

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

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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

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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

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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 (Haenssger & 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).

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

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

91 The remainder of this paper situates the study in the fields of technology adoption and ICTD,
92 followed by a detailed description of the analytical framework (Section 2). Section 3 explains the
93 empirical model to analyse the household panel data from the IHDS, using fixed-effects linear
94 probability models with village-cluster robust standard errors to estimate households' probability to
95 access healthcare as a function of mobile phone adoption and district-level phone diffusion. The results
96 are described in Section 4, showing that households who failed to acquire a mobile phone between
97 2005 and 2012 are on average poorer, and that poor households without mobile phones are less likely
98 to gain access to "responsive" private healthcare providers if mobile phones have otherwise diffused
99 widely in their district. Section 5 will argue that the results correspond to the analytical framework.
100 On the demand side, diffusion drives competition and creates divides between poor phone users and
101 non-users. On the supply side, healthcare providers who are more responsive to patients' mobile phone
102 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; Roztock & 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,

152 2006:274-275; Helsper, 2012:411-414; May & Diga, 2015:100; Pearce, 2013:78; Robinson *et al.*,
153 2015; van Dijk, 2006:224). Donner (2015:137-154), Graham *et al.* (2014:758-759), and Schroeder
154 (2015:2828-2830) go yet further and analyse digital divides between social groups and across countries
155 in terms of technology-aided media content creation and consumption.

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

163 Beyond digital divides, this paper also speaks to the related field of “inclusive innovation” in
164 ICTD, which considers innovation and inclusion typically from a descriptive and prescriptive angle in
165 an attempt to overcome the patterns of inequity often found in mainstream innovations originating
166 from firms (Heeks *et al.*, 2014; Papaioannou, 2014). Different forms, or “levels,” of inclusiveness are
167 defined, for example, by Heeks *et al.* (2013:6), ranging from inclusion by intention via inclusion
168 through adoption and impact to inclusion by inclusive design processes and innovation in an inclusive
169 discourse. The broader inclusive innovation literature tends to focus on deliberate innovative activity
170 rather than general diffusion patterns of technology as in the present case (Foster & Heeks, 2014;
171 Fressoli *et al.*, 2014),² but it is conscious of the potential inequities that can result from the innovation
172 and diffusion process across and within excluded groups (Heeks *et al.*, 2013:5-6; Papaioannou,
173 2014:11). In the present case, the diffusion of mobile phones as an innovation could be considered as
174 “inclusive” for instance if its adoption and impacts are distributed equitably or in a pro-poor fashion
175 (Foster & Heeks, 2013:335). I investigate in this paper whether a positive process approach to digital
176 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 (Haenssger, 2015b; Haenssger & 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.

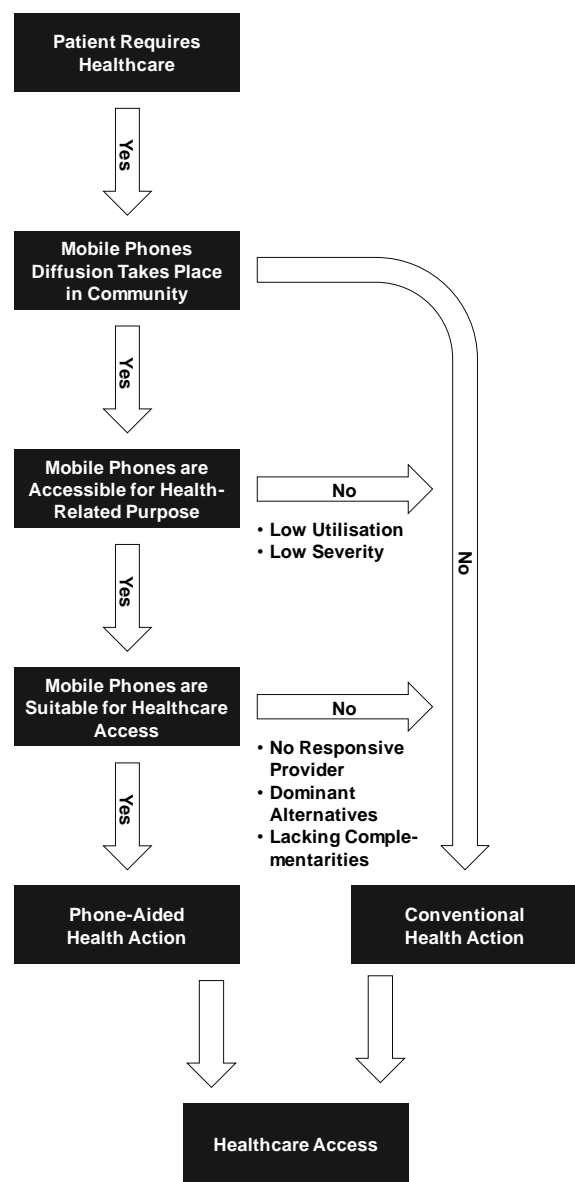


Fig. 1. Stylised Description of Phone-Aided Health Action Decision-Making Process

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 Pusponogoro (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 & Pusponogoro, 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.

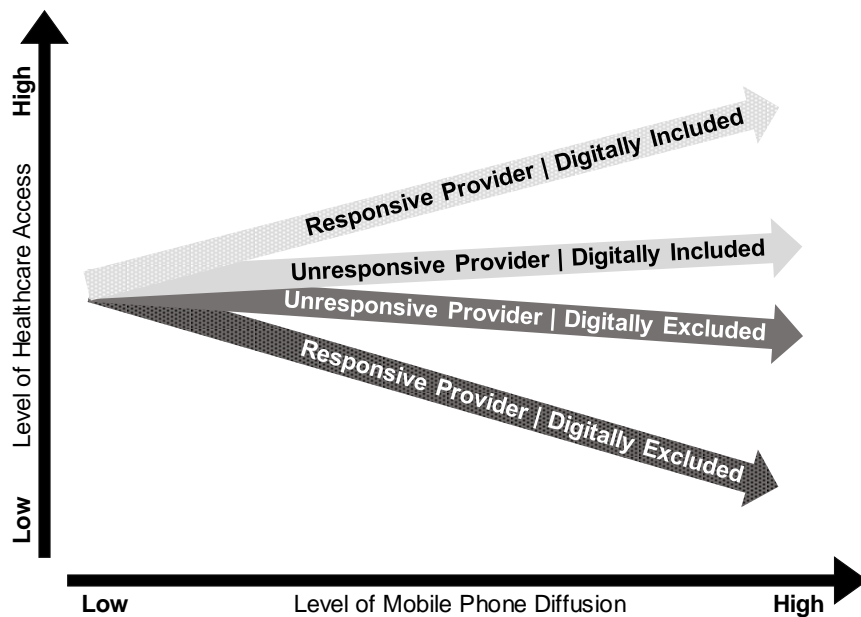


Fig. 2. Hypothesised Relationship Between Healthcare, Mobile Phone Diffusion, Health Provider Responsiveness, and Digital Inclusion of Patient

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

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

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333 Where $\ddot{Y}_{kit} = Y_{kit} - \bar{Y}_{ki}$ etc. are time-demeaned variables; \ddot{MOB}_{it} is household-level mobile
 334 ownership; \ddot{DIST}_{it} is district-level mobile phone diffusion (as a proxy for health system adaptation to
 335 mobile phone use); $\ddot{MOB \times DIST}_{it}$ is an interaction term; $\ddot{CONTROLS}_{it}$ are other household-level, time-
 336 variant variables controlling for healthcare access; \ddot{YEAR}_t is a trend variable; and \ddot{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.

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

	Variable	Description
Y_{it} (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
	$MOB \times DIST_{it}$ (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

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Sources: Author, based on Beals (1976); Colson (1971); Gulliford *et al.* (2002); Kroeger (1983); Lieber *et al.* (2006); Meessen *et al.* (2011); Nyamongo (2002); Shaikh *et al.* (2008); Shaikh and Hatcher (2005); Storla *et al.* (2008); van Egeren and Fabrega (1976); Ward *et al.* (1997).

Notes: HH is household; defined as “people living under one roof and sharing the same kitchen” (Desai *et al.*, 2010a:222).

^a. Wealth index includes mobile phones. Robustness checks excluding phones from index confirmed main results. Robustness checks separating vehicles from wealth index have reproduced the model results without notable differences, while the vehicle coefficient was 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 (Haenssger, 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 $MOB \times DIST_{it}$ 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

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

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

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

Source: World Bank (2017).

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).

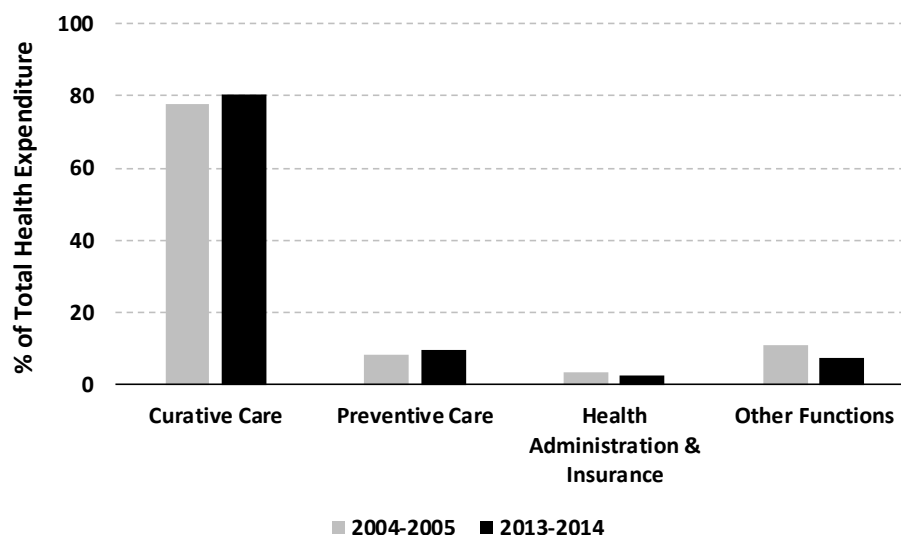


Fig. 3. Health Expenditure by Healthcare Function, National Level

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

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

4.1.2 Descriptive Statistics

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

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

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

		Round I: 2005					Round II: 2012					First Difference 2005-2012				
		<i>n</i>	Mean	Std. Dev	Min	Max	<i>n</i>	Mean	Std. Dev	Min	Max	<i>n</i>	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

Notes: Unweighted statistics. First difference morbidity statistics for households who experienced a minor/major illness in both survey rounds. HH is household.

^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.

^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=“completed higher secondary education (12th class).”

^c 1 = per capita household expenditure < poverty line (which varies by state; 2005 poverty line adjusted by village-wise deflator).

^d Unweighted sum of 33 household assets, using the same household asset categories in 2005 and 2012.

^e Village-level data, as recorded in medical facility questionnaire.

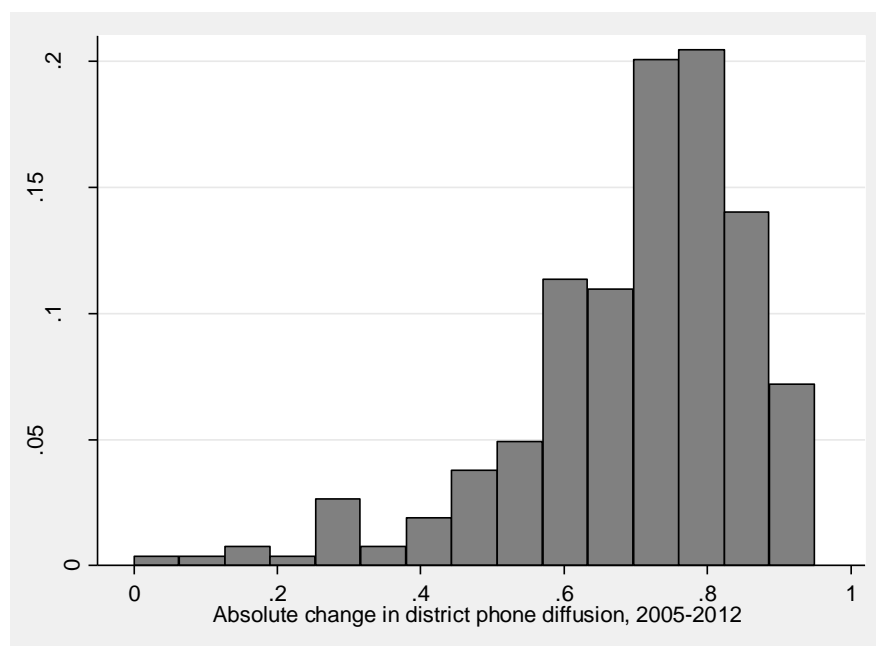


Fig. 4. Change in District-Level Mobile Phone Diffusion in Survey Sample, 2005-2012

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.

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

Notes: HH is household.

^a. “Poor” and “affluent” categorised as below/above median wealth index, using average unweighted household wealth between both survey periods.* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

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,

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

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

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

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

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

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

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

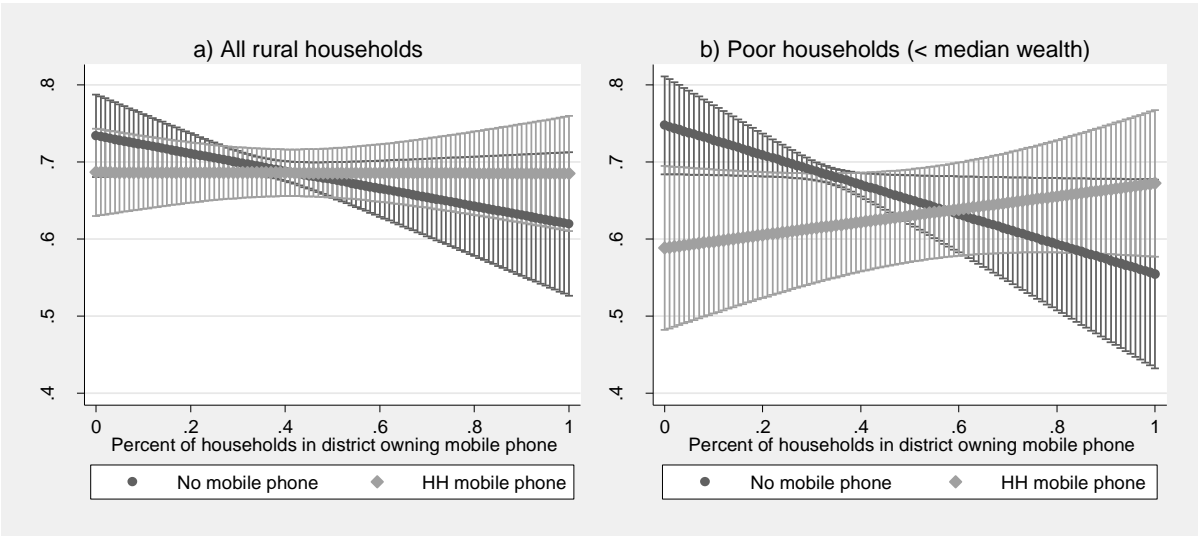


Fig. 5. Predicted Access to Private Healthcare by Phone Ownership and Household Wealth

Source: Author, derived from Desai *et al.* (2010b, 2016).

Notes: Prediction based on fixed-effects linear probability models for households with private healthcare access in either survey round (Table 4, Models 3 and 8). Vertical lines indicate 95%-confidence interval.

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

5 Discussion

5.1 Limitations

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

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

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

685 Lastly, and perhaps most importantly, the panel data of the IHDS only permits a household-
 686 level analysis of narrow healthcare access and mobile phone diffusion indicators, which limits the
 687 depth of the analysis. In the present case, household-level healthcare access as a binary variable
 688 obscures the potentially sequential logic of healthcare-seeking behaviour (Balabanova & McKee,
 689 2002; Haenssger & Ariana, 2017a; Kibadi *et al.*, 2009; Moshabela *et al.*, 2011; Shaikh *et al.*, 2008),
 690 the nature of potentially collective healthcare decision-making (Peglidou, 2010:49), and, as a variable
 691 of “revealed behaviour,” only captures successful access and ignores whether an individual “sought”
 692 but failed to obtain healthcare. Considering the study focus on curative healthcare access (which
 693 accounts for four-fifths of healthcare expenditures during the study period), the analysis also cannot
 694 speak for health education (e.g. provided by local community health workers like ASHAs), preventive

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

697 Likewise, household-level mobile phone ownership maps only imperfectly onto individuals'
698 actual health-related use of a mobile, be it directly by the patient or mediated through a third person.
699 Health-related mobile phone use takes many forms (e.g. home calls, arranging a taxi to reach a health
700 facility, calling a family member to pay a hospital bill) and it takes place in light of a broad range of
701 healthcare functions (e.g. preventive, curative, rehabilitative), healthcare providers (community-level
702 outreach staff, nurses, public and private doctors, untrained medical practitioners, non-governmental
703 organisations), and a network of healthcare access modes (walking, hiring rides, use) (Haenssger,
704 2015b; Haenssger & Ariana, 2015). Approximating health-related mobile phone use through
705 household phone ownership (or, more precisely, approximating the absence of such use through the
706 absence of a household mobile; Haenssger, 2015a:8) thereby prevents the analysis of the exact channel
707 through which mobile phone diffusion interacts with healthcare access and how health-related access
708 developed vis-à-vis other modes of healthcare access during the study period.¹¹

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

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

5.2 Interpretation

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

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

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

The second puzzle is the average negative effect of mobile phone diffusion on healthcare access. A possible interpretation of this pattern may be related to social capital. Qualitative and quantitative sociological research around the world has made the claim that mobile phones enable 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

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

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

843 2015b; Haenssger & Ariana, 2017b). I suggest that, in the struggle created during the process of digital
844 inclusion, persistently excluded parties require protection through conventional means such as efficient
845 public transport links, dependable and convenient clinic hours in local health centres, and guidelines
846 preventing healthcare providers to privilege patients accessing them through mobiles. Where mobile
847 phone use reduces the costs of public health service delivery, these savings can be put usefully towards
848 sustaining the healthcare access of more vulnerable parts of the population.

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

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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).