0.00	**-0.00***	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00****	**-0.00***	0.00	0.00
HH Below Poverty Line	-0.01	0.01	**-0.05*****	-0.01	0.01	-0.01	0.01	**-0.05*****	-0.01	0.02	-0.01	0.02	**-0.05***	0.00	0.00
HH Asset Index	0.00	**-0.01*****	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**-0.01*****	0.00	0.00	0.00
Minor Illness in Last 12m	**0.07*****	**0.08*****	**0.16*****	**0.06*****	**0.02*****	**0.10*****	**0.06****	**0.18*****	**0.07*****	**0.03*****	**0.05*****	**0.09*****	**0.15*****	**0.06*****	**0.01***
Major Illness in Last 12m	**0.02*****	**0.12*****	**0.13*****	**0.04*****	**0.03*****	**0.03*****	**0.13*****	**0.12*****	**0.04*****	**0.03*****	**0.01****	**0.11*****	**0.14*****	**0.04*****	**0.03*****
No. of Public Clinics	0.00	-0.03	0.00	-0.02	**0.02***	0.00	-0.05	-0.01	-0.03	0.04	0.00	-0.02	0.00	0.00	0.01
No. of Private Clinics	0.01	-0.02	0.04	**0.03***	0.00	0.02	-0.01	0.05	0.02	0.00	0.01	-0.03	0.04	0.03	0.00
No. of Other Clinics	-0.01	0.02	0.00	**-0.04***	0.00	0.00	0.05	0.00	**-0.06****	0.02	-0.01	0.00	0.00	-0.02	-0.02
Year 2012 Dummy	0.08	0.02	0.06	**0.11*****	0.04	0.11	0.02	0.12	**0.11****	0.03	0.05	-0.05	0.01	**0.11***	**0.06***
Constant	0.81	**0.23*****	**0.45*****	**-0.14*****	-0.06	0.73	**0.24***	**0.34*****	**-0.14****	-0.05	0.88	**0.27****	**0.56*****	**-0.12***	**-0.07***
Number of Observations	24,006	24,006	24,006	24,006	24,006	12,672	12,672	12,672	12,672	12,672	11,334	11,334	11,334	11,334	11,334
R^2 (Within)	0.03	0.02	0.03	0.02	0.01	0.04	0.03	0.04	0.02	0.01	0.02	0.02	0.03	0.02	0.02
Model Test ($p > F$)	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000

575 *Notes:* HH is household.
576 [a.] "Poor" and "affluent" categorised as below/above median wealth index, using average unweighted household wealth between both survey periods.
577 *p<0.05, **p<0.01, ***p<0.001.

The results allow three main observations. First, mobile phone diffusion is associated with changes in overall healthcare access (Models 1 and 6), private healthcare access (Models 3 and 8), access to pharmacists (Models 4, 9, and 14), and access to traditional and other healthcare providers (Model 15). Public healthcare access appears to be independent of mobile phone diffusion on the household and district levels, and the relationship between mobile phones and healthcare access appears to be weaker for affluent households. These differences across healthcare providers, and especially the response of private clinics, corresponds to my argument that some actors in the health system are more responsive to mobile phone use.

Secondly, compared to affluent households, poorer households show a more pronounced negative link between district-level mobile phone diffusion and overall healthcare utilisation (Model 6, significant at the five-percent level) and access to pharmacists (Model 9, significant at the one-percent level). The regression coefficients suggest that a 10 percentage point increase in district-level mobile phone diffusion is linked to a 1.5 and 1.3 percentage point decrease in overall healthcare and pharmacist access for the poor household sub-sample (1.0 and 1.3 percentage point decrease for the overall sample). The relatively weaker effect for the affluent subsample corresponds to my notion that richer households have more means to access healthcare, which reduces their need for mobile phones and insulates them from potentially adverse consequences.

Thirdly, the effect of district-level mobile phone diffusion on access to private clinics varies depending on whether a household owns a mobile. The interaction term in Model 3 is statistically significant at the five-percent level for the aggregate sample, and at the one-percent level in Model 8 for the poor sub-sample. In both cases, the interaction term needs to be understood in connection with the interacting variables: If the interaction term is statistically significant, both interacting variables are significant as well (Hilbe, 2009:197). The positive coefficient of the interaction term thereby indicates that the relationship between private healthcare access and household-level mobile phone diffusion becomes “more positive” as mobile phones diffuse more widely in the district. In Model 3,

603 mobile phone owners and non-owners are initially at the same starting point (the interacting variables
604 are statistically insignificant), in line with the pattern depicted in Fig. 2, Section 2.2.3. The results in
605 Model 3 therefore correspond to the hypothesis that the value of a mobile phone to access responsive
606 (private) healthcare providers changes in a system that adapts to such use.

607 A similar relationship between mobile phone diffusion and household-level ownership emerges
608 for Model 8. However, while the interaction term is positive, the coefficients of the interacting
609 variables are both negative. The effect of a household mobile phone is initially negative, but higher
610 degrees of district-level diffusion have a positive effect for households owning mobile phones, leading
611 to a combined effect that gradually increases and exceeds households without mobile phones at
612 approximately 57% district-level diffusion. While the direction of the interaction corresponds to the
613 theoretical model, the varying starting points of the poor sub-sample are at odds with my initial
614 argument. In addition, any linear combination of the coefficients remains negative (numerically, it
615 would only turn positive if around 180% of a district's households had acquired a phone). I discuss in
616 Section 5 reasons for the negative starting points and the average negative effect.

617 Other control variables include for example landline telephone access.[10] Considering that the
618 portion of households owning a landline phone decreased from 11% to 5% across the study periods,
619 and that landlines are less likely to be installed in remote locations, the coefficients indicate that a
620 household is less likely to access public healthcare if it loses its landline connection. Beyond landlines,
621 disease severity, and the constant term, none of the control variables for public healthcare access for
622 poorer households are significant at the five-percent level. Growing households and those surpassing
623 the poverty line become more likely to access private healthcare.

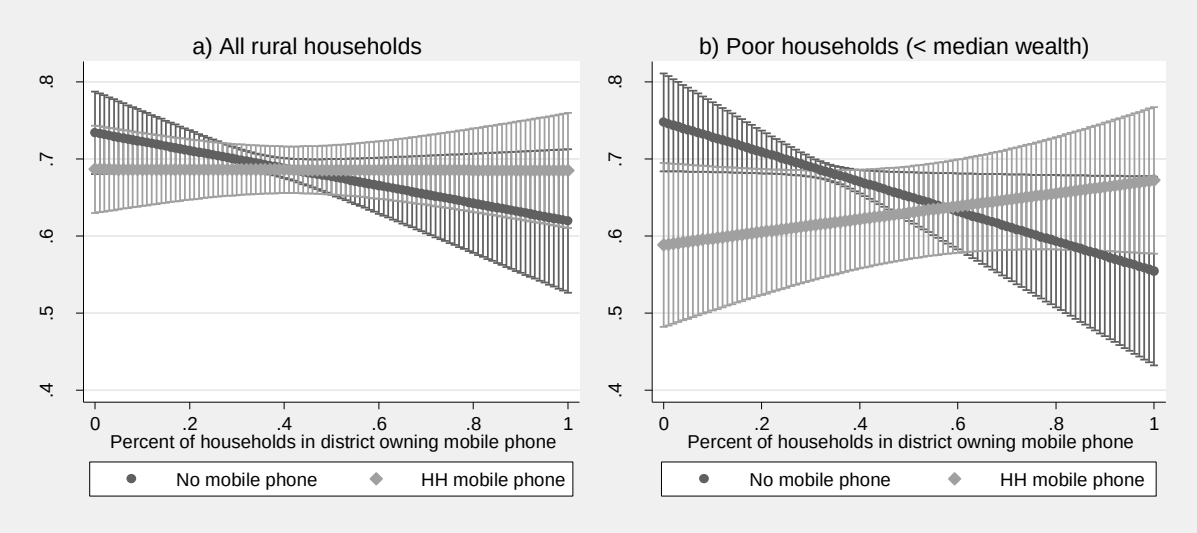
624 In order to explore the relevance of these results, it is instructive to compare the predicted
625 effects of mobile phone diffusion across all rural households and the poor sub-sample. For example,
626 linear predictions based on Models 1 and 6 suggest that an increase of district-level mobile phone
627 diffusion from 25% to 75% corresponds to a decrease in any kind of healthcare access from 98% to

628 93% for all rural households that experienced an illness, and from 96% to 90% for poor households.
629 Access to pharmacists would decrease from 9% to 3% for both groups in these scenarios.

630 The relationship between private healthcare access and mobile phone diffusion is less
631 straightforward, due to the interaction term. For the sample of all rural households, the linear
632 predictions suggest that a household without a mobile phone would see its probability to access a
633 private doctor decrease from 70.5% in a district with 25% diffusion to 64.8% in a district where 75%
634 of households own a phone. In contrast, a household with a mobile phone would see its probability
635 virtually unchanged at 68.6%. The differences are yet more pronounced for poor households, where a
636 similar expansion of district-level mobile phone diffusion would be associated with a decrease from
637 70.0% to 60.3% for households without mobile phones, and an increase from 60.9% to 65.1% for
638 households who own a mobile.

639 Fig. 5 visualises the predicted probability of a household to access private doctors (y-axis),
640 depending on household wealth (Panel a for all rural households, Panel b for poor households), on
641 household-level mobile phone ownership (dark-grey markers for households without, light-grey
642 markers for households with mobile phones), and on the extent to which mobile phones have diffused
643 on the district level (x-axis). The predictions indicate that households without mobile phones have
644 decreasing access to private doctors in districts where mobile phones have diffused more widely, and
645 this decrease is particularly pronounced for the poor rural households in Panel b. In contrast, the
646 probability of access is independent of diffusion rates if the household has a mobile phone—which
647 could mean that owning a mobile phone helps to prevent a deterioration in access—and a poor
648 household with a mobile phone is increasingly likely to access healthcare if phones have diffused more
649 widely.

650



651

652 *Fig. 5. Predicted Access to Private Healthcare by Phone Ownership and Household Wealth*

653 Source: Author, derived from Desai *et al.* (2010b, 2016).
654 *Notes:* Prediction based on fixed-effects linear probability models for households with private healthcare access in either survey round
655 (Table 4, Models 3 and 8). Vertical lines indicate 95%-confidence interval.
656

657 Overall, these results support the hypothesis that non-users of mobile phones have less access
658 to healthcare in contexts where mobile phones have diffused rapidly. Poor households' access to
659 overall healthcare, to private doctors, and to pharmacists is negatively linked to mobile phone diffusion
660 either on the district level or personal level. In contrast, affluent rural households' healthcare access is
661 largely independent of these developments.

662 ## 5 Discussion

663 ### 5.1 Limitations

664 While I have already hinted at a possible interpretation of the results in the previous section, it
665 is important to consider at least three important limitations of the analysis before discussing its
666 significance. Firstly, it could be considered problematic that the severity of illness, which controls for
667 households' healthcare access, is defined by the survey agency rather than by the respondents
668 themselves. Individuals' initial decisions to seek care are more likely to be driven by their
669 own observations and socially agreed notions of appropriate health action than by later diagnoses by

doctors and researchers (Beals, 1976:184-185; Gulliford *et al.*, 2002:187). While this may skew the predictive power of control variables for "minor" and "major" illnesses, they remain statistically significant and improve model fitness. Robustness checks that replaced binary disease severity indicators with the number of household members with "minor" and "major" illnesses did not affect the results.

Secondly, the panel is not a representative sample of all rural Indian households over time, but of those whose members experienced illnesses repeatedly across the survey periods. The panel structure used in this study enables an analysis of how households with sick members change their behaviour in a dynamic mobile diffusion context, but it leaves open the question how an "average" household would behave, given that only 60.2% of the sample reported an illness in 2005, and 71.7% in 2012. For example, mobile phone may enable some people to recognise a discomfort as an illness. Nevertheless, average household characteristics of the full rural sample are similar to the panel of ill households (see Section 3), and the household-fixed-effects analysis controls for unobserved, time-invariant household characteristics. This makes it plausible that deviations from average rural household behaviour in India are minor.

Lastly, and perhaps most importantly, the panel data of the IHDS only permits a household-level analysis of narrow healthcare access and mobile phone diffusion indicators, which limits the depth of the analysis. In the present case, household-level healthcare access as a binary variable obscures the potentially sequential logic of healthcare-seeking behaviour (Balabanova & McKee, 2002; Haenssgen & Ariana, 2017a; Kibadi *et al.*, 2009; Moshabela *et al.*, 2011; Shaikh *et al.*, 2008), the nature of potentially collective healthcare decision-making (Peglidou, 2010:49), and, as a variable of "revealed behaviour," only captures successful access and ignores whether an individual "sought" but failed to obtain healthcare. Considering the study focus on curative healthcare access (which accounts for four-fifths of healthcare expenditures during the study period), the analysis also cannot speak for health education (e.g. provided by local community health workers like ASHAs), preventive

care (e.g. vaccination), and other forms of healthcare provision (e.g. nutritional services provided in Anganwadi centres).

Likewise, household-level mobile phone ownership maps only imperfectly onto individuals' actual health-related use of a mobile, be it directly by the patient or mediated through a third person. Health-related mobile phone use takes many forms (e.g. home calls, arranging a taxi to reach a health facility, calling a family member to pay a hospital bill) and it takes place in light of a broad range of healthcare functions (e.g. preventive, curative, rehabilitative), healthcare providers (community-level outreach staff, nurses, public and private doctors, untrained medical practitioners, non-governmental organisations), and a network of healthcare access modes (walking, hiring rides, use) (Haenssgen, 2015b; Haenssgen & Ariana, 2015). Approximating health-related mobile phone use through household phone ownership (or, more precisely, approximating the absence of such use through the absence of a household mobile; Haenssgen, 2015a:8) thereby prevents the analysis of the exact channel through which mobile phone diffusion interacts with healthcare access and how health-related access developed vis-à-vis other modes of healthcare access during the study period.[11]

The proxy variable of household mobile phone ownership also creates the impression that very few non-users remain at near-100% district-level diffusion, which could raise questions about the relevance of this study. Although mobile phones have continued to diffuse and household phone ownership may soon be near universal, it is important to consider the nature of the proxy indicators: As my process model explained, personal and household mobile phone ownership do not automatically entail health-related phone use. For example, a recent survey in rural Rajasthan indicated that 47% of the adult population owned and 93% shared a mobile phone over the past 12 months prior to the survey, but only 7.5% actually made use of mobile phones during an illness (Haenssgen & Ariana, 2017b:293). This suggests that digital exclusion and equity considerations continue to be relevant, and systemic health system adaptation processes are unlikely to cease, even in high-diffusion contexts.

719 Taken together, these complications mean that the estimated models are only an incomplete
720 representation of the actual relationship between healthcare access and phone usage. I am nonetheless
721 able to discern effects that are consistent with the empirically grounded hypothesis that non-users of
722 mobile phones are worse off in contexts of fast diffusion, at least as far as curative health services are
723 concerned. The limitations of the secondary data thereby do not necessarily mean that the analysis is
724 insensitive to other modes of healthcare access or to broader village-level developments. For example,
725 the underlying theoretical model accounts for the possibility of "offline" access in the process of
726 mobile phone diffusion, and the regression model controls for general health system trends (year
727 dummy) and for household-level solutions to access healthcare e.g. by means of personal
728 transportation and purchasing power (wealth index). A more fine-grained analysis would require
729 higher-frequency panel survey data geared specifically towards individuals' health-related mobile
730 phone use and health system actors' capacity to absorb the demand from phone-using patients. As such
731 data is not presently available to the best of my knowledge, the present analysis is a first step towards
732 a better understanding of the dynamic relationship between mobile phone diffusion and healthcare
733 access.

734 **5.2 Interpretation**

735 In light of the limitations, considering that the linear probability models control for unobserved
736 heterogeneity while focusing on the change within households, and given that the panel regression
737 results correspond to hypotheses and findings derived from primary rural Indian survey data
738 (Haenssgen & Ariana, 2017b), I have reason to trust the robustness of the results and the causality
739 running from changes in household- and district-level mobile phone adoption to households'
740 healthcare access. The identified relationship between district-level mobile phone diffusion and
741 household-level healthcare access suggests that health systems adapt to increasing mobile phone use,
742 which gradually improves the effect of a household mobile phone for rural households' access to
743 private healthcare. In the absence of a household mobile phone, poor households in districts with fast

744 mobile phone diffusion are less likely to access such healthcare. I see this as evidence that rapid mobile
745 phone diffusion can create new forms of marginalisation, given that digitally excluded households tend
746 to be poorer on average.

747 Drawing on the initial explanatory framework, the findings can be explained through factors
748 on the demand as well as the supply side. On the demand side, mobile phone use appears to contribute
749 to healthcare access, enabling for example the ability to arrange home visits of doctors, to make
750 appointments, call a taxi, or simply to talk with relatives about treatment options (note that increased
751 access need not entail improved health outcomes). Not all but some households will make use of this
752 option, especially if it is the dominant strategy compared to alternative solutions, such as walking for
753 half an hour to a health post. Where such dominant phone-aided strategies among otherwise access-
754 constrained poor households exist, they increase their competitiveness relative to poor households
755 without mobile phones. This would bear resemblance to patterns observed in other contexts, for
756 instance the UK middle class reportedly exercising their "sharp elbows" towards other health system
757 users and thereby contributing to the reinforcement of healthcare inequities vis-à-vis poorer and more
758 vulnerable population groups (Seddon, 2007:88). Mobile phone users would therefore increasingly
759 join the "healthcare middle class," which is populated customarily by more affluent rural households
760 who face fewer healthcare access constraints and a wider range of choices, both of which insulate them
761 from the effects of mobile phone adoption and diffusion. As the data suggest, poor mobile phone users
762 gravitate towards the rural average level of private healthcare access in situations where phones have
763 diffused widely. The group losing the competitive struggle comprises households who are prevented
764 from adopting mobile technology. On the demand side, mobile phones therefore appear to create new
765 divisions and emerge as a somewhat regressive tool that benefits the "better-off" poor rural population.

766 The demand-side reactions interact with developments on the healthcare supply side. In
767 particular, the improved effects of phone ownership in contexts of fast mobile phone diffusion suggests
768 that health systems adapt to increasing mobile phone use and thus privilege phone-aided healthcare-

769 seeking strategies. But not all elements of the health system react equally to these developments. Public
770 health service access has not been affected, thanks probably to variations in responsiveness across
771 different health system actors and to the provision of mobile healthcare services as part of the Indian
772 health sector developments (especially the NRHM). However, this may soon change, as my qualitative
773 and quantitative research in rural Rajasthan in 2013 and 2014 has indicated that local public doctors
774 and nurses (based in sub-centres and primary health centres) increasingly use mobile phones in their
775 everyday work (Haenssgen, 2015b). Flexible working conditions for local government providers (e.g.
776 nurses and village doctors) and gradually evolving guidelines that encourage health centre staff to deal
777 with patients' mobile-phone-aided healthcare behaviour suggest that public healthcare might not be
778 protected from patients' competitive pressure for much longer.

779 Although these findings largely correspond to my analytical framework, two patterns are at
780 odds with the hypothesised relationship between phone diffusion, personal phone use, and healthcare
781 access. Firstly, the sub-sample analysis of poor rural households suggested that, at low levels of
782 district-level mobile phone diffusion (indicating a low level of health system adaptation to mobile
783 phone use), household mobile phone ownership is associated with lower rates of access to responsive
784 private healthcare providers. At low levels of diffusion, it is possible that mobile phones held by one
785 family member (traditionally a male) do not enable potentially facilitating effects to transpire to other
786 household members (Dodson *et al.*, 2013:82; Jeffrey & Doron, 2013:166, 172; Sreekumar, 2011:176).
787 Compared to more affluent households, the early acquisition of a mobile phone might instead
788 compromise other dimensions of household wealth and therefore the ability to access care. However,
789 further research is required to establish this hypothesis more firmly.

790 The second puzzle is the average negative effect of mobile phone diffusion on healthcare
791 access. A possible interpretation of this pattern may be related to social capital. Qualitative and
792 quantitative sociological research around the world has made the claim that mobile phones enable
793 people to uphold relationships with close contacts with "strong" ties, but they do not necessarily lead

794 to more communication among networks with "weak" ties and they may even enable people to avoid
795 their immediate social environment (Horst, 2006:147-148; Ling, 2008:106; Miritello *et al.*, 2013:93-
796 94; Saramäki *et al.*, 2014:946). Accordingly, mobile phones might enable rural Indian villagers to
797 maintain relationships with family members and close social contacts across villages, but these
798 improvements come at the expense of eroding local social capital. If this argument holds, then phone
799 diffusion might reduce people's ability to find help locally. However, because this explanation was
800 not part of my framework and cannot be tested with the present data set, it remains speculative and
801 subject to further research.

802 Taken together, this study is a considerable challenge for common narratives of digital
803 inclusion. As one group increasingly "benefits" from mobile phone use and an adapting environment,
804 another loses because healthcare supply does not pick up accordingly. This group—already poor—
805 becomes increasingly marginalised in contexts of otherwise rapid mobile phone diffusion. Drawing on
806 the conceptualisation of levels of inclusive innovation by Heeks *et al.* (2013:6), inclusive innovation
807 (in terms of mobile phone adoption) among parts of the poor population can therefore create new forms
808 of exclusion elsewhere (potentially in terms of adverse socioeconomic impact). Indeed, during the
809 process of diffusion, one may *have to* become digitally included in order to maintain the same relative
810 position in healthcare access. At the same time, where mobile phones have not diffused rapidly,
811 acquiring a phone need not necessarily mean better access to services if the service providers are not
812 responsive to phone use.

813 **6 Conclusion**

814 Challenging the framing of "digital inclusion" as an unproblematic process, this paper explored
815 the relationship between mobile phone diffusion and rural Indian households' access to curative
816 healthcare. Based on previous research in rural India, I hypothesised that households without mobile
817 phones are increasingly disadvantaged in their healthcare access if mobile phones diffuse rapidly in

818 their environment. This assumed that health systems comprise actors with different degrees of
819 "responsiveness" to mobile phone use, and that increasing phone diffusion leads these responsive
820 providers to expect health-related phone use among the population. Fixed-effects linear probability
821 models with village-cluster robust standard errors using nationwide panel data from 2005 and 2012
822 lend support to this hypothesis: District-level mobile phone diffusion depresses the healthcare access
823 of rural non-adopters of mobile phones, especially for poor households who tend to face more
824 constraints, and for private healthcare providers who tend to be more responsive to health-related
825 mobile phone use. Contrary to its common depiction, the process of digital inclusion delivers tools that
826 intensify the competition for scarce healthcare resource among deprived populations. These conditions
827 indicate that new phone-based technologies may help a broad part of the population to gain access to
828 services, but these innovations are unlikely to include the most marginalised groups. Yet, acquiring a
829 phone before everyone else need not be advantageous either if the system cannot respond to its usage.

830 While the conclusion might look like we need more mobile phones for poor people to keep
831 them "competitive" and maintain or enhance their access to healthcare, there are two important points
832 that challenge this argument. First, households who had not managed to acquire a mobile phone are
833 increasingly pressured to do so in order to maintain the same level of healthcare access at a higher
834 level of competition (note the resemblance to Lewis Carroll's Red Queen's race; Carroll, 1872:42),
835 which is akin to a "tyranny" of technology adoption. This would not be the first argument of its kind,
836 as authors like Rich Ling argue that mobile technology has indeed now become so pervasive in some
837 domains of Western urban life that it is simply expected of everyone to use it so as to not inconvenience
838 others (Ling, 2012:178-179). In such situations, technology adoption stops being a free choice. Second,
839 more access to healthcare is not access to better healthcare. The gradual democratisation of health
840 system utilisation can instead entail unnecessary treatment for minor ailments, bypassing of referral
841 systems (put in place to ensure efficient health system operation), and possible shifts away from less
842 to more responsive healthcare providers with implications for the quality of care received (Haenssgen,

2015b; Haenssgen & Ariana, 2017b). I suggest that, in the struggle created during the process of digital inclusion, persistently excluded parties require protection through conventional means such as efficient public transport links, dependable and convenient clinic hours in local health centres, and guidelines preventing healthcare providers to privilege patients accessing them through mobiles. Where mobile phone use reduces the costs of public health service delivery, these savings can be put usefully towards sustaining the healthcare access of more vulnerable parts of the population.

This study raises questions for future research. Considering the nature of the household panel, one of the more immediate questions is whether individual-level healthcare-seeking panel data can shed further light on the implications and nuances of mobile phone diffusion in India. Broader questions from a comparative perspective would investigate whether the experience of rural India is generalizable, and, if not, what individual, social, infrastructural, technological, and health system factors contribute to the mitigation and amplification of such effects. But struggles in the process of digital inclusion might not be unique to healthcare, which raises the possibility that other domains of digital development are affected as well. This might especially be the case where mobile phone use skews demand for scarce resources, for example employment, governmental services, or time with social contacts. In addition to these mostly empirical considerations, further work to theorise the social implications involved in the process of technology adoption is necessary to move away from idealised notions of inclusion. As Tim Unwin's book *ICT4D* opens with the lines "This book is about how information and communication technologies (ICTs) can be used to help poor and marginalised people and communities make a difference to their lives" (Unwin, 2009:1), perhaps we should also start reflecting on how we can prevent ICTs from making poor and marginalised people's lives worse.

References

Aker, J. C., Ksoll, C., & Lybbert, T. J. (2012). Can mobile phones improve learning? Evidence from a field experiment in Niger. *American Economic Journal: Applied Economics, 4*(4), 94-120. doi: 10.2307/23269743

Aker, J. C., & Mbiti, I. M. (2010). Mobile phones and economic development in Africa. *The Journal of Economic Perspectives, 24*(3), 207-232. doi: 10.2307/20799163

Andersson, A., & Hatakka, M. (2013). *What are we doing? Theories used in ICT4D research*. Paper presented at the 12th International Conference on Social Implications of Computers in Developing Countries, 19-22 May, 2013, Ocho Rios, Jamaica.

Ayanso, A., Cho, D. I., & Lertwachara, K. (2013). Information and communications technology development and the digital divide: a global and regional assessment. *Information Technology for Development, 20*(1), 60-77. doi: 10.1080/02681102.2013.797378

Balabanova, D., & McKee, M. (2002). Access to health care in a system transition: the case of Bulgaria. *The International Journal of Health Planning and Management, 17*(4), 377-395. doi: 10.1002/hpm.687

Bandiera, O., & Rasul, I. (2006). Social networks and technology adoption in northern mozambique. *The Economic Journal, 116*(514), 869-902. doi: 10.1111/j.1468-0297.2006.01115.x

Barzilai-Nahon, K. (2006). Gaps and bits: conceptualizing measurements for digital divide/s. *The Information Society, 22*(5), 269-278. doi: 10.1080/01972240600903953

Beals, A. R. (1976). Strategies of resort to curers in South Asia. In C. M. Leslie (Ed.), *Asian medical systems: a comparative study* (pp. 184-200). Berkeley: University of California Press.

Bédoucha, G. (2002). The watch and the waterclock: technological choices/social choices. In P. Lemonnier (Ed.), *Technological choices: transformation in material cultures since the neolithic* (pp. 77-108). London: Routledge.

Besley, T., & Case, A. (1993). Modeling technology adoption in developing countries. *The American Economic Review, 83*(2), 396-402.

890 Burrell, J. (2010). Evaluating shared access: social equality and the circulation of mobile phones in
891 rural Uganda. *Journal of Computer-Mediated Communication, 15*(2), 230-250. doi:
892 10.1111/j.1083-6101.2010.01518.x
893 Burrell, J., & Toyama, K. (2009). What constitutes good ICTD research? *Information Technologies &*
894 *International Development, 5*(3), 82-94.
895 Carroll, L. (1872). *Through the looking-glass, and what Alice found there. With fifty illustrations by*
896 *John Tenniel*. London: Macmillan and Co.
897 Chaudhury, N., Hammer, J., Kremer, M., Muralidharan, K., & Rogers, F. H. (2006). Missing in action:
898 teacher and health worker absence in developing countries. *Journal of Economic Perspectives,*
899 *20*(1), 91-116.
900 Chib, A. (2015). Research on the impact of the information society in the global south: an introduction
901 to SIRCA. In A. Chib, J. May & R. Barrantes (Eds.), *Impact of Information Society Research*
902 *in the Global South* (pp. 1-17): Springer Singapore.
903 Chipchase, J. (2006). How do you manage your contacts if you can't read or write? *interactions, 13*(6),
904 16-17. doi: 10.1145/1167948.1167966
905 Colson, A. C. (1971). The differential use of medical resources in developing countries. *Journal of*
906 *Health and Social Behavior, 12*(3), 226-237. doi: 10.2307/2948558
907 Desai, S., Dubey, A., Joshi, B. L., Sen, M., Sharif, A., & Vanneman, R. (2010a). *Human development*
908 *in India: challenges for a society in transition*. Oxford: Oxford University Press.
909 Desai, S., Vanneman, R., & National Council of Applied Economic Research. (2010b). *India Human*
910 *Development Survey (IHDS), 2005 [ICPSR22626-v8]*. Ann Arbour, MI: Inter-university
911 Consortium for Political and Social Research. Retrieved from
912 http://doi.org/10.3886/ICPSR36151.v3.
913 Desai, S., Vanneman, R., & National Council of Applied Economic Research. (2016). *India Human*
914 *Development Survey-II (IHDS-II), 2011-12 [ICPSR36151-v2]*. Ann Arbour, MI: Inter-

university Consortium for Political and Social Research. Retrieved from http://doi.org/10.3886/ICPSR36151.v3.

Dewan, S., & Frederick, J. R. (2005). The digital divide: current and future research directions. *Journal of the Association for Information Systems, 6*(12), 298-336.

Díaz Andrade, A., & Urquhart, C. (2012). Unveiling the modernity bias: a critical examination of the politics of ICT4D. *Information Technology for Development, 18*(4), 281-292. doi: 10.1080/02681102.2011.643204

Directorate General of Health Services. (2011a). *Indian public health standards (IPHS) for 31 to 50 bedded sub-district/sub-divisional hospitals: draft, revised 2010*. New Delhi: Government of India.

Directorate General of Health Services. (2011b). *Indian public health standards (IPHS) for 301 to 500 bedded district hospitals: draft, revised 2010*. New Delhi: Government of India.

Directorate General of Health Services. (2011c). *Indian public health standards (IPHS) for community health centres: draft, revised 2010*. New Delhi: Government of India.

Directorate General of Health Services. (2011d). *Indian public health standards (IPHS) for primary health centres: draft, revised 2010*. New Delhi: Government of India.

Directorate General of Health Services. (2011e). *Indian public health standards (IPHS) for sub-centres: draft, revised 2010*. New Delhi: Government of India.

Dodson, L. L., Sterling, S. R., & Bennett, J. K. (2012). Considering failure: eight years of ITID research. *Information Technologies & International Development, 9*(2, ICTD2012 Special Issue), 19-34.

Dodson, L. L., Sterling, S. R., & Bennett, J. K. (2013). Minding the gaps: cultural, technical and gender-based barriers to mobile use in oral-language Berber communities in Morocco *Proceedings of the Sixth International Conference on Information and Communication*

939 *Technologies and Development: Full Papers - Volume 1* (pp. 79-88). Cape Town: Association
940 for Computing Machinery.
941 Donner, J. (2015). *After access: inclusion, development, and a more mobile Internet*. Cambridge, MA:
942 MIT Press.
943 Duncombe, R. (2012). *Understanding mobile phone impact on livelihoods in developing countries: a*
944 *new research framework* [Manchester Centre for Development Informatics Working Paper no.
945 48]. Manchester: Centre for Development Informatics, Institute for Development Policy and
946 Management.
947 Dupas, P. (2011). Health behavior in developing countries. *Annual Review of Economics, 3*(1), 425-
948 449. doi: doi:10.1146/annurev-economics-111809-125029
949 Flor, A. (2015). Constructing theories of change for information society impact research. In A. Chib,
950 J. May & R. Barrantes (Eds.), *Impact of Information Society Research in the Global South* (pp.
951 45-62): Springer Singapore.
952 Foster, A. D., & Rosenzweig, M. R. (2010). Microeconomics of technology adoption. *Annual Review*
953 *of Economics, 2*(1), 395-424. doi: doi:10.1146/annurev.economics.102308.124433
954 Foster, C., & Heeks, R. (2013). Conceptualising inclusive innovation: modifying systems of
955 innovation frameworks to understand diffusion of new technology to low-income consumers.
956 *The European Journal of Development Research, 25*(3), 333-355. doi: 10.1057/ejdr.2013.7
957 Foster, C., & Heeks, R. (2014). Nurturing user–producer interaction: inclusive innovation flows in a
958 low-income mobile phone market. *Innovation and Development, 4*(2), 221-237. doi:
959 10.1080/2157930X.2014.921353
960 Fressoli, M., Arond, E., Abrol, D., Smith, A., Ely, A., & Dias, R. (2014). When grassroots innovation
961 movements encounter mainstream institutions: implications for models of inclusive innovation.
962 *Innovation and Development, 4*(2), 277-292. doi: 10.1080/2157930X.2014.921354

963 Fu, X., & Polzin, C. (2010). Sustainability of technology-intensive social innovation in India: the role
964 of absorptive capacity and complementary assets. In X. Fu & L. Soete (Eds.), *The rise of*
965 *technological power in the South* (pp. 320-340). Basingstoke: Palgrave Macmillan.
966 Gagliardone, I. (2015). 'Can you hear me?' Mobile-radio interactions and governance in Africa. *New*
967 *Media & Society*, (ahead of print), 1-16. doi: 10.1177/1461444815581148
968 Graham, M. (2011). Disintermediation, altered chains and altered geographies: the Internet in the Thai
969 silk industry. *Electronic Journal of Information Systems in Developing Countries, 45*(5), 1-25.
970 Graham, M., Hogan, B., Straumann, R. K., & Medhat, A. (2014). Uneven geographies of user-
971 generated information: patterns of increasing informational poverty. *Annals of the Association*
972 *of American Geographers, 104*(4), 746-764. doi: 10.1080/00045608.2014.910087
973 Greene, W. H. (2008). *Econometric analysis* (6th ed.). Upper Saddle River, N.J.: Pearson/Prentice
974 Hall.
975 Gudeman, S. (1992). Remodeling the house of economics: culture and innovation. *American*
976 *Ethnologist, 19*(1), 141-154. doi: 10.2307/644829
977 Gulliford, M., Figueroa-Munoz, J., Morgan, M., Hughes, D., Gibson, B., Beech, R., *et al.* (2002). What
978 does 'access to health care' mean? *Journal of Health Services Research & Policy, 7*(3), 186-
979 188. doi: 10.1258/135581902760082517
980 Haenssgen, M. J. (2015a). Exploring the mismatch between mobile phone adoption and use through
981 survey data from rural India and China. *Proceedings of the 2015 IEEE International*
982 *Symposium on Technology and Society (ISTAS)*, 1-15. doi: 10.1109/ISTAS.2015.7439402
983 Haenssgen, M. J. (2015b). *Mobile phone diffusion and rural healthcare access in India and China.*
984 (D.Phil. Thesis), University of Oxford, Oxford. Retrieved from
985 http://ora.ox.ac.uk/objects/uuid:3f48fc8b-5414-4851-926b-07a57eed6cfe
986 Haenssgen, M. J., & Ariana, P. (2015). *Does the rapid mobile phone diffusion in rural low- and middle-*
987 *income contexts undermine equitable access to healthcare? Survey evidence from rural India*

and China. Paper presented at the 13th Globelics International Conference, 23-25 September 2015, Havana.

Haenssgen, M. J., & Ariana, P. (2017a). Healthcare access: a sequence-sensitive approach. *SSM - Population Health, 3*, 37-47. doi: http://dx.doi.org/10.1016/j.ssmph.2016.11.008

Haenssgen, M. J., & Ariana, P. (2017b). The social implications of technology diffusion: uncovering the unintended consequences of people's health-related mobile phone use in rural India and China. *World Development, 94*, 286-304. doi: http://doi.org/10.1016/j.worlddev.2017.01.014

Hahn, H. P., & Kibora, L. (2008). The domestication of the mobile phone: oral society and new ICT in Burkina Faso. *The Journal of Modern African Studies, 46*(1), 87-109. doi: doi:10.1017/S0022278X07003084

Hampshire, K., Porter, G., Owusu, S. A., Mariwah, S., Abane, A., Robson, E., *et al.* (2015). Informal m-health: How are young people using mobile phones to bridge healthcare gaps in Sub-Saharan Africa? *Social Science & Medicine, 142*, 90-99. doi: http://dx.doi.org/10.1016/j.socscimed.2015.07.033

Hampshire, K. R., Porter, G., Owusu, S. A., Tanle, A., & Abane, A. (2011). Out of the reach of children? Young people's health-seeking practices and agency in Africa's newly-emerging therapeutic landscapes. *Social Science & Medicine, 73*(5), 702-710. doi: 10.1016/j.socscimed.2011.06.035

Heeks, R. (2008). ICT4D 2.0: the next phase of applying ICT for international development. *Computer, 41*(6), 26-33. doi: 10.1109/MC.2008.192

Heeks, R. (2009). *The ICT4D 2.0 manifesto: Where next for ICTs and international development?* [Development Informatics working paper series no. 42]. Manchester: Institute for Development Policy and Management.

1011 Heeks, R. (2014). *ICT4D 2016: new priorities for ICT4D policy, practice and WSIS in a post-2015*
1012 *world* [Development Informatics working paper series no. 59]. Manchester: Institute for
1013 Development Policy and Management.
1014 Heeks, R., Amalia, M., Kintu, Robert, & Shah, N. (2013). *Inclusive innovation: definition,*
1015 *conceptualisation and future research priorities* [Development Informatics Working Paper
1016 Series no. 53]. Manchester: University of Manchester.
1017 Heeks, R., Foster, C., & Nugroho, Y. (2014). New models of inclusive innovation for development.
1018 *Innovation and Development, 4*(2), 175-185. doi: 10.1080/2157930X.2014.928982
1019 Helsper, E. J. (2012). A corresponding fields model for the links between social and digital exclusion.
1020 *Communication Theory, 22*(4), 403-426. doi: 10.1111/j.1468-2885.2012.01416.x
1021 Hilbe, J. M. (2009). *Logistic regression models*. London: Chapman & Hall.
1022 Horst, H. A. (2006). The blessings and burdens of communication: cell phones in Jamaican
1023 transnational social fields. *Global Networks, 6*(2), 143-159. doi: 10.1111/j.1471-
1024 0374.2006.00138.x
1025 Horst, H. A., & Miller, D. (2006). *The cell phone: an anthropology of communication*. Oxford: Berg.
1026 Jack, W., & Suri, T. (2014). Risk sharing and transactions costs: evidence from Kenya's mobile money
1027 revolution. *The American Economic Review, 104*(1), 183-223. doi: 10.1257/aer.104.1.183
1028 Jeffrey, R., & Doron, A. (2013). *The great Indian phone book: how the cheap cell phone changes*
1029 *business, politics, and daily life*. London: Hurst.
1030 Karnowski, V., von Pape, T., & Wirth, W. (2011). Overcoming the binary logic of adoption. In A.
1031 Vishwanath & G. A. Barnett (Eds.), *The diffusion of innovations: a communication science*
1032 *perspective* (pp. 57-76). New York: Peter Lang.
1033 Katz, J. E. (2008). Introduction. In J. E. Katz (Ed.), *Handbook of mobile communication studies* (pp.
1034 1-11). Cambridge, MA: MIT Press.

1035 Kibadi, K., Boelaert, M., Kayinua, M., Minuku, J.-B., Muyembe-Tamfum, J.-J., Portaels, F., *et al.*
1036 (2009). Therapeutic itineraries of patients with ulcerated forms of Mycobacterium ulcerans
1037 (Buruli ulcer) disease in a rural health zone in the Democratic Republic of Congo. *Tropical*
1038 *Medicine & International Health, 14*(9), 1110-1116. doi: 10.1111/j.1365-3156.2009.02324.x
1039 Kleine, D. (2013). *Technologies of choice? ICTs, development, and the capabilities approach*.
1040 Cambridge, MA: MIT Press.
1041 Kroeger, A. (1983). Anthropological and socio-medical health care research in developing countries.
1042 *Social Science & Medicine, 17*(3), 147-161. doi: http://dx.doi.org/10.1016/0277-
1043 9536(83)90248-4
1044 Kurniawan, S. (2008). Older people and mobile phones: a multi-method investigation. *International*
1045 *Journal of Human-Computer Studies, 66*(12), 889-901. doi:
1046 http://dx.doi.org/10.1016/j.ijhcs.2008.03.002
1047 Lieber, E., Li, L., Wu, Z., Rotheram-Borus, M. J., & Guan, J. (2006). HIV/STD stigmatization fears
1048 as health-seeking barriers in China. *AIDS and Behavior, 10*(5), 463-471. doi: 10.1007/s10461-
1049 005-9047-5
1050 Ling, R. S. (2008). *New tech, new ties: how mobile communication is reshaping social cohesion*.
1051 Cambridge, MA: MIT Press.
1052 Ling, R. S. (2012). *Taken for grantedness: the embedding of mobile communication into society*.
1053 Cambridge, MA: MIT Press.
1054 May, J., & Diga, K. (2015). Progress towards resolving the measurement link between ICT and poverty
1055 reduction. In A. Chib, J. May & R. Barrantes (Eds.), *Impact of Information Society Research*
1056 *in the Global South* (pp. 83-104): Springer Singapore.
1057 Mbiti, I. M., & Weil, D. N. (2011). *Mobile banking: the impact of M-PESA in Kenya* [NBER Working
1058 Paper no. 17129]. Cambridge, MA: National Bureau of Economic Research.

1059 Mechael, P. (2006). *Exploring health-related uses of mobile phones: an Egyptian case study*.
1060 (Unpublished PhD thesis), London School of Hygiene and Tropical Medicine, London.
1061 Mechael, P. (2008). Health services and mobiles: a case from Egypt. In J. E. Katz (Ed.), *Handbook of*
1062 *mobile communication studies* (pp. 91-103). Cambridge, MA: MIT Press.
1063 Meessen, B., Bigdeli, M., Chheng, K., Decoster, K., Ir, P., Men, C., *et al.* (2011). Composition of
1064 pluralistic health systems: how much can we learn from household surveys? An exploration in
1065 Cambodia. *Health Policy and Planning, 26*(Suppl. 1), i30-i44. doi: 10.1093/heapol/czr026
1066 Miller, D. (2010). *Stuff*. Cambridge: Polity Books.
1067 Miritello, G., Moro, E., Lara, R., Martínez-López, R., Belchamber, J., Roberts, S. G. B., *et al.* (2013).
1068 Time as a limited resource: communication strategy in mobile phone networks. *Social*
1069 *Networks, 35*(1), 89-95. doi: http://dx.doi.org/10.1016/j.socnet.2013.01.003
1070 MoHFW. (2002). *National health policy – 2002*. New Delhi: Ministry of Health and Family Welfare.
1071 MoHFW. (2006). *Broad framework for preparation of district health action plans*. New Delhi:
1072 Ministry of Health and Family Welfare.
1073 MoHFW. (2014). *NRHM: five years (2009-2014): achievements & new initiatives*. New Delhi:
1074 Ministry of Health and Family Welfare.
1075 MoHFW. (2016). *National health accounts: estimates for India 2013-2014*. New Delhi: Ministry of
1076 Health and Family Welfare.
1077 Moshabela, M., Pronyk, P., Williams, N., Schneider, H., & Lurie, M. (2011). Patterns and implications
1078 of medical pluralism among HIV/AIDS patients in rural South Africa. *AIDS and Behavior,*
1079 *15*(4), 842-852. doi: 10.1007/s10461-010-9747-3
1080 Munn, N. D. (1992). The cultural anthropology of time: a critical essay. *Annual Review of*
1081 *Anthropology, 21*, 93-123. doi: 10.2307/2155982

1082 Nakahara, S., Saint, S., Sann, S., Ichikawa, M., Kimura, A., Eng, L., *et al.* (2010). Exploring referral
1083 systems for injured patients in low-income countries: a case study from Cambodia. *Health*
1084 *Policy and Planning, 25*(4), 319-327. doi: 10.1093/heapol/czp063
1085 Napoli, P. M., & Obar, J. A. (2014). The emerging mobile Internet underclass: a critique of mobile
1086 Internet access. *The Information Society, 30*(5), 323-334. doi: 10.1080/01972243.2014.944726
1087 Nyamongo, I. K. (2002). Health care switching behaviour of malaria patients in a Kenyan rural
1088 community. *Social Science & Medicine, 54*(3), 377-386. doi: http://dx.doi.org/10.1016/S0277-
1089 9536(01)00036-3
1090 Organisation for Economic Co-operation and Development. (2017). *OECD.Stat* [Data file]. Retrieved
1091 from: http://stats.oecd.org/index.aspx?DataSetCode=HEALTH_STAT
1092 Papaioannou, T. (2014). How inclusive can innovation and development be in the twenty-first century?
1093 *Innovation and Development, 4*(2), 187-202. doi: 10.1080/2157930X.2014.921355
1094 Pearce, K. E. (2013). Phoning it in: theory in mobile media and communication in developing
1095 countries. *Mobile Media & Communication, 1*(1), 76-82. doi: 10.1177/2050157912459182
1096 Pedersen, M. A., & Bunkenborg, M. (2012). Roads that separate: sino-mongolian relations in the inner
1097 Asian desert. *Mobilities, 7*(4), 555-569. doi: 10.1080/17450101.2012.718938
1098 Peglidou, A. (2010). Therapeutic itineraries of 'depressed' women in Greece: power relationships and
1099 agency in therapeutic pluralism. *Anthropology & Medicine, 17*(1), 41-57. doi:
1100 10.1080/13648471003600404
1101 Pitt, E., & Pusponegoro, A. (2005). Prehospital care in Indonesia. *Emergency Medicine Journal, 22*(2),
1102 144-147. doi: 10.1136/emj.2003.007757
1103 Prasad, S., & Sathyamala, C. (2006). Introduction and overview. In S. Prasad & C. Sathyamala (Eds.),
1104 *Securing health for all: dimensions and challenges* (pp. 11-24). New Delhi: Institute for Human
1105 Development.

1106 Qureshi, S. (2014). Overcoming technological determinism in understanding the digital divide: Where
1107 do we go from here? *Information Technology for Development, 20*(3), 215-217. doi:
1108 10.1080/02681102.2014.930981
1109 Qureshi, S. (2015). Are we making a better world with information and communication technology
1110 for development (ICT4D) research? Findings from the field and theory building. *Information*
1111 *Technology for Development, 21*(4), 511-522. doi: 10.1080/02681102.2015.1080428
1112 Ramani, S. V., SadreGhazi, S., & Duysters, G. (2012). On the diffusion of toilets as bottom of the
1113 pyramid innovation: Lessons from sanitation entrepreneurs. *Technological Forecasting and*
1114 *Social Change, 79*(4), 676-687. doi: http://doi.org/10.1016/j.techfore.2011.06.007
1115 Rao, K. D., Bhatnagar, A., Berman, P., Saran, I., & Raha, S. (2008). *India's health workforce: size,*
1116 *composition and distribution* [HRH Technical Report no. 1]. New Delhi: World Bank & Public
1117 Health Foundation of India.
1118 Rao, M., Rao, K. D., Kumar, A. K. S., Chatterjee, M., & Sundararaman, T. (2011). Human resources
1119 for health in India. *The Lancet, 377*(9765), 587-598. doi: 10.1016/S0140-6736(10)61888-0
1120 Rashid, A. T., & Elder, L. (2009). Mobile phones and development: an anaylsis of IDRC-supported
1121 projects. *Electronic Journal of Information Systems in Developing Countries, 36*(2), 1-16.
1122 Reisdorf, B. C., Axelsson, A.-S., & Söderholm, H. M. (2012). *Living offline: a qualitative study of*
1123 *Internet non-use in Great Britain and Sweden*. Paper presented at the Association of Internet
1124 Researchers Conference, 18-21 October 2012, Salford, UK.
1125 Robinson, L., Cotten, S. R., Ono, H., Quan-Haase, A., Mesch, G., Chen, W., *et al.* (2015). Digital
1126 inequalities and why they matter. *Information, Communication & Society, 18*(5), 569-582. doi:
1127 10.1080/1369118X.2015.1012532
1128 Roztocki, N., & Weistroffer, H. R. (2014). Information and communication technology in transition
1129 economies: an assessment of research trends. *Information Technology for Development, 21*(3),
1130 330-364. doi: 10.1080/02681102.2014.891498

1131 Sæbø, Ø., & Furuholt, B. (2013). *The importance of unintended use: What are we not looking for in*
1132 *ICT4D projects?* Paper presented at the 12th International Conference on Social Implications
1133 of Computers in Developing Countries, 19-22 May, 2013, Ocho Rios, Jamaica.
1134 Saramäki, J., Leicht, E. A., López, E., Roberts, S. G. B., Reed-Tsochas, F., & Dunbar, R. I. M. (2014).
1135 Persistence of social signatures in human communication. *Proceedings of the National*
1136 *Academy of Sciences, 111*(3), 942-947. doi: 10.1073/pnas.1308540110
1137 Sathyamala, C. (2006). Health security for the poor: a view from the grassroots. In S. Prasad & C.
1138 Sathyamala (Eds.), *Securing health for all: dimensions and challenges* (pp. 129-145). New
1139 Delhi: Institute for Human Development.
1140 Schroeder, R. (2010). Mobile phones and the inexorable advance of multimodal connectedness. *New*
1141 *Media & Society, 12*(1), 75-90. doi: 10.1177/1461444809355114
1142 Schroeder, R. (2015). A Weberian analysis of global digital divides. *International Journal of*
1143 *Communication, 9*, 2819–2837.
1144 Seddon, N. (2007). *Quite like heaven? Options for the NHS in a consumer age*. Bury St Edmunds: St
1145 Edmundsbury Press.
1146 Sen, A. (1999). Health in development. *Bulletin of the World Health Organization, 77*(8), 619-623.
1147 Senior, K. (2010). Wanted: 2.4 million nurses, and that's just in India. *Bulletin of the World Health*
1148 *Organization, 88*(5), 327-328. doi: 10.2471/blt.10.020510
1149 Shaikh, B. T., Haran, D., & Hatcher, J. (2008). Where do they go, whom do they consult, and why?
1150 Health-seeking behaviors in the northern areas of Pakistan. *Qualitative Health Research, 18*(6),
1151 747-755. doi: 10.1177/1049732308317220
1152 Shaikh, B. T., & Hatcher, J. (2005). Health seeking behaviour and health service utilization in Pakistan:
1153 challenging the policy makers. *Journal of Public Health, 27*(1), 49-54. doi:
1154 10.1093/pubmed/fdh207

1155 Sreekumar, T. T. (2011). Mobile phones and the cultural ecology of fishing in Kerala, India. *The*
1156 *Information Society, 27*(3), 172-180. doi: 10.1080/01972243.2011.566756
1157 StataCorp. (2013). Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.
1158 Steenson, M. W., & Donner, J. (2009). Beyond the personal and private: modes of mobile phone
1159 sharing in urban India. In R. Ling & S. W. Campbell (Eds.), *The reconstruction of space and*
1160 *time: mobile communication practices* (pp. 231-250). New Brunswick, NJ: Transaction
1161 Publishers.
1162 Stewart, F. (1978). *Technology and underdevelopment* (2nd ed ed.). London: Macmillan.
1163 Storla, D. G., Yimer, S., & Bjune, G. (2008). A systematic review of delay in the diagnosis and
1164 treatment of tuberculosis. *BMC Public Health, 8*(15).
1165 Stump, R. L., Wen Gong, & Zhan Li. (2008). Exploring the digital divide in mobile-phone adoption
1166 levels across countries: Do population socioeconomic traits operate in the same manner as their
1167 individual-level demographic counterparts? *Journal of Macromarketing, 28*(4), 397-412. doi:
1168 10.1177/0276146708325386
1169 Sudhinaraset, M., Ingram, M., Lofthouse, H. K., & Montagu, D. (2013). What is the role of informal
1170 healthcare providers in developing countries? A systematic review. *PLoS ONE, 8*(2), e54978.
1171 doi: 10.1371/journal.pone.0054978
1172 Thompson, E. P. (1967). Time, work-discipline, and industrial capitalism. *Past & Present*(38), 56-97.
1173 doi: 10.2307/649749
1174 UNDP. (2014). *Human development report 2014: sustaining human progress: reducing vulnerabilities*
1175 *and building resilience*. New York, NY: United Nations Development Programme.
1176 Unwin, T. (2009). Introduction. In T. Unwin (Ed.), *ICT4D: information and communication*
1177 *technology for development* (pp. 1-6). Cambridge: Cambridge University Press.
1178 van Dijk, J. (2005). *The deepening divide: inequality in the information society*. Thousand Oaks, CA:
1179 Sage.

van Dijk, J. A. G. M. (2006). Digital divide research, achievements and shortcomings. *Poetics, 34*(4–5), 221-235. doi: http://dx.doi.org/10.1016/j.poetic.2006.05.004

van Egeren, L., & Fabrega, H. (1976). Behavioral science and medical education: A biobehavioral perspective. *Social Science & Medicine, 10*(11–12), 535-539. doi: http://dx.doi.org/10.1016/0037-7856(76)90021-4

Walsham, G. (2013). Development informatics in a changing world: reflections from ICTD2010/2012. *Information Technologies & International Development, 9*(1), 49-54.

Ward, H., Mertens, T. E., & Thomas, C. (1997). Health seeking behaviour and the control of sexually transmitted disease. *Health Policy and Planning, 12*(1), 19-28.

WHO. (2007). *Strengthening health systems to improve health outcomes: WHO's framework for action*. Geneva: World Health Organization.

WHO. (2009). *National health accounts: India, 2004-05*. New Delhi: World Health Organisation and Government of India.

WHO. (2010). *Strengthening care for the injured: success stories and lessons learned from around the world*. Geneva: World Health Organization.

World Bank. (1993). *World development report 1993: investing in health*. Washington, DC: World Bank.

World Bank. (2017). *World development indicators | DataBank*. Retrieved April 5, 2017, from http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#

Wyche, S. (2015). *Exploring mobile phone and social media use in a Nairobi slum: a case for alternative approaches to design in ICTD*. Paper presented at the Proceedings of the Seventh International Conference on Information and Communication Technologies and Development, Singapore. http://delivery.acm.org/10.1145/2740000/2738019/a12-wyche.pdf?ip=129.67.117.236&id=2738019&acc=ACTIVE%20SERVICE&key=BF07A2EE685417C5%2EF2FAECDC86A918EB%2E4D4702B0C3E38B35%2E4D4702B0C3E38B3

5&CFID=529628244&CFTOKEN=96446614&__acm__=1437484468_d40f28b620a3a74c81e11d749c1f5e95

Ziefle, M., & Bay, S. (2005). How older adults meet complexity: aging effects on the usability of different mobile phones. *Behaviour & Information Technology, 24*(5), 375-389. doi: 10.1080/0144929042000320009

1212 **Endnotes**

[1] The term "adopter" here implies that a mobile phone is being used for a health-related purpose. Theoretically, owning or using a phone in general might not necessarily entail health-related uses.

[2] This does not exclude the possibility that actions underlying the broader diffusion trend of mobile phones can be characterised as inclusive innovation (Ramani *et al.*, 2012).

[3] See for example Schroeder (2010:80-81) on complementarities between of mobile phones and other ICTs in the context of social interaction, and Fu and Polzin (2010:326-327) on a discussion of "complementary assets" in a developing-country enterprise setting.

[4] Households that split over the study period are included as duplicates in the 2005 survey in order to not bias the sample towards growing and stable units. The assumption of this procedure is that descendants from one household share the same beliefs as the original unit.

[5] While tempting, robustness checks using the share of sick household members who accessed a particular kind of healthcare provider conflate intensity of care-seeking with overall exclusion and are therefore less suitable for this estimation.

[6] Unweighted statistics; based on cleaned panel data set of 26,517 households each in 2005 and 2012, compared to 12,003 households in the estimation sample.

[7] This section only considers allopathy as the most relevant part of the Indian systems of medicine for the research question. Other Indian systems of medicine include ayurveda, yoga, unani, siddha, homeopathy, and amchi (Rao *et al.*, 2011:588). Owing to the focus on curative allopathic care, I also omit potential interactions between mobile phone diffusion and health education, preventive care, and other forms of health service provision (e.g. nutritional services like Anganwadi centres or services provided by non-governmental organisations).

[8] Based on Indian Public Health Standards (Directorate General of Health Services, 2011a, 2011b, 2011c, 2011d, 2011e).

[9] The relationship between mobile phone ownership and household wealth suggests that a potential endogeneity problem might affect the analysis of healthcare access. However, it is worth bearing in mind that still 14% of phone owning households in 2012 were below the poverty line. In addition, the analytical strategy using a fixed-effects model does not focus on levels of access but rather on changes in access across the study periods, controlling for changes in household wealth (i.e. a poverty indicator) as well as phone ownership alongside other control variables (wealth and ownership statuses do not change in tandem). The fixed-effects model also corrects for unobserved, time-invariant household characteristics that might influence healthcare access. Moreover, the principal findings of the analysis do not relate to

household mobile phone ownership per se, but to the relationship between changes in district-level phone diffusion and household-level mobile phone ownership. The regression results will indicate that changes in household wealth are a statistically insignificant control variable, but the sub-group analysis (stratifying poor and non-poor households) suggests that poor households (below median wealth) behaved differently from more affluent households. The cause of lower mobile phone use is therefore not directly attributed to lower household mobile phone ownership, but to the non-acquisition of mobile phones in a context that adapts increasingly to health-related mobile phone use and therefore discriminates against phone users over time.

[10] Note that the coefficients in the models are identified by the change within households' conditions, with invariant variables on the household level dropping from the estimation.

[11] Based on the secondary data from the IHDS, my analysis considers a relatively constant healthcare supply. It is possible that mobile phone diffusion does not only alter the interface between patients and healthcare providers, but also that the supply-side organization changes in response to technological change (e.g. increasing the effective supply of healthcare resources at constant inputs through lower coordination costs). In the present analysis, the average relationship between expanding mobile phone diffusion and personal healthcare access is negative (as reported in Model 1 in Table 5). However, the focus in this study was on the demand-side implications in response to supply-side adaptations, and I cannot rule out that mobile phone diffusion enhances (or diminishes) the health services provided per unit of input. Claims about the supply side organisation in response to mobile phone diffusion can therefore only be speculative and further investigations require different study designs (e.g. analysis of administrative data).