Open sky latrines: Social reinforcing in the case of a (very) impure public good

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Abstract

Among the third of the world's population that continues to use nature's "Open Sky Latrines," improved sanitation facilities represent an impure public good. For both epidemiological and social reasons, an individual household's payoff to latrine use will depend on the sanitation decisions of other households in the village. Data from a randomized sanitation intervention in Orissa allow us to measure the role of social interactions in households' decisions to build and use latrines. Three alternative econometric strategies produce consistent and robust evidence of social reinforcing. Interventions targeting social drivers of behavior change may be more effective than those that focus only on private incentives.

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1. Introduction

Two thousand eight was the International Year of Sanitation, marking the fact that inadequate access to sanitation infrastructure among a half of the world's population helps perpetuate inequalities in health and social outcomes. Despite the importance of this problem – diarrhea is the most significant cause of child mortality worldwide – economists have devoted little attention to the sanitation problem. Our review of the economics literature yields only a handful of studies specifically addressing households' demand for sanitation, often relying on stated preference methods (e.g., Anjum Altaf and Hughes 1994, Persson 2002, Whittington et al. 1993). Whether as a cause or a consequence of this lack of attention from economists and other social scientists, the prevailing view has been that improving access to sanitation is largely a public health problem requiring engineering fixes by a paternalistic state. However, after years of policies that focused solely on expanding the supply of sanitation technologies (e.g., building latrines), there is a growing recognition that inadequate attention to demand-side factors contributes to policy failures (Figueroa and Kincaid 2006, Kar 2003). Rigorous empirical examination of household sanitation choices is crucial for public policies aimed at solving this major global health challenge.

This paper examines changes in sanitation practices – specifically, transitions from near-universal "open defecation" to latrine use – following a randomized community-level information and communication intervention in rural Orissa, India. As our conversations with village members in the study area of Bhadrak District revealed, sanitation behaviors are motivated by a number of complex and competing factors. Many households perceive a link between latrine use and improved health risks, but equally important is a desire for convenience, privacy, and dignity, especially for the women. At the same time, others acknowledged the difficulty of changing norms and overcoming inertia. As one man remarked, “If [open defecation] was good enough for the Maharajas, it’s good enough for me.” Some women said that going out together in the evenings for open defecation gave them a chance to spend time together and gossip. Another man spoke about his preference for using “Open Sky Latrines,” rather than newer, man-made facilities. These vignettes reinforce the conclusions from other water and sanitation studies that a better understanding of the demand-side drivers of households’ sanitation choices is needed (Figueroa and Kincaid 2006, Jenkins and Curtis 2005, Kar 2003).

While social scientists have spent relatively little time specifically examining households’ sanitation decisions, several existing models are potentially relevant in the context of understanding demand for sanitation. The majority of existing economic studies of water and sanitation apply a health production function model, in which sanitation is an “averting behavior” that is valued as an input into the health of household members (Pattanayak et al. 2005, Whittington et al. 1993). One motivation for this approach is that it facilitates calculations of benefits – i.e., households’ willingness to pay for sanitation – to feed into cost-benefit analysis for planning and policy analysis. Another relevant branch of models are those addressing technology adoption (Foster and Rosenzweig 1995, Geroski 2000, Griliches 1957, Jaffe et al. 2002). These models fall predominantly into two categories: the probit model, which focuses on how heterogeneity across agents explains differences in perceived benefits of a technology and hence its adoption, and the epidemic model, in which information is the main factor limiting technology adoption (Geroski 2000). Related to these epidemic models are studies of information cascades (Bikhchandani et al. 1992), network externalities (Katz and Shapiro 1985), threshold effects (Granovetter 1978), bandwagons (Leibenstein 1950), and tipping (Schelling 1971). In these “density-dependent” models, the benefits to an individual of adopting a new practice are an increasing function of the number of others adopting the same behavior. Adoption decisions are thus mutually reinforcing, creating opportunities for systems to "tip" from one equilibrium to another (Heal and Kunreuther 2007).

While these models address one type of externality that is potentially involved in households' sanitation choices (the network externality), other externalities are also present. In particular, the epidemiology of diarrhea and other water-borne diseases is such that the use of latrines by one household affects community-level environmental quality and, thus, the health outcomes of other households in the community. In the language of impure public goods models (Cornes and Sandler 1984, 1994, Kotchen 2006, Vicary 1997), latrine use jointly produces private characteristics (e.g., privacy) and the public characteristic of improving environmental quality. (In an Appendix to this paper, we follow Cornes & Sandler (1984) to describe a simple model of latrines as an impure public good.) The public aspects of sanitation create the potential for collective action problems (Coase 1960, Hardin 1982, Olson 1965) and "tragedies of the commons" (Hardin 1968) in which self-interested individual actions lead to sub-optimal collective outcomes. In the context of sanitation in rural India, the typical prescriptions to these problems (privatization and government mandates) seem infeasible, but conditions may be ripe for successful common property regimes (Bromley 1992, Ostrom 1990) to manage the sanitation "resource." A key feature of the impure goods literature offers reasons for hope: as Cornes and Sandler (1994) explain: "If the joint products are complementary, then private outputs have a privatizing effect, not unlike the establishment of property rights. As a result, free-riding motives are attenuated" (p. 404). For example, the private benefits of latrines (e.g., privacy and dignity) are likely to increase with the public benefit of a cleaner environment that improves health - if you are sick, you are unlikely to care.

Each of these models helps to highlight a different aspect of the sanitation problem, and any one of these approaches could be usefully applied to the study of this complex challenge. However, synthesizing the lessons from all of these models, one key insight emerges: for any given household, the decision to adopt a latrine will likely depend on the actual or expected behaviors of other households in the community. These social effects arise for a number of reasons. As the impure public goods model highlights, the health outcomes of one household will be a function of the aggregate community contribution to the sanitation public good. To the extent that decisions are based on expected health outcomes (as the health production models posit), these epidemiological externalities will affect households' choices. Meanwhile, models of technology adoption suggest that information is a key input into household decisions, and the experiences of one's contacts is an important source of new information. Finally, perhaps as a mechanism for addressing collective action problems, households will face pressure to conform to community sanitation norms.

In theory, a model could be developed that would incorporate each of these social effect pathways. However, separately identifying each of the implied parameters empirically would be difficult if not impossible in most settings. Our objective here is thus more modest, though hardly trivial. Given the preceding models' consensus that social interactions are likely to matter in the context of households' sanitation choices, we aim to measure the aggregate social effects driving latrine adoption in one population undergoing a sanitation revolution. Because we seek to identify a *causal* social effect – i.e., the impact of community-level latrine adoption on a household's own probability of adopting this technology—even this modest goal poses distinct challenges.

The paper is organized as follows. Section 2 outlines the basic model of households' sanitation choices in the presence of social interactions, as well as our empirical strategy for identifying these interactions in the context of sanitation decisions in Orissa. Drawing on the social interactions literature, (Hartmann et al. 2008, Manski 1993, Moffitt 2001) we discuss the identification issues in separating endogenous or causal social effects from alternative explanations for similarities in behavior within groups. Our approach to addressing these challenges has two main advantages. First, we use panel data from a randomized community-mobilization intervention that allows us to observe *changes* in behavior following an exogenous shock to both individual-level incentives and community sanitation behaviors. Second, we employ three separate econometric estimation strategies to measure social effects in household decisions following the sanitation campaign. Because the identification strategies vary across these models, our application of all three approaches serves as a robustness check.

After describing our data and empirical methods, we present our results in Section 3. Across the different models, we find consistent evidence that latrine adoption among other households in the villages significantly increases the probability that a given household will also adopt a latrine. The remarkable consistency of our results across the different estimation strategies suggests that confounding from unobserved correlated or contextual effects is unlikely to be driving our results. Rather, these analyses indicate that social interactions and social pressure play an important role in households' latrine adoption decisions. Section 4 provides policy implications and conclusions. In particular, we argue that policies targeting "social" components of households' utility functions may be more effective than those focusing solely on private incentives in the context similar impure public goods.

2. Empirical Strategy for Identifying Social Interactions in Latrine Adoption Decisions

As we argued in the previous section, there are multiple potential pathways through which the sanitation choices of other households may affect an individual household's latrine adoption decision, ranging from epidemiological spillovers to information and learning effects to pressure to conform to sanitation norms. Rather than separately parameterizing each of these pathways, we assume simply that a household's latent utility from adopting a latrine, g_{ij}*, depends on household and village characteristics (X_{ij} *and* Z_j, respectively), as well as the *average level* of sanitation adoption among one's peers, $\bar{g}_{-ij}$: i.e., the proportion of other households in the reference group adopting latrines. That is:

$$g_{ij}^{*} = \beta X_{ij} + \delta Z_{j} + \phi \bar{g}_{-ij} + \varepsilon_{ij} \qquad 1$$

We observe $g_{ij} = 1$ if $g_{ij}^{*} > 0$, and $g_{ij} = 0$ otherwise.

Our primary interest here is in identifying the causal social effect parameter, ϕ. However, an extensive body of literature on social interaction outlines several factors that may potentially confound the identification of these "endogenous social effects" (Hartmann et al. 2008, Jackson 2008, Manski 1993, Moffitt 2001, Soetevent 2006). These confounding factors fall into three broad categories. The first is the presence of correlated unobservables, i.e., correlation in ε_{ij} across households within a reference group. A closely related problem, and a potential explanation for the presence of correlated unobservables, is endogenous group formation or homophily, i.e., the propensity of individuals with similar tastes or characteristics to associate with one another (Jackson 2008). The second potential confounding factor is what Manski terms "contextual (exogenous) effects," i.e., common group or neighborhood characteristics that affect group members' behavior. Like individual-level correlated unobservables, unmeasured contextual effects will create a correlation in error terms across individuals resulting in a correlation between ε_{ij} and $\bar{g}_{-ij}$ in eq. 1. The third problem involves "simultaneity," also known as Manski's "reflection problem" (1993). This problem results when agent 1's action affects agent 2's choice, and vice versa. Once again, this generates a correlation between the individual error term and the group outcomes (particularly in small groups). Thus, in the presence of correlated effects, contextual effects, and/or simultaneity, direct estimation of eq. 1 will yield a biased estimate of the causal social effect parameter, ϕ.

Given the identification problems outlined above, our primary empirical task is to estimate the role of social effects in driving latrine adoption decisions, controlling for multiple sources of confounding. Our approach rests on two main pillars. First, we use panel data from a randomized community-level sanitation intervention in Bhadrak District, Orissa. Randomization into the treatment group introduced an exogenous shock to private components of utility (through subsidies for latrine adoption for poor households) as well as altering the proportion of one's neighbors peers adopting latrines. Furthermore, panel data allow us to observe household behaviors before and after the campaign, controlling for household- and village-level time-invariant fixed effects. The second pillar in our estimation strategy is our use of three separate econometric models to estimate social effects using data from Bhadrak. These models address the identification challenges (correlated, contextual, and simultaneous effects) in somewhat different ways, so that using all three methods in combination provides a robustness check on the validity of measured social effects. This section briefly introduces the data, describing the randomized sanitation campaign and its effects, and then outlines the econometric strategies used to identify social effects.

<u>Data: Information, Education & Communication Campaign in Bhadrak, Orissa</u>

To explore the drivers of latrine adoption in Orissa, we conducted a community-level intensive sanitation promotion campaign (Pattanayak et al. forthcoming). The study took place in 40 rural villages located in two adjacent blocks, Tihidi and Chandbali, within Bhadrak District (Figure 1). Twenty of the 40 sample villages were randomly selected and assigned to the "treatment" group, while the other 20 villages served as "controls" (Figure 2). Baseline data were collected in all 40 villages in August of 2005. The intervention took place in the 20 treatment villages between January and May of 2006, and post-intervention data were collected in August and September of 2006. Our primary data collection instrument was a comprehensive household survey that was conducted in all 40 villages in 2005 and 2006, resulting in a balanced panel of 1050 households (treatment =529, control =521).

The intervention that was applied in the 20 study village in Bhadrak District fell under the Total Sanitation Campaign of the Government of India. However, the campaign was intensified in these villages, drawing on a model of "Community-led Total Sanitation" (CLTS), which was initiated in Bangladesh (Kar 2003) and subsequently employed in Indian states like Maharashtra (Sanan and Moulik 2007). The CLTS approach focuses on "empowering local people to analyze the extent and risk of environmental pollution caused by open defecation" (Kar 2003). In Bhadrak, the intervention involved a number of participatory activities designed to create a sense of shame about open defecation and of pride in achieving an "open-defecation free" village. For example, in the "walk of shame" activity, a procession of village members paraded through the village as Knowledge Links motivators helped draw attention to the volume and location of feces, and the impact on the village environment. While campaign activities varied somewhat from village to village, a similar protocol was followed across the 20 intervention villages and the end goal -- self-analysis of the sanitation situation leading to community consensus to end open defecation -- was the same.

In addition to social mobilization activities, village production centers (PCs) were also established to produce the materials needed for latrine construction, such as rings and pans, using local material. Finally, while CLTS typically de-emphasizes subsidies, trying instead to motivate households to adopt latrines on their own, subsidies were employed in the Bhadrak intervention. The typical cost of construction for the type of latrine (off-pit) promoted under this campaign was Rs. 1500 (about US$30), of which households below the poverty line (BPL) were only required to pay Rs. 300 (about US$6). Direct subsidies were not provided to households above the poverty line (APL), a point we will return to in our discussion of econometric identification approaches.

Table 1 presents descriptive statistics for a number of household and village characteristics in 2005 and 2006. In general, treatment and control villages are fairly similar, with few significant[2] differences in observable covariates prior to the sanitation intervention. However, treatment villages do appear to be slightly "worse off" along a few dimensions, such as distance from all-weather roads, expenditure over the past 30 days, and ownership of consumer durables like TVs. Furthermore, when we turn to the main outcomes of interest, we see that treatment villages had a lower rate of latrine ownership and use compared to control villages prior to the intervention. Only 6.4% of households in treatment villages owned latrines in 2005, and a slightly lower percentage (4.3%) consistently used these latrines. These percentages are somewhat higher (13% and 10%, respectively) in control villages, and the differences are statistically significant. Thus, through simple luck of the draw it appears that the baseline sanitation situation in treatment villages was slightly worse than in control villages prior to the intervention. It should be noted, however, that even in control villages, sanitation conditions appear quite poor in absolute terms.

Following the intervention, there are no major changes in the covariates across treatment and control villages. However, Table 1 shows that there is a substantial increase in latrine ownership in the

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[2] Throughout this discussion, we refer to statistics as "marginally significant" when they have a p-value less than 10%, "significant" p-value is less than 5%, and "highly significant" when p-value is less than 1%.

treatment villages, with no change in control villages. Treatment effect estimates computed using a number of regression and difference-in-difference estimators confirm that the campaign had a fairly large and significant impact on latrine ownership, increasing the percent of households owning a latrine by about 30% in the treatment villages within a few months of the campaign's conclusion (Pattanayak et al. forthcoming). Reported latrine use also increases, though by a lower amount (about 25%).

The significant increase in latrine ownership and use had the desirable impacts on water quality, measured in terms of E.coli levels in samples taken from main village source (Figure 3). While E.coli level rose from 1.3 to 3.7 CFUs per 100ml in control villages, E.coli declined from 0.9 to 0.1 CFUs in treatment villages. Critically, the number of water sources with E.coli contamination *increased* from 4 to 6 in control villages and *decreased* from 9 to 2 in treatment villages.

Econometric Estimation of Social Impacts

Our main interest here is in assessing the role of social interactions in driving observed sanitation behavior changes in Bhadrak. Fortunately, several features of the Bhadrak dataset facilitate this task by providing opportunities to address correlated and contextual effects, as well as the simultaneity problem. First, examining the decision to adopt a latrine allows us to use a discrete choice framework. As Brock & Durlauf (2001) and others have pointed out, identifying social effects in a nonlinear (e.g., discrete choice) model avoids some of the problems of the linear-in-means model by because there is no longer a linear relationship between group characteristics and group behaviors. However, a correlation in error terms across individuals may still bias social effect results even in a discrete choice setting. Fortunately, another advantage of our data is that we observe households at two points in time (before and after the campaign), and thus observe *changes* in behavior within households. By using the differenced dependent variable, we are thus controlling for time-invariant household-level unobservables across a very short period of time. To the extent that these factors are correlated across households, our data allow us to rule out the hypothesis that these factors are driving similarities in outcomes that we observe within social units (i.e., villages).

Furthermore, the randomized sanitation intervention aids in the identification of social effects in a few ways. The campaign provided an exogenous shock at the village level, explicitly targeting social drivers of latrine adoption and influencing both private and public characteristics essential to impure public goods. With regards to public characteristics, this intervention was essentially an attempt to move communities from one social norm (open defecation) to another (universal latrine use). The intervention encouraged villages to establish systems for punishing free-riders (e.g., through monetary fines or social sanctions such as mocking or even throwing stones at those who continue to practice open defecation). Because the intervention was intended to operate through social norms, its success (in terms of latrine adoption) in and of itself provides evidence suggesting those norms' importance. Moreover, the campaign essentially introduced random variation in the proportion of one's peers adopting latrines. If simultaneity and other confounders are appropriately addressed, this fact will prove extremely useful in identifying social effects.

However, the intervention also targeted private components of utility, emphasizing privacy and dignity and, most notably, providing financial incentives via reduced costs of latrine construction for certain households. Thus, without any further analysis, one could argue that the campaign's effects operated largely or entirely through these private channels. Fortunately, the structure of the incentives (i.e., variation in eligibility based on poverty status) actually provides additional opportunities to identify social effects, as we will discuss below.

While the data themselves are nicely suited to the task of identifying social effects in households' latrine adoption decisions, appropriate data analysis methods must be employed to address any remaining sources of confounding. We employ three separate strategies that treat the data in somewhat different ways. The first method we use to estimate social interactions is based on Brock & Durlauf (2001). In this specification (hereafter referred to as the B&D model), the average level of adoption among other households in the village is simply included as a regressor in a nonlinear (probit) regression in which the dependent variable records whether or not the household adopted a latrine between 2005 and 2006. That is, this approach assumes that individual error terms are independently and identically normally distributed, so that the likelihood function is of the form:

$$P(g_{ij} = 1 | X_{ij}, Z_j, \bar{g}_{-ij}) = 1 - F(-\beta X_{ij} - \gamma Z_j - \phi \bar{g}_{-ij}) \qquad 3$$

where *i* indexes individuals, *j* indexes villages, and *F(.)* is the normal cumulative density function. Regressors include household and village characteristics, as well as an indicator for whether or not the household was in a "treatment" village. While this approach has the advantage of being easy to implement, identification of social interactions relies on functional form assumptions – i.e., we are assuming that the panel specification successfully controls for all sources of correlated and contextual unobservables across households within villages. While this may be a reasonable assumption given the data, it is theoretically possible that time *variant* correlated or contextual effects could be present. Moreover, this method does not explicitly address the simultaneity concern, except through the nonlinearity of the model's functional form.

To address some of these issues, we also implement a variant of the two-stage estimation strategy outlined in Bajari et al. (2006). In this approach (BHKN), identification of social effects uses exclusion restrictions – i.e., household characteristics (X_{1ij}) that only affect the household's own adoption decision, without having any direct effect on the adoption decisions of other households. The logic behind this approach is that neighbors are influenced in their latrine adoption decisions by the expected behavior of their peers, and expectations about peers' behavior are based on neighbors' observable characteristics. If we can identify a subset of neighbors' characteristics that have no direct effect on a household's own adoption decision (i.e., that can be excluded from the household's own utility function), then any observed impact of these characteristics on the household's behavior must be through their impact on neighbors' behavior. This is the social effect we are seeking to identify.

Once a valid set of exclusion restrictions has been identified, estimation proceeds in two stages. The first stage estimates latrine adoption decisions as a function of the exclusion restrictions and a set of village dummies:

$$g_{ij}^{*} = f(X_{1ij}, D_j) + \varepsilon_{ij} \qquad 4$$

This regression captures the component of latrine adoption that is solely influenced by the household's own attributes, as well as common village characteristics that influence all households within the village. Results from this regression are then used to generate predicted probabilities of adoption for each household. In the second stage, latrine adoption is regressed on the full set of household and village characteristics, as well as the predicted level of adoption among other households in the village, $\widehat{g}_{-ij}$:

$$g_{ij}^{*} = f(X_{1ij}, X_{2ij}, Z_j, \widehat{g}_{-ij}) + \varepsilon_{ij} \qquad 5$$

The coefficient on $\widehat{g}_{-ij}$ provides an estimate of the social effect. Variables included in the second stage of this regression are similar to the set of covariates included in the B&D model, and include both household and village characteristics. Assuming valid exclusion restrictions can be identified, this method will control for simultaneity as well as correlated unobservables.

In addition to running the B&D and BHKN models on the full set of villages, we also run this regression limiting the sample to treatment villages only. This is equivalent to interacting each of the regressors with the treatment variable. Since we see virtually no additional uptake of latrines in the control villages between 2005 and 2006, there is reason to believe that there is a fundamentally different process of adoption operating in the treatment villages. Limiting the sample to these villages allows us to examine this process in more detail. In treatment village-only regressions, additional variables are included to capture variation in the sanitation campaign both across and within villages. To account for variation in exposure to the campaign across households, we include regressors that record whether or not the survey respondent said that she was aware of the campaign that occurred in the village, and whether or not s/he participated in any campaign activities. Finally, the sanitation campaign was implemented by different local NGOs in each village. Dummy variables for each of these NGOs are included to capture possible differences in intervention quality across villages.

An alternative set of analyses of the role of social interactions takes advantage of apparent variation in the incentives provided under the Bhadrak sanitation campaign. According to Moffitt (2001), one way to look for social interactions is to examine the effects of an intervention that changes incentives (e.g., prices) for one group, but not for others. If changes in behavior are observed for those who were not directly affected by the incentive change, this may provide evidence for social interactions. In the case of the sanitation campaign, only households classified as “below the poverty line” (BPL) were eligible for latrine subsidies. Thus, if we observe increases in latrine uptake among households that should not have received the subsidy (APL households), this may provide evidence that the impact of the intervention was partially due to social interactions.

To test this hypothesis, analyses are conducted limiting the sample to households not classified as BPL. First, we replicate the impact evaluation analyses using only non-BPL households to assess the level of adoption within this group. Next, to test the hypothesis that adoption among APL households is being influenced by increases in adoption among other households in the village (particularly among BPL households), two sets of analyses are conducted. The first is identical to the Brock & Durlauf model described above. For APL households, latrine adoption is regressed on own household characteristics as well as the percent of other households in the village adopting latrines. We then implement a two-stage approach in which the percent of BPL households in a village serves as an instrument for the percent of households who adopt latrine in that village. This analysis tests the hypothesis that the social incentive to adopt a latrine will be higher for APL households that live in villages with a greater proportion of households receiving the subsidy (BPL households). The identifying assumption in this model is that the only way that the percent of BPL households in a village affects an APL household's adoption decision is through the social channel. That is, having more BPL households in a village increases the number of households who adopt latrines, thus increasing the social pressure on APL households to adopt as well. This assumption will be violated if there are other reasons for which having more BPL households in a village would influence an APL household's adoption decision. These validity threats can be minimized by including other observed village characteristics (e.g., distance from roads) in the analyses, but the threat of unobserved confounders remains.

3. Results: Drivers of latrine adoption by households

As a reference point, we begin by presenting results from discrete choice models of latrine adoption that exclude social effects (Table 2). In each of these models, the dependent variable records whether or not the household adopts a latrine between 2005 and 2006. The first column presents results using the full sample of villages. Column two replicates this model limiting the sample to treatment villages and replacing the "treatment" dummy variable with indicators for awareness of and participation in the sanitation campaign. The third column adds dummy variables for the NGOs that implemented the sanitation campaign in each village. All three models also include "social preference" indicators, discussed in more detail below. Because the intervention was at the village level, all errors are clustered at the village level for making inferences about statistical significance in all models discussed next.

Sanitation Campaign Variables

Model results confirm that the sanitation intervention had a significant impact on latrine adoption across the study area. In the full sample, the treatment variable is highly significant, replicating the impact evaluation results. Turning to the treatment-only samples, these models show that awareness of the campaign is significantly positively correlated with latrine adoption, while participation in the campaign (conditional on being aware of it) has no additional effect. In fact, participation is not significant even in models that do not include campaign awareness (results not shown). One interpretation of this result is that hearing about the campaign from one's neighbors is more effective than actually participating in the campaign activities. This may provide initial evidence for the role of social effects in driving latrine adoption.

Village and Household Characteristics

Several household and village level covariates are included in these regressions. Turning first to village characteristics, population density could potentially affect the benefits of adopting a latrine in a couple of ways. In a pure public goods model, the incentive to free ride will increase as group size increases. However, higher population density may also lead to more crowding and less space available for open defecation, increasing the benefits of latrine adoption. Our results show an insignificant effect of population density on latrine adoption, possibly suggesting that these effects offset one another. Other village characteristics include distance to roads and surface water.[1] In two of the three models, we find that distance to an all-weather road is negatively correlated with latrine adoption, likely due to less access to building materials and higher costs. Surface water distance is not significant.

Results from these models reveal a few significant correlations between latrine adoption and household characteristics. Education does appear to increase the propensity to adopt latrines – households headed by individuals with at least a primary education are significantly more likely to adopt latrines than those in which the household head has no formal education. This effect is greater in the treatment-only sample compared to the full sample (18% versus 8%), suggesting that the increase in adoption in treatment villages occurred more frequently among somewhat more educated households. Turning to caste, these results do not reveal strong differences in adoption between open castes and other castes (including scheduled castes, other backwards castes, and other groups) once a range of other household characteristics are controlled for. Interestingly, wealth measures like expenditure on food and non-food items in the past 30 days, and ownership of consumer durables (TVs, mattresses) also do not show strong or consistent relationships with latrine adoption. In the full sample, households with TVs are marginally *less* likely to own latrines, while in the treatment only sample controlling for implementing NGOs, we do see a positive relationship between expenditure and latrine adoption. However, we do find a consistent correlation between housing quality variables (particularly, whether or not the house has mud or thatch walls) and latrine adoption. We return to this result in our discussion of the BHKN social interactions analyses.

Social Preferences

The three models whose results are presented in Table 3 all include a set of covariates intended to measure respondents' "social preferences," such as attitudes toward community, altruism, spitefulness, willpower, and conformism. Each of these questions had respondents choose among alternative statements (e.g., "Improving our community is just as important as looking after my immediate family " versus "Taking care of my immediate family (household members) is my first responsibility"). Table 4 provides a list of these questions and the proportion of the sample giving different responses in treatment and control groups.

Returning to our analyses of latrine adoption in Table 3, chi-squared statistics imply that the social preference variables are jointly significantly correlated with households' sanitation decisions. In particular, one indicator has a consistently positive and significant coefficient across the different models. Households that expressed the belief that "community is as important as family" were significantly more likely to adopt a latrine compared to households that put their own family first. This may reflect a perception that latrines are a public good, and that households have an obligation to adhere to village sanitation norms.

NGO Dummies

The last column in Table 2 also includes a set of dummy variables for the 10 NGOs that implemented the CLTS campaign in the 20 treatment villages. The inclusion of these dummy variables is highly significant. Notably, there are three treatment villages in which there is no latrine adoption following the CLTS campaign, and one NGO (JSM) was operating in two of these three villages. Because there is no variation in the adoption variable within these villages, they are dropped from the analysis when NGO dummies are added. Furthermore, these two villages are also significantly farther from all-weather roads than the rest of the villages, which explains why the road distance variable is no longer significant in column three. Thus, it is unclear whether the lack of success in these villages was due to the villages' remote location or the (in)effectiveness of the NGO. Nonetheless, the significance of the NGO dummies even when these villages are dropped and a number of other covariates are accounted for provides evidence of variation in the effectiveness of different NGOs in implementing the sanitation campaign (i.e., variation in treatment quality across villages).

Social Interactions Estimates: Functional form and exclusion restrictions

Table 5 present results from four different social interactions analyses. The first two columns present Brock & Durlauf-style models using the full sample of villages and then limiting the sample to treatment villages only. Models 3 and 4 use the Bajari et al. identification strategy. In the models presented here, the first stage regresses latrine adoption on housing quality variables as well as a set of village dummies. In the basic discrete choice models, we found that housing material variables (whether or not the household has a mud floor, mud or thatch walls, and a thatch roof) are jointly significantly correlated with the probability of latrine adoption. These variables may be serving as proxies for some other, unobserved household characteristic that is influencing the adoption decision. It seems reasonable to assume that whether or not one's neighbor has a mud floor will not directly affect a household's own payoff to adopting a latrine, except through its effect on the neighbor's adoption decision. Thus, neighbors' housing materials may reasonably be excluded from the household's own utility function. However, as a robustness check, the BHKN models were also estimated using a different set of variables for inclusion in the first stage (expenditure and ownership of consumer durables). These models produced very similar results to those presented in Table 4, reassuring us that the choice of exclusion restrictions is not driving these models' results.

Estimated Social Effects

In the B&D models, the social effect is estimated from the coefficient on the percent of others adopting in the village. In the BHKN models, this effect is identified by the coefficient on the predicted share of others adopted in the second stage. In both sets of models, this effect is defined as the predicted increase in one's own probability of adoption given a 1% increase in the (predicted) share of others adopting a latrine.

Across the four models, social effects are positive and highly significant, suggesting that adoption among one's peers is one factor driving a household's own decision to adopt latrines. In both the B&D and BHKN models, the magnitude of the estimated social effect is smaller in the whole sample (about .4%) than in the models using treatment villages only (where the effect is about .8%). Thus, we find evidence that the sanitation campaign may have increased latrine adoption in part through increasing the social pressure or social incentive to adopt latrines. This is consistent with the campaign's focus on sanitation as a community-level priority, necessitating village-wide action. To the extent that village members followed through with the campaign's encouragement to establish systems of fines and punishments for those that continued to practice open defecation, we would expect to find larger social effects in these villages.

Finally, the similarity among the result we obtain in these different models is reassuring given that the two estimation strategies used rely on different assumptions to identify social effects. The B&D model uses functional form assumptions while the BHKN model relies on the validity of the exclusion restrictions. The fact that estimated peer effects vary little among the different models is evidence that neither of these assumptions is driving the models' results.

Other Covariates

It is also interesting to note what happens to the coefficients on other covariates in the models that include social interactions. CLTS campaign variables (treatment dummy, campaign awareness) remain highly significant across these models. However, other covariates that were found to be correlated with latrine adoption in previous models, such as distance to all-weather roads, generally lose their significance when social interactions are included. Education and housing quality variables remain significant.

Social Interactions Estimates: Excluded groups

As an additional test of the role of social interactions in driving latrine adoption in Bhadrak, we turn our attention to households above the poverty line, who were not eligible to receive subsidies under the CLTS intervention. The first analysis we conduct replicates impact evaluation models (regressions in levels as well as difference-in-differences) for APL households only. Results from these models indicate that the CLTS campaign had a similar effect on adoption among APL households when compared with the whole sample, increasing the share of households owning latrines by 30 to 40%. Thus, we find that the impact of the campaign was not limited to the subset of households receiving direct government subsidies for latrine adoption.

Additional analyses estimate the size of the social effect among households above the poverty line. Results from these models are presented in Table 6. The first two columns present model estimates when percent of others adopting is included directly as a right hand side variable, while the last two columns report results from a two-stage model in which percent BPL is used to instrument percent adopting latrines. Each of these models is estimated using the full set of villages as well as treatment villages only. The results are generally similar to those estimated in the B&D and BHKN models. Estimated social effects are higher when the sample is limited to treatment villages, suggesting more social pressure to adopt latrines within villages exposed to the CLTS campaign. Estimated social effects are also higher in the models that use % BPL as an instrument for percent adopting latrines. This may provide evidence that the social pressure to adopt is higher for APL households living in villages with more BPL households, providing further support to the hypothesis that social interactions are an important factor driving latrine adoption in the study area.

Social Effects for Sub-groups Within Villages: Gender, Age, and Caste

Results presented thus far indicate that households were generally influenced by other households in the village in their decisions to build latrines. However, an important consideration in studies of social effects is the definition of relevant "reference groups." That is, which "neighbors" or "peers" do households look to in deciding whether or not to adopt a certain behavior? Each of the models described above implicitly assumes that villages are the relevant reference groups. That is, each household is influenced uniformly by other households in its own village, and households are not influenced by outcomes in other villages. Turning first to the latter assumption, measures were taken in the design of the sample to minimize potential spillovers across study villages: villages are not physically adjacent to one another, nor do they belong to the same administrative units (panchayats). While we cannot rule out the possibility of cross-village interactions, it seems plausible that these interactions will be substantially weaker than within-village social effects. The assumption that households interact uniformly *within* villages may be more problematic. Indeed, it seems likely that households will weight the behaviors of certain peers more heavily than others in making their decisions. While we do not have data on specific patterns of interactions within villages, we can begin to explore this issue in a couple of ways. Here we present several exploratory analyses to examine whether social effects may have varied within villages.

The first set of results is presented in Table 7. While previous models examined social effects in the decision to build a latrine, the models in Table 6 take a closer look at *use* of latrines among various subgroups within the household. For households with access to a latrine, survey respondents provided information on whether or not men, women, and children in the household "usually/always" used latrines for defecation. This data allows us to construct three binary indicators for use of latrines among each of these subgroups within each household. We then estimate a variety of Brock & Durlauf-type models examining social effects for different sub-groups.

For each sub-group (i.e., men, women, and children), two models were estimated. The first model includes a single indicator for use of latrines among other members of the *same* subgroup within the village (e.g., effect of average use levels among men on men's use within the household). The second model includes three separate indicators for use levels among each of the three subgroups (e.g., effect of average use levels among men, women, and children on men's use). All models are replicated using the whole sample of villages as well as treatment village-only samples.

A few points are worth noting. First, looking at Model 1 for all three sub-groups, we see a pattern of social effects that is similar to those we found in earlier models of latrine adoption. Effects are positive and significant, and generally somewhat larger in the treatment-only samples. Effect sizes are also quite similar for men and women (around .5% in the whole sample, compared to .8% in treatment villages), while they are substantially smaller among children (around .3% in all samples). Overall use *levels* are also consistently quite low among children (11% in treatment villages and 4% in control villages in 2006). Together, these findings suggest that social norms seem to be promoting latrine use among adults more strongly than among children. Model 1 also confirms that when use among other groups is excluded, there appear to be strong within-group social effects – i.e., men are more likely to use latrines if use levels among other men in the village are high.

Results in Model 2, which includes separate variables for use among men, women, and children, are more complicated. For men and women in the whole sample, we see some evidence of within-group social effects: that is, the share of other men using latrines is a significant predictor of latrine use among men, and use among other women appears to influence women's use. However, these effects are less clear cut in the treatment-only sample. In fact, use among other *women* in the village is a significant predictor of latrine use by *men* (and is also marginally significant in predicting children's use), while none of the social effects is statistically significant when men's, women's, and children's use are included separately to predict use among women. We may cautiously interpret these results as evidence that the sanitation campaign changed gender dynamics among latrine use somewhat, perhaps making use among women more influential. The campaign placed a strong emphasis on benefits of latrines such as privacy and convenience for women, and the finding that women's use significantly predicts men's use may indicate that women subsequently increased pressure on their husbands to use latrines. This is highly speculative, however, and further analysis is needed to clarify the role of gender and gender dynamics in determining sanitation outcomes.

We turn finally to a set of analyses examining social interactions within and among different caste groups in the study area. To begin with, Table 8 shows adoption of latrines among three different caste groups: scheduled castes, other backwards castes, and open castes. (About 94% of study households fall into one of these three groups.) Chi-squared tests of equality in latrine adoption across these three groups are rejected at the 5% level in the whole sample as well as the treatment only sample. That is, rates of latrine adoption do differ significantly across different caste groups. Rates of latrine adoption are lowest among scheduled castes, and, interestingly, highest among households belonging to “other backwards castes.” However, as shown in Tables 3-5, these apparent caste differences are not significant once other observable village and household characteristics are controlled for.

Table 9 explores the hypothesis that households look primarily to other individuals within their own caste group in deciding whether or not to use a latrine. This analysis includes as regressors the percent of others within one’s *own* caste who have adopted latrines, as well as the percent of households in *other* households who have adopted. Results provide some evidence that households weight adoption by other members of their own caste group more heavily than latrine adoption among households belonging to other castes. While both own and other caste variables are positive and significant, own caste effects are substantially larger. In the whole sample, a 1% increase in adoption among other households in one’s own caste increases a household’s probability of adopting a latrine by .26%, compared to .09% for other castes. Similarly, limiting the sample to treatment villages yields an “own” effect of .57% and an “other” effect of .3%. A chi-squared test of the hypothesis that own and other effects are equal can be rejected at the 10% level in the whole sample, and cannot be rejected in the treatment-only sample. As with gender, additional analysis is required to more fully explore the relationships among caste, social networks, and sanitation outcomes.

4. Discussion and Conclusions

The theoretical considerations of this paper emphasize the impure public good aspects of latrines. Consequently, the sanitation intervention in Bhadrak, which bundled the private and public characteristics of latrines, starkly contrasts with the two dominant paradigms in the water and sanitation sector. While public health supply-siders have typically focused on subsidized engineering fixes by paternalistic states, the more recent Washington consensus (with its strong faith in private sector participation) has argued for reliance on pure market forces resulting from the careful weighing of private costs and benefits of latrines.

The substantial short-term impact on latrine adoption in the study area suggests that the intervention succeeded by operating through a combination of private and social channels. The campaign's emphasis on privacy and dignity is likely to have replicated the success described in earlier studies of sanitation. For example, Jenkins & Curtis (2005) studied the motives for latrine construction in rural Benin, and found that "prestige" and a desire to identify with the urban elite were cited by a number of households as reasons for building or wanting to build a latrine. Just as crucially, at least some of the intervention's impacts were most likely due to the subsidies and increased supply of materials provided under this program, which reduced the cost to households of constructing a latrine. It is worth noting, however, that subsidies have long been a part of the Government of India's Total Sanitation Campaign, yet government staff members report that TSC has not been as effective in inducing latrine ownership and use in other areas.

Thus, the intervention succeeded to a large extent by combining these private drivers of sanitation demand with its public aspects using emotional motivators such as public shaming. Frank (1988) emphasizes that emotions serve social functions by enabling us to make commitments we could not otherwise keep. More broadly, the sanitation intervention was consistent with a number of lessons from 30 years (1970s – today) of experience with behavioral health interventions (i.e., targeting lifestyle changes) in the U.S. that also relied on information and communication. As Cutler (2004) posits, such interventions succeeded to the extent that they (1) highlighted the external consequences of private choices - e.g., drunk driving kills children; (2) permeated widely and overcome individual inertia; and (3) triggered peer-effects. The sanitation campaign employed in Bhadrak did each of these things.

As discussed earlier, almost by definition private features of latrine use such as women's privacy as well as public dimensions such as impacts on a neighbor's child's health are social constructs that will be reinforced by peer interaction and pressure. Thus, across the different estimation strategies we employ, we find consistent evidence that adoption among other households in the village had a significant impact on an individual household's own probability of adopting a latrine. These effects are stronger in treatment villages relative to control villages, possibly indicating that the Bhadrak campaign caused households to place more weight on social components of utility, increasing the social pressure to adopt latrines. Further evidence for the role of social factors in driving latrine adoption comes from the large increase in adoption we observe among households who were not eligible for direct subsidies. We find that households above the poverty line were just as likely to adopt latrines as households below the poverty line. While it is possible that some of this increase is a result of a de facto "subsidy" for APL households as well as BPL households arising from the increased availability of sanitation materials, we also find evidence of social effects operating within this group. In particular, it appears that APL households are more likely to adopt latrines if they live in villages with more subsidy-eligible BPL households.

These results have several policy implications that draw on the impure public goods literature. First, simply the presence of (partially) public goods creates the potential for sub-optimal social outcomes under individual decision making. Moreover, attempts to convince individuals that they should adopt a given technology solely on the basis of its public benefits are likely to fall short of achieving socially optimal outcomes. This may help to explain the failure of sanitation promotion campaigns emphasizing the "germ theory" linking open defecation to child diarrhea. To the extent that diarrhea is influenced by community-level environmental quality, individual latrine use contributes toward a public good, with the associated problems of free riding and underprovision.

Second, technologies that appropriately bundle private and public characteristics can be more effective (Heal, 2003). How much can bundling help? Only when public and private characteristics are complements rather than substitutes. The degree of complementarity between these characteristics is an empirical matter that will likely vary across different environmental health issues and technologies. The success of the CLTS campaign in South Asia and now Indonesia, Kenya and Latin America rests to some extent on the effective marketing of the bundled outcomes of health and dignity that result from using a latrine.

Finally, while bundling public and private characteristics may, under certain conditions, reduce free riding, the literature does not imply that bundling alone is sufficient to eliminate collective action problems. As our results suggest, policies should target social along with private components of utility. While interventions that reduce individual costs of latrine adoption through information and subsidies may result in some increase in adoption, policy makers should also consider the role of social norms in determining household behaviors (Sethi and Somanathan, 1996; Young, forthcoming). Importantly, policies such as the Bhadrak sanitation campaign that strengthen social norms may actually increase the effectiveness of subsidies and other policies that focus on private incentives by creating a "multiplier effect." For example, in the case of the sanitation campaign employed here, subsidies to households below the poverty line may have had the added effect of increasing social pressure to adopt latrines among subsidy-ineligible APL households.

It is also worth noting that there may be alternative ways of incorporating knowledge of social interactions into public policy, such as using policies to target a small number of influential individuals within each village. The Bhadrak intervention targeted villages as a whole, directly involved a (non-random) subset of the population in campaign activities, and then relied on these individuals to spread the message throughout the community. Prior knowledge of which individuals are most influential within a community could be helpful in targeting such campaigns more narrowly. However, to determine whether this type of policy might be more cost-effective than the broad-based approach employed in the Bhadrak study, more information on the patterns of social interactions within villages would be required.[3] Exploratory results presented here indicated a possible role of both gender and caste in shaping social interactions and peer effects, but more detailed information on social networks would be useful. Fortunately, methods for gathering data on social networks have been developed and applied in previous studies (e.g., Conley and Udry 2005). However, to the extent that this information is costly to gather, it is possible that the CLTS approach will be simpler and more cost-effective to implement.

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[3] Furthermore, the study was initially designed to minimize the amount of spillovers between the treatment and control groups, ensuring that villages in the sample frame were not physically adjacent to one another or members of the same administrative sub-unit (panchayat). While this methodology allowed a "cleaner" measurement of the campaign impacts, the spillovers are themselves part of the story and potentially a key part of the campaign's long-term impacts on latrine adoption and health outcomes. Thus, monitoring the spread of adoption from treatment villages to surrounding villages is another potentially fruitful direction for additional work, helping to shed light on the ongoing process of sanitation-related behavior change.

Finally, the results presented here only begin to tell the story of the full impact of the sanitation campaign on behavior change in Bhadrak District. Latrine uptake and use are likely to change over time; indeed, data provided by the Government of Orissa in 2007 suggest that latrine uptake increased considerably in the year following this study's endline data collection, with up to ten of the twenty treatment villages achieving 100% latrine ownership (Pattanayak et al., forthcoming). Since social change is a dynamic process, much could be done to use the results of this study to analyze an unfolding sanitation revolution in more detail. Follow-up data collection within the villages included in this study can continue to monitor the pace and patterns of adoption among different groups.

5. Appendix: The Simple Analytics of Sanitation Choices

Following Cornes & Sandler (1984), we construct a model of latrines as an impure public good. Adopting a latrine (*g*) generates β units of a private characteristic (*x*=privacy) and γ units of the public characteristic (*Z* = reduced microbial contamination of the environment). Households have utility over the private and public characteristics, as well as a numeraire consumption good, *c*, with $p_c = 1$. The price of adopting a latrine is *p*, and households have income *I*. Writing utility maximization problem over *characteristics* gives:

$$\max_{c,x,z} u_i\,(c_i, x_i, Z_{-i} + z_i) \text{ s.t } (1/\beta)\, x_i = (1/\gamma) z_i,\, c_i + (p/\beta)\, x_i = I_i \qquad \text{A1}$$

Alternatively, we can write utility over the *goods*, c and g:

$$\max_{c,x,z} v_i\,(c_i, \beta g_i, Z_{-i} + \gamma g_i) \text{ s.t. } c_i + p g_i = I_i \qquad \text{A2}$$

The standard result from equation A2 is that consumers will choose *c* and *g* such that

$$p = MRS_{gc} = (\partial u/\partial g)/(\partial u/\partial c)$$

Meanwhile, equation A1 produces the analogous condition that

$$p = \beta MRS_{xc} + \gamma MRS_{Zc} \qquad \text{A3}$$

Combining these results shows that $MRS_{gc} = \beta MRS_{xc} + \gamma MRS_{zc}$, i.e., the marginal rate of substitution between g and c is a weighted sum of the marginal rates of substitution between x and c and z and c.

Suppressing individual notation for the moment, for a given equilibrium outcome of x, Z, and u, define $MRS_{xc} = \pi_x(x, Z, u)$ and $MRS_{zc} = \pi_z(x, Z, u)$. Cornes and Sandler (1984) demonstrate that we can alternatively think of these functions as:

1. the partial derivatives with respect to x and Z of a conditional cost function, $c(x, Z, u) = \min_c[c|u(c, x, Z) \geq u)$
2. virtual prices for x and Z at the equilibrium allocation; or
3. inverse demand function for x and Z at the equilibrium allocation.

We consider now a two-person community, so that $Z = z_1 + z_2 = \gamma(g_1 + g_2)$. For individual 1, equation A3 implies that

$$p = \beta\pi_x(x_1, Z, u_1) + \gamma\pi_z(x_1, Z, u_1) = \beta\pi_x(\beta g_1, \gamma g_1 + \gamma g_2, u_1) + \gamma\pi_z(\beta g_1, \gamma g_1 + \gamma g_2, u_1) \qquad \text{A4}$$

Our goal is to determine the response of individual 1, dg_1, to a change in the behavior of individual 2, dg_2. To derive this response function, we take the total differential of equation A4, which yields:

$$0 = \beta[\beta\pi_{xx}dg_1 + \pi_{xz}(\gamma dg_1 + \gamma dg_2) + \pi_{xu}du] + \gamma[\beta\pi_{zx}dg_1 + \pi_{zz}(\gamma dg_1 + \gamma dg_2) + \pi_{zu}du_1)$$

Rearranging gives (A5):

$$\frac{dg_1}{dg_2} = \left[\frac{\gamma(\beta\pi_{xz} + \gamma\pi_{zz})}{\Phi}\right] + \left[\frac{(\beta\pi_{xu} + \gamma\pi_{zu})}{\Phi}\right]\frac{du_1}{dq_2} \text{ where } \Phi \equiv -(\beta\gamma)\begin{bmatrix}\pi_{xx} & \pi_{xz}\\ \pi_{zx} & \pi_{zz}\end{bmatrix}\begin{pmatrix}\beta\\ \gamma\end{pmatrix} > 0 \qquad \text{A5}$$

The second term on the right hand side of equation A5 is a real income term, capturing the fact that individual 1 enjoys an increase in real income when individual 2 contributes to the public good. Assuming that x and z are normal goods, π_{xu} and π_{zu} will both be positive, so that this income term will generally be positive. The first term on the RHS of A5 is more complicated. Using the cost function interpretation of $\pi_x(x, Z, u)$ and $\pi_z(x, Z, u)$, positive semidefiniteness of the Hessian matrix,

$$\begin{bmatrix}-\pi_{xx} & -\pi_{xz}\\ -\pi_{zx} & -\pi_{zz}\end{bmatrix}$$

implies that π_{xx} and π_{zz} are non-positive. However, depending on the relationship between x and Z, $\pi_{xz} = \pi_{zx}$ may be positive or negative. In particular, if x and Z are q-complements, then $\pi_{xz} > 0$, whereas if x and Z are q-substitutes, then $\pi_{xz} < 0$.

This impure public good story has a few key implications. First, the response function (equation A5) shows that household 1's sanitation decision (adopting a latrine) will depend on the decisions of other households in the village. The presence of a public good alone (ignoring learning etc.) is sufficient to generate social interactions in households' sanitation decisions.

Second, the impure public goods model is ambiguous with respect to the sign of social effects. In particular, reaction curves (the response of household 1 to household 2's sanitation choice) may be upward or downward sloping depending on the specific parameters. Most notably, the relationship between the private characteristic, *x*, and the public characteristic, *Z*, plays a central role. Taking the case of latrines, the public benefit of improved environmental cleanliness is combined with private attributes that include increased privacy (it could also be dignity and or convenience). On the one hand, healthier individuals that are exposed to less environmental contamination may derive greater utility from having a greater degree of privacy and increased time availability, leading to a complementarity between x and Z. On the other hand, increased productivity due to decreased disease may substitute for the greater amount of time required to walk to open defecation sites. The former hypothesis initially seems more compelling to us, although the precise relationship is an empirical matter. Assuming a strong complementarity is present between privacy and improved health (due to a cleaner environment), positive reaction curves are possible, implying that the "bundling" of public and private characteristics may generate positive social effects and help to reduce easy ridership (Cornes and Sandler, 1994).

6. References

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Figure 1: Map Showing Location of Bhadrak District

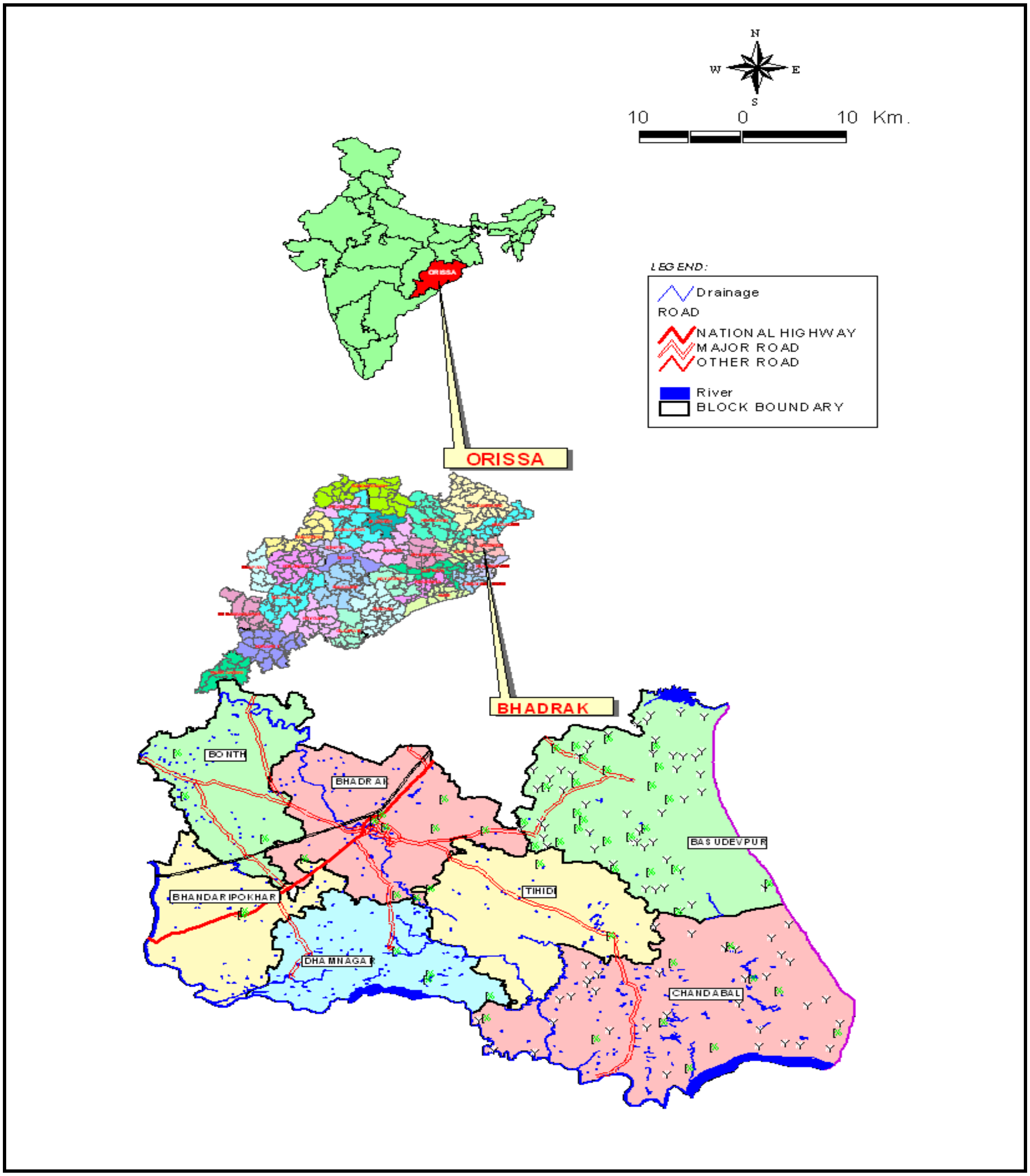


Figure 2: Location of Treatment and Control Villages in Tihidi and Chandbali Blocks, Bhadrak, Orissa

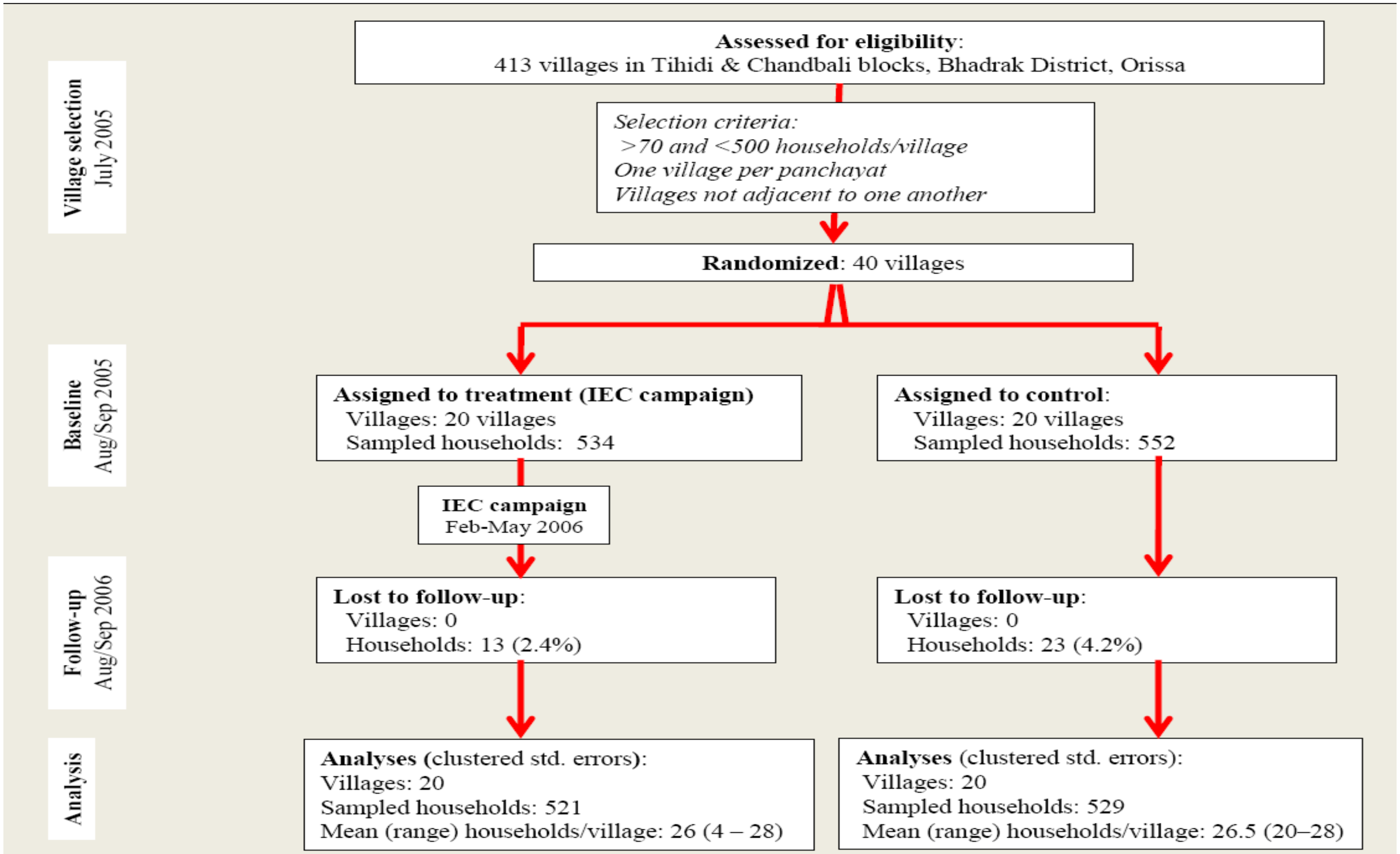
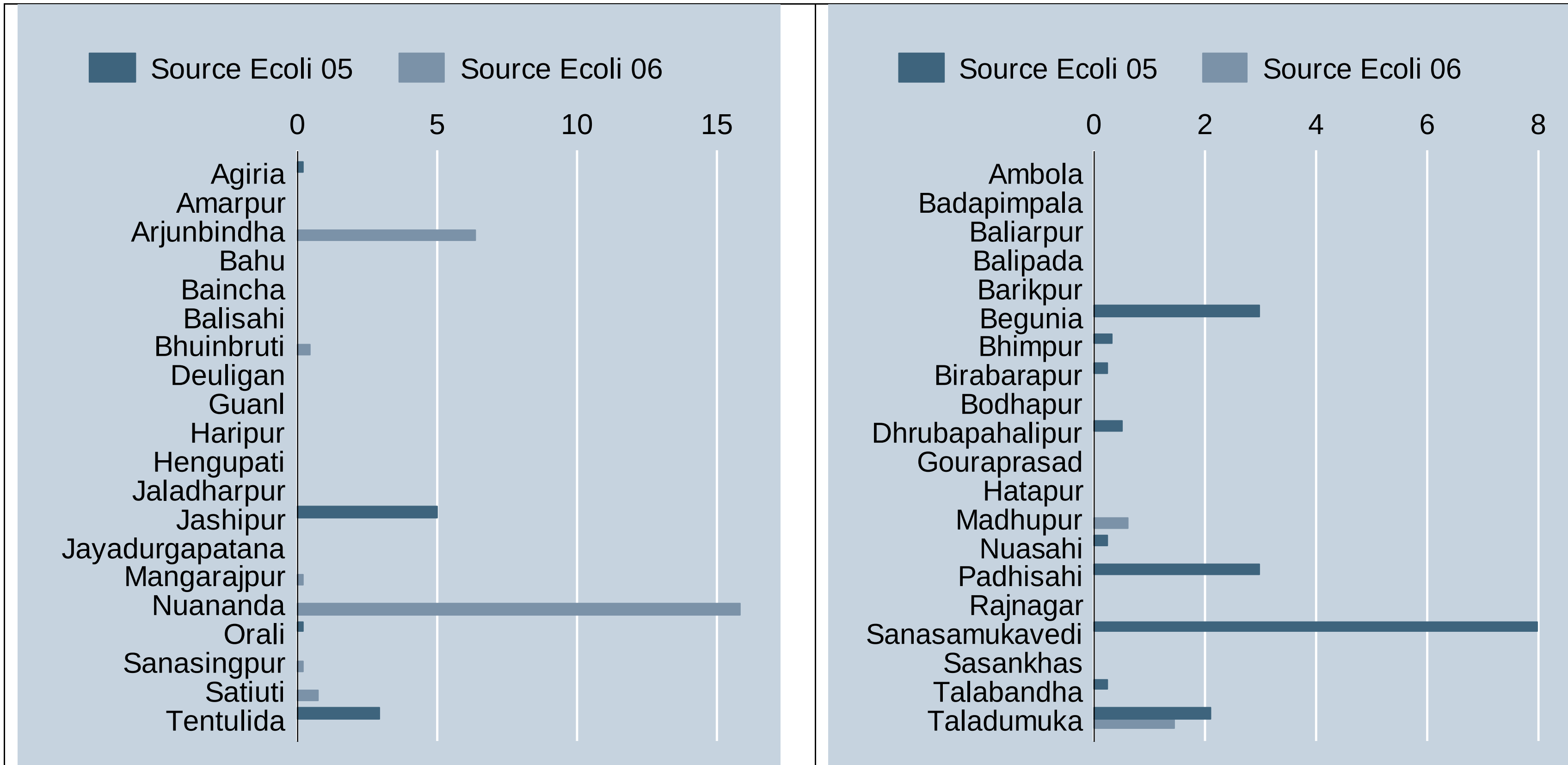


Figure 3. Water quality contamination (level of E. coli measured in CFUs per 100 ml) in each of 40 sample villages



Control Villages: Average e. coli contamination in source water increased from 1.3 (CFUs per 100ml) to 3.7 between 2005 and 2006.	Treatment Villages: Average e. coli contamination in source water decreased from 0.9 (CFUs per 100ml) to 0.1 between 2005 and 2006.

Table 1: Comparison of Means for Selected Household & Village Characteristics†

Variables		Overall	Treatment	Control	T-C
Village population		1509 (445)	957 (102)	2034 (856)	-1076 (862)
Village area (acres)		456 (67.6)	372 (47.6)	535 (123)	-163 (132)
Village population density (people/acre)		15.9 (8.4)	7.04 (3.62)	24.2 (16.0)	-17.2 (16.4)
% BPL		69% (1.5%)	67% (2.2%)	72% (2.1%)	-5.3%* (3.0%)
% Hindu		97% (.5%)	96% (.8%)	98% (.6%)	1.6% (1.0%)
% Scheduled caste/tribe		28% (1.4%)	29% (2.0%)	27% (1.9%)	2.5% (2.7%)
Distance from all-weather road (minutes by foot)		45 (1.4)	51 (2.0)	40 (2.0)	11*** (2.6)
Education: % of HH heads with >primary education		53% (1.5%)	52% (2.2%)	54% (2.1%)	-1.3% (3.1%)
HH Size		6.96 (.09)	6.95 (.13)	6.97 (.12)	-.02 (.18)
Number of children<5		1.44 (.02)	1.48 (.03)	1.40 (.03)	.08* (.04)
Expenditure in past 30 days (Rs.)		2627 (82)	2461 (107)	2790 (123)	-328** (163)
% owning TV		14% (1.1%)	10% (1.4%)	18% (1.7%)	-8.0%*** (2.2%)
% owning latrine	2005	9.7% (.9%)	6.4% (1.1%)	13% (1.4%)	-6.4%*** (1.8%)
	2006	23% (1.3%)	32% (2.0%)	13% (1.5%)	19%*** (2.6%)
% of household members who always use latrines	2005	7.2% (0.7%)	4.3% (0.8%)	10.0% (1.2%)	-5.7%*** (1.5%)
	2006	13.5% (1.0%)	19.6% (1.6%)	7.4% (1.1%)	12.2%*** (1.9%)

† Standard errors are in parentheses

* = significant at 10% level, **= significant at 5% level, ***= significant at <1% level

Table 2: Analysis of Latrine Uptake using Probit Model

	Dependent Variable: HH adopts latrine in 2006		
	Full Sample: N= 990 Pseudo-R^2=.214	Treatment Villages Only: N= 490 Pseudo-R^2=.133	Treatment Villages Only: N= 442 Pseudo-R^2=.199
Treatment	.253***		
Aware of Campaign		.159***	.130**
Participated in Campaign		-.031	.015
Population density	.0005	.002	.005
Distance to all-weather road	-.0006**	-.002**	-.0002
Distance to surface water	-.0002	-.000	.001
Open caste	.018	.010	.042
HH Head Education: primary †	.078***	.172***	.182***
HH Head Education: secondary+ †	.034*	.048	.058
Household size	-.004	-.009	-.004
Children <5	.002	.014	-.003
Household owns land	-.043*	-.107*	-.065
Mud floor ‡	-.082	-.207*	-.245**
Mud or thatch walls‡	.081**	.235***	.269***
Thatch roof‡	.012	-.029	-.040
Mosquito Net	.007	.013	.011
TV	-.053*	-.065	-.090
Ln(expenditure)	.031	.077	.090**
Tubewell	.013	.026	-.016
Handwashing frequency: Mother	.003	.004	-..005
Handwashing frequency: Children	.008	.017	.006
Household treats water	-.037	-.087	-.095
Social preference variables included?	Yes	Yes	Yes
NGO dummies included?	No	No	Yes
‡ χ^2-stat for joint significance of housing material variables	9.03**	9.40**	14.57***
χ^2-stat for significance of social preference variables	17.47**	44.2***	43.5***
χ^2-stat for joint significance of NGO dummies			241.4***

Table reports marginal effects calculated from probit regressions.
†Omitted category: no formal education
* = significant at 10% level, **= significant at 5% level, ***= significant at <1% level

Table 3: Comparison of Means for Responses to Social Preferences Questions†

Responses to Social Preference Questions	Treatment	Control	T-C
Percent choosing statement "Improving our community is just as important as looking after my immediate family " over "Taking care of my immediate family (household members) is my first responsibility"	41%	41%	-.1% (3.0%)
Percent choosing statement "We should embrace progress and adopt new technologies and behaviors " over "It is important to maintain our community's customs and traditions"	39%	40%	-1.3% (3.0%)
Percent choosing statement "We are often the first household in the village to adopt new technologies and practices" over "We tend to wait until several others in our community have adopted a new technology before we try it ourselves"	35%	42%	-6.8%** (3.0%)
"If we see someone breaking one of our community's laws, we usually:"			
Percent choosing "Scold him publicly and report him to the village council" over "Don't say anything; it is better to mind one's own business"	90%	88%	2.1% (1.9%)
"Imagine that someone has given you some sweets (or, if you don't like sweets, think of something you do like a lot!). You know that eating them all right away may give you an upset stomach. Do you usually:"			
Percent choosing "Eat a little immediately and save the rest for later" over "Eat them all anyway"	92%	86%	5.9%*** (1.9%)
"It is important to our family:"			
Percent choosing "To be accepted by our village people" over "To make our own choices whether others approve or not"	60%	52%	7.3%** (3.1%)
"You are walking through the village and you come across a large puddle blocking your path. Do you:"			
Percent choosing "Find some stones and sticks and build a path through the puddle" over "Take a different path"	83%	82%	.9% (2.3%)

† Standard errors are in parentheses

* = significant at 10% level, **= significant at 5% level, ***= significant at <1% level

Table 4: Estimated social effects from Brock & Durlauf (B&D) and Bajari et al. (BHKN) estimation strategies

	Dependent variable: HH adopts latrine in 2006			
	Model 1: B&D	**Model 2: B&D**	**Model 3: BHKN‡**	**Model 4: BHKN‡**
	Whole sample: N=990 Pseudo R^2=0.381	Treatment villages only: N=490 Pseudo R^2=0.361	Whole sample: N=990 Pseudo R^2=0.371	Treatment villages only: N=490 Pseudo R^2=0.334
Estimated social effect†	**.371%*** **	**.841%*** **	**.348%*** **	**.756%*** **
Treatment	.111***		.123***	
Aware of Campaign		.134***		.116**
Participated in Campaign		.060		.063
Population density	.0001	-.0003	.0000	-.0006
Distance to all-weather road	.0000	.0001	-.0000	-.0002
Distance to surface water	.0004	.002**	.0004	.002*
Open caste	.022	.027	.023	.038
HH Head Educ.: primary ††	.049**	.102**	.055**	.118**
HH Head Educ.: secondary+ ††	.024	.013	.030*	.027
Household size	.0007	.001	.001	.002
Children <5	-.009	-.014	-.007	-.009
Household owns land	-.020	-.062	-.010	-.043
Mud floor	-.092**	-.250***	-.081*	-.233**
Mud or thatch walls	.079***	.226***	.078***	.227***
Thatch roof	.0006	-.051	.008	-.201
Mosquito Net	.0003	-.0006	-.0002	-.003
TV	-.056*	-.058	-.058*	-.061
Ln(expenditure)	.016	.023	.010	.017
Tubewell	.009	.007	.012	.014
Handwashing freq.: Mother	.002	.007	-.002	-.001
Handwashing freq.: Children	-.0007	-.005	.003	.003
Household treats water	-.027	-.056	-.028	-.058

Table reports marginal effects calculated from probit regressions.

Social preference variables also included.

* = significant at 10% level, **= significant at 5% level, ***= significant at <1% level

† In the B&D models, this is the coefficient on the percent of others in the village adopting latrines. In the BHKN models, this is the coefficient on the predicted level of adoption generated in the first stage. In all models, this variable captures the impact of a 1% increase in the (predicted or actual) share of others adopting on one's own probability of adopting.

‡ BHKN models employ a two stage estimation strategy. Variables included in the first stage (exclusion restrictions) are housing materials (mud floor, mud or thatch walls, thatch roof), as well as village dummies. Reported coefficients for these models are from the second stage estimation.

†† Omitted category: no formal education

Table 5: Analysis of Social Effects using APL Households

	Dependent Variable: HH adopts latrine in 2006			
	Model 1: Percent of others adopting included directly		**Model 2: Percent of others adopting instrumented using percent BPL**	
	APL Households in Full Sample: N= 419 Pseudo R2=.396	APL Households in Treatment Villages Only: N=220 Pseudo R2=.382	APL Households in Full Sample: N=419 Pseudo R2=.303	APL Households in Treatment Villages Only: N=220 Pseudo R2=.244
Estimated social effect†	**.341%*** **	**.763%*** **	**.420%*** **	**1.31%*** **
Treatment	.079***		.154***	
Aware of Campaign		.083*		.073
Participated in Campaign		.043		-.026
Population density	-.0001	-.08	-.0000	-.002
Distance to all-weather road	-.0000	.07	-.0008**	-.001*
Distance to surface water	.0001	.001	-.0001	.02
Open caste	.0313	.036	.043	.081
HH Head Educ.: primary ††	.0845*	.098	.098*	.138
HH Head Educ.: secondary+ ††	.0471***	.052	.056**	.087*
Household size	.003	-.002	.0001	-.003
Children <5	-.021	-.030	-.005	.012
Household owns land	-.008	.004	-.012	-.030
Mud floor	-.056	-.251	-.013	-.189*
Mud or thatch walls	.026	.160	.025	.168
Thatch roof	.046	.012	.026	-.061
Mosquito Net	-.005	-.009	-.09	-.005
TV	-.058	-.084	-.046	-.104
Ln(expenditure)	.006	.002	.024	.058
Tubewell	-.016	-.008	-.005	.016
Handwashing freq.: Mother	.005	.019***	.004	.024**
Handwashing freq.: Children	.001	-.004	-.004	-.002
Household treats water	.013	-.026	.016	-.024

Table reports marginal effects calculated from probit regressions.
Social preference variables also included.

† In Model 1, this is the coefficient on the percent of others in the village adopting latrines. In Model 2, this is the coefficient on the predicted level of adoption generated in the first stage. In all models, this variable captures the impact of a 1% increase in the (predicted or actual) share of others adopting on one's own probability of adopting.

†† Omitted category: no formal education
* = significant at 10% level, **= significant at 5% level, ***= significant at <1% level

Table 6: Analysis of Social Effects for Use of Latrines by Various Household Members

	Whole sample		Treatment only	
	Dependent variable: MEN in household use latrines always/usually			
	Model 1	Model 2	Model 1	Model 2
N	964	964	432	432
Pseudo R^2	.316	.317	.272	.276
% of other men using	.48%***	.36%***	.75%***	-.04%
% of other women using		.03%		.83%**
% of other kids using		.20%		-.02%
	Dependent variable: WOMEN in household use latrines always/usually			
N	964	964	432	432
Pseudo R^2	.329	.330	.278	.283
% of other men using		.08%		.94%
% of other women using	.46%***	.31%***	.84%***	-.05%
% of other kids using		.15%		-.09%
	Dependent variable: CHILDREN in household use latrines always/usually			
N	964	964	407	407
Pseudo R^2	.247	.257	.291	.338
% of other men using		.08%		-.03%
% of other women using		.04%		.33%*
% of other kids using	.25%***	.07%	.27%***	-.25%

Results presented are marginal effects from probit regressions. In all models, the reported social effects indicate the impact of a 1% increase in use among the relevant group of peers (all others, men, women, or children) on one's own probability of using latrines.

Models also include the same list of covariates reported in tables 3-5.

* = significant at 10% level, **= significant at 5% level, ***= significant at <1% level

Table 7: Adoption of IHL in 2006 among different castes in treatment and control villages

	Whole sample	Treatment only
Scheduled caste	31/285 (10.9%)	29/144 (20.1%)
Other backwards castes	53/227 (18.9%)	50/152 (32.9%)
Open caste	63/364 (14.8%)	53/189 (28.0%)
Chi-squared statistic	7.26	6.18
p-value	0.027	0.045

Table 8: Social effects for latrine adoption within one's own caste and between different castes

	Whole sample	Treatment only
N	925	469
Pseudo R^2	.382	.361
Effect of adoption by others in OWN caste	.255%***	.574%***
Effect of adoption by others in OTHER castes	.092%**	.295%**
Chi-squared tests:		
Own=Other	3.33*	1.38

Samples are limited to households belonging to three main caste groups: scheduled castes (SC), other backwards castes (OBC), and open castes. These groups comprise 94% of the sample.
Results are marginal effects from probit regressions.
In all models, the reported social effects indicate the impact of a 1% increase in use among the relevant group of peers (own caste, other castes) on one's own probability of using latrines.
Models also include the same list of covariates reported in tables 3-5.
* = significant at 10% level, **= significant at 5% level, ***= significant at <1% level