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Public Health in Rural India: Exploring Sanitation Outcomes and the Role of Community Health Workers

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Public Health in Rural India: Exploring Sanitation Outcomes and the Role of Community Health Workers

By

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Professor Kirk R. Smith, Chair
Professor Lia Fernald
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Abstract

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India found itself on the brink of economic collapse in early 1991. An emergency loan secured from the International Monetary Fund helped stave off national financial ruin. Terms of the loan agreement required India to liberalize its economy, opening it up for the first time since independence in 1947, to foreign investment. While nationalists were dismayed at the time, there is little dispute that those reforms in the early 1990s spurred India's rapid economic growth, turning it in to one of the world's largest economies today. As a result, more Indians than ever before are enjoying middle class lives; with increased access to world class educational opportunities and health services.

Yet this growth has in many ways widened the gap between India's rich and poor. On the other side of this lacuna are hundreds of millions of Indians forced to endure inhumane conditions. For example, nearly 520 million Indians defecate in the open every single day, leading to the spread of fecal contamination. Epidemiological studies have drawn inextricable causal links between open defecation and disease. One gram of feces can contain viral pathogens, bacterial pathogens, protozoan cysts, and helminth eggs, thereby leading to diarrheal disease, the second leading cause of deaths in children under the age of five globally. Fecal contamination can also cause tropical diseases such as trachoma and schistosomiasis. This morbidity has been linked to a reduction in early-life growth, an important marker and predictor of human capital.

Similarly, maternal and child health outcomes remain poor. India still accounted for 15% of maternal deaths (45,000) worldwide in 2015. And while India's under-5 mortality rate now matches the global average (39 deaths per 1,000 live births), its infant mortality rate, 32 deaths per 1,000 live births, is nearly three times the global average. Additionally, the Global Nutrition Report from 2018 highlights the burden of wasting and stunting in children under the age of five in India. According to the report, nearly a third of the world's 150 million stunted children live in India, and over half of the world's 50.5 million wasted children live in India. Furthermore, both stunting and wasting are associated with increased mortality, especially for those children who suffer from both. Finally, the National Family Health Survey conducted by the Ministry of Health and Family Welfare found that in 2015-2016, 53% of all Indian women were anemic. Anemia, combined with poor antenatal care, is particularly problematic as it is associated with a higher likelihood of a poor birth outcomes.

Paper one is an exploratory paper that qualitatively examines why people in rural Bihar, a state in north India, do not own or use toilets. This paper is rooted in the field of social epidemiology, and as such, seeks to elucidate the possible social determinants of latrine ownership and use in rural India. This paper is guided by the research question: what are people's lived experiences in trying to build and use latrines in rural Bihar? Overall, we found that not owning a toilet cannot be conflated with a preference for open defecation, the government's mode of subsidy payment for latrine construction matters, and urban bias – either real or perceived – could be a barrier to improved sanitation outcomes. These findings will help generate new hypotheses that should be tested in future research.

Paper two builds on this work by using the the 69th round of the National Sample Survey in India to examine the association between one specific social determinant – the amount of dwelling space owned by households – and the likelihood of latrine ownership. This paper also examines the variation in household latrine ownership that is attributable to village and state context. Findings from this paper suggest that the amount of dwelling space owned by households is significantly associated with their likelihood of latrine ownership. Furthermore, a significant amount of variation in household latrine ownership is attributable to village and state context. Further research is required to elucidate how village and state context is associated with household latrine ownership.

Paper three focuses on Anganwadi Workers (AWWs) in India. AWWs are one group of community health workers in India who are responsible for ensuring improved maternal and child health outcomes throughout India. The Ministry of Women and Child Development in India has issued guidelines on the amount of time AWWs are expected to spend on key activities. Given that time spent on activities is an indicator of AWW performance, this paper examines the association between various AWW characteristics and whether or not they spend the expected amount of time on certain activities. Our findings suggest that AWW characteristics such as caste, years of experience, and having a helper are significantly associated with whether or not AWWs spend the required amount of time on home visits, feeding children, preschool education, and filling out their paper registers.

Dedication

"Men make their own history, but they do not make it as they please; they do not make it under self-selected circumstances, but under circumstances existing already, given and transmitted from the past." – Karl Marx, 1852

This dissertation is dedicated to my parents and my sister, for being the best family a boy could ask for.

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Last but not least, thank you to my parents and my sister. Everything I am today is because of you.

Onwards

Introduction

Sanitation in India

An estimated 1.1 billion people still practice open defecation [1], and over 90% of them live in rural areas [2]. Open defecation is associated with the spread of serious illnesses, including diarrhea, urinary tract infections, soil-transmitted helminth infection, trachoma, schistosomiasis, and, cholera [3]. Diarrhea alone accounts for 1.4 million deaths around the world annually [4], and nearly 20% of all deaths in children under the age of five [5].

In India, nearly 520 million people defecate in the open daily [6]. Open defecation costs India nearly $54 billion annually, of which over $38 billion is the health-related economic impact [7], and poses a significant threat to children under the age of five. Studies in India reveal that a 10% increase in open defecation leads to a 0.7% increase in stunting and severe stunting [8], both of which are proxy indicators for long-term social and economic outcomes [9]. Thus open defecation in India is a significant global health challenge.

Swachh Bharat Abhiyan (SBA), the Government of India's flagship sanitation campaign, was launched on October 2, 2014. This program aims to end open defecation by focusing resources on individual-level behavior change, while providing a financial subsidy to families to help them cover a portion of the cost of latrine construction. Over 18 million toilets were built in 2017 alone thanks to SBA [10]. But evidence suggests that this progress has been unequal throughout India as some states and regions have done better than others [10]. Furthermore, members of some households continue defecating in the open despite having access to a latrine [11].

There is a need to understand why improved sanitation outcomes have progressed unequally throughout India, and why despite latrine ownership, some people continue defecating in the open. More specifically, there is a need to examine the possible social determinants of latrine ownership and use in India, instead of focusing primarily on individual-level determinants.

Paper one does so by qualitatively examining people's lived experience of trying to build and use a latrine in rural Bihar, a state in north India. As of 2012, nearly 68% of households in Bihar practiced open defecation [12]. The findings from this paper are intended to guide the development of hypotheses that can be tested in the future. Paper two builds on the work of paper one and examines the association between a specific social determinant – the amount of dwelling space owned by a household – and their likelihood of latrine ownership. In places such as Bihar, the average rural households own 360 ft^2 of land [13] while the government's recommended pit latrine requires 67 ft^2 [14]. Thus there is need to examine whether people even have enough space to construct a latrine. Paper two also elucidates the amount of variation in household latrine ownership that is attributable to village and state context. Both of these papers aim to shift the focus away from individual-level determinants of latrine ownership and use towards the possible social determinants.

Anganwadi worker time use

The UN Sustainable Development Summit adopted 17 Sustainable Development Goals (SDGs) in 2015, with the aim of ensuring peace and prosperity for people around the world. SDG 3, focuses explicitly on good health and well-being. Goals to lower maternal mortality and improve child health outcomes are included within SDG 3. For example, SDG 3 calls for a reduction in the global maternal mortality rate (MMR) to less than 70 per 100,000 live

births by 2030, while also calling for a reduction in under-5 mortality to at least as low as 25 per 1,000 live births [15].

Globally, tremendous progress has been made towards both of these goals since 1990. For example, the global MMR decreased by 44% between 1990 and 2015 [16], while under-five mortality decreased by 58% between 1990 and 2017 [16]. India has also progressed towards these goals. For example, India's MMR fell nearly 64% percent between 1990 and 2015, from 495 deaths per 100,000 live births to 180 deaths per 100,000 live births [16]. During the same period, India's under-five mortality rate fell 65% from 126 per 1,000 live births to 44.1 per 1,000 live births [16].

Yet India still accounted for 15% of maternal deaths (45,000) worldwide in 2015. And while India's under-5 mortality rate now matches the global average (39 deaths per 1,000 live births), its infant mortality rate, 32 deaths per 1,000 live births, is nearly three times the global average [17]. Nearly a third of the world's 150 million stunted children live in India, and over half of the world's 50.5 million wasted children live in India [18]. Furthermore, National Family Health Survey conducted by the Ministry of Health and Family Welfare found that in 2015-2016, 53% of all Indian women were anemic. Anemia, combined with poor antenatal care, is particularly problematic as it is associated with a higher likelihood of a poor birth outcomes.

Anganwadi Workers (AWWs) have long been at the front lines of preventing morbidity and mortality among women and children in India, and continue to play that role. AWWs provide supplementary nutrition to children under the age of six and to pregnant and lactating mothers, perform health checkups for children below the age of six, refer beneficiaries to doctors, provide preschool education, and disseminate key health information regarding nutrition, family planning, and immunizations to women and children in their catchment area [19].

Time spent on these activities is one indicator of AWW performance. As such, the Ministry of Women and Child Development in India, which is responsible for managing the AWW program, has issued guidelines on the amount of time AWWs are expected to spend on key activities. Paper three of this dissertation examines the associations between various AWW characteristics – such as caste, education, and years of experience – and the likelihood that they spend the expected amount of time on home visits, feeding children, preschool education, and filling out their paper registers. Understanding these associations could help inform how AWWs with varied backgrounds can be better supported to spend the adequate amount of time providing essential services to improve the health of the mothers and children in their catchment areas.

Dissertation goals and research questions

The broad goal of this dissertation is to contribute to the understanding of the root causes of health inequalities in India by 1) understanding the social determinants of latrine ownership and use in India, and 2) examining the associations between AWW characteristics and the likelihood that the spend the expected amount of time on conducting home visits, feeding children, preschool education, and filling out paper registers. The following research questions were answered:

1. What are people's lived experiences in trying to build and use latrines in rural Bihar?

2. What are the associations between the amount of dwelling space owned by households and their likelihood of latrine ownership, and what proportion of the variation in household latrine ownership is attributable to village and state context?
3. What are the associations between AWW characteristics and the likelihood that they spend the expected amount of time on home visits, feeding children, preschool education, and filling out their paper registers?

Significance of dissertation research

The research conducted as a part of this dissertation is significant in several ways. First, this research adds to a growing body of literature that shifts the focus away from the individual-level determinants of latrine ownership and use in India towards the possible social determinants. In doing so, this research aims to contribute to the understanding of why inequalities in sanitation outcomes persist throughout India.

Additionally, AWWs are among a group of frontline health workers who are responsible for ensuring better health outcomes for women and children in India. This research contributes to the understanding of whether AWW characteristics are associated with their likelihood of spending the expected amount of time on various activities. In doing so, this research aims to contribute to the understanding of AWW performance, which is significant given the enormous role AWWs play in preventing maternal and child morbidity and mortality in India.

Paper One
The Lived Experiences of Building and Using Latrines in Rural Bihar

1. Introduction

1.1 Background

Sustainable Development Goal (SDG) 6, calls on the global community to "ensure availability and sustainable management of water and sanitation for all" [20]. This specific call was motivated in large part by the fact that in 2015, 12% of the world's population was still using some form of unimproved sanitation, and another 12% of the world's population was defecating in the open [6]. The Joint Monitoring Programme (JMP) defines unimproved sanitation as the use of pit latrines that are open to the environment (no slab or platform covering), hanging latrines, or the use of bucket latrines [6]. Unimproved sanitation also includes open defecation, which is defined as the disposal of human feces in open areas, such as fields, forests, road-side, beaches, open bodies of water, or other open spaces [6].

Open defecation, which results in the spread of untreated fecal contamination throughout the environment, is associated with a variety of negative health outcomes. For example, fecal contamination is associated with stunting, which is a common measure of linear growth retardation often used as a proxy for long-term educational and economic outcomes [21]. Untreated fecal contamination has also been linked to urinary tract infections, soil-transmitted helminth infections, trachoma, cholera, and schistosomiasis [22]. Furthermore, there is evidence that open defecation, and inadequate access to sanitation more generally, is associated with psychosocial stress. For example, one study found that women and girls in Odisha, India, experienced environmental, social, and sexual violence stressors resulting from inadequate access to sanitation [23]. Similar results have been found in Kenya where women have reported an increase in psychosocial stress due to not having access to a toilet [24].

In India, a lower middle-income country, approximately 520 million people (nearly 40% of India's total population) were still defecating in the open on a daily basis in 2015 [6]. Unimproved sanitation accounts for 2.5% of the total burden of disease in India, expressed as Disability-Adjusted Life Years [25]. Furthermore, open defecation costs India $38 billion annually as a result of health care costs, lost tourism, and losses in productivity [10].

In 2014, the Government of India launched Swachh Bharat Abhiyan (Clean India Mission) with the goal of eliminating open defecation by October 2, 2019. Official government reports suggest that over 18 million toilets were built throughout India as a part of this program in 2017 alone [10]. Yet there seems to be significant state-level variation in toilet construction and use [10, 26]. For example, in 2017, latrine coverage was 36% in Bihar compared to 96% in Maharashtra [10]. Additionally, some studies have shown that certain communities might continue defecating in the open despite owning a toilet, further contributing to the high rate of open defecation throughout India [27]. The narratives that might explain these phenomena could inform policy, investments, and practice, and as such, this paper examines people's lived experience of trying to build and use a private household latrine in rural Bihar in the age of Swachh Bharat Abhiyan.

Examining the possible determinants of population-level health outcomes is one way to elucidate unequal health outcomes [28] As such, an emerging body of literature attempts to examine the possible explanations of population-level sanitation outcomes in India. For example, one study examined gender-based experiences of owning and using latrines in Odisha, India [23]. The authors found that many women regulated their sanitation behaviors in response to various stressors, such as the threat of sexual violence, that are unique to women [23]. Furthermore, they found that women felt as though they had very little agency to improve or change their sanitation environments [23]. Additionally, women in Bangalore had varying degrees of access to sanitation during the work day based on their occupation [29]. Household characteristics, such as the number of family members living in a home, or the amount of dwelling space owned by families, could also be important social determinants of latrine access and use [26, 30]

Similarly, this research aims to examine why population-level disparities in sanitation outcomes across communities, within India, persist. Doing so could help shift the focus away from lifestyle theories of disease causation towards understanding population-level differences in sanitation outcomes, and the extent to which certain communities might be at greater risk for these poor outcomes [31].

This focus on population-level determinants is a key feature of social epidemiology, a discipline that is "distinguished by its insistence on explicitly investigating social determinants of population distributions of health, disease, and wellbeing, rather than treating such determinants as mere background to biomedical phenomena" [32]. Social determinants of health can be defined in various ways. For example, social determinants are a society's economic, political, and legal systems, both past and present [32]. Social determinants are also shaped by a society's political and economic relationships, which can be implemented through government interactions and international agreements [32]. Finally, in addition to economic, political, and legal systems, common social determinants include gender, wealth, income, occupation, social group or ethnicity, education, housing characteristics, and life stage [33].

As an extension of this focus on population-level outcomes, social epidemiology focuses on examining distal and upstream causal factors as opposed to those factors that are proximate to the individual. For example, McMichael writes, "to understand the determinants of population health in terms beyond proximate, individual-level risk factors (and their biological mediators) requires a social-ecologic systems perspective" [34]. McMichael goes on to talk about the preoccupation with trying to understand disease outcomes in terms of individual behaviors, exposure to harmful agents, and genes [34].

The social epidemiology literature emphasizes that human health cannot be separated from social, political, economic, and environmental contexts [34], and that interventions must address these factors in order to be effective [35]. Cassel's concept of "host resistance" furthers this argument and emphasizes a need to shift away from the pathways between specific etiologic factors and specific disease outcomes, toward the idea that certain groups are at higher risk for a range of diseases due to social factors [36]. Kaplan builds on Cassel's assertion by offering a definition of social environment, which encompasses Individual health, pathophysiologic pathways, genetic/constitutional factors, individual risk factors, social relationships, living conditions, neighborhoods and communities, institutions, and social and economic policies [37].

Therefore, an individual's health experiences and outcomes are a function of this dynamic, multilevel, and upstream model [37].

This paper draws on two theories that emanate from the field of social epidemiology to build upon existing literature that examines the social determinants of latrine ownership and use in India. First, it draws on Krieger's ecosocial theory which at its core asks, "who and what is responsible for population patterns of health, disease, and wellbeing…" [32]. A key tenet of this theory is agency and accountability, which explores the responsibility of institutions (government and business), academics, policy makers, and communities in shaping population-level health outcomes [32]. It also draws from the political economy of health [38]. This theory allows for the examination of the political and economic determinants of health, and emphasizes the need for structural change, and the removal of structural barriers, to ensure equity, and improve health and health service delivery [39, 40]. Thus, using this theory allows for a shift away from lifestyle theories, which prioritize an individual's responsibility to choose their health option [39].

Incorporating these two theoretical frameworks into the analysis allows for an exploration of who is, or should be, responsible for improving sanitation outcomes in places such as rural India, and what the possible structural barriers to these improvements might be. Overall, the findings from these exploratory interviews suggest that 1) not owning a toilet should not be conflated with a preference for open defecation, 2) the government's mode of payment for latrine construction could be problematic, and 3) urban bias, whether real or perceived, could also be a barrier to latrine ownership in rural areas. These findings do not confirm or reject an existing hypothesis given the small sample size. Rather they can help generate new testable hypotheses about key aspects of sanitation programs and policies in India that should be further examined with the ultimate goal of reducing unequal sanitation outcomes.

2. Methods

2.1 Study Location

This study took place in Bihar, a state in north India with poor economic, social, and health outcomes. I collected the data with the assistance of a colleague from UC Berkeley and a female translator. As per the 2011 census, Bihar has a population of over 104 million people [41]. Bihar has one of the fastest growing economies for a low-income state in India [12] but continues to lag behind the rest of India in terms of social, economic, and health outcomes. For example, Bihar performed the worst out of all Indian states in terms of MDG performance [42]. These poor outcomes seem to be clustered within historically marginalized groups. For example, 18% of all households in Bihar belong to a Scheduled Caste (SC) – the most marginalized caste group in India – and 51% of them live in poverty, the highest rate for SC households across India [12]. Furthermore, in 2012, secondary education attainment among females was the second lowest in the nation at just 15% [12].

Bihar is a compelling research site when examining the social determinants of poor sanitation outcomes because these outcomes are common across caste and income lines. In Bihar, 31% of households have access to improved sanitation and 68% of households defecate in the open in Bihar [12]. Open defecation is most common among SC households (85%) when compared with

Other Backwards Caste (71%) or General Caste (35%) [12]. Open defecation is highest among households in the lowest two income quintiles (81% and 82% respectively), but also high in the highest income quintile (49%). This research was conducted in the Supaul district of Bihar. The total population of Supaul as per the 2011 census was 2.2 million, 95% of which live in villages [43]. In 2015-2016, only 15.3% of rural households in Supaul had access to improved sanitation, which is lower than the statewide average [44].

There are 11 administrative blocks within the district of Supaul, one of which is also called Supaul. While block-level NFHS data on latrine coverage from 2015-2016 is not available, the 2011 census shows that only 10% of households in the Supaul block had access to some form of improved sanitation [43]. Within the Supaul block, our participants were from three villages, Sukhpur, Karanpur, and Baukar.

2.2 Study Sample

We sampled participants living in the Supaul district of Bihar based on our pre-specified inclusion criteria. This helped us ensure variation in age, gender, caste, household latrine ownership, occupation, and education, as each of these characteristics might be associated with latrine ownership. Our sample (N=13) included women (N=7) and men (N=6) across the life-course. As such, we interviewed unmarried boys and girls below the age of 22, women and men with young children, and women and men with grandchildren. Our participants also had varied educational backgrounds, ranging from no formal education to college educated. We also sampled across caste lines as caste identity is often associated with varying degrees of social advantage or disadvantage, which can result in varying degrees of access to material goods, such as latrines. Finally, our sample included individuals who did and did not own household latrines. This was done to help us better determine factors that enable latrine construction, and factors that inhibit it.

2.3 Data Collection

Data collection for this study took place between June and August of 2018. Overall, we conducted 13 in-depth one-on-one interviews. Six of these interviews were with men, and seven were with women. We also conducted two focus groups with men, each of which had four participants. All of the interviews were semi-structured, a format in which a rough guide of questions is followed to examine broad themes and ideas [45].

The research team began each interview by collecting basic demographic information. This included asking the respondent about their caste, age, education, occupation, and approximate monthly earnings. These questions were followed by a question about whether or not the respondent owned a household latrine. If not, the research team followed up with questions about why the respondent did not own a household latrine, whether they knew about the benefits of latrine ownership and use, waste management, and what the government could do to help people gain access to household latrines. If the respondent did have a toilet, the research team asked them questions about when their toilet was built, whether it is used consistently, what it takes to manage the waste, and why they think others in the community might not own a toilet.

All of the interviews were conducted in Hindi or Maithili (the language spoken in north Bihar) by the two primary researchers from UC Berkeley, and one female translator, who was proficient

in English, Hindi, and Maithili. Each interview was digitally recorded, and then transcribed from Hindi/Maithili to English. The translator worked alongside the researchers to ensure that each interview was being properly translated and transcribed. Furthermore, a random set of recordings and transcriptions was given to a second translator as a quality control step.

2.4 Data Analysis

We conducted thematic analysis, an iterative technique that allows for the systematic identification and organization of common themes across transcripts [46]. This was conducted over multiple iterative stages. During this period, an initial set of interview was reviewed to develop the first draft of the codebook. Notes and memos were made, and the rest of the codebook was developed from the remaining data. Each researcher individually coded each transcript line-by-line using ATLAS.ti (version 8.3.1), and then discussed how transcripts were coded, and identified discrepancies.

Table 1: Summary of our sample

		Men	Women	Total	Percent
IHHL	Yes	2	2	4	19%
	No	12	5	17	81%
Education	None/Illiterate	2	4	6	29%
	1st - 8th grade	10	1	11	52%
	9th - 12th grade	1	1	2	10%
	College and/or above	1	1	2	10%
Caste/Religion	SC	5	3	8	38%
	OBC	8	1	9	43%
	Gen	0	1	1	5%
	Muslim	1	2	3	14%
Age	18 - 24	1	4	5	24%
	25 - 39	4	1	5	24%
	40 - 65	4	1	5	24%
	> 65	5	1	6	29%
Family size	0 - 4 family members	5	2	7	33%
	5 - 8 family members	7	4	11	52%
	More than 8 family members	2	1	3	14%

In addition to these confirmatory results, this research contributes three new initial findings that could help generate new testable hypotheses that further examine sanitation programs and policies in India. First, the findings suggest that non-adoption of toilets is not equal to a preference for open defecation. Next, the design of payment mechanism used by the government to reimburse families who construct families under the SBA guidelines matters given respondents' cash flow, credit constraints, and overall SES profile. Finally, the bias towards

urban development – whether real or perceived – could be a possible barrier to improved sanitation outcomes in places such as rural Bihar.

Table 2: Summary of key indicators Bihar and India [12]

	Bihar	India
Percent of households that defecate in the open	68%	44%
Caste/Religious composition		
Scheduled Tribe	2%	9%
SC	18%	19%
OBC	62%%	43%
General	18%	29%
Muslim	17%	14%
Percent of adults with secondary school education	24%	32%
Percent of population below poverty line	34%	22%

3 Results

3.1 *"Going outside doesn't feel good, but what will we do?"*

First, all of the respondents in the sample indicated that toilets are good in some way or another. In fact, respondents describe wanting a household latrine, and that latrines are important for a variety of reasons. For example, one respondent stated, "A toilet - for safety, to live in cleanliness, to be away from dirtiness. For these reasons. So that there won't be sickness. Lots of diseases can spread from these things. A fly can sit on the shit, then come sit on your food. Lots of reasons." Another respondent stated, "We all think that there should be a toilet, so that we are protected from disease, and that we are safe from everything." These statements demonstrate that people not only want household toilets, but that they understand the links between sanitation, disease, and safety.

Next, several of the respondents describe open defecation as "majburi", and recognize just how problematic it is. Majburi is a Hindi word that translates to coercion, or something that one is forced to endure. One respondent, whose family now owns and uses a latrine, stated directly, "Going in the open was majburi for us. But how did it feel? It was very bad". Another respondent, who does not currently own a latrine, said, "Going outside does not feel good, but what will we do? We have to go, you have to shit! You have to go outside". In addition to describing open defecation as something that people are forced to endure, several respondents explicitly mentioned the risk, dangers, and shame that are associated with this health behavior. For example, one elderly female respondent said, "Going to forest. I am scared about toilet...I don't want to go at night. I don't eat food. If I eat food, then I need to go to toilet". A younger male respondent noted, "If I go outside, I have a reputation in this village ok? If someone sees

me and says, ‘oh there goes X shitting on the side of the road’, then my reputation will be ruined. So you feel shame, but also your reputation is ruined”.

Yet, while respondents described wanting a toilet, and the problems associated with open defecation, they also suggested that open defecation might be a better option if the sanitation solution they were presented with did not suit their needs, or that it could make their hygiene situation worse. One respondent said, “In the back, we dug a 5ft deep hole one time as a toilet. It was technically open. But then it filled up with all the waste and it began to stink, so we closed it by filling it with dirt. This is the story. Better than this is to shit in the open”. Similarly, another respondent’s family had also tried to build an inexpensive temporary toilet by digging a hole on their land, but said, “Yeah if it filled up, you fill it with dirt, and then you dig a new one. But then you’d have to dig a new hole in the same place again. Imagine, in a small amount of space, what will you do?”.

Furthermore, those who want a toilet are not always in decision-making positions within the family. When one respondent, a 19 year old young woman, was asked whether or not she wants a toilet, she responded, “Yes”. However, she stated, “but I don’t have money”, and stated that her father is a day laborer, but is unable to work right now because he is sick, and that the family’s earnings were going towards his care. Another young woman mentioned that her family already has one toilet but, “it’s not enough for me. I want more toilet, because my family members are bigger”. She went on to say, however, that her family will not build another one at this time because, “they are saving money for my marriage”.

3.2 *“Firstly, you have to build a toilet, then they will give you money. If I don’t have money, how I build?”*

Swachh Bharat Abhiyan offers an incentive of INR 12,000 ($172) to households that construct a toilet as a means to facilitate behavior change and adoption of improved sanitation. However, conversations revealed that the mode of payments does not seem to be working for people living in rural Bihar. To receive this money, people must first pay for the construction out of pocket, then submit a picture and forms to prove that they did so. Almost everyone we spoke with raised questions about how poor people could be expected to pay for these upfront costs. One man asked this explicitly, “For those who don’t have money, how will they build? For poor people, whatever they earn, gets spent on food to survive. How will they build a toilet?” This sentiment was echoed by many respondents, saying things like “for poor people, whatever they earn, gets spent on food to survive. How will they build a toilet?” and, “for those who don’t have money, how will they build it? You can’t build it without money.”

Others expressed fears about taking out loans to cover the costs of construction, especially since people who have gone through the motions of submitting documents for reimbursement still have not received the INR 12,000. One resident of Sukhpur laid out his rationale clearly, saying, “So what, I’ll take a loan to build a toilet, and then if the money doesn’t come [from the government] for five years, then I’ll owe twice the price of the toilet in interest. So what’s the benefit then? That’s why we defecate in the open.” Many other community members expressed similar concerns about how long it would take them to receive the money and the interest that would accumulate while they were waiting. One man explained: “Some poor family will first take a loan. But it comes on interest. So I build it, but my interest is ongoing...and now when that

INR 12,000 will come, no one knows. It's not like you make it, take the photo, submit the paperwork, and then you get the money. It could take 1 year, 2, 3. Like this. This is the problem. This is why people don't build. If everyone actually got the INR 12,000 benefit, then I think everyone would build a toilet."

Many respondents pointed to the fact that people they knew who had built toilets expecting to be reimbursed had not received the money in their accounts as evidence that the policy was flawed. One man commented, "How should I do whether they will even give the money or not. There is no guarantee of this," highlighting the lack of faith that the government would follow through on its promises, and possible corruption, as exemplified by comments about politicians "eating the money". Another man described his experience trying to access his incentive, saying, "I have written in forms and given it. But the money hasn't come. He said it would come to our account. But it didn't come to that either. I gave my mother's account. But it didn't come." Other respondents described submitting the forms multiple times in the hopes that the money would come through, but without success. This seems to contribute to the hesitancy around taking out loans since people are worried that they will end up in debt, unable to pay them back.

In addition, ambiguity vis-à-vis SBA's rules has also deterred toilet construction. One man complained, "The government keeps changing the rules…Until at least 95% of the ward has toilets, then it is open defecation free, and only after a ward becomes open defecation free will households receive the money." One man articulated the impact of this, saying, "The government keeps changing the rules, so people are scared". Others reiterated how this discourages them from building toilets because they are unsure if their neighbors will build them too and they do not want to be punished if they do not.

3.3 "We don't have any value. No one helps us with our homes. We don't have any land, no service, no one cares."

Whether real or perceived, respondents pointed to a possible bias towards urban development, and development for some, but not others. Perceptions of differential treatment and a lack of fairness seem to underlie this sentiment. As one focus group participant lamented, "[Government officials] don't care about anyone else. Those who become Mukhiya will first pray for their own stomach." Another man spoke to the impact of this, saying "The people who eat, eat a lot. But those who don't, go hungry. That's the type of country this is." Another participant raised his experience of seeing poor people not being valued or treated equally, and certain voices and experiences mattering more than others, saying, "Right now India is clean for big [wealthy] people, but it isn't clean for little people."

Some respondents explicitly indicated that this lack of faith was tied to their status as rural villagers. For example, one man said, "in the rural areas, those who are corrupt, those [politicians] eat everything." Another respondent questioned, "who is going to look after us here?". Some even tied this place-based difference to specific services. For instance, one focus group participant noted, "when women are menstruating there is a big problem. There is no toilet, so they have to go outside...In the cities maybe they have different things, but here in the villages these are the problems". Thus, despite having suggestions for improvement, respondents did not feel that the government, or anyone, was willing to listen to them.

The notion of this bias was also apparent when talking about waste management, which might could be crucial to ensuring consistent toilet use. Several respondents were asking for something better, and more comprehensive, as it pertains to waste management. For example, when asked about a centralized sewer system, one respondent said, “If we have this system, then even if the government doesn’t give any money, then we won’t have a problem. If they do this, then the government won’t have to give money for anything to the public”. In other words, this respondent suggested that the government would not have to give money for the latrine superstructure if they provided a centralized sewer system that households could plug in to. Another respondent suggested that the government “should say yes, if your pit fills, we will empty it”. While this respondent does not mention a specific method of waste management, he indicated that managing the waste should be the government’s responsibility. Yet there was a sense that these types of systems were reserved for spaces other than rural Bihar. As one respondent noted, “Delhi has all of this. Like any settlement in Delhi, I’ve seen everywhere throughout Delhi, throughout Delhi there are drains and big pits. And people living together can use a pipe in to a big drain”. This idea was echoed by another respondent who said, “look, there are cities and towns, there are bins for waste everywhere. Here, for us, where do we throw our waste? Outside the house, and then the waste will obviously spread...There is no clean India for little people”.

4. Discussion

It is evident that some of the results were consistent with the findings in other papers. For example, several female respondents indicated that they feel a sense of fear or anxiety when they defecate in the open [23, 47]. Some respondents also indicated that they are unable to build latrines due to space constraints, an issue that Jain et al. also highlight [26]. The remainder of this section examines the new findings through the theoretical lenses used in this paper.

4.1 Accountability & Agency

In 1999, the Government of India made a philosophical change in its approach to addressing inadequate access to sanitation and began advocating for lower hardware subsidies in favor of efforts that would spur demand for latrines. This approach has continued on until today, as the SBA guidelines state, “It is important that ODF has been achieved through a focus on collective behavior change and demand generation, and not through supply-driven mode” and that “sanitation is primarily a behavioral and demand driven issue…” [14]. This framing places the onus of improving sanitation outcomes on individuals, and assumes they are the primary agents of this change.

Making beneficiaries the agents of change has been reinforced by academics who suggest that generating demand for latrines can be elicited by changing individual-level knowledge, attitudes, and beliefs about the benefits of latrine ownership and use. To do so, they emphasize the need for information, education, and communication (IEC) activities. For example, Ban et al. suggest that “much needs to be done through health education outreach to make citizens aware of the connection between sanitation and their own wellbeing in terms of exposure to disease” [48]. Banda et al. suggest something similar as the respondents in their study did not seem to know that there was an association between open defecation and diarrheal disease [49], while Pattanayak et al. call for shaming through social pressure as a means of demand generation [50].

Yet researchers have found that IEC activities tend to rely too heavily on making individuals the agents of change, and that there is not enough evidence to suggest that this even works [51, 52]. It should be noted, however, that some behavior change programs, such as CLTS, attempt to make entire communities the agents of change by triggering feelings of shame and disgust to change community-wide attitudes, behaviors, and beliefs towards sanitation. However, even these attempts are largely underpinned by individual-level theories of behavior change [53]. Furthermore, CLTS inappropriately assumes homogeneity within communities (caste, income status, education levels, etc) [54], and the ethical concerns with triggering shame and putting community needs ahead of individual rights have been well documented [55-57]. These issues, coupled with the fact that many people might already be aware of the health, social, and economic benefits of toilet use, brings into question why demand generation via IEC, at either the individual or community level, remains the preferred policy approach.

Additionally, respondents in this study had very concrete suggestions for how the government could change its sanitation policies based on their lived economic, social, and political realities, to ensure better sanitation outcomes. However, they were doubtful that their concerns would be heard. This underscores the fact that the range of their agency is severely limited, largely confined to changing factors proximate to themselves.

This limited agency is certainly not unique to people living without adequate access to sanitation in India. Borrowing from development theory, Ferguson talks about the concept of depoliticization, which posits that development projects often fail to acknowledge the economic, political, or social realities of a community or society [58]. That the government's recommended toilet design in rural India requires people to manage their own waste typifies this point given that notions of purity and pollution, which stem from India's ancient caste system, deter people from wanting to manage their own waste [11]. And while social norms emanating from India's caste system are in themselves dangerous and should be changed, it is important to question why, despite this widespread rejection of waste management, policy makers, program implementers, and academics continue calling for these types of toilet technologies, and why waste management has been so chronically underfunded [52].

Thus, people such as the respondents in this study, might be being held accountable for actuating change within themselves. Yet, they do not feel as they have any agency to advocate for change at higher levels, which could in many ways absolve the state and policy makers of being held accountable for the types of services they deliver. This could be true in the context of waste management, a key step on the sanitation value chain. Future research could examine whether making waste management the responsibility of the government could motivate people to build, and use, household toilets more consistently.

4.2 Structural barriers and the need for structural change

These initial findings also point to the various structural barriers that might inhibit people's ability to gain access to a toilet. For example, respondents identified a variety of issues with the mode of payment, including the fact that there is ambiguity with regards to when households might actually receive the reimbursement. In fact, section 5.2.9 of the SBA guidelines note, "States may decide to provide incentive to households in two or more phases at different stages

of construction and usage. In the case of community incentive model, the state may also release the funds to an entire village after it has been open defecation free for a significant length of time" [14]. This structure has led to the perception that SBA's rules and policies are inconsistent, which has led many people to become skeptical of the program and deterred from building toilets, as noted in the results.

Most respondents indicated that they could not afford the upfront cost of toilet construction, thereby highlighting the fact that structuring the payment as a reimbursement is problematic. There could be a possible moral hazard associated providing the money upfront, but this argument is often used as a mechanism by state actors to scale back public services [59], which is in and of itself a structural barrier to improved sanitation. Additionally, this could be avoided altogether if the government built the toilets, as some respondents suggested.

The question of *what* people are being asked to spend this INR 12,000 on is also worth examining. Dupas notes that short-term subsidies increase long-term adoption if the new technology has a lower usage cost than the status quo [60]. In this case, the status quo is open defecation (no financial cost to use), while the new technology (the twin-pit latrine) requires people to not only build the toilet superstructure, but manage the waste over the long-run.

Perhaps then the type of sanitation technologies being promoted in places like rural India undermine the need for structural change, such as government supplied waste management services, which are far more common in urban India (although certainly not ubiquitous). The twin-pit latrine is one such example, as are the toilet designs encouraged by the Gates Reinvent the Toilet Challenge, which call for pro-poor toilets that are "designed to kill pathogens that make people sick and transform human waste into valuable resources at a low cost to users – all without connections to water supply or sewer systems" [61]. The provision of government waste management services has been further undermined by academics who claim, without citation, that "sewers and sewage treatment facilities in rural areas is very costly…" [62]. This leads to a question similar to the one Pulido asks when writing about the ongoing water crisis in Flint MI [63] - are sewers and sewage systems too expensive, or are our respondents right to believe their lives have been overlooked in favor of the lives of those in urban areas, to the point where government and policy makers do not feel the need to institute structural changes which could perhaps lead to better sanitation outcomes?

Examining these results through the lens of structural barriers re-emphasizes the need to further examine the associations between waste management and latrine ownership and use. More research is required to determine the feasibility of more centralized waste management systems. Additionally, looking at these findings through this lens also suggests that future research should examine SBA's mode of payment. Research should look at alternative modes of payment (upfront versus ex post), along with varying amounts, to elucidate the associations between SBA's mode of payment and household latrine ownership and use.

5. Conclusions

October 2, 2019 marks the five-year anniversary of SBA. This national program has helped millions of families throughout India build latrines. Yet progress remains unequal. In the Supaul

district of Bihar, for example, only 15% of households had a latrine in 2015. Understanding why sanitation progress remains unequal is key to ensuring improved sanitation outcomes. This paper explored people's lived experiences of trying to build and use latrines in rural Bihar, with an explicit focus on agency and accountability, and structural barriers. In doing so, this paper helps generate new hypotheses about the possible social determinants of latrine ownership and use throughout India, by suggesting that 1) not owning a latrine cannot be conflated with a preference for open defecation, 2) SBA's mode of payment might need to be redesigned, and 3) a bias towards urban development might be a barrier to sanitation progress in rural India. Future research on these three themes could elucidate the social determinants of latrine ownership and use in India, and could inform policies that result in more equitable sanitation outcomes.

Paper Two
Sanitation in Rural India: Exploring the Associations between Dwelling Space and Household Latrine Ownership

1. Introduction

In 2010, the UN General Assembly established access to safe drinking water and toilets as basic rights as they are essential for the "full enjoyment of life and all human rights" [64]. This resolution was adopted because inadequate access to toilets can lead to open defecation, resulting in the spread of fecal contamination throughout the environment. If left untreated, pathogens from this contamination can spread diarrheal disease, the second leading cause of death in children worldwide aged 1 – 59 months in 2015 [65]. Fecal contamination can also lead to urinary tract infections, soil-transmitted helminth infections, trachoma, cholera, and schistosomiasis [11], and is associated with stunting, a measure of linear growth retardation that can be used as a proxy for economic or educational outcomes [21]. Inadequate access to sanitation also exposes women and girls to unsafe, and sometimes violent, situations [66], while also making menstrual hygiene management extremely difficult. Women in India, for example, have reported withholding food and water in order to limit the number of times they might have to urinate or defecate either during the day or at night [47], while women in Kenya have noted an increase in psychosocial stress associated with not having access to a toilet [24]. Thus, toilets are necessary as a means to prevent infectious diseases, and can also help ensure physical and mental well-being.

In India, a lower middle-income country with a GDP per capita of $1,940 in 2017 [67], approximately 520 million people (almost 40% of the total population) do not have access to any kind of toilet, and thus defecate in the open [65]. Open defecation accounts for nearly 2.5% of the national burden of disease in India, expressed as Disability Adjusted Life-Years according to the Institute for Health Metrics and Evaluation [25], and is estimated to cost India $38 billion annually due to health care costs, losses in productivity, and losses in tourism [26].

The Government of India has engaged in efforts to improve toilet coverage over the past several decades. For example, the Central Rural Sanitation Programme, which was founded in 1986, worked with state governments to provide subsidies for individual household latrine construction throughout India [68]. This nation-wide program became the Total Sanitation Campaign in 1999, which evolved in to Swachh Bharat Abhiyan (SBA) in 2014.

Behavior change curricula, such as Community-Led Total Sanitation (CLTS), have also tried to spur demand for toilet construction by raising awareness about the negative consequences of open defecation [68]. CLTS has been implemented throughout India, in addition to South Asia, East Asia Africa, Latin America and the Caribbean [68]. Families living in communities exposed to CLTS are thus supposed to encourage one another to construct and use toilets [68]. However, there is inconclusive evidence that behavior change curricula such as CLTS are effective in encouraging toilet construction [69]. Additionally, CLTS is primarily underpinned by theoretical frameworks designed to motivate individual-level health behavior change, and thus might not account for a broader set of contextual determinants of toilet ownership and use [53]. For example, CLTS has not historically considered the role of gender as a determinant of toilet ownership or use in India [54].

A growing body of literature has started examining the possible social determinants of latrine ownership and use in places such as India. Social determinants can be defined as "…specific features of and pathways by which societal conditions affect health and that potentially can be altered by informed action" [32]. In other words, social context is thought to influence health various health behaviors and outcomes. For example, Novotny et al. conclude that sanitation change will not be achieved "through specific interventions alone without addressing structural constraints related to educational, economic, and sociocultural inequalities" [70]. Coffey et al. examined one such sociocultural inequality, India's deeply entrenched caste system, which might perpetuate open defecation. They found that notions of untouchability that stem from India's caste hierarchy deter people from using their pit latrines as they do not want to clean them out when they fill up [62].

Housing characteristics are also considered social determinants of health outcomes [71], and might be associated with sanitation outcomes. For example, recent studies in Uzbekistan and China suggest that certain housing characteristics, such as access to centralized water supply, are positively associated with improved water-borne illness outcomes and improved sanitation coverage rates [72, 73]. Another critical housing characteristic, the amount of dwelling space owned by a family, is important because the toilet design recommended by the Government of India requires 67ft^2 of land [14]. The World Health Organization (WHO) issued Guidelines for Healthy Housing in 1988, which noted the importance of specifying residential density norms so that households would have enough space for a clean latrine, to ensure good environmental conditions and hygiene [74]. The report notes that access to sanitation is less likely for those families that live on insufficient amounts of land as they do not have enough space for building a toilet and managing waste [74].

Dwipayanti identified various other social determinants that might be associated with poor sanitation outcomes in Bali, Indonesia [75]. These include poor collaboration, and a lack of capacity, amongst local government agencies responsible for improving sanitation coverage, village-level economic and social conditions, and a misallocation of responsibility amongst the various agencies responsible for sanitation [75]. Additionally, 13% of the variation in household-level poverty in India is attributable state-level factors, while 12% is attributable to village-level factors [76]. Thus, state and village variation in household poverty, along with the social determinants identified by Dwipayanti, suggest that contextual factors at both the village and state levels might be associated with poor sanitation outcomes in India.

Thus, the purpose of this paper is to analyze data from the 69th Round of the National Sample Survey in India to 1) elucidate the associations between the amount of dwelling space owned by a household and latrine ownership; 2) examine what proportion of the variation in household latrine ownership is attributable to village-level or state-level factors, using a three-level multilevel analysis (household, village, state). Our hypotheses were that 1) households with larger amounts of dwelling space are more likely to own a toilet than those households with smaller amounts of dwelling space, and 2) there is village-level and state-level variation in toilet ownership.

2. Methods

2.1 Data

2.1.1 Sampling Strategy

We used the 69th round of the National Sample Survey (NSS) in India, which took place between July–December 2012 to access data about latrine ownership and access [13], which was made available by the National Sample Survey Office (NSSO) at the Ministry of Statistics and Program Implementation in India. This survey used a stratified multi-stage sampling design to determine household-level access to drinking water, sanitation, and housing characteristics, as described in the survey report published by the NSSO [77]. We restricted analyses to rural areas in all states and Union Territories. A full description of how villages were selected can be found in the NSSO report [77].

2.1.2 Sample Size and Outcome

We restricted our analysis to rural India, where the majority of households that lack access to a toilet are located [6]. Overall, the survey captured data from 53,361 rural households located in 4,453 rural villages. Latrine access in the survey was divided in to five categories: (1) exclusive use by household, (2) common use by households in a building, (3) public/community latrine without payment, (4) public/community latrine with payment, and (5) no latrine. For the purposes of this paper, we only considered categories (1) and (5). This is because the World Health Organization's Joint Monitoring Program defines improved sanitation as those "facilities that are designed to hygienically separate excreta from human contact, and that are not shared with other households" [6]. There are several reasons why shared sanitation is not considered improved. For example, some studies suggest that shared sanitation facilities are harder to maintain, leading to unhygienic conditions, which could deter consistent toilet use [78-82]. Thus, we analyzed data from 48,793 households located in 4,432 villages after restricting the sample to only those households either with an exclusive household toilet or no toilet at all.

2.2 Measures

2.2.1 Independent Variables

Primary predictor variable: Amount of dwelling land owned by a household was divided by 100 to look at the association between every 100ft^2 increase in dwelling space and household latrine ownership. We also included a squared term for dwelling space owned by a household as the association between dwelling space owned and latrine ownership might not be linear.

Covariates: We included total monthly expenditure (divided by 250 Rupees to facilitate interpretation), gender of household head (m/f), household head age (years), caste (scheduled tribe, scheduled caste, and other backwards caste), highest educated male in the household, highest educated female in the household, and total number of family members. We also included various household characteristic variables such as dwelling condition[1] (good, satisfactory, and bad), household electrification, floor type, access to drainage[2] (underground, covered solid, open solid,

[1]Condition refers to the structure of the dwelling. Enumerators subjectively assessed whether it was good, satisfactory, or bad.

[2] Drainage refers to how liquid/solid waste is removed from the dwelling. Solid drainage refers to the system being built with concrete, while open means that it was open to the environment without any cover

open, and no drainage), and roof type. Average amount of dwelling space owned by households in each village and in each state was also included.

Interaction Terms: Our analysis included two interaction terms to test if the association between household dwelling space and toilet ownership is moderated by the average amount of land owned by households in a given village or state. These interaction terms were included because we hypothesized that the strength and direction of the association between the amount of household dwelling space and the likelihood of latrine ownership could be influenced by average household dwelling space by village or by state.

2.3 Analysis

2.3.1 Levels of Analysis

We conducted a three-level analysis in which households (level-1) were nested in villages (level-2), which were nested in states (level-3). We hypothesized that contextual factors at each of the higher levels of analysis could be associated with household (level-1) toilet ownership.

India underwent large economic and political reform in 1991 [83], during which time states were granted greater autonomy in how policies are implemented. This variation in policy implementation at the state-level highlights the importance of conducting state-level analysis. Variation in economic outcomes could potentially be associated with a variation in household toilet ownership between states, given the significant variation in state-level economic performance and outcomes [84].

Villages represent the most similar social, political, and economic environments in which a household could be nested [76]. Thus, there is a need to examine village-level variation in household toilet ownership.

2.3.2 Analytical Approach

We specified four random-intercept logistic regression models to assess the probability of toilet ownership of household i in village j in state k ($y_{ijk} = 1$). The four models built on one another in the following way: (1) a fully unadjusted model with only the primary predictor, (2) household-level demographic variables added, (3) housing characteristics added, and (4) average household dwelling space by village and state added. In this final model, we also included two cross-level interaction terms between household dwelling space and the average dwelling space owned by village and state, respectively.

Each model took the basic form of: $\text{logit}(\pi_{ijk}) = \beta_0 + \beta X'_{ijk} + (u_{0j} + v_{0jk})$, where β_0 is the odds ratio of owning a toilet for a household in the referent category for all of the categorical variables, and when all of the continuous variables are equal to 0, and X' is the set of variables specified above. We transformed each of the log-odds values to an odds ratio by exponentiating the log-odds result for easier interpretation. In these models, we assume that both random effects (u_{0j} and v_{0jk}) are normally distributed with variances of σ^2_{u0j} and σ^2_{v0jk} respectively, which signify the between village and between state variations in the odds ratio of latrine ownership, after adjusting for the household level and village level variables. It should be noted that it is not possible to ascertain the level 1 (household) random effect or variance in a logistic regression. Next, we used the

variance estimates of the random effects to calculate the variance partitioning coefficient (VPC). This highlighted the proportion of the variation in the log odds of household latrine ownership attributable to the village-level and state-level [85]. We used the latent variable method to calculate the VPC. This method allows for the VPC to be calculated by dividing the variance attributable to a particular level by the total variance. Browne et al. describe the latent variable method and show that it allows for the estimation for the level 1 variance to be $\pi^2/3 = 3.29$ [85]. This value is used given that there is no level 1 variance in logistic regressions. Thus Browne et al. also show that the variance for level-2, j, is calculated using the following formula: $\sigma^2_j/(\sigma^2_j + \sigma^2_z + 3.29)$, where the subscript σ^2_z denotes the level-3 variance [85].

Lastly, we conducted a sensitivity analysis by running a state-level fixed effects model to control for all possible state-level covariates. We did this by including dummy variables for each state in to each of our four regression models (description of models in regression results section). We did not include Delhi, Chandigarh, Sikkim, or Lakshadweep as these four Union Territories/States all reported having 100% toilet ownership, and would thus be dropped from the fixed effects model.

We used Stata 13 SE for descriptive statistics. We used MLwiN 3.00 to conduct the multilevel logistic regression analysis for both the three level models and the sensitivity analysis. More specifically, we used iterative generalized least squares (IGLS) to estimate all of the parameters in each of our random effects models and the fixed effects models.

3. Results

We analyzed 48,793 households nested in 4,432 villages and in all 28 states and seven union territories in India[3]. The largest sample of villages and households was in Uttar Pradesh with 4,914 households in 606 villages, while Dadra & Nagar (D&N) Haveli was the smallest third-level territory with seven villages and 55 households. Jharkhand and Odisha had the lowest percentage of household latrine ownership, at 14% and 15% respectively. Overall, 52.9% of the households in our sample did not have a toilet. Furthermore, 87.1% of the households had a male head, while the largest share of households (40.5%) belonged to the Other Backwards Caste category. Additionally, 55.4% of the households in our sample had between three and six family members. In terms of household characteristics, 53.7% of the houses in our sample did not have access to any form of drainage, but 78.2% were electrified. A full set of descriptive statistics, and chi-square test values for all of the covariates we included in our models, is shown in the table below.

Table 1. Descriptive Statistics and Chi Square Test Values.

	Household Latrine Access		Percent with Latrine	Chi Square Test for Independence
	No	Yes		
Household Dwelling Space Tertiles (sq ft)				
<= 270	14,349	2,155	13%	χ^2 (2) = 9,300
>270 & <=629	12,740	9,512	43%	p = 0.000
>629	2,844	7,193	72%	

[3] There are seven union territories in India. These areas are controlled directly by the federal (national) government. It should also be noted that there were 28 states at the time of this survey (2012), but there are now 29.

Monthly Household Expenditure Tertiles (Rupees)				
<= 3,435	11,956	2,608	18%	χ^2 (2) = 6,700
>3,435 & <= 7,000	15,078	9,431	38%	p = 0.000
>7,000	2,899	6,821	70%	
Household Head Gender				
Female	3,887	2,389	38%	χ^2 (1) = 1.05
Male	26,046	16,471	39%	p = 0.31
Household Head Age (years)				
Below 18	259	134	34%	χ^2 (1) = 3.47
Above 18	29,674	18,726	39%	p = 0.063
Caste Groups				
Scheduled Caste	4,416	3,967	47%	χ^2 (3) = 3,600
Scheduled Tribe	7,741	2,296	23%	p = 0.000
Other Backwards Caste	13,425	6,316	32%	
Other	4,351	6,281	59%	
Male Formal Education				
No Formal Education	5,321	743	12%	χ^2(4) = 4,200
Literate w/o school, or below primary	2,816	890	24%	p = 0.000
Primary & upper primary	12,043	6,165	34%	
Secondary & higher secondary	6,970	7,328	51%	
Diploma & above	2,783	3,734	57%	
Female Formal Education				
No Formal Education	10,844	1,863	15%	χ^2 (4) = 6,400
Literate w/o school, or below primary	3,426	1,250	27%	p = 0.000
Primary & upper primary	10,419	7,460	42%	
Secondary & higher secondary	4,157	6,329	60%	
Diploma & above	1,087	1,958	64%	
Housing Condition				
Good	5,953	9,072	60%	χ^2 (2) = 5,000
Satisfactory	15,531	7,896	34%	p = 0.000
Bad	8,449	1,892	18%	
Floor Type				
Mud Floor	21,089	5,904	22%	χ^2 (1) = 7,200
Other	8,844	12,956	59%	p = 0.000
Household Drainage				
Underground	1,145	1,649	59%	χ^2 (4) = 2,200
Covered Solid	950	1,260	57%	p = 0.000
Open Solid	3,428	3,769	52%	
Open	6,086	4,260	41%	
No Drainage	18,324	7,922	30%	
Household Electricity				
Not electrified	9,110	1,537	14%	χ^2 (1) = 3,400
Electrified	20,823	17,323	45%	p = 0.000
Household Size (# of people)				
<= 3	8,749	4,374	33%	χ^2 (2) = 219.1
>3 & <= 6	15,872	10,708	40%	p = 0.000

>7	5,312	3,778	42%	
Roof Type				
Grass/leaves/straw/bamboo	8,764	2,123	20%	χ^2 (6) = 5,800
Timber	1,702	436	20%	p = 0.000
Burnt brick/stone	7,530	2,755	27%	
Iron/metal sheet	2,479	1,075	30%	
Cement/RBC/RCC	4,667	6,336	58%	
Other solid	4,501	5,903	57%	
Other	290	232	44%	

Latrine ownership was significantly associated with having a larger household dwelling space (Model 1 odds-ratio: 1.35, 95% CI: 1.34, 1.37) (Table 2). This finding was sustained with the inclusion of monthly household expenditure and age of household head, both of which were associated with significantly higher odds of latrine ownership (Model 2 odds-ratio: 1.53, 95% CI: 1.49, 1.57). The findings were also significant after controlling for housing characteristics (Model 3, odds-ratio: 1.35, 95% CI: 1.31, 1.38), and when controlling for household-level socioeconomic variables, housing conditions, and the average amount of space owned by households by village and state (Model 4, odds-ratio: 1.15, 95% CI: 1.09, 1.22).

In examining the other covariates included in the analytic models, we found that higher odds of latrine ownership were significantly associated with having a higher monthly household expenditure and older head of household, and these associations remain consistent throughout models 2, 3, and 4. Conversely, we found that significantly lower odds of latrine ownership were associated with being of a certain caste (ST, SC, and OBC households), as well as being in a household in which the highest educated man or woman had less than a college degree.

There were higher odds of latrine ownership among households with electricity, and those classified as either in good or satisfactory condition compared with those without electricity or in bad condition. Lower odds of latrine ownership were associated with living in households with mud floors (compared with solid floors), open-solid drainage, open drainage, no drainage (compared with underground drainage), and with greater than three family members (compared with fewer than three family members). We found that the odds associated with latrine ownership increased significantly as the average amount of land owned by households in a village or state increased (by 100 ft^2).

Lastly, we interpreted the interaction terms and found that the average amount of dwelling space owned by households in a village or state significantly moderates the relationship between the amount of dwelling space owned by a household and the likelihood of latrine ownership (Model 4, odds-ratio: 0.99, 95% CI 0.99, 1.00 & odds-ratio: 1.03, 95% CI 1.02, 1.04, respectively). Thus, the odds of latrine ownership associated with the amount of dwelling space owned by a household increased significantly when the average amount of land owned by households in a village or state increased (by 0.99 and 1.03, respectively).

We conducted sensitivity analysis by running a state-level fixed effects model that controlled for all state-level variables that might be associated with latrine ownership. We re-did the analysis for models 1 and 4 described above by including dummy variables for each state.

The results of this analysis, presented in the appendix 1, show that higher odds of latrine ownership were significantly associated with larger household dwelling space. Thus, even after controlling for state-level variables that might have been also associated with the odds of latrine ownership, the same household-level covariates remain significantly associated with the odds of latrine ownership.

Table 2. Regression results (95% CI of OR in parentheses). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Response	Model 1		Model 2		Model 3		Model 4	
Fixed Part								
Constant	0.58	(0.25, 1.33)	1.26	(0.5, 3.16)	2.36*	(0.90, 6.20)	0.06 **	(0.00, 0.92)
Total Dwelling Space (per 100 ft^2)	1.35 ***	(1.34, 1.37)	1.53 ***	(1.49, 1.57)	1.35 ***	(1.31, 1.38)	1.15 ***	(1.09, 1.22)
Total Dwelling Space (per 100 ft^2) Squared			0.99 ***	(0.99, 0.99)	0.99 ***	(0.991, 0.993)	1.00 ***	(0.99, 1.00)
Total Monthly Expense (per 250 Rupees)			1.01 ***	(1.008, 1.013)	1.01 ***	(1.00, 1.01)	1.01 ***	(1.00, 1.01)
Household Head Gender			1.10 **	(1.01, 1.20)	1.13 **	(1.03, 1.25)	1.10 **	(1.01, 1.20)
HH Head Age			1.08	(0.92, 1.27)	1.12	(0.95, 1.34)	1.10	(0.94, 1.29)
Scheduled Tribe			0.39 ***	(0.34, 0.45)	0.52 ***	(0.46, 0.60)	0.56 ***	(0.49, 0.63)
Scheduled Caste			0.49 ***	(0.44, 0.54)	0.57 ***	(0.52, 0.63)	0.63 ***	(0.58, 0.69)
Other Backwards Caste			0.66 ***	(0.60, 0.71)	0.71 ***	(0.65, 0.78)	0.75 ***	(0.69, 0.81)
Male Ed: Illiterate			0.45 ***	(0.40, 0.51)	0.56 ***	(0.49, 0.64)	0.63 ***	(0.56, 0.71)
Male Ed: Literate w/o School or Below Primary			0.51 ***	(0.44, 0.58)	0.63 ***	(0.54, 0.73)	0.68 ***	(0.60, 0.78)
Male Ed: Primary and Upper Primary			0.54 ***	(0.49, 0.59)	0.63 ***	(0.57, 0.70)	0.68 ***	(0.62, 0.75)
Male Ed: Secondary and Higher Secondary			0.73 ***	(0.67, 0.80)	0.78 ***	(0.70, 0.86)	0.81 ***	(0.74, 0.89)
Female Ed: Illiterate			0.43 ***	(0.38, 0.49)	0.53 ***	(0.46, 0.61)	0.59 ***	(0.52, 0.67)
Female Ed: Literate w/o School or Below Primary			0.48 ***	(0.41, 0.55)	0.61 ***	(0.52, 0.72)	0.66 ***	(0.57, 0.77)
Female Ed: Primary and Upper Primary			0.57 ***	(0.51, 0.65)	0.69 ***	(0.60, 0.79)	0.73 ***	(0.65, 0.83)
Female Ed: Secondary and Higher Secondary			0.76 ***	(0.67, 0.86)	0.84 **	(0.73, 0.96)	0.87 **	(0.77, 0.99)
Mud Floor					0.50 ***	(0.46, 0.54)	0.55 ***	(0.51, 0.59)
Condition: Good					1.81 ***	(1.61, 2.02)	1.59 ***	(1.44, 1.77)
Condition: Satisfactory					1.29 ***	(1.17, 1.42)	1.21 ***	(1.11, 1.32)
Drainage: Covered					0.88	(0.73, 1.04)	0.85 *	(0.73, 1.01)
Drainage: Open Solid					0.71 ***	(0.61, 0.82)	0.73 ***	(0.64, 0.83)
Drainage: Open					0.53 ***	(0.46, 0.61)	0.57 ***	(0.49, 0.65)
No Drainage					0.35 ***	(0.30, 0.40)	0.41 ***	(0.36, 0.46)
Electrified HH					1.95 ***	(1.176, 2.16)	1.73 ***	(1.58, 1.89)
HH Size: >3 and ≤6					0.81 ***	(0.75, 0.87)	0.84 ***	(0.78, 0.90)
HH Size: >7					0.67 ***	(0.60, 0.74)	0.70 ***	(0.64, 0.77)
Roof Type: Grass/Leaves/Straw/Bamboo, etc.					0.62 ***	(0.55, 0.69)	0.72 ***	(0.65, 0.80)
Roof Type: Other					0.71 ***	(0.60, 0.85)	0.75 ***	(0.64, 0.88)
Roof Type: Timber					0.77 ***	(0.70, 0.85)	0.81 ***	(0.74, 0.89)
Roof Type: Burnt Brick/Stone					0.66 ***	(0.57, 0.76)	0.72 ***	(0.63, 0.81)
Roof Type: Iron/Metal Sheet					0.74 ***	(0.66, 0.82)	0.78 ***	(0.71, 0.86)
Roof Type: Other Solid					0.86	(0.65, 1.15)	0.90	(0.69, 1.17)
Mean Village Dwelling Space (per 100 ft^2)							1.05 **	(1.01, 1.09)
Mean State Dwelling Space (per 100 ft^2)							2.01 **	(1.17, 3.46)
Village HH Dwelling Space Interaction							0.99 ***	(0.99, 1.00)
State HH Dwelling Space Interaction							1.03 ***	(1.02, 1.04)
Random Part								
State Variance	6.07		6.166		6.472		4.323	
Village Variance	1.159		1.171		1.216		0.773	

3.1. Partitioning the Variance

In model 1, we found that 11.1% of the variation in latrine ownership is attributable to the village-level, while 57.7% is attributable to the state-level. Furthermore, we found that there is not much change in the proportion of variance attributable to the village and state levels when comparing models 1, 2, and 3 (Appendix, Table 2). For example, in model 3, we found that 11.2% of the variation in latrine ownership is attributable to villages, while 58.9% of the variation is attributable to states. The total amount of variance attributable to the village and state levels decreases in model 4, however, after we included covariates at each of these levels.

4. Discussion

Our key findings were that the amount of dwelling space owned by households was significantly associated with latrine ownership after adjusting for all household-level covariates, and after adjusting for the average amount of dwelling space at the village and state levels. This association remained significant even in our fixed effects model in which we controlled for all state-level covariates. Furthermore, our finding that the average amount of dwelling space owned by households in a village or state significantly moderates the aforementioned relationship could be reflective of the effects of community-wide crowding or density on the likelihood of latrine ownership. Lastly, 11.1% and 11.2% of the variation in household latrine ownership is attributable to villages, while 57.7% and 58.9% of the variation in household latrine ownership is attributable to states (in our fully unadjusted and adjusted models, respectively). This is possibly indicative of some contextual factors at the village-level and state-level that are associated with household latrine ownership.

There are several limitations to the current study. First, the amount of land owned by a family is often considered a proxy for wealth [86], and thus it might not be a true predictor as we hypothesize it to be in this paper. We mitigated for this by including household-level socioeconomic covariates and housing characteristics, which would account for the "wealth effect", but may not have accounted for it fully. Additionally, the unit of measurement for area varies regionally across India. Thus, respondents and enumerators might not have accurately captured exactly how much dwelling space a given household owned. Next, these data were initially collected in 2012. While not outdated, they were collected almost six years ago. The number of toilets that have been built since then has increased significantly under SBA, which is not reflected in this analysis. The survey also did not capture certain key demographic information, such as the number of individuals by age in a household. Furthermore, while we used 2nd-order Predictive Quasi-Likelihood (2PQL) to estimate the parameters in our random effects models, we used 1st-order PQL to estimate our parameters in our fixed effects model due to constraints within MLwiN. This could impact the parameter estimates as estimates from 1PQL are often biased downwards [76].

Despite these possible limitations, these findings, which quantify the association between dwelling space and the likelihood of latrine ownership, could have several implications. For example, in states such as Bihar, a latrine, which is 67ft^2, would take up 18.1% of a household's dwelling space. Families might be deterred from investing in this infrastructure given that it takes up so much space, especially considering that most Indian households in the sample we analyzed have between three and six family members, which increases crowding thus further decreasing the amount of available space.

Additionally, these findings could further the claims that programs such as SBA and CLTS do not do enough to help families actually gain access to a toilet. While SBA was designed to provide financial assistance for latrine construction, no aspect of the policy was designed to account for space constraints that might prohibit a family's ability to build a toilet. Similarly, CLTS hoped to trigger demand for toilet construction by first spurring awareness about the importance of sanitation. Yet focusing on altering individual attitudes about the importance of sanitation can not help families overcome space constraints. Thus, these findings could be used to suggest that other types of sanitation be considered as policy makers and governments seek to end open defecation.

For example, while individual household latrines (exclusively for one family) are considered the gold standard, shared sanitation facilities could be a viable option for those households and communities that have insufficient space, something the World Bank acknowledges [87].

Our results show that a considerable proportion of variation in household latrine ownership is attributable to both village and state conditions. This remains true even after controlling for the average amount of land owned by households per village and state. This suggests that there are possible village-level and state-level contextual factors that are associated with household latrine ownership. For example, Shakya et al. found that social cohesion was a predictor of latrine ownership, a community-wide effect on toilet ownership [88]. Corruption at the village/state levels could also impact latrine ownership outcomes. Indeed, a wide range of corrupt practices in sanitation service delivery were found throughout India [89]. Yet neither social cohesion nor corruption were focuses of this paper, and more research would need to be done to investigate the association between theses village and state level factors on latrine ownership.

Lastly, only 5.7% of the households in our sample had access to underground drainage. In fact, 53.7% of the households in our sample did not have access to any form of drainage. This leaves many families without an option for waste management. Our analysis reveals that the estimated odds of household latrine ownership for those with access to underground drainage are 2.7 as much as for households without any drainage (odds-ratio: 0.35, 95% CI: 0.30, 0.40). Having underground drainage could be an indicator of greater household wealth, which in and of itself could be a predictor of latrine ownership. However, we control for household socio-economic variables to help account for this effect.

The absence of adequate waste management options could deter family latrine family ownership for another reason. That is, the Indian government's recommended sanitation technology in rural communities is the pit latrine. Waste is stored in underground pits, which once full, need to be manually emptied. The ritual impurity associated with this task – stemming from India's ancient caste system – could serve as a deterrent to toilet ownership or use [4].

5. Conclusions

Despite decades of government-led sanitation interventions, approximately 520 million people continue defecating in the open throughout India [9]. Our findings, that there exists a significant association between the amount of dwelling space owned by a family and the odds of latrine ownership, could explain why rates of latrine ownership remain low in India, where the average rural household owns less than 500ft^2. We also found that this association could be moderated by the mean amount of household dwelling space owned at the village and state levels, which could be indicative of the association between over-crowding and latrine ownership. Lastly, variation in latrine ownership attributable to both villages and states underscores the need for further investigation in to various factors that could also be associated with latrine ownership. For example, further research might be needed to understand the associations between state-specific sanitation policies, social cohesion, and corruption on latrine ownership. Overall, our findings suggest that sanitation interventions should consider these, and other, social determinants as a way to bolster India's progress towards achieving universal sanitation coverage.

Paper Three
Anganwadi Worker Time Use in Madhya Pradesh, India

1. Introduction

1. 1 Background

The role of community health workers (CHWs) has expanded considerably over the past 50 years. A World Health Organization (WHO) report from 2006 highlights that there is a chronic shortage of experienced health care workers, especially in low-and-middle-income countries (LMICs) [90]. Many of these countries, for example, are simply unable to train and sustain an educated health workforce needed to ensure well-being and good health [90]. Thus, the burden of morbidity and mortality, particularly in poor countries, often falls on the shoulders of a limited number of professionally trained health care workers [91].

The need for CHWs was reaffirmed by the Joint Learning Initiative (JLI),a consortium of health leaders who convened in 2004 to strengthen human resources and change the approach to preventive health in order to prevent health crises in LMICs. One proposed strategy for improving outcomes was "task-shifting", or delegating the simplest health care tasks from health professions to local community members [91]. This approach could reduce the workload on professional health care workers while ensuring that community members have their basic health care needs met. Historically, CHWs perform a far more intrinsic role than simply providing the most basic health services. For example, Kahssay et al. suggest that "the most important developmental or promotional role of the CHW is to act as a bridge between the community and the formal health services in all aspects of health development" [92]. In bridging this gap, CHWs can help ensure that their beneficiaries are receiving the care that they need.

A number of studies have examined CHW impact and have demonstrated that CHWs are essential to improving health outcomes. For example, in a meta-analysis of community-based interventions in India, Tanzania, Pakistan, Philippines, Nepal, Bangladesh, and Indonesia, CHW efforts to identify and treat pneumonia led to a 24% reduction in mortality among neonates, infants, and preschool children in India [93]. In another study set in Ethiopia, CHWs were effective in teaching mothers about promptly giving their children anti-malarials, which resulted in a 40% reduction in under-5 mortality [94].

There are currently three groups of CHWs in India, including auxiliary nurse-midwives (ANMs), Anganwadi workers (AWWs), and accredited social health activists (ASHAs) [95]. As per Government of India guidelines, each village selects its AWW and ASHA, while ANMs are appointed by the district health administration; as of 2014, there were 208,000 ANMs, 1.2 million AWWs, and 857,000 ASHAs throughout India [95]. This study was part of a larger evaluation that only examined AWWs, as will be described later, and as such, we restricted our analysis to AWWs.

The AWW program began in 1975 as a part of the Integrated Child Development Services (ICDS) program, which is operated by the Ministry of Women and Child Development. AWWs are based at Anganwadi centers (AWCs) and have a variety of roles and responsibilities. For example, AWWs provide supplementary nutrition to children under the age of six, and to

pregnant and lactating mothers [19]. This service is provided at the AWC. AWWs also perform health check ups for children below the age of six, and pregnant and lactating mothers in their catchment area [19]. These check ups are typically done at the beneficiary's home. AWWs also perform referral services in case any of their beneficiaries need to see a doctor or a specialist [19]. Children between the ages of 3-6 are also able to attend pre-school, which is hosted at the AWC by the AWW, a service that is intended to bolster early childhood development [19]. Growth monitoring and weighing children is also done by the AWW at the AWC as a means of tracking and preventing stunting and wasting [19]. Additionally, AWWs are responsible for disseminating key health information regarding nutrition, family planning, and immunizations to the women and children in their catchment area [19]. Finally, AWWs are required to maintain detailed registers that track key beneficiary data, updates on health status, supply inventory, and follow up appointments with beneficiaries.

Various studies have examined the impact of AWWs on health outcomes. For example, there is evidence of lower prevalence of underweight boys in those communities with AWCs [96]. Reductions in the prevalence of underweight children have also been attributed to the AWW program [97], along with significant increases in child height [98].

1.2 CHW Performance

Globally, CHWs play a key role in ensuring lower morbidity and mortality rates in the communities that they serve. Their performance and success in achieving those goals is often measured by whether or not they adhere to international standards of care [99]. Quantity, timeliness, and quality are three key dimensions of CHW performance in addition to adherence to care guideline [100]. Quantity refers to the number of home visits performed by a CHW, for example, while timeliness refers to the number of beneficiaries seen or treated within the past 24-hours [100]. Quality is defined as the number of beneficiaries served in a given time period without protocol error [100]. Whidden et al. found that quantity, timeliness, and quality all significantly improved among CHWs in Mali who received dedicated monthly supervision [100].

A number of studies have shown that in some cases CHW performance has been inadequate in improving outcomes related to child health, family planning, obstetrics, maternal health, and diabetes [101-104] In some extreme cases, CHW practices have been found to be harmful, the unnecessary provision of antimicrobials being one example [105].

Thus, there is a need to understand what factors improve CHW performance. Some of these factors include shared culture between CHWs and beneficiaries, and the careful institutionalizing of CHWs in to national health care systems [106]. Health-worker factors (knowledge of the health care standards, belief that these standards are useful, level of comfort dealing with various health issues, and fear of poor clinical outcomes) also influence CHW performance, as do beneficiary characteristics (such as age, wealth, social group, and sex) [99]. Additionally, administrative conditions (relationship with boss, regularity and amount of payment, quality of supervision, and job security) are also associated with CHW performance. In fact, the lack of frequent and supportive supervision has been found to negatively affect CHW motivation [107-110] and performance [111]. Lastly, political and economic conditions at the country or state level can often influence the allocation of key resources, which in turn can influence CHW performance [99].

1.3 Research Question and Motivation

As noted above, AWWs are expected to perform a large number of tasks on a daily basis. How AWWs spend their time on these various tasks is a less-studied factor that could also influence their performance. Furthermore, how AWWs use their time might be also be associated with quantity, timeliness, and quality [100]. For example, one study found that CHWs in three districts of Tanzania often have too many administrative obligations, which takes away from time spent on direct work with beneficiaries [112]. Another study from South Africa found that CHWs often struggle providing diabetic patients with adequate care because they spend on average only six minutes per patient [113].

Time is recognized as a valuable resource for reducing poverty and improving well-being [114]. As such, studies that measure how time is used have become increasingly common. Broadly speaking, time-use studies are designed to examine how people use their time. There are many possible applications of time use data such as keeping more detailed economic accounts, especially of non-market production [115]. Time use studies have also been conducted to examine women's empowerment, and whether or not policies intended to bolster women's empowerment are actually doing son (for example, time use studies can help answer whether or not microcredit initiatives influence how women allocate their time) [115]. Time use studies have also been used to paint a fuller picture of labor activities, and can elucidate constraints on workers' time [115].

The Ministry of Women and Child Development, which oversees India's AWW program, also views time as an important resource, and as such, has issued guidelines for the expected amount of time to be spent of various activities. These guidelines expect AWWs to spend 120 minutes to be spent on preschool education, 30 minutes for the preparation and distribution of supplementary nutrition (feeding), 30 minutes for filling out records and registers (register work), and 60 minutes for home visits every day [116].

Given this, the research question asked was: Do AWWs in rural Madhya Pradesh spend the expected amount of time on preschool education, feeding, register work, and home visits, and what, if any, AWW characteristics are associated with this? The motivation for answering these questions is to understand what factors enable or inhibit AWWs from spending the necessary amount of time to conduct various activities. Understanding AWW performance in this way is key given the enormous role played by AWWs throughout rural India in ensuring positive health outcomes for mothers, infants, and children.

2. Methods

2.1 Study Area

This time use study was a part of a larger endline evaluation of a mobile health application intervention, called Common Application Software (CAS). The evaluation examined 1) whether CAS improves the timeliness/frequency of AWW visits to the homes of pregnant women, infants, and their mothers, and 2) whether CAS improves the extent or level of counselling from AWWs to pregnant women and mothers and infants. This larger study took place in both Madhya Pradesh and Bihar. However, this analysis was restricted to Madhya Pradesh as a AWW

strike in Bihar prevented endline data collection from taking place. Madhya Pradesh has a high burden of under-five mortality at 69 per 1,000 live births in 2015 [117]. Additionally, over 43% of children between the ages of 0-5 are stunted in Madhya Pradesh, and over 55% of pregnant women aged 15-49 are anemic, as are nearly 70% of children aged 6-59 months [117]. Furthermore, only 50% of children between the ages of 12-23 months are fully immunized, and only 8.3% of mothers have had full antenatal care [117].

2.2 Participants and sampling

The sample included 519 AWWs from six different districts in Madhya Pradesh. Three CAS intervention districts (Barwani, Katni, and Ujjain) were matched with three control districts (Alirajpur, Jabalpur, and Dewas). Additionally, 333 AWWs in the endline sample had been surveyed during the CAS baseline survey, while 186 were from villages not previously sampled. It should be noted that CAS intervention villages were paired with villages in the corresponding comparison district using 1:1 nearest neighbor propensity score matching. A full description of the CAS evaluation sampling strategy can be found in previously published work [118].

2.3 Measurement tool

Time use data were collected from AWWs using a survey method known as stylized questions, which involves asking respondents questions about how much time they spend conducting various activities in a given time range. For example, AWWs were asked how much time they spent conducting a variety of activities on the day that they were being interviewed. This method was used as a part of the Women's Empowerment in Agriculture survey that was conducted in Uganda and Bangladesh [119]. Similarly, a version of stylized questions was used in a study that examined on 1,108 women in the United States spent their time [120].

Developing the final list of activities was an iterative process. It began with a time use study in 2018 during which we shadowed 36 AWWs and noted all of their daily activities, and the amount of time spent doing each one. The results from this pilot were used to develop a list of 64 key activities that could be grouped in to nine categories. The guidelines issued by the Ministry of Women and Child Development were also used to gain an understanding about the key activities that AWWs are responsible for executing on a daily basis, along with the amount of time that should be spent on these activities [116]. These learnings were combined to develop a final list of 11 key activities that AWWs are responsible for executing on a daily basis, which were: filling out paper registers, updating CAS (for AWWs in intervention areas), preschool education, child care, feeding children, growth monitoring, home visits, meetings, other work, non-AWW work, and resting.

2.4 Measures

2.4.1 Outcomes

Four outcomes were included in our study. These were: time spent conducting home visits, time spent filling out paper registers, time spent feeding children in the AWC, and time spent doing preschool education work. These are the four activity categories that the Ministry of Women and Child Development have identified the most critical and have specified the expected amount of time that should be spent on each one. Each of these were transformed into binary outcomes. Thus, 0 represented if an AWW spent below the expected amount of time on the activity, and 1

represented if an AWW spent the expected time or more on the activity. The unit for time spent was number of minutes.

2.4.2 Independent Variables
The models adjusted for AWW caste (scheduled tribe, scheduled caste, other backwards caste, and general caste), age (tertiles), education (above/below 11th grade), years of experience working as an AWW(tertiles), whether or not they work another job (yes/no), whether or not they have a helper (yes/no), wealth (additive index of 30 components), and family size (tertiles). General caste was the reference group for caste. The bottom tertile was the reference category for age, education, years of experience, and family size (which includes any extended family members also living with the AWW), while "no" was the reference category for if the AWW has a helper and works at another job.

2.5 Analytical Approach

The general form of the model estimated was: $\text{logit}(\pi_{ij}) = \beta_0 + \beta_1 X_{ij} + \varepsilon_{ij}$, where π_{ij} represents the odds for a given outcome for AWW i in village j. Results were exponentiated so that β_1 estimates the odds of spending the expected time, or more, on the outcome activity for all of the independent variables specified above.

3. Results

3.1 Sample results
The largest share of AWWs in the sample belonged to the Scheduled Tribe caste category (44%). 36% of AWWs had between 10-18 years of experience working as AWWs. There was an even split in educational attainment in the sample, while the average age of AWWs in the sample was 40. 94% of the AWWs reported having no other form of work. Median AWW wealth was 17 on an additive scale, and the median AWW family size was 5.

Table 1: AWW Characteristics

Caste	SC	64	12%
	ST	230	44%
	OBC	113	22%
	General	112	22%
Experience	< 10 years	180	35%
	10 - 18 years	188	36%
	> 19 years	151	29%
Education	Below 11th Grade	257	50%
	Above 11th	262	50%
Age	< 36 years	177	34%
	36 - 44 years	169	33%
	> 44 years	173	33%
Other Work	Yes	29	6%

	No	490	94%
Family Size	< 4 member	67	13%
	4 - 7 members	311	60%
	> 7 members	141	27%
Has a helper	Yes	498	96%
	No	21	4%
	Median	**Min**	**Max**
Wealth	17	5	29
Family size	5	1	21

Table 2: Summary of outcome variables (in minutes)

	Median	**Min**	**Max**
Home Visits	30	0	120
Feeding	60	0	120
Preschool Work	90	0	210
Paper Register Work	50	0	180

3.2 Home visits

Higher odds of spending the expected amount of time on home visits was significantly associated with being Scheduled Tribe (odds-ratio: 1.73, 95% CI 0.98, 3.04) and having more than seven family members (odds-ratio: 1.94, 95% CI 0.99, 3.83) after controlling for all other covariates.

3.3 Feeding

Lower odds of spending the expected amount of time on feeding were significantly associated with being Scheduled Tribe (odds-ratio: 0.383, 95% CI 0.16, 0.93) and being above 44 years old (odds-ratio: 0.25, 95% CI 0.09, 0.72) after controlling for all other covariates. Higher odds of spending the expected amount of time on feeding activities were significantly associated for those AWWs who had a helper (odds-ratio: 3.93, 95% CI 1.27, 12.21) after controlling for all other covariates.

3.4 Preschool work

Lower odds of spending the expected amount of time were significantly associated if AWWs had other work besides being an AWW (odds-ratio: 0.42, 95% CI 0.18, 0.98) after controlling for all other covariates. There were no other significant associations for preschool work.

3.5 Paper registers

Lower odds of spending the expected amount of time on paper registers were significantly associated with being Scheduled Tribe (odds-ratio: 0.29, 95% CI 0.12, 0.71), being above the age of 44 (odds-ratio: 0.39, 95% CI 0.17, 0.89) and wealth (odd-ratio: 0.94, 95% CI 0.88, 1.00) after controlling for all other covariates. Higher odds of spending the expected amount of time on paper registers were significantly associated with having attained above a 11th grade education (odds-ratio: 2.14, 95% CI 1.16, 3.92), after controlling for all other covariates.

Table 3: Logistic regression results

	Home Visits	Feeding	Preschool Work	Paper Register Work
Scheduled caste	1.146	0.670	0.855	0.443
	(0.57, 2.32)	(0.20, 2.23)	(0.44, 1.65)	(0.16, 1.25)
Scheduled tribe	1.726*	0.383**	0.704	0.298***
	(0.98, 3.04)	(0.16, 0.93)	(0.41, 1.19)	(0.12, 0.71)
Other backwards caste	0.882	1.454	0.906	0.639
	(0.48, 1.62)	(0.46, 4.61)	(0.52, 1.57)	(0.24, 1.69)
Above 11th grade	1.355	0.665	0.767	2.137**
	(0.87, 2.11)	(0.32, 1.38)	(0.50, 1.17)	(1.16, 3.92)
36 - 44 years old	1.097	0.629	0.898	0.748
	(0.66, 1.81)	(0.25, 1.61)	(0.55, 1.45)	(0.37, 1.53)
Above 44 years old	0.929	0.248**	1.246	0.391**
	(0.49, 1.73)	(0.09, 0.72)	(0.69, 2.25)	(0.17, 0.89)
10 - 18 years of experience	1.043	0.500	0.925	1.298
	(0.62, 1.75)	(0.19, 1.29)	(0.56, 1.52)	(0.61, 2.73)
Above 19 years of experience	0.950	0.961	0.691	1.812
	(0.51, 1.77)	(0.31, 2.95)	(0.38, 1.25)	(0.77, 4.25)
Other work	1.774	2.855	0.420**	1.119
	(0.81, 3.88)	(0.37, 22.10)	(0.18, 0.98)	(0.36, 3.47)
Wealth	0.996	1.011	1.006	0.939*
	(0.95, 1.05)	(0.93, 1.09)	(0.96, 1.05)	(0.88, 1.00)
4 - 7 family members	1.203	0.738	0.921	0.759
	(0.65, 2.22)	(0.27, 2.02)	(0.53, 1.60)	(0.34, 1.69)
Above 7 family members	1.944*	0.526	0.868	0.739
	(0.99, 3.83)	(0.17, 1.61)	(0.46, 1.62)	(0.30, 1.82)
Has helper	1.765	3.933**	1.081	1.465
	(0.62, 4.99)	(1.27, 12.21)	(0.44, 2.65)	(0.47, 4.57)
Constant	0.159**	15.32**	1.269	26.26***
	(0.03, 0.79)	(1.35, 174, 29)	(0.29, 5.44)	(2.96, 233.21)
Observations	519	519	519	519

(95% CI)

***** p<0.01, ** p<0.05, * p<0.1**

4. Discussion

The purpose of this study was to elucidate what factors are associated with AWWs spending the expected amount of time on key activities. The findings show that spending the expected amount of time on home visits, feeding, register work, and preschool education is significantly associated with AWW caste, education, age, wealth, family size, and whether or not the AWW has another job. Specifically, these results show that ST AWWs and AWWs with more than seven family members were significantly more likely to spend the expected amount of time on home visits

than general caste, the highest caste status category in India AWWs and AWWs with fewer than four family members, respectively. AWWs with large families might be more likely to spend the expected amount of time conducting home visits in order to avoid the responsibilities of their own home, perhaps. However, further research would be required to test this hypothesis. Also, the odds of spending the expected amount of time on preschool work were significantly higher for AWWs who had above a 12th grade education when compared to those AWWs who had below at 10th grade education. However, AWWs who have another job are significantly less likely to spend the expected amount of time on preschool work. Additionally, the odds of spending the expected amount of time on feeding children were significantly lower for AWWs belonging to Scheduled Tribes than for general caste AWWs. Similarly, the odds of spending the expected amount of time on paper register work were significantly lower for AWWs belonging to Schedule Tribes than for general caste AWWs. However, the odds of spending the expected amount of time on paper register work were 2.1 times higher for AWWs with above an 11th grade education when compared to AWWs who had less than an 11th grade education.

There are several limitations to this study. First, as noted above, stylized questions were used to collect data about how AWWs spent their time. The stylized questions approach is useful when the sample size is large given that it is cheap and can be scaled quickly, unlike direct observations, for example [121]. However, this approach is also prone to error given that it asking respondents to recall how much time they spent on various activities [121]. Furthermore, the outcomes were constructed as binary variables, indicating only whether an AWW spent above or below the expected amount of time on an activity. At a certain point, spending too much or too little time on an activity might be problematic. Spending too much time could take away from an AWW's ability to spend time on other essential tasks, while not spending enough time on certain tasks could be associated with poor outcomes. Additionally, the survey did not capture data about AWW duties and responsibilities in her own home. AWWs with a greater burden of responsibilities in their own homes might be less able to spend the expected amount of time on their duties in the AWC.

Despite these limitations, this study suggests that various AWW characteristics are associated with the amount of time that they spend on essential activities such as home visits, feeding children, register work, and preschool work. More research is required to elucidate why Scheduled Tribe AWWs, and AWWs older than 44, are less likely to spend the expected amount of time on feeding and doing paper register work when compared to general caste AWWs and AWWs below the age of 36, respectively. For example, while AWWs might be expected to spend a certain amount of time on activities, these guidelines might not account for caste dynamics within villages, or age-related ability, both of which might be associated with how much time an AWW is actually able to spend on an activity. Studies have shown linkages between caste-based discrimination and poor nutrition outcomes [122] and more research is required to understand how this discrimination could possibly be impacting low-caste AWW's job performance. Additionally, AWWs in some parts of India have reported significant stress and job dissatisfaction [123], and often complain about being overworked, job insecurity, and the lack of proper AWC infrastructure [124, 125]. These factors, coupled with the fact that AWWs often report delays in being paid their salaries [126] could undermine an AWW's motivation to spend adequate amounts of time performing her duties. The fact that AWW salaries are delayed might also be why some AWWs have to take up other jobs, which could explain why they are

are able to spend less time performing key tasks such as preschool work. This also raises the question about the extent to which the tasks performed by ANMs, ASHAs, and helpers (95% of AWWs in our sample reported having a helper) might complement the work performed by AWWs. This study only included AWWs, but ANMs, ASHAs, and helpers could be making up for work not done by AWWs in a given village, something that should be further studied.

Furthermore, perhaps the expected amounts of time should be reexamined. AWWs who live in catchment areas with large numbers of beneficiaries might struggle to update all of their paper registers in only 30 minutes, which could impact the amount of time they are expected to spend doing home visits (60 minutes). More research needs to be conducted to examine how the expected amounts of time mandated by the Ministry of Women and Child Development were determined, and what, if any, impact there is on health outcomes from adjusting these expectations.

5. Conclusions

AWWs play a central role in ensuring improved maternal and child health outcomes throughout rural India. How AWWs spend their time conducting various activities might could also be an indicator of AWW performance. As such, the Ministry of Women and Child Development has issued guidelines on how much time AWWs are expected to spend on home visits, feeding children, preschool education, and filling out their paper registers. This paper examined the associations between various AWW characteristics and their likelihood of spending the expected amount of time on those activities. Overall, this study found that spending the expected amount of time on home visits, feeding, preschool education, and register work is significantly associated with AWW caste, education, age, wealth, family size, availability of a helper, and whether or not the AWW has another job. These results suggest that further research is required to understand the relationships between these factors and AWW time use, and the different types of support that should be provided to AWWs to ensure they are able to spend the expected amount of time on these activities. Additional research should also focus on examining whether or not the expected amounts of time as mandated by the Ministry of Women and Child Development are actually associated with better outcomes, or if they should be revised to help optimize AWW performance.

Conclusion

Summary of key results

The purpose of this dissertation was to elucidate the root causes of health inequalities in India by studying the social determinants of latrine ownership and use in India, and examining the associations between AWW characteristics and the likelihood that the spend the expected amount of time on conducting home visits, feeding children, preschool education, and filling out paper registers.

The first paper qualitatively examined people's lived experiences of trying to build and use latrines in rural Bihar. Overall, this paper found that not owning a latrine should not be conflated with a preference for open defecation. Additionally, the design of payment mechanism used by the government to reimburse families who construct latrines under the SBA guidelines matters given our respondents' limited cash flow, credit constraints, and overall SES profile. Finally, this paper found that whether real or perceived, the bias towards urban development, or development for some but not others, could be a possible barrier to improved sanitation outcomes in places such as rural Bihar. These results are useful in that they point to a variety of possible social determinants of latrine ownership and use that should be examined in future research.

Paper two examined the association between the amount of dwelling space owned by a household and their likelihood of latrine ownership, and the amount of variation in household latrine ownership that is attributable to village and state context. This paper found a positive and significant association between the amount of dwelling space owned by households and their likelihood of latrine ownership. Additionally, a significant proportion of the variation in household latrine ownership is attributable to village and state context. Thus, these findings highlight the importance of considering social determinants, such as dwelling space, and contextual factors when designing sanitation policies. Future research should focus on elucidating the specific contextual factors, at both the village and state levels, that might be associated with household latrine ownership.

Finally, paper three examined the associations between AWW characteristics and the likelihood that they spend the expected amount of time on home visits, feeding children, preschool work, and filling out their paper registers. Findings show that spending the expected amount of time on home visits, feeding, register work, and preschool education is significantly associated with AWW caste, education, age, wealth, family size, the presence of a helper, and whether or not the AWW has another job. For example, AWWs with a helper were 3.9 times as likely to spend the expected amount of time feeding children than AWWs without a helper, while Scheduled Tribe AWWs were 0.29 times as likely to spend the expected amount of time filling out their paper registers when compared to general caste AWWs. Future research should focus on examining the role of helpers and other community health workers, who could provide support to AWWs, and what resources should be made available to AWWs from historically marginalized caste groups to ensure that they can best serve their communities.

Implications of study results

As noted in the introduction of this dissertation, India has experienced rapid economic growth since 1991. However, progress towards improved health has remained unequal, especially when looking at sanitation, and maternal and child health outcomes. This dissertation contributes to existing literature, which also tries to understand the root causes of these inequalities, by focusing on the social determinants of latrine ownership and use, and factors that are associated with AWW performance. The results of this dissertation highlight the need for continued research on how social, political, and economic factors determine latrine ownership and use patterns in India. Additional research should also be conducted to understand how India's sanitation policy can be modified to ensure equitable sanitation outcomes. Furthermore, AWWs play a vital role in ensuring improved maternal and child health outcomes throughout India. The findings from this dissertation demonstrate that AWW characteristics are significantly associated with whether or not AWWs spend the expected amount of time conducting home visits, feeding children, preschool education, and filling their paper registers. As such, these findings point to the need for future research that examines what types of support AWWs need in order to best support their communities achieve equitable maternal and child health outcomes.

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Appendix

Table A1. Fixed Effects Results | 95% CI of OR in parentheses | *** p < 0.01, ** p < 0.05, * p < 0.1.

Response	Model 1		Model 2	
Fixed Part				
Constant	0.09***	(0.07, 0.11)	0.53***	(0.37, 0.75)
Total Dwelling Space (per 100 ft^2)	1.38***	(1.36, 1.39)	1.38***	(1.34, 1.41)
Total Dwelling Space (per 100 ft^2) Squared			0.99***	(0.990, 0.992)
Total Monthly Expense (per INR 250)			1.01***	(1.00, 1.01)
HH Head Gender			1.11**	(1.01, 1.23)
HH Head Age			1.10	(0.90, 1.34)
ST			0.48***	(0.42, 0.55)
SC			0.55***	(0.50, 0.61)
OBC			0.69***	(0.63, 0.75)
Male Ed: Illiterate			0.58***	(0.51, 0.66)
Male Ed: Literate w/o school or below primary			0.64***	(0.56, 0.74)
Male Ed: Primary and upper primary			0.64***	(0.58, 0.71)
Male Ed: Secondary and higher secondary			0.80***	(0.72, 0.87)
Female Ed: Illiterate			0.50***	(0.44, 0.58)
Female Ed: Literate w/o school or below primary			0.59***	(0.51, 0.69)
Female Ed: Primary and upper primary			0.67***	(0.60, 0.77)
Female Ed: Secondary and higher secondary			0.82***	(0.72, 0.94)
Mud Floor			0.49***	(0.46, 0.53)
Condition: Good			1.90***	(1.69, 2.13)
Condition: Satisfactory			1.32***	(1.19, 1.45)
Drainage: Covered			0.89	(0.75, 1.06)
Drainage: Open Solid			0.68***	(0.59, 0.79)
Drainage: Open			0.50***	(0.43, .058)
No Drainage			0.31***	(0.27, 0.36)
Electrified HH			2.01***	(1.81, 2.23)
HH Size: >3 & <=6			0.83***	(0.77, 0.89)
HH Size: >7			0.67***	(0.61, 0.75)
Roof Type: grass/leaves/straw/bamboo etc			0.57***	(0.51, 0.65)
Roof Type: Other			0.76***	(0.64, 0.91)

Roof Type: Timber			0.74***	(0.68, 0.82)
Roof Type: Burnt brick/stone			0.63***	(0.55, 0.72)
Roof Type: Iron/metal sheet			0.69***	(0.62, 0.76)
Roof Tyle: Other solid			0.87	(0.65, 1.17)
Jammu & Kashmir	2.21***	(1.49, 3.28)	2.35***	(1.58, 3.51)
Himachal Pradesh	3.65***	(2.43, 5.50)	2.85***	(1.89, 4.29)
Punjab	5.73***	(3.82, 8.59)	4.64***	(3.04, 7.08)
Chandigarh	20.11***	(4.01, 100.89)	8.71**	(1.27, 59.56)
Uttaranchal	6.53***	(3.80, 11.20)	5.55***	(3.19, 9.65)
Haryana	4.39***	(2.87, 6.71)	2.38***	(1.54, 3.68)
Rajasthan	0.53***	(0.38, 0.73)	0.64***	(0.45, 0.89)
Uttar Pradesh	0.56***	(0.42, 0.73)	0.66***	(0.49, 0.87)
Bihar	0.66***	(0.48, 0.90)	0.99	(0.72, 1.38)
Arunachal Pradesh	18.69***	(10.01, 34.88)	35.34***	(18.12, 68.99)
Manipur	72.31***	(38.63, 135.23)	132.42***	(69.69, 251.64)
Mizoram	405.45***	(119.22, 1378.4)	738.78***	(215.51, 2532.60)
Tripura	151.56***	(81.78, 280.62)	472.48***	(249.64, 894.26)
Meghalaya	45.47***	(26.79, 77.17)	83.01***	(48.81, 141.17)
Assam	11.19***	(8.00, 15.63)	34.43***	(24.34, 48.76)
West Bengal	3.49***	(2.60, 4.67)	5.95***	(4.41, 8.02)
Jharkhand	0.23***	(0.15, 0.34)	0.28***	(0.18, 0.43)
Odisha	0.48***	(0.35, 0.67)	0.64**	(0.46, 0.90)
Chhattisgarh	0.38***	(0.25, 0.59)	0.67*	(0.44, 1.02)
Madhya Pradesh	0.38***	(0.28, 0.52)	0.51***	(0.37, 0.71)
Daman & Diu	2.53	(0.82, 7.84)	1.09	(0.35, 3.36)
D & N Haveli	0.12***	(0.03, 0.45)	0.43	(0.12, 1.53)
Maharashtra	1.37**	(1.02, 1.83)	1.06	(0.79, 1.43)
Andhra Pradesh	1.70***	(1.25, 2.31)	1.01	(0.74, 1.38)
Karnataka	0.88	(0.63, 1.23)	0.54***	(0.39, 0.76)
Goa	8.77***	(3.34, 22.97)	6.13***	(2.33, 16.10)
Kerala	31.66***	(21.85, 45.83)	41.47***	(28.13, 61.19)
Tamil Nadu	0.98	(0.72, 1.34)	0.58***	(0.42, 0.80)
Puducherry	1.00	(0.32, 3.07)	0.53	(0.17, 1.61)
A & N Islands	3.19***	(1.47, 6.90)	3.47***	(1.60, 7.52)
Random Part				
Village Variance	1.911		1.765	

Table A2. Percent of Variance Attributable to Village & State.

	Model 1	**Model 2**	**Model 3**	**Model 4**
Village	11.1%	11.1%	11.2%	9.3%
State	57.7%	58%	58.9%	51.6%