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Revealed preference for open defecation:
Evidence from a new survey in rural north India

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Abstract

Despite economic growth, government latrine construction, and increasing recognition among policy-makers that it constitutes a health and human capital crisis, open defecation remains stubbornly widespread in rural India. Indeed, 67% of rural Indian households in the 2011 census reported defecating in the open. We present evidence from new survey data collected in villages in five states in India: Bihar, Haryana, Madhya Pradesh, Rajasthan, and Uttar Pradesh. We find that rural households do not build inexpensive latrines of the sort that commonly reduce open defecation and save lives in Bangladesh, Southeast Asia, and sub-Saharan Africa. Many survey respondents' behaviour reveals a preference for open defecation: over 40% of households with a working latrine have at least one member who defecates in the open. In the sample from the four largest states, more than half of people in households which own a government latrine defecate in the open. We apply a demographic model of latrine use which predicts that if the government were to build a latrine for every rural household that lacks one, without changing sanitation preferences, most people in our sample in these states would nevertheless defecate in the open. Further evidence supports a preference for open defecation: many survey respondents report that open defecation is more pleasurable and desirable than latrine use. Among people who defecate in the open, a majority report that widespread open defecation would be at least as good for child health as latrine use by everyone in the village. These findings suggest that intensifying existing policies of latrine construction will not be enough to substantially reduce open defecation. Policy-makers in India must lead a large scale campaign to promote latrine use.

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1. Introduction

Most people who live in India defecate in the open. Most people worldwide who defecate in the open live in India. Open defecation has dire consequences: it kills babies, impedes the physical and cognitive development of surviving children, and reduces the human capital of India's workforce. Open defecation is associated with significant negative externalities: it releases germs into the environment which harm the rich and poor alike—even those who use latrines.

As the rest of the world steadily eliminates open defecation, this behaviour stubbornly persists in India. Indeed, with 67% of rural households and 13% of urban households defecating in the open (Census 2011), India now accounts for 60% of the world's open defecation.[2]

Our study focuses on sanitation in rural India for several reasons. First, open defecation is far more common in rural India than in urban India. Second, about 70% of the Indian population lives in rural areas. Indeed, 89% of households without a toilet in the 2011 census were in rural areas. Finally, improving rural sanitation poses particular challenges. India has seen decades of government spending on latrine construction and sustained economic growth, but rural open defecation has remained stubbornly high.

Why do people in rural India defecate in the open in such large numbers? Answering this question requires understanding the behaviour of hundreds of millions of people. We asked people in 3,235 rural households in five north Indian states where they defecate and what they think about it. We are aware of no prior study that is similarly broadly representative of sanitation views and behaviours in India.[3]

The central claim of our paper is that people in the states that we study display a "revealed preference" for open defecation. Economists identify a decision-maker's revealed preference from what he chooses out of a set of alternatives. This use of the word "preference" differs from everyday language because it says nothing explicitly about people's likes and dislikes.

[2] See the WHO/Unicef Joint Monitoring Programme database at http://www.wssinfo.org/ (WHO and UNICEF 2014) for more information about open defecation in India and around the world.

[3] Most related prior research has been in the context of the success or failure of particular sanitation projects. A series of careful impact evaluations in rural India have found very small effects of sanitation interventions on behavior change; indeed, one reason why it has been difficult to produce experimental estimates of the effect of open defecation in India on health outcomes is the difficulty of achieving a sufficient "first stage" effect of a sanitation program on open defecation. For related prior evidence on sanitation attitudes and challenges of behavior change in India see: Arnold *et. al*. 2010; Patil *et al*. 2013.

Instead, the principle of revealed preference holds that a decision maker's choice among his options reveals a "preference" that can be usefully applied to predict his future choices, and used to simulate the effects of policy changes. See Appendix A for a more detailed framework for sanitation preferences.

Our claim that survey respondents display a revealed preference for open defecation relies on three central observations. Section 3.1 shows that households in India rarely build the types of inexpensive latrines that are widely used by poor households to reduce open defecation and save infant lives in Bangladesh, Southeast Asia, and sub-Saharan Africa. Section 3.2 presents the finding that many people in households that own working latrines nevertheless defecate in the open, and section 3.3 shows that government-provided latrines are especially unlikely to be used. In section 3.3.2, a demographic model applied to our survey data predicts that if the government were to build a latrine for every household in Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh, without changing anybody's preferences, most rural people in our sample would still defecate in the open. Finally, section 3.4 observes that many people are also willing to state a preference for open defecation. In short, we find that many people have a revealed preference for open defecation, such that merely providing latrine "access" without promoting latrine use is unlikely to importantly reduce open defecation.

The findings of our survey have clear implications for sanitation policy in India: programs must concentrate on behaviour change and promoting latrine use. Amidst repeated calls for ambitious government latrine construction schemes by prominent policy-makers and opinion leaders, we conclude that our findings may be surprising. Although building latrines could be part of a successful policy package, little will be accomplished by planning to build latrines that will go unused, or, due in part to lack of demand on the ground, not be built at all. Latrine construction is not enough. Instead, if the Government is to achieve its goal of eliminating open defecation by 2019, it must concentrate on building demand for latrine use in rural India.

2. Context and survey methodology

2.1 The international context

This paper is far from the first to emphasize the importance of latrine use, and to point beyond policies of latrine construction (Mehta and Movik, 2011; O'Reilly and Louis,

forthcoming). Many of our conclusions will be familiar to sanitation professionals who have struggled for years to promote behaviour change in India and worldwide (Galbraith and Thomas, 2009; Perez, *et al*, 2012; Bartram, *et al*, 2012; Venkataramanan, 2013; Ghosh and Cairncross, forthcoming). Yet, the magnitude of resistance to latrine use in rural north India might surprise even experts: we find that even among the demographic sub-groups in our survey who are most likely to use a toilet, open defecation is still more common than among the populations of some of the poorest countries in the world.

Table 1 reports the fraction of people who defecate in the open according to UNICEF-WHO Joint Monitoring Programme (JMP) data for a set of countries and regions that we have selected for illustration. Open defecation is much more common in India than it is in many of the poorest countries of the world, such as the Democratic Republic of the Congo, Malawi, Burundi, and Rwanda – to say nothing of richer countries that are still much poorer than India, such as Afghanistan, Kenya, and Bangladesh.

The statistics in Table 1 are important to our analysis because even the sub-groups within our rural Indian sample that are *most likely* to use latrines report higher rates of open defecation than the JMP does for many of these countries. For example, we will see that the fraction of males *in households that own latrines* who defecate in the open in our sample is greater than the percent of all people in sub-Saharan Africa or Haiti who defecate in the open, latrine owners or not. A larger fraction of females in our sample *in households that own latrines* defecate in the open than do people in Afghanistan, Swaziland, or Kenya, to say nothing of the lower rates of open defecation in some even more deeply impoverished countries.

2.2 Open defecation in rural north India

We report results from the SQUAT survey: a survey in rural north India of Sanitation Quality, Use, Access, and Trends. We conducted our survey in rural villages of five north Indian states in the "Hindi Heartland."[4] Four of these states were *focus states*, where rural open defecation is particularly common: Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh. One state, Haryana, was included as a potential *contrast state*, where households are richer, on average, and open defecation is less common. We will see, however, that

[4] We note explicitly that our survey is not designed to be directly informative about other Indian states. However, our focus states are where the world's open defecation challenge is most concentrated. If evidence from other sources were to show that beliefs and behaviours were different in other parts of India and other parts of the world, then this fact would reinforce our conclusion that sanitation policy faces special challenges in this region.

Table 1: Open defecation is more common in India than in poorer countries, 2012 JMP data

country	% open defecation	% shared or unimproved	% improved sanitation	GDP per capita
India (2011 census)	49.8			
India (JMP)	48	16	36	5,050
Southern Asia*	38	20	42	4,666
Sub-Saharan Africa*	25	45	30	3,171
Pakistan	23	29	48	4,360
Haiti	21	55	24	1,575
Low-Income Countries*	21	42	37	1,569
Ghana	19	67	14	3,638
Senegal	17	31	52	2,174
Zambia	16	41	43	2,990
Afghanistan	15	56	29	1,892
Swaziland	14	29	57	5,912
Kenya	13	57	30	2,109
Southern Asia without India*	12	31	57	-
Nicaragua	10	38	52	4,254
Democratic Republic of Congo	9	60	31	451
Republic of Congo	8	77	15	5,631
Uganda	8	58	34	1,134
Malawi	7	83	10	739
Cameroon	6	59	45	2,551
Myanmar	5	18	77	-
Bangladesh	3	40	57	2,364
Burundi	3	50	47	737
Rwanda	3	33	64	1,379
Gambia	2	38	60	1,565
Vietnam	2	23	75	4,912
China	1	34	65	10,771

Distribution of the population into each sanitaiton category (% of population) from WHO and UNICEF (2014).
India figures from Census 2011 from Government of India (2012) and relate to proportion of households not having a toilet in their house and not using a public toilet. Per Capita GDP PPP figures from World Bank (2014).

* Categories are defined by the World Bank; low-income includes countries with GNI per capita, calculated using the World Bank Atlas method, of $1,035 or less in 2012 (World Bank 2014).

Haryana primarily provides a contrast in wealth and latrine construction, not in sanitation preferences.

The states of Bihar, Uttar Pradesh, Rajasthan, Madhya Pradesh and Haryana are home to 40% of the population of India, and to 45% of households in India without a toilet or latrine, according to the 2011 Census. At least 30% of *all people worldwide* who defecate in the open live in these five Indian states.[5] Our results, therefore, are relevant not merely to sanitation policy in India, but also to addressing much of the global sanitation challenge.

Table 2 summarizes our sample, and contextualizes it using the 2011 Census. Except for Haryana, which is much richer, the states where the survey was carried out have very high rural rates of household open defecation, ranging from 78% in Uttar Pradesh to 87% in Madhya Pradesh. Although all states showed a decline between 2001 and 2011 in the fraction of households defecating in the open, these were modest declines of between two and five percentage points in the four focus states.

These declines, however, may not represent an improvement in *exposure* to open defecation. The decline in household open defecation fractions in many states has not kept up with population growth, which has led to an increase in the density of open defecation. As Table 2 shows, in all four of the survey's focus states the number of households defecating in the open increased between 2001 and 2011. Based on census data, the increase in the number of households defecating in the open was approximately equivalent to adding the population of the rural parts of about 30 average sized districts – all defecating in the open – to these four states.[6] Our sample therefore studies a region of India that, by this measure, is facing a growing sanitation challenge.

2.3 Sampling strategy

We conducted interviews in 3,235 households in 13 districts in Bihar, Rajasthan, Uttar Pradesh, Madhya Pradesh and Haryana. Because we asked about the defecation behaviour of each member of the household, we have data on 22,787 individual household members.

Our survey used a four-stage sampling strategy to select respondents:

[5] We compute this estimate by making the (incorrect) assumption that household latrine ownership in the Indian Census implies individual use for the numerator, and taking UNICEF-WHO Joint Monitoring Programme data for the denominator.

[6] According to the 2011 census, there are 63,014,757 rural households in these four states; split into 197 districts yields 319,871 rural households per average district in these four states.

Table 2: The SQUAT sample and state-level open defecation

	our survey (sampled districts)			Indian census (state-level rural data)		
	districts	households	persons	2011 OD %	% change OD*	change in OD: # of households**
Bihar	3	749	6,066	82.4	-3.7	3,047,547
Haryana	2	603	3,606	43.9	-27.4	-447,934
Madhya Pradesh	3	772	5,190	86.9	-4.2	2,263,646
Rajasthan	2	354	2,498	80.4	-5.0	1,518,427
Uttar Pradesh	3	757	5,427	78.2	-2.6	3,284,725
combined	13	3,235	22,787	79.5	-4.6	9,666,412

* percentage point change in the fraction of households defecating in the open, 2001-2011.

** change in the number of households defecating in the open, 2001-2011.

- **Districts:** Districts were purposively selected to match the state-level trend in rural household open defecation rates. That is, we considered eligible districts to be those districts in which the percentage point change in rural open defecation between the 2001 and 2011 Census rounds most closely matched the state-wide percentage point change in rural open defecation.[7] As will be discussed in more detail below, we randomly selected villages from the list of villages visited during the Government of India's DLHS-2 Survey, conducted by the International Institute of Population Sciences. Because village lists were not available from IIPS for all districts, we chose those eligible districts for which these lists were available. Finally, as our survey team was Hindi speaking, we only visited districts in which Hindi was commonly spoken in villages. This constraint was only binding for Rajasthan.
- **Villages:** We used as our sampling frame the list of villages prepared by the Government of India's DLHS-2 survey. Villages were randomly selected using probability proportionate to population size sampling to ensure a representative sample within districts. The population count that we used for sampling was included in the DLHS data. In order to limit the effect on respondents of intra-village discussion of our survey, we surveyed for no more than one half-day in each village. In the first half of each day, we visited a village selected from the list of villages in the DLHS-2. In the second half of each day, we visited a different village, randomly selected from a set of five nearby villages identified by the survey team leader during the first half of the day.
- **Households:** Households were selected using a similar in-field randomization technique to the one used in Pratham's ASER survey. The team leader identified a central point in the village and spun a spinner to send interviewers in different directions. Half of the interviewers proceeded out towards the edge of the village from the centre and half of the interviewers proceeded in from the edge of the village towards the centre. Interviewers attempted to interview every third household while proceeding towards the edge of the village and every fifth household while proceeding towards the central point. After sending the interviewers in their randomly assigned directions, the team leader circumambulated the village. In some cases, if she judged that the geography of the village was such that a section was inappropriately excluded from eligibility by the in-field randomization procedure, she accompanied one of the interviewers to a central point in that section and repeated the random assignment of direction.
- **Persons:** Interviewers first completed a household roster with a knowledgeable member of the household. After completing the roster of household members, one person was selected to complete the individual interview privately with the interviewer. Because the interview was substantially about beliefs and preferences – which are properties of individuals – the interviewer was required to conduct this part of the interview with only the selected respondent present. Interviewers used a randomization sheet to select an adult household member between the ages of 18 and 65 of the same sex as himself or herself. If the randomly selected person was not available, interviewers randomly selected another adult of the same sex from the household roster, subject to a maximum of three attempts, after which the interviewer ended the interview. If the randomly selected member refused to participate in the interview, or the individual interview could not be conducted alone with the respondent, the interviewer ended the interview for that household.

[7] We planned to eliminate any eligible district where the 2011 rural open defecation fraction was more than two cross-district standard deviations away from the state-level average, but this constraint was never binding.

In every state, the households we interviewed are more likely to own a latrine than that state's state-wide fraction in the 2011 census; this suggests that the sample of households or villages may have been biased towards richer people. If so, true demand for latrine use may be even lower than what we document. Some of the difference between the census and the latrine ownership that we observe may be explained by improvements in latrine coverage since 2011. However, the procedure to select persons within households required ensuring that respondents could understand the purpose of the study and would sit alone with the interviewer; this could bias the sample towards higher socioeconomic status respondents but was important for minimizing social desirability bias. It is further possible that interviewers imperfectly implemented in-field randomization, favoring higher socioeconomic status households. See Appendix B. for more information on respondent selection.

Our survey instrument was written in Hindi. The original Hindi survey instrument and an English translation are available online at http://squatreport.in. We used separate male and female questionnaires. These were identical in the initial sections, but the male form included an extensive section on the construction and price of latrines and the female form included sections on household water use and on sexual harassment and violence. The median interview duration was 55 minutes, with an interquartile range from 48 to 65 minutes.

The survey was specially designed to capture the sanitation beliefs and behaviours of men and women living in north Indian villages. We made special efforts to minimize social desirability bias, and other forms of bias in the responses; Appendix B outlines our approach in more detail. The study received ethical approval from Princeton University's Institutional Review Board (IRB) for protection of human subjects.

3. Results

In this section, we present four sets of results. First, we note that people in rural India have an expensive concept of an acceptable latrine, and do not use simple, affordable latrines which are very commonly used in other countries. Second, we document that many people living in households with latrine access nevertheless defecate in the open. Third, we describe patterns of use among owners of government-supported and government-constructed latrines, and use our data to predict the effects of a universal government latrine construction program. Finally, we consider respondents' stated preferences and beliefs about latrine use and open defecation.

3.1 Lack of demand for simple, affordable latrines

3.1.2 Respondents conceive expensive latrines

Do people in rural India defecate in the open because they are poor? In Table 1, we have already seen evidence against this proposition: in many poorer countries, a much smaller fraction of the population defecates in the open. This suggests that most households in India could afford to build the kinds of inexpensive latrines that are widely used in poorer countries. Yet, in our survey, over 78% of respondents who do not have a latrine also cite the cost of a latrine as an important reason for why they defecate in the open. How can this perception be understood, in comparison with the international context? One explanation is that people in rural India have a globally unique concept of the minimal requirements for an acceptable latrine.

We find that respondents indeed have a very expensive notion of what constitutes a latrine. We asked male respondents to enumerate for us what features an inexpensive, but usable latrine would have and how much each of the parts would cost. The latrines that they described cost more than Rs. 21,000, on average, and in many cases much more. Given these large estimates, it is no surprise that people perceive cost as a barrier to building a latrine. What this suggests is not that these respondents could not afford to build latrines that safely contain faeces, but rather that there is a widely held belief that latrines are expensive assets, perhaps even luxuries.

In fact, a usable latrine that safely contains faeces could be built much less expensively; such a latrine could importantly improve health relative to open defecation. Indeed, the simple latrines that have been used to essentially eliminate open defecation in Bangladesh cost around Rs. 2,500, at purchasing power parity[8]: this is much less than even the Rs. 10,000 allocated for latrine construction by the Indian Government, to say nothing of the Rs. 21,000 which our respondents imagined that is required to build a latrine.

Our respondents' estimate of Rs. 21,000 can be compared with results of a recent, large-scale experimental study in rural Indonesia. Cameron, *et al*. (2013) asked survey respondents how much they were willing to spend on a "cheap" latrine. Indonesian respondents imagine much less expensive latrines: the average reported minimal cost to build a latrine was only Rs.

[8] This calculation uses the 2011 International Comparison Project's (ICP) PPP exchange rate for household consumption.

4,492 in ICP purchasing power parity terms. The lower price for a latrine in Indonesia is particularly striking in light of the fact that Indonesians are richer than Indians, on average, and could therefore afford to spend more: according to the ICP, per capita real expenditure is approximately twice in Indonesia what it is in India.[9] Of course, prices are an equilibrium outcome of supply and demand: rural Indonesians think of inexpensive latrines in part because they are available for sale, but they are available for sale only because rural Indonesians are willing to use inexpensive latrines.

3.1.2 Missing "middle rungs" on the sanitation ladder

Many international sanitation professionals and experts describe a "sanitation ladder": ranging from open defecation up to flush toilets with a piped sewer. Successive rungs on the ladder represent more hygienic and more expensive sanitation options – for example, progressing from open pit latrines to pit latrines with a slab to pour-flush toilets that connect to a septic tank or even a sewer. However, the sanitation ladder in India appears to be missing its middle rungs, with no intermediate steps on which households climb gradually up from open defecation.

Table 1, which presents UNICEF-WHO JMP data on the types of toilets used in different countries, illustrates this point. Table 1 splits the population into three categories: open defecation, unimproved or shared sanitation, and improved sanitation. The data for India show a "missing middle:" no country listed has a smaller "middle" fraction of unimproved or shared sanitation. Many countries, in contrast, have both a lower fraction of the population defecating in the open and a lower fraction with improved sanitation.

In India, only 16% of the population is on a middle rung, compared with 40% in Bangladesh, and 45% for sub-Saharan Africa overall. Although the table only presents country-level statistics, the contrast for rural India is even starker: only 6% of rural Indians are in a middle category. In many countries, proceeding up the sanitation ladder was not only the path out of open defecation, but also an important step towards improved health and human capital.

For India to follow this path, policy-makers must learn how to convince people in rural India to use "middle" alternatives to open defecation. Promoting the use of less expensive latrines

[9] Households in our sample are much poorer than households in Cameron et al.'s sample: where over a third of household heads in our sample have received no schooling, less than one percent of household heads in the Indonesian sample have not competed elementary school. Where 68 percent of the Indonesians' households' home is made of brick or cement, only 50 percent of our households have a *pucca* (formal construction) home, and 67 percent have at least one *kaccha* (informal construction) room.

is necessary in part because buying a toilet for each of the 123 million households that lacks one at our respondents' estimated minimal price of 21,000 rupees would cost rupees two-lakh fifty-six thousand crore, or approximately one-sixth of the annual total expenditure of the Government of India in 2012-2013. This is therefore not a serious policy alternative to building demand for simple, "middle-rung" latrines.

3.2. Households, individuals, and latrine use

Measuring sanitation behaviour at the household-level has created a blind spot for many studies in the literature: in rural north India, many people who live in households that own a latrine nevertheless defecate in the open. Unlike other widely cited data sources,[10] our survey asked about usual sanitation behaviour for each person in the household.[11] Therefore, we know both who lives in households with a latrine, and who usually uses one. In particular, we asked whether each person over 2 years old usually defecates in the open or in a toilet or latrine.[12]

3.2.1. Open defecation despite latrine access

Figure 1 divides the households in our sample into three groups: those in which everybody defecates in the open, those in which no one defecates in the open, and those in which some people defecate in the open but some do not. The third category is a considerable 18% of households. This suggests that estimates of person-level open defecation rates based on the number of households who own latrines likely underestimate exposure to open defecation.

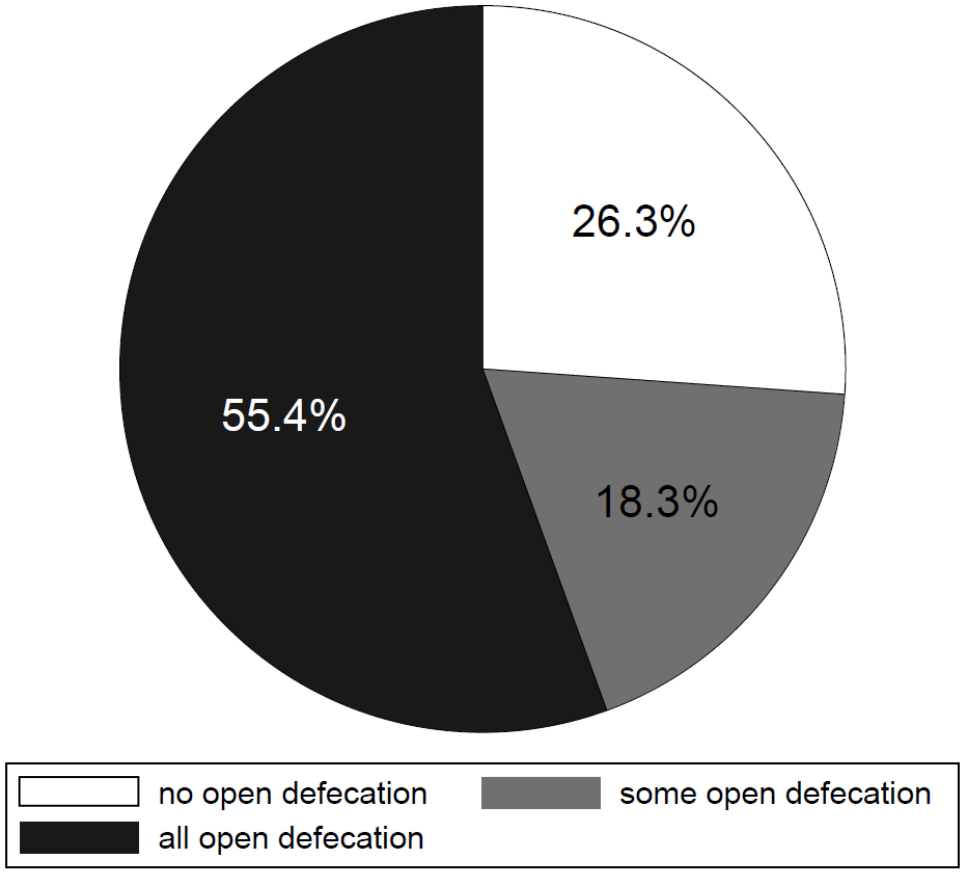
Table 3 summarizes latrine use at the household and at the person level, for our full sample and separately for each of the states our survey visited. Panel A presents household-level statistics. Open defecation is very common, even in households with access to a latrine. In our four focus states, 80% of all interviewed households had at least one member who defecates in the open. 48% of households with a working latrine, which we determined either by the fact that someone in the household used it or by the presence of a pit and seat, had at

[10] Three notable recent exceptions in India are a dataset collected by Barnard and coauthors (2013) in Orissa, Patil and coauthors (2013) in Madhya Pradesh, and a valuable data collection project in India in progress by the South Asia region of the World Bank Water and Sanitation Programme. These surveys record individual-level behaviour.

[11] We asked the one survey respondent from each household about the latrine use of all other household members. In particular, we asked whether persons "usually" use a toilet or latrine or defecate in the open.

[12] We did not ask about latrine use for children under 2 because they often cannot use a latrine. For more discussion of disposal of child faeces, see Majorin and coauthors (2014).

Figure 1: Households, by members' open defecation



Observations are households, categorized by open defecation behavior of household members. "Some open defecation" indicates households where at least one member defecates in the open and at least one member uses a toilet or latrine.

Table 3: Open defecation, by households and persons

statistic	sub-sample	all states	focus states*	Bihar	MP	Rajasthan	UP	Haryana
Panel A: Household-level averages								
owns latrine	all households	43.2%	34.7%	27.4%	40.3%	28.3%	39.1%	79.9%
any member ODs	all households	73.8%	79.8%	84.1%	75.6%	87.6%	76.2%	47.2%
any ODs, despite latrine	households that have a latrine	40.1%	42.9%	43.8%	41.9%	57.4%	38.5%	34.9%
any ODs, despite a user	households with at least one latrine user	41.1%	44.7%	51.6%	35.8%	64.2%	39.8%	34.0%
any ODs, despite working latrine	households with a working latrine	43.9%	47.9%	54.2%	40.8%	66.2%	42.5%	35.7%
Panel B: Person-level averages								
defecates in the open	all persons over 2 years old	64.1%	70.4%	75.0%	67.5%	76.7%	65.0%	30.8%
ODs, despite HH owning latrine	persons >2, in households owning latrine	21.1%	23.4%	22.5%	25.6%	30.5%	19.7%	15.8%
ODs, despite user in HH	persons >2, in households with a user	21.0%	23.7%	29.3%	17.7%	37.7%	18.4%	13.9%
male OD, despite having latrine	males >2, in HH owning a latrine	25.1%	27.8%	26.4%	30.1%	33.6%	24.8%	19.1%
female OD, despite having latrine	females >2, in HH owning a latrine	16.6%	18.6%	18.1%	20.8%	27.1%	13.4%	12.0%
Panel C: Person-level open defecation, combined estimate reweighting survey latrine use using 2011 Census latrine ownership								
households wihtout a latrine	[2011 Census of India]	79.5%	81.2%	82.2%	86.9%	80.4%	78.2%	43.9%
combined OD estimate	all persons over 2 years old	81.6%	83.0%	83.1%	88.4%	83.1%	80.7%	50.4%

* "Focus states" are Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh.

OD = open defecation.

least one member who nevertheless defecates in the open.[13] Strikingly, in the four focus states, 45% of households *with a latrine user* also had at least one household member who defecates in the open.

Panel B presents person-level statistics. These illustrate what is missed by household-level counts of latrine ownership. 57% of *households* in our sample do not own a latrine, but 64% of *people* defecate in the open. This gap is not because of a difference in household size between households with and without latrines: households with latrines have an average of 7.36 members in our data, slightly and insignificantly *more* than in households without latrines. Rather, the gap exists because many people who live in households with latrines usually defecate in the open.

Comparing across states, Haryana indeed provides some contrast: in every row, the Haryana average is statistically significantly different from the combined average of the four focus states. However, the gap between Haryana and the focus states is largest for latrine ownership; it is more similar to the other states on sanitation behaviour conditional on ownership.

This pattern suggests that open defecation may be less common in rural Haryana largely because people there are richer, and more likely to own expensive latrines – not because people there are more committed to latrine use, or more willing to build and use simple, inexpensive latrines. The data support this conjecture: 57% of the difference in household latrine ownership between Haryana and the focus states can be accounted for by the fact that households in Haryana are richer, in the sense of owning more assets.

So, what fraction of people living in these states defecate in the open? We note that our survey has oversampled latrine owners, relative to the 2011 census. We therefore combine both data sources in Panel C to present our best estimate of the percent of rural persons over 2 years old who defecate in the open in these states. We take estimates of open defecation conditional on latrine ownership from the SQUAT survey data and reweight these to match census data on latrine ownership. In particular, for each state we compute

$$estimated\ OD = \ (OD|owners) \times \%\ owners + \ (OD|nonowners) \times \%\ nonowners,$$

[13] Although many of our most important results are conditional on latrine ownership, we note that our respondents report higher levels of latrine ownership than their rural states as a whole; if this indeed reflects a bias in our sampling, then the true preference for open defecation may be even greater than we document.

where "% owners" and "% non-owners" are household-level fractions from the 2011 census and conditional open defecation rates are from our survey. Relative to estimates using only the census, this computation takes into consideration that open defecation among latrine owners is greater than zero and that open defecation among latrine non-owners is less than one.

Our overall estimate of 81.6% of rural persons in these states defecating in the open is not very different from the household-level census figure of 79.5% because the fraction of households that own latrines is relatively small, and because latrine use by non-owners partially balances open defecation by latrine owners. The difference between the census fraction of households without latrines and our combined estimate of person-level open defecation is greatest for Haryana because it is the state with the most latrine ownership. Our best estimate suggests that most people in rural Haryana defecate in the open. This fact illustrates that the gap between household latrine ownership rates and person open defecation rates is likely only to grow as India continues to become richer and to build more latrines that go partially unused.

3.2.2 Demographics of defecation

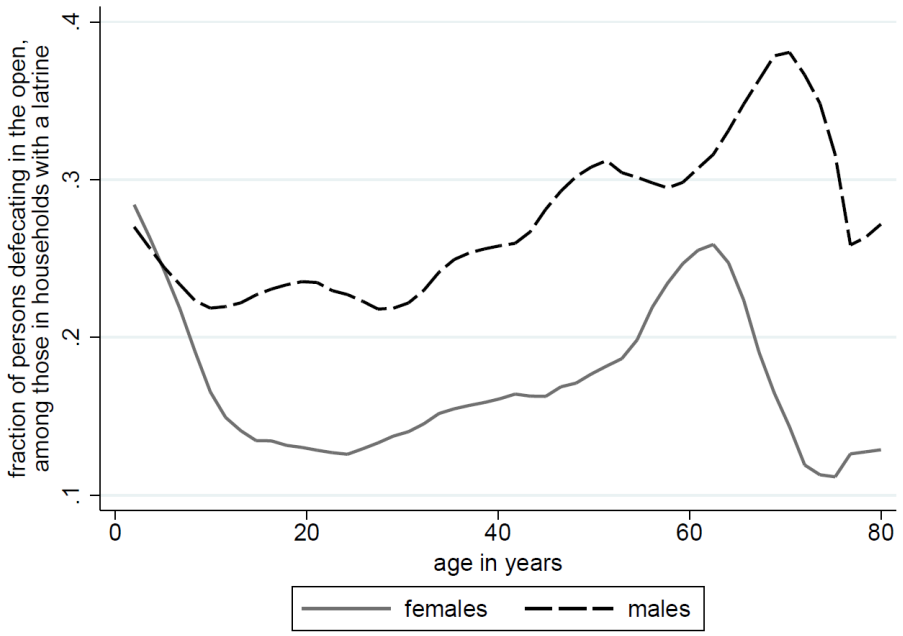
Within households with access to a latrine, who uses it? The bottom rows of Panel B of Table 3 contrast the latrine use of males and females, conditional on being a member of a household that owns a latrine. In every state, men living in households with latrines are more likely to defecate in the open than women living in households with latrines.

Rural north Indian households are well-known to prescribe different social roles and ranks according to sex and age. Males have higher intra-household social status than females; older people of the same sex have higher status than younger people; and young women have very low intra-household status. Figure 2 presents average rates of open defecation by age and sex, among households that own a latrine. Section 4.1 will discuss Panel B of Figure 2, which shows particularly high rates of open defecation among individuals in households with a government-supported latrine; here we focus on Panel A, which includes all latrines, constructed by the government or privately.

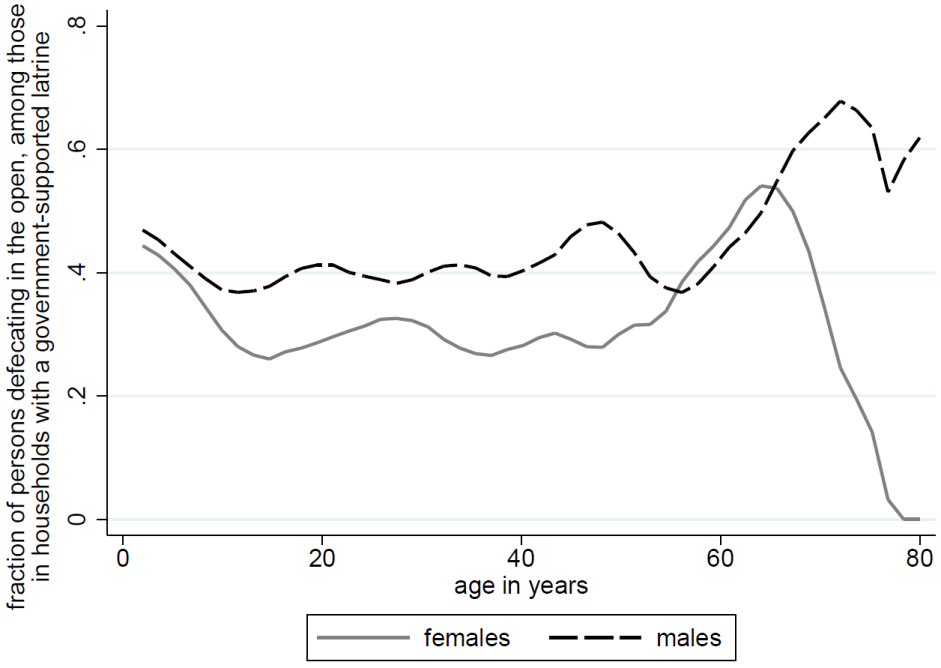
Open defecation conditional on latrine ownership tracks the pattern of intrahousehold status described above. Except for among young children, males are more likely to defecate in the

Figure 2: Open defecation by age and sex, in households with a latrine

Panel A: All persons in a household that owns a latrine



Panel B: Persons in a household that owns a government-supported latrine



Observations are persons above two years of age, living in a household that owns a latrine. Kernel-weighted local regressions are plotted. *n* = 9,628. In Panel B, government-supported latrines are either built entirely by the government, or built with government materials or funding. In Panel A, privately constructed and government latrines are included.

open than females at every age. During the late childhood and teenage years, open defecation decreases quickly in age for young women with access to latrines. This could be driven by at least two factors: a preference among young women to use latrines, or a north Indian cultural norm that keeps women in their reproductive years inside the home.

For most of the adult age range, open defecation is increasing in age. This probably reflects two factors. First, older people, on average, are able to move more freely outside their homes and to enact their preferences. Second, in this cross-sectional survey, older people are members of earlier cohorts, born into earlier years when open defecation was even more common than it is today. However, open defecation decreases sharply in age among the oldest household members in the sample. In many cases, this change reflects disability or incontinence that makes open defecation difficult or impractical.

It is noteworthy that the people who appear to have the most demand for latrine use – young women and the very old – are typically not economic decision-makers within their households. It is likely an important constraint on latrine adoption in rural India that the people who are most likely to use latrines are the least likely to have the intra-household power to allocate resources to building one

3.3. Use of government latrines

Media coverage of sanitation in India often emphasizes the need for the government to provide "access" to sanitation. There may be considerable private benefits of owning a latrine, and therefore having the option to use one, especially in times of illness and bad weather. However, in this paper we build on existing research that demonstrates the negative externalities of open defecation. Therefore, when we consider rural Indians' sanitation behaviour or the likely effects of hypothetical government sanitation efforts, we focus on the implications for open defecation. From the perspective of reducing the negative externalities of open defecation to improve health and human capital, latrine "access" is an importantly incomplete description of the sanitation challenge for rural India, where demand for latrine use is a key barrier.

Here, we focus on a related dimension of this issue: are the latrines that are being used provided by the government? Only a minority of all households in the survey – merely 9% – report having received either money or materials from the government for latrine

Table 4: Privately constructed latrines are more likely to be used than government constructed latrines

		household-level		person-level		
	% of households	any OD %	any use %	male OD %	female OD%	person OD%
	(1)	(2)	(3)	(4)	(5)	(6)
government provided neither money nor materials	78.8	35.7	95.6	20.0	11.7	16.1
government provided either money, materials, or both	21.2	54.4	79.4	41.7	32.6	37.1
government provided materials	12.2	61.7	71.6	49.5	38.1	44.2
government provided money	7.5	38.4	92.9	21.7	17.5	19.7
government provided both money and materials	1.5	75.0	75.0	65.3	50.7	57.8
government independently constructed entire latrine	6.9	67.4	66.3	58.0	48.6	53.7

(1) "% of households" reports the distribution of the sample in to categories by government construction, among households owning a latrine.
(2) reports the fraction of households, within each construction category, where any member defecates in the open.
(3) reports the fraction of households, within each construction category, where any member uses the latrine.
(4), (5), and (6) report the fraction of persons within each construction category who defecate in the open, for males, females, and both pooled.

construction; [14] 32% of households in the survey own a toilet that was built without any government support, and the rest do not own a latrine. Thus, the large majority of households with latrines – 79% – received neither money nor materials (under which we include receiving a complete latrine) from the government to build their latrine.

Focusing only on households that own a latrine, Table 4 shows open defecation according to whether the household received government support to build its latrine or not. People who live in households with a latrine that was built with government support are more than twice as likely to defecate in the open as people who live in households whose latrine was privately constructed. Indeed, over 60% of households which received latrine materials from the government have at least one household member who defecates in the open.

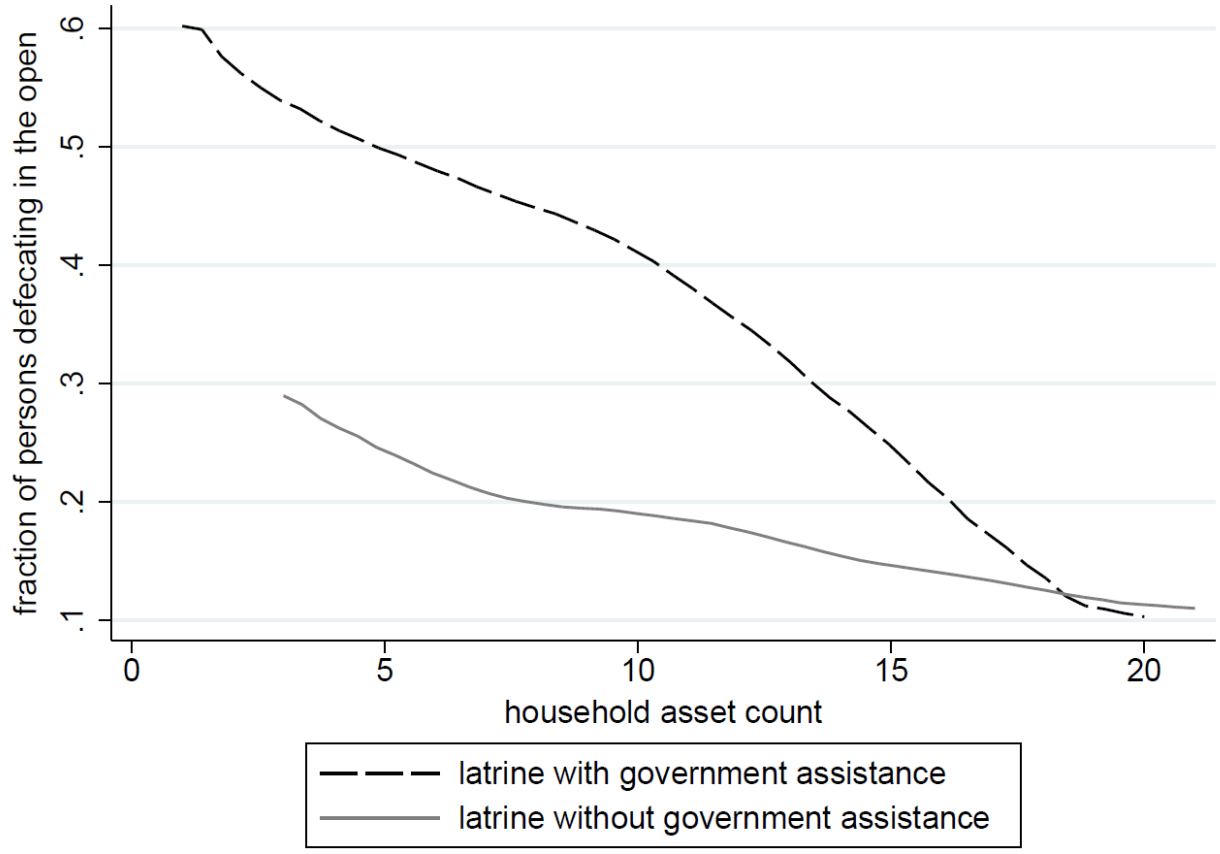
The latrines that are least likely to be used are those that were built in entirety by the government, rather than constructed in part using government money or materials. More than half of people who live in a household with such a latrine defecate in the open; over two-thirds of such households have a member who defecates in the open; and one-third of such latrines are not usually used by anyone at all.[15] In households with completely government-constructed latrines, even most young females in their 20s – a demographic group particularly likely to use available latrines – defecate in the open.

Returning to Figure 2, Panel B plots individual-level toilet use by age among people living in households with a latrine that was fully or partially supported by the government. In general, the patterns are similar to those found in panel A: males are more likely to defecate in the open than females; children are more likely to than working age adults; and older adults are more likely to defecate in the open than younger adults, except among the very old. However, relative to Panel A these demographic differences are more muted; essentially throughout the age and sex distribution, people with government-supported latrines are more likely to defecate in the open than people in the full sample of latrine owners.

These differences in use according to private or government construction reflect several possible mechanisms. First is selection: households that build their own latrines are, on average, households that have more demand for latrines, possibly because of higher socioeconomic status, better education, or a greater awareness of the health benefits of

[14] Our information on latrine construction, like all data collected in our survey, is as reported by households themselves and may differ from government latrine construction records.

Figure 3: Latrine use by household asset wealth and government or private construction



Observations are persons above two years of age, living in a household that owns a latrine. "With government assistance" indicates receiving either money or materials from the government for the latrine, or both; "without" indicates households that received neither. Kernel-weighted local regressions are plotted.

latrines. Second is quality: households that build their own latrines may choose to build a more expensive latrine, or one that more closely matches their own preferences.

Figure 3 provides evidence that selection based on socioeconomic status is not the only reason for differences in government and private latrine use. It plots the fraction of people defecating in the open at each level of asset wealth, measured as the count of a list of assets that the household owns. It plots this separately for people in households that did and did not receive government assistance to construct the latrine. Unsurprisingly, a higher fraction of people in richer households use an available latrine. However, the vertical distance between the lines indicates that – except among the very richest households – at all levels of rich and poor, people are more likely to use privately built latrines than latrines constructed with government assistance.

3.3.1. Pit size and latrine use

Why are government-supported latrines so much less likely to be used than private latrines? Although we will be unable to fully answer this question, it is clear that part of the explanation must be selection into latrine ownership: it is unsurprising that households which choose to build their own latrine are the most likely to use one. However, it is also the case that privately and government constructed latrines are physically different, on average. In particular, privately-constructed latrines have much larger pits below ground.

Table 5 presents summary statistics about the volume of latrine pits owned by surveyed households, as reported by respondents. Questions about pit size were only asked to male respondents; so pit volume is missing for many households with latrines. However, volume data is not differentially missing across any of the categories we will discuss. The data are skewed by a few very large pits, so we present both means and medians.

Panel A splits latrines into those built with no government support, those built with at least some government support, and those fully built by the government. Government-constructed latrine pits are much smaller than privately constructed latrine pits: the median fully

[15] In a related qualitative study, we found that sometimes households may keep – rather than repurpose – government constructed latrines for occaisional "emergencies," times when a household member is sick and cannot make it to the field to defecate in time.

Table 5: Latrine pit size: Government-constructed latrines have smaller pits, with implications for use

Panel A: by construction	no government support	some government support	fully government construction
mean pit volume	392	169	92
median pit volume	240	83	42
volume missing	64%	62%	58%
n (household latrines)	377	108	39
Panel B: by use	no open defecation	some open defecation	majority open defecation
mean pit volume	349	321	277
median pit volume	214	177	157
volume missing	64%	66%	67%
n (household latrines)	297	191	93

Volume is in cubic feet.

government constructed pit is less than a fifth the size of the median fully privately constructed pit.[16]

Panel B shows that latrines with larger pits are more likely to be used than latrines with smaller pits. Alongside the SQUAT survey we conducted a companion qualitative study of behaviours, beliefs, and attitudes among households in rural UP, Haryana, Gujarat, and Nepal which do and do not have a member who has switched to latrine use in the past ten years.[17] In these qualitative interviews, people suggested that concerns about pit emptying importantly reduce latrine use. Very large pits are perceived to last a family at least a generation. This stands in important contrast with the simple, inexpensive latrines that we discuss in section 3.1, which are periodically emptied or moved.

What are the implications of this preference for latrines with very large pits? As discussed above, it would not be a feasible policy for the government to undertake to build every household a very large septic tank. However, this preference is nevertheless important for policy because it contributes to identifying why households do not build and use the simple pit latrines which exist throughout the developing world. Qualitative and applied research about households' understanding of latrine pit size and emptying may help inform solutions to promote safe and hygienic latrine use.

3.3.2. Predicting effects of government latrine construction

Prominent policy-makers have recently suggested that the Indian government should build a latrine for every household without one. How much open defecation would remain if the government indeed built a latrine for every household in our survey that does not have one, but did nothing to change preferences about open defecation? Here we would like to know: what would be the effect of the *marginal* latrines that the government has yet to construct?

However, the data we have describe the observed use of *average* government-constructed latrines. Households that have government latrines are different from households that do not on a number of observed dimensions, including age and sex structure, district, caste, religion

[16] Privately constructed pits are very large: in our qualitative fieldwork "*das-das*" repeatedly emerged as a normative size for ideal latrine pits, meaning a cube 10 feet wide, long, and deep, although only 5% of observed pits were in fact this large. Such large pits are often expensively lined with brick or cement walls, similar to building a formal room below ground.

[17] For more information on this qualitative study, visit http://riceinstitute.org/wordpress/switching-to-latrines-in-rural-south-asia-a-study-of-health-technology-adoption-2014/

and other variables. Although our survey collects these demographic data, there are also a number of unobserved differences between households that have government latrines and those that do not, for instance, the desire to restrict the movement of women, health problems that make going in the open more difficult, and the value placed on convenience of latrines. These unobserved differences are probably related to demand for latrine use; in particular, people living in households that already have latrines are almost certainly more likely to want to use latrines than people living in households without latrines. People in households with latrines – even government built latrines – wanted them enough to accept them and maintain them sufficiently intact such that they still existed as latrines when surveyors visited.

However, making the incorrect assumption that people living in households without latrines are as likely to use a government-provided latrine as are people in households with latrines who share the observable demographic characteristics that we model, we can make an econometric prediction of how many people would defecate in the open, if they were given an average government latrine.

Among households with a government-supported latrine, we estimate a logistic regression of an indicator for individual level open defecation on age as a quadratic, asset count as a quadratic, education, and district indicators, each interacted with an indicator for being female, as well as caste category, religion category, and perceived village size category. This estimates a very simple model to predict open defecation by the demographic properties of people living in households with government latrines. This modelling is necessary because households without a latrine are observably different, on average, from households with a latrine: for example, they are poorer, and their average resident is older. Appendix C provides more details on the regressions, including alternative model specifications.

We perform this procedure twice: among households with a latrine that was partially government constructed and again among households with a latrine that was fully government constructed. These models fit the data well: the model for partially government-supported latrine owners correctly predicts 73.7% of individual cases and the model for fully government-constructed latrine owners correctly predicts 72.2% of cases.

Then, for people in households that do not own a latrine, we use these regression models to predict what average open defecation would be from logistic predicted probabilities. This approach uses demographically similar people living in households with a government latrine to predict what people in households without a government latrine would do if they were to

Table 6: Predicted open defecation after universal latrine construction policy

Panel A: Model fit using households with fully government-constructed latrines		
	focus states	all 5 states
open defecation among new latrine recipients	66.0%	66.3%
open defecation among all persons	50.5%	46.4%
Panel B: Model fit using households with government-supported latrines		
	focus states	all 5 states
open defecation among new latrine recipients	56.5%	54.8%
open defecation among all persons	44.2%	39.9%

receive and accept one. The basic assumption is that, within these demographic categories, people would be equally likely to use a government constructed latrine, whether or not they happen to own one.[18]

Table 6 presents results of this simple policy simulation. The model predicts that 55% of people would defecate in the open if they received a latrine that was constructed with *any* government support, among those currently living in households without a latrine. Because fully government-constructed latrines are less likely to be used in our data than are partially government-supported latrines, 66% of people living in recipient households are predicted to defecate in the open if they received a latrine that were *fully* government constructed.

We can now return to the original question of this subsection: How much open defecation do our data, in combination with this simple demographic model, predict would remain if a statistically average fully government constructed latrine were built for and accepted by every household that does not currently own a latrine? We answer this question by combining the actual latrine use data for people who live in households with a latrine with the predicted probability of latrine use from the demographic model for people who do not.

For the full sample of five states, the model predicts that open defecation among all persons in our sample (including those who currently own and use latrines) would fall from the observed 64% by about 18 percentage points to 46% of people in our sample defecating in the open. In the four focus states, person-level open defecation in our sample would fall from the observed 70% to a predicted 51%. Therefore, we conclude conservatively that our data predict that even if the government were to construct a latrine for every rural household in Bihar, MP, Rajasthan, and UP that does not currently have one, more than half of all rural persons in our sample would still defecate in the open.

This is not to suggest that an 18 percentage point decline in open defecation, if achieved, would not be an important advance in human development: Kov, *et al.* (2013) find an increase in child height in Cambodia – where population density is lower than in India – from a 14 percentage point reduction in open defecation over five years; however, even after such

[18] It is also possible that households that differ on these demographic characteristics systematically receive different quality latrines from the government; if so, then this modelling exercise assumes that any such differentiation would be replicated in newly constructed latrines.

an ambitious construction scheme, rural India would still be very far from ending open defecation.[19]

There are three main reasons to expect that the figures presented in Table 6 significantly underestimate the fraction of people who would defecate in the open if the government embarked on a universal latrine building program, without any further efforts to change preferences about open defecation. First, they assume that there is no corruption or leakages in construction. However, lack of demand for latrines decreases accountability for construction projects, such that latrine construction programs may be more susceptible to corruption and leakages than other programs that provide resources to poor households. Second, these calculations assume that every household that receives a latrine accepts it and does not repurpose the materials or the superstructure for something else. The SQUAT survey did not measure rates of latrine or latrine material repurposing among those offered a government latrine, but our allied qualitative research suggests that this happens sufficiently often to matter for program outcomes. Third, they ignore the fact that observed latrine ownership is correlated with greater preference for latrine use, such that households in which the *marginal* latrines that would be built would almost certainly have a lower demand for latrine use than households in which the *average* latrine exists.

3.4. Stated preferences

By examining the kinds of latrines that are built and by observing the behaviour of individuals within households that own latrines, we have seen evidence that many people in rural north India reveal a preference for open defecation. In this section, we consider a different type of evidence: what people tell us. Our respondents explain that there are many pleasant advantages of open defecation, and that using a latrine is probably no healthier than going outside.

[19] Note that our survey finds more latrine ownership than in the Indian census, suggesting our sampling may be optimistically biased away from people who defecate in the open. If we scale up the fraction of households in our sample that do not have a latrine to match the 2011 census (keeping predicted conditional open defecation rates constant within categories), our model would predict about 59% open defecation after universal construction of government latrines, rather than about 51% as in Table 6.

3.4.1. The benefits of open defecation

We asked an open-ended question, where household members could volunteer their explanations of what is good or bad about open defecation and latrine use. Of people who defecate in the open, 47% explain that they do so because it is pleasurable, comfortable, or convenient. Of individuals who defecate in the open despite having access to a latrine in their household, fully 74% cite these same reasons.

Many respondents told us that defecating in the open provides them an opportunity to take a morning walk, see their fields, and take in the fresh air. 14% of individuals who defecate in the open mention that they prefer going in the open because there are problems with using a latrine. 12% say it is habit or tradition to defecate in the open.

Although it is beyond the scope of this paper to present these results in detail, the qualitative study found commonly held perceptions about benefits of open defecation, substantially similar to what we report here. Many people regard open defecation as part of a wholesome, healthy, virtuous life.

3.4.2. Failure to recognize health effects

One reason that latrine use is not a priority may be that open defecation is not widely recognized among rural north Indians as a threat to health. This is unlikely to be the leading factor, however, because sanitation behaviour is often not motivated by health in other countries: for example, in rural Benin, Jenkins and Curtis (2005) find that health benefits were not an important part of motivating latrine adoption.

At the beginning of our survey, before it would have been clear that we were primarily interested in sanitation, we asked respondents to imagine a series of two villages, and in each case to tell us where they thought children would be healthier, or whether they thought there would be no difference:

- In a village where everyone eats rice, or in a village where everyone eats wheat bread (*roti*)?
- In a village where everyone cooks by burning cow dung, or in a village where everyone cooks on kerosene?
- In a village where everyone uses a latrine, or in a village where everyone defecates in the open?

The first two questions had clearly winning answers: 73% of respondents report that wheat is healthier for children, and 88% believe that cooking on cow dung (which is, in fact, a health hazard) is better. Responses to the sanitation question are more halting and mixed, perhaps because respondents are less used to thinking of toilets in terms of health. 43% of all respondents report that latrine use is no better for child health than open defecation.[20]

Even this figure fails to fully capture the policy challenge because it includes many respondents who already use latrines. Among those who defecate in the open, fully 51% report that widespread open defecation would be at least as good for child health as latrine use by everyone in the village. Women are more likely to report that open defecation is healthy than men are: 55% of women who defecate in the open respond that children would not be healthier in a village where everyone uses a latrine. Respondents with higher educational attainment have more accurate health beliefs. Nevertheless, fully 18% of respondents who studied past the 12th standard report that open defecation is at least as good as latrine use for child health.

Subsequent survey questions confirm that households are unaware of or unconcerned by the health consequences of widespread open defecation, including those that decided to build a latrine. 89% of households that built a latrine decided to build one for reasons of convenience and comfort. Among respondents who defecate in the open, only 26% mention health improvements from latrine use as a benefit that could result from building a latrine; moreover, even these were often talking about the convenience of having a latrine for people who *already* have stomach ailments.

In order to better understand health knowledge about diarrhoeal disease among our respondents, we asked an open-ended question on why children get diarrhoea. Only 26% responded with an answer that displays an understanding of any possible infectious causes of diarrhoeal disease. This figure includes all mentions of infection, bacteria, not washing hands,

[20] In at least one sense, these responses were biased towards *over*estimating people's concern about the health consequences of open defecation. Respondents may have pictured villages similar to real-life villages where everyone uses latrines and everyone defecates in the open, without mentally "controlling for" socioeconomic status. Because villages where everyone uses latrines would be richer and have better educated mothers, children are healthier on average there for unrelated reasons. If perceived wealth contaminated respondents' answers, then their true beliefs would be even *less* concerned about the health consequences of open defecation than these figures suggest.

or defecating in the open as at least one answer to the question (even if respondents further included other non-infectious explanations).[21]

4. What our study did not find

4.1. Is access to water a constraint on latrine use?

Policy discussions and media accounts of open defecation in rural India often assert that access to water is a reason why so many people in India do not use latrines. The reasoning behind this claim is that large quantities of water are supposedly required to use and maintain latrines.

However, existing data suggest that access to water is not an important constraint. In the 2005 India Human Development Survey, rural households with piped water are only 9 percentage points less likely to defecate in the open than rural households without piped water. This difference can be completely statistically accounted for by consumption, income, household size and literacy, suggesting that it merely reflects a spurious correlation with socioeconomic status, and is not a true effect of access to water on open defecation.

The results of the SQUAT survey corroborate this interpretation. In the survey, less than 1% of men and only 5% of women who defecate in the open suggest that lack of access to water could be a reason not to use a latrine. In our related qualitative research project, water was not raised as a constraint on latrine use in any of 99 in-depth semi-structured interviews.

4.2. Are shared latrines a solution?

In urban India and in other places worldwide where sanitation remains a policy challenge, many people use shared or community latrines which are also used by members of other households. The social distance and fragmentation within many rural Indian villages that we observed in our allied qualitative data collection suggest to us that shared latrines may be unlikely to be a large part of a sanitation policy solution for rural India. According to UNICEF-WHO JMP data, while 20% of urban households without a household toilet or latrine used a shared or public toilet, only 5% of rural households did.

[21] These findings can again be compared with those from rural Indonesia (Cameron, et al., 2013). When asked about many possible causes of diarrhoea, over two-thirds of respondents in the control group claimed that diarrhoea could be caused by "others practicing open defecation."

Our survey finds similar results. Only 2% of households say that they use a community latrine. Of households that have a latrine that is used by someone in the household, only 7% report that any non-household members also use their latrine, and even these are often extended family members living in other houses. Although these statistics only describe what exists and not what might be possible, these small fractions, together with our qualitative data, suggest that people in rural India would likely resist using a latrine that is not owned by their household.

4.3. Are people receiving latrine use messages from the government?

Although only 9% of surveyed households have a government-supported latrine, it is possible that government sanitation promotion messages have reached more households. Included in the guidelines for the *Nirmal Bharat Abhiyan* and the Total Sanitation Campaign – two recent government sanitation programs – is funding for IEC programs, or Information, Education, and Communication. To what extent have these programs reached rural households with their messages promoting latrine use?

61% of respondents report knowing of a government scheme which helps people to construct toilets, and 44% know at least one person who has received assistance from the government for their latrine. However, this basic awareness of sanitation policy does not appear to translate into substantial engagement with latrine use promotion programs. Only 31% say that they have ever seen a poster, wall-painting, pamphlet, street play, or film about the use of latrines. Only 16% of respondents say they have heard of village level meetings on sanitation.

5. Conclusion

Widespread open defecation in rural India is a unique human development emergency. Each year when global figures are recomputed, India is home to a larger and larger fraction of the remaining people in the world who defecate in the open. Enduring open defecation needlessly kills hundreds of thousands of babies and stunts the development and lives of those who survive, and the economy that all Indians share.

Standing in contrast to the importance of reducing open defecation are the revealed and stated preferences for open defecation that we described in this paper. Few households construct affordable latrines, many people who own latrines nevertheless defecate in the open, and

people in households with government provided latrines are particularly likely to defecate in the open.

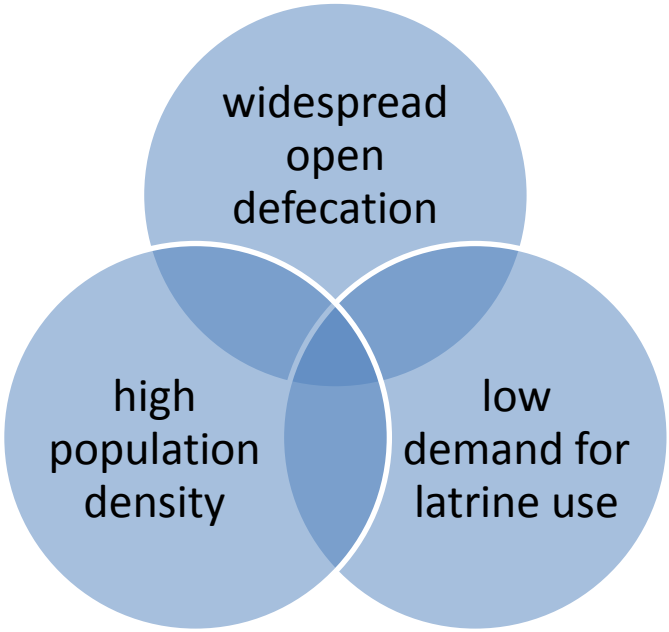


Figure 4: Rural India's triple challenge

Figure 4 illustrates the intersecting policy challenges for sanitation policy in the rural Indian states we study. First is the enormous scale of the problem: 70 percent of rural Indians – or approximately 550 million people, according to the UNICEF-WHO JMP – defecate in the open, adding up to staggering health and economic costs. Second is high population density (Hathi, *et al*., 2014, Spears, 2014). High population density increases the costs for health and human capital of open defecation: germs are more easily transmitted in high population density environments. Because population density is very high in rural India – even compared with many places in *urban* sub-Saharan Africa – open defecation is particularly costly here. Finally, as this paper has documented, there is very low demand for latrine use, sharply limiting what mere latrine construction can accomplish. There is no logical necessity that required these challenges to intersect in one country, but they do. Whether open defecation can be importantly reduced in India – and thus whether significant further progress can be made in reducing open defecation rates globally – will depend on the ability of policy-makers to confront these intersecting challenges in rural north India.

Latrine construction is not enough to substantially reduce open defecation in the northern plains states where it is concentrated. Indeed, our data, in combination with a simple demographic model, predict that more than half of people in our focus state sample would still be defecating in the open even if the government were to build a latrine for every household that does not have one, without changing preferences. However, the insufficiency of building latrines does not excuse the government from responsibility. Our results suggest that India needs a large scale campaign to change sanitation preferences and promote latrine use.

Appendix A. A framework for sanitation preferences

When we write that people in the rural plains states of north India predominantly prefer open defecation, in what sense do we use the word "preference"? And to what alternatives do people prefer open defecation?

Latrines are an asset, but open defecation is a behaviour. Reducing open defecation will require knowing under what circumstances people will choose to defecate in the open and under what circumstances people will choose to use a latrine.

Therefore, we follow economists' definition of preference as chosen behaviour. Economists identify a decision-maker's revealed preference from what he[22] chooses out of a set of alternatives. This use of the word "preference" may differ from everyday language because it says nothing explicitly about people's likes and dislikes. Instead, the principle of revealed preference holds that a decision maker's choice among his options reveals a "preference" that can be usefully applied to predict his future choices.

Sanitation behaviour is, in fact, the result of two decisions (Cameron, *et al.*, 2013). First is a household-level decision about whether or not to own a latrine. In India, this decision is typically made by high-ranking members of the household: working-age males. Sometimes government actors decide to build a latrine for a household, but in our qualitative research we have observed many cases of households taking it apart for materials, or turning it into something other than a latrine, such as a storage room or bathroom, so owning a government latrine also reflects choice.

Second is a person-level decision about whether or not to use a latrine, among people who have access to one.[23] In principle, people without latrines in their homes could use latrines belonging to neighbors or extended family members. Indeed, Cameron *et al*. (2013) find that a behavior change campaign in Indonesia reduced open defecation in part by promoting latrine sharing. However, our quantitative and qualitative findings suggest that latrine sharing in rural north India is rare. Therefore, in practice, it is those who have access to a latrine who choose between latrine use and open defecation. Of course, these decisions are only in part shaped by what people "like;" they are also shaped by a variety of other personal

[22] We choose the masculine pronoun to reflect the fact that many decisions in rural Indian households are made by men.
[23] This is in part because people see the latrine pit as a depleteable resource; pit emptying is considered a major burden.

and social forces, all of which are captured in economists' concept of "preference" revealed by a person's behaviour.[24]

We sometimes combine these two household-level and person-level decisions when we write about "demand for latrine use" or "preference for open defecation." This does not mean that members of the same household always agree: indeed coexistence of open defecation and latrine use within the same household is a central observation of this paper. Yet, the two decisions are closely related: whether or not a household builds a latrine is influenced, to varying degrees, by whether people in the household want to use one.

Because we are primarily interested in revealed preference, this paper has little to say about any ultimate historical, cultural, or social roots of the preference that we document. Moreover, we do not believe this preference is immutable. Indeed, we are optimistic that a serious campaign for latrine use could be revolutionary.

Appendix B. A survey designed to learn about beliefs and behaviours

The survey was specially designed to capture the sanitation beliefs and behaviours of men and women living in north Indian villages. We asked detailed questions to understand how people prioritize latrine use, what they think is healthy, where they defecate, why they defecate the way they do, and what they think are the advantages and disadvantages of open defecation versus latrine use. We faced several challenges in collecting these, at times, sensitive data. Here we describe some of challenges associated with the data collection and how we overcame them.

Like many groups that conduct scientific studies in rural India, we were faced with the problem that many people initially understood our interviewers to be means testing, or identifying poor households for government or NGO benefits. We particularly wanted to avoid the misconception that we were means testing for a latrine building program, as it might have led respondents to overstate their demand for latrines. In addition to obtaining the informed consent of each person with whom we spoke, we made special efforts to stress that we were not from the government, but rather that we were doing a study about village life. Interviewers who felt that a respondent was not able, after patient explanation, to

[24] It is noteworthy that the behaviour of young women, who have particularly low intra-household status, may be particularly uninformative about what these women "like." For example, some women with a latrine may nonetheless defecate in the open because the other members of their family do not want the pit to fill quickly. Other young women may wish to defecate in the open in order to meet their friends or get out of the house, but be prevented from doing so because their relatives want them to stay inside.

understand this objective were instructed to follow the selection procedure to find another household to interview.

We also paid careful attention to minimizing social desirability bias—bias that occurs when survey respondents say what they think the interviewers want to hear (Groves et al., 2009). Most rural men and women are aware that urban people typically use toilets and latrines. Outsiders who visit the village are often assumed to be from urban areas, and assumed to themselves use latrines. Therefore, our survey team had to create a social environment in which respondents could open up and share their real views on latrine use and open defecation. We trained the interviewers to be sensitive to how they asked questions and how they interacted with respondents. We took care to ask questions in a balanced way so as not to suggest one behaviour or opinion was more desirable than another. Interviewers were also trained to sit alone with respondents to prevent their responses from being influenced by other household members. Interviewers were trained be respectful at all times, and to show interest in the respondent's answers, no matter what those answers were. Despite this careful training, a qualitative study conducted alongside the SQUAT survey using more experienced interviewers suggests that, due to social desirability bias, the SQUAT survey's figures may yet underestimate preferences for open defecation.

For the first half of the survey, we were careful not to let respondents know that the focus of the study was sanitation. We initially obscured our focus because we were trying to study whether latrines and latrine use are a priority for respondents. If the respondents believed that latrines were a priority for the interviewers, they would have been more likely to report prioritizing latrines, no matter what their actual views were. In order to ensure that respondents did not initially know about the sanitation focus of the survey, respondents were given a broad explanation of the purpose of the study – to learn about village life – and questions at the beginning of the survey covered a variety of other topics in addition to sanitation. We also spent only a half day in each village so that neighbours did not have the opportunity to tell one another about the survey questions. Finally, we did not visit households that lived right next door to one another, but rather every third or fifth household depending on whether the interviewer began at the centre or edge of the village. The need to obscure the primary focus of the study meant that we were not able to revisit selected households where no one was home, or where no adult of the same sex as the interviewer was available – in such cases, the interviewer was required to select another household.

Appendix C: Predicted open defecation after universal government latrines

What fraction of recipients would use government constructed latrines, if they were built for households that do not currently own latrines? We observe (reported) latrine use for persons who live in households that own a government latrine. Average latrine use among people who do not have a latrine, if they were to receive a government latrine, could differ from average latrine use among people who currently have a latrine for two types of reasons:

1. **Observed differences.** Among people who have government constructed latrines, some people are predictably more likely to use them than others, according to observable demographic categories in our data, such as age, sex, wealth, district of residence, and others. People who have no latrine are different, on average, from people with government constructed latrines according to some of these categories, and therefore can be expected to be differently likely to use latrines. We can approximately correct for these observed differences with a statistical model.
2. **Unobserved differences.** Because having a latrine is not a randomly assigned treatment in our data, having a government latrine (rather than having no latrine) reflects selection into government latrine ownership. Because people who want to use a government latrine are more likely to seek and accept one, people without latrines are almost certainly more likely to defecate in the open than people with a government latrine, even if they are similar in every other observable way. We cannot address these unobserved difference in our model, so we will proceed assuming that there are no such differences, knowing that in fact such differences will lead us to predict less open defecation than would actually occur.

We build a model for observed differences by fitting a logistic regression to the sub-sample of persons who live in households that own a government latrine. We perform this procedure twice: for the sample of households with latrines that were at least partially government supported, and for the sample of households with latrines that were fully government constructed. Because the policy that we seek to predict is full government construction of a latrine for every household, we emphasize the latter. The simple regression model we fit is:

$$\ln\left(\frac{\pi_{ihd}}{1-\pi_{ihd}}\right) = A_{ihd}\alpha + B_{hd}\beta + \delta_d,$$

where π_{ihd} is the probability that person *i* living in household *h* in district *d* defecates in the open (although this is not explicit in the equation, in statistical inference we cluster observations at the village level). We add several sets of standard demographic independent variables: variables at the individual level *A*, variables at the household level *B*, and district indicators δ_d. Individual level variables include age, age^2, sex, education, and perceived village size. Household level variables include religion, caste and asset count. Note that we do not assume that any of the coefficients we estimate identify causal effects; rather, we assume that the average differences across observed demographic categories would be similar to what they are among households with government latrines, among people living in households that do not have latrines.

After fitting the model, we use the estimated coefficients to predict $\hat{\pi}_{ihd}$ the probability of open defecation among each person who lives in a household without a latrine, based on the demographic characteristics that were used to fit the model. It is exactly in this step that we assume away unobserved differences in preference for latrine use or open defecation: although the model was fit using data on latrine owners, we predict open defecation probabilities among people who live in households without latrines. Finally, we complete the prediction of the fraction of people defecating in the open in the entire rural population by making the "prediction" that people living in households that already have latrines will continue to behave as they do now.

The appendix table presents the results from fitting these models. Focusing on columns 1 through 6, which use people living in households with fully government constructed latrines, we add independent variables in stages to examine the effect on the fit of the model as more parameters are added. Each addition statistically significantly improves the fit of the model, [25] although the reduction in the deviance is statistically significant only at a $p = 0.104$ level in the case of education in column 5. When we reach our final model, we have improved the model's correct classification of the data for government latrine owners from 53.6% of person-level cases in the starting null model (which includes only a constant) to 72.2%. Even still, the predicted probabilities of open defecation must be regarded as approximate illustrations.

[25] The model predicts a probability for open defecation between 0 and 1. People whose predicted probability is 0.5 or higher are classified as people who defecate in the open.

Appendix Table: Predicted open defecation after new government latrines, logistic regressions using households with latrines

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
sample: fully or partially government	fully	fully	fully	fully	fully	fully	partially
	person-level open defecation, after latrine construction for all non-owner households						
new latrine recipients, all states	53.6%	53.7%	58.0%	59.4%	60.5%	66.3%	54.8%
new latrine recipients, focus states	53.6%	54.3%	57.3%	59.0%	60.3%	66.0%	56.5%
all persons, all states	39.9%	39.6%	42.4%	42.6%	43.2%	46.4%	39.9%
all persons, focus states	43.0%	43.1%	45.6%	46.2%	47.0%	50.5%	44.2%
	models and model fit						
correct classification	53.6%	60.5%	63.5%	65.6%	68.0%	72.2%	73.7%
independent variables:	none (null)	age	districts	districts	districts	districts	districts
		sex		age	age²	age²	age²
		assets		sex	× sex	× sex	× sex
				assets	assets	assets	assets
					education	education	education
						religion	religion
						caste	caste
						village size	village size
deviance	878.4	847.8	799.6	767.0	741.2	653.4	1983.0
χ^2 test for model addition, *p* -value		0.000	0.000	0.000	0.104	0.000	

Each column is a separate logistic regression. "× sex" indicates that district indicators, age as a quadratic, and the asset count are each interacted with an indicator for being female.

"Fully" or "Partially" indicates that the model is fit on the sample of households who report owning fully or partially government-constructed latrines.

"Correct classification" is the percent of persons' open defecation in observed data that the model correctly predicts.

The χ^2 test tests that additional independent variables improve the fit of the model, relative to the previous column.

We are not surprised that every time the *fit* of the model is improved on the dataset of latrine owners, the *predicted open defecation* is increased for the set of latrine non-owners. This is because every improvement in the predictive power of the model allows us to better capture the different composition of the set of latrine owners, who have been by some processes sorted into owning a latrine. This trend is one reason that we suspect that open defecation would in fact be even substantially more common than our model predicts if all non-owners were given a government latrine without changing preferences.

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