Neighbors Can Make You Sick: Hygiene Behavior and Health

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Abstract

While the first order effects of access to clean water, and of personal hygiene and sanitation on health have been well documented, the effects of community hygiene and sanitation, along with personal hygiene and sanitation, have not been comprehensively studied. In this paper, incorporating the features of models from agricultural household (Bardhan and Udry, 1999) and reciprocal externalities (Dasgupta, 1993), we present a simple model of health externalities of households’ hygiene and sanitation, showing how the choices of one household affects ill-health incidences of other households. Then using micro level survey data of 1,530 households in rural Uttarakhand, India, we show that both household and community hygiene are significant inputs in the determination of households’ ill-health incidences (i.e. diarrhea, cholera, typhoid, dysentery, worm infestation and jaundice), with the latter having greater impact than the former, over and above effects attributable to households’ socioeconomic status. That is, there is a large health externality of a household’s hygiene and sanitation. In the presence of such health externality of households’ hygiene and sanitation, which is strongly associated with the access to safe water, universal access to safe water may be required to combat water-related illnesses. This implies that the governments’ consideration of alternative proposals to improve water services must be informed by health externalities in households’ hygiene and sanitation, and in the provision of water across communities.

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Keywords: health, water, hygiene behavior, health externality, and poverty

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1 Introduction

Consumption of contaminated drinking water, improper disposal of human excreta, lack of personal and food hygiene, and improper disposal of solid and liquid waste have been the major causes of waterborne illnesses (e.g. diarrhea) in developing countries. It is estimated that 4% (60.7 million DALYs) of the global burden of disease and 1.6 million deaths per year are attributable to unsafe water and sanitation, including lack of hygiene (WHO, 2003). In India 80% of diseases are water related: over 4 hundred thousand children die every year due to unsafe drinking water, unsafe water makes 1 in 5 babies ill every fortnight, and it has been estimated by the World Bank that a loss of Rs. 19,995 crore (approx $4 billion) annually because of water pollution alone (Sharma, 2006).

The first order effects of access to clean water, and of personal hygiene and sanitation on health have been well documented (Merrick, 1985; Behrman and Wolfe 1987; Esrey et al. 1991; Lavy et al. 1996; Lee, Rosenweig and Pitt 1997; Jalan and Ravallion 2003; and Gamper-Rabindran, Khan and Timmins, 2010). But the effects of community hygiene and sanitation, along with personal hygiene and sanitation, have not been comprehensively studied.

Policymakers have often relied on projects like the expansion of municipal water systems and the construction of local deep wells to combat the lack of hygiene and sanitation. Public health evaluations of these projects, however, are mixed: access to clean water seems beneficial in some contexts, but ineffective or even harmful in others (Fewtrell et al. 2005; Bennett, 2011). That is, factors of domestic and community hygiene and sanitation are not yet fully understood.

Although most countries are committed to improving water supply\footnote{At the 2000 Millennium Summit, member countries of the United Nations unanimously agreed on a set of eight goals to reduce poverty by 2015, among which are reducing child mortality by two-thirds and cutting in half the number of households that do not have access to safe water.}, there is little con-
sensus on how to actually achieve this goal. In developing countries the public provision of water supply has been a common policy response to increase access to safe water (VanDerslice and Briscoe, 1995; and Bennett, 2007). An alternative proposal under consideration by many governments is to turn water provision over to private sector. The consideration to privatize water systems is motivated by potential efficiency gains. The hope is that these efficiency gains will be translated into expanded access and enhanced service quality, and thereby improved health outcomes. This argument finds a strong empirical support in Galiani, Gertler and Schargrodsky (2005). They examine the impact of the privatization of water services on child mortality in Argentina, finding that child mortality fell 8 percent in the areas that privatized their water services and that the effect was largest in the poorest areas. It is, however, not clear whether any efficiency gains from privatization would necessarily be translated into improved health outcomes. Private water companies may provide suboptimal levels of service quality because they fail to take into account the significant health externalities that may be present in the water sector (Shirley, 2000). Moreover, given that most waterborne diseases are contagious, universal access to a safe water may be required to combat the incidence of waterborne illnesses. And there is no reason to believe that privatization of water services will result into universal access to safe water supply.

In this paper, we present a simple model of health externalities of households’ hygiene and sanitation, showing how the choices of one household affects ill-health incidences of other households. The model incorporates the features from agricultural household models (Bardhan and Udry, 1999) and models of reciprocal externalities (Dasgupta, 1993). Then using micro level survey data of 1,530 households in rural Uttarakhand, India, we show that both household and community hygiene and sanitation are significant inputs in the determination of households’ ill-health incidences (i.e. diarrhea, cholera, typhoid, dysentery, worm infestation and jaundice), with the latter having a greater impact than the former, over and above effects attributable to households’ socioeconomic status. That is, there is
a large health externality of a households’ hygiene and sanitation. Then we explore the determinants of households’ hygiene and sanitation, and of water availability inside the house. We document that while households’ hygiene and sanitation choices are strongly correlated with their economic status, access to water inside the house, and awareness about the causes of diarrhea, and a household’s education, occupation and social status. Access to water is correlated with a household’s economic status and the geographical characteristics of the villages. Finally, we discuss the policy implications, including for public or private provision of water services, of our findings.

The remainder of this paper is organized as follows. Section 2 presents a simple model of health externalities of households’ hygiene and sanitation. Section 3 discusses the context and data including measurements of ill-health of household. In Section 4, we discuss empirical framework and estimation strategy. The results are presented in Section 5. Section 6 explores the factors of households’ hygiene and sanitation, and of the availability of water supply. In Section 7, we discuss the implications of the results, including for a public or private provision of water services. We conclude in Section 8.

2 Theory

Our theoretical model incorporates features from two kinds of widely used models: agricultural household models (Bardhan and Udry, 1999) and models of reciprocal externalities (Dasgupta, 1993). We assume that there are two identical villagers, A and B. A and B subscripts are used to denote these two villagers. We concentrate on A’s choices, and point the resulting externalities these choices by A imply for B. Since villagers are identical, by symmetry the reverse holds for A when B makes choices.

We assume that the villagers enjoy utility arising from consumption of cooked food \((C_F)\),
consumption of other goods \((C_{\text{Other}})\), sickness \((S)\) and leisure time \((t_L)\).

\[ U = U(C_F, C_{\text{Other}}, S, t_L) \]  

(1)

Sickness is assumed to be a function of bacterial exposer \((E)\), consumption of cooked food, and individual characteristics \((Z^i)\).

\[ S = S(E, C_F, Z^i) \]  

(2)

Bacterial contamination is a complex phenomenon. For simplicity, we assume that bacterial exposure experienced by A is an additively separable function of a baseline level of exposure \((E_0)\), water supply inside the house of A \((W_A)\), latrine not dependent on water inside A’s house \((L_{\text{NW}}^A)\), and latrine dependent on water inside A’s house \((L_{\text{W}}^A)\). In addition, bacterial exposure depends on the total level of cleaning of drains in the village, given by \(D_A + D_B\), where A pays for \(D_A\) and B for \(D_B\). Finally, bacterial exposure experienced by A also depends on whether B uses a latrine inside his/her house, whether with water or not. Thus,

\[ E_A = E_0 - g1(W_A) - g2(L_{\text{NW}}^A) - g3(L_{\text{W}}^A(W_A)) - g4(L_{\text{NW}}^B(W_B)) - g5(L_{\text{W}}^B(W_B)) - g6(D_A + D_B), \]  

(3)

where the g’s denote functions. We expect \(g2\) and \(g3\) to have stronger effects than \(g4\) and \(g5\). By symmetry, B has the same function, with subscripts swapped. Also, if \(W_A\) is zero, then we would expect \(g1\) to be zero, and similarly for the other functions in (3). If the latrine used by A uses water, then the use of that latrine is facilitated by provision of water supply inside A’s house. In writing (3), we are treating water inside the house and the presence of the latrine inside the house as continuous variables whereas they are discrete. However, we will stay with this for the simplicity of the exposition, and when the first order conditions
(FOCs) are derived, will indicate how the substance of the FOCs is not different even if the we consider discreteness.

We assume that A and B have two sources of income: wage income and self-production of agricultural goods. We denote time spent working outside by $t_W^O$, and the wage received by $p_W$. We expect $p_W$ to depend on educational characteristics ($Z^E$) and occupation ($Z^O$). We denote time spent working on the villager’s own land by $t_W^I$. We expect output on this land, $O$, to be a function of:

$$O = O(t_W^I k(S), Z^L),$$

where $k$ is a shift operator depending on sickness, and $Z^L$ is the land owned. The dependence of the villager’s labor productivity on his/her health, is a feature of efficiency wage models (Bardhan and Udry, 1993).

We assume that the villager sells all his/her agricultural output, and together with his/her wage earnings, buys food, other consumables, water supply, latrine and village drain cleaning. Thus the budget constraint, denoting prices by $p$ with suitable subscripts, is:

$$t_W^O p_W + t_W^I p^O = p_F C_F + p_{Other} C_{Other} + p_{water} W + p_{NW}^L L^{NW} + p_{NW}^W L^W + p_D D$$

(5)

Since water supply inside the house and latrine have important discrete and durable components, their ‘prices’ in (5) can be thought of as annualized costs. The villager’s time constraint is:

$$T = t_L - S - t_W^O - t_W^I$$

(6)

The villager aims to maximize his/her utility subject to the time and budget constraints. We substitute for $t_L$ from (6) into the utility function, and then maximize the resulting utility subject to the budget constraint. Denoting the Lagrange by $J$, the FOCs are listed
and discussed below.

\[ \frac{\partial J}{\partial C_F} = \frac{\partial U}{\partial C_F} + \frac{\partial U}{\partial S} \frac{\partial S}{\partial C_F} - \lambda p_F = 0 \]  \hspace{1cm} (7)

In (7), the villager gets two kinds of benefits from consuming an extra unit of food: the direct utility from eating and the utility from lower sickness. The cost of the extra unit of food in utility terms is the product of the multiplier and the price of food.

In the case of other consumption, there is only a direct utility benefit, and so FOC:

\[ \frac{\partial J}{\partial C_{Other}} = \frac{\partial U}{\partial C_{Other}} - \lambda p_{Other} = 0 \]  \hspace{1cm} (8)

\[ \frac{\partial J}{\partial W_A} = \left[ \frac{\partial U}{\partial S} - \frac{\partial U}{\partial t_L} + \lambda \frac{\partial O}{\partial t_W} \frac{\partial k}{\partial S} \right] \frac{\partial S}{\partial E} \left[ - \frac{\partial g_1}{\partial W_A} - \frac{\partial g_1}{\partial L_A} \frac{\partial L_W}{\partial W_A} \right] - \lambda p_{water} = 0 \]  \hspace{1cm} (9)

In the FOC (9) we see that having water in the house leads to the following benefits through less sickness, a direct utility benefit, greater leisure time, and greater productivity of the villager in agricultural production. The reduction in sickness is through a reduction in bacterial exposure which in turn is through the direct effect of water in the house and the indirect effect of water availability on latrines that use water.

As we have said above, water supply inside the house versus getting water supply inside the house has an important discrete and durable component. Our interest is in tracing the pathways of effects between health and poverty and in embedded externalities. It is easy to see the discrete version of (9), in which the household will go in for the water supply if the benefits exceed the costs. The discrete version of (9) is:

\[ \left[ \frac{\partial U}{\partial S} - \frac{\partial U}{\partial t_L} + \lambda \frac{\partial O}{\partial t_W} \frac{\partial k}{\partial S} \right] \frac{\partial S}{\partial E} \left[ - \Delta E_1 W_A - \Delta E_3 W_A \right] > X W_A, \text{ if } W_A > 0, \]  \hspace{1cm} (10)

where \( \Delta E_1 W_A \) denotes the reduction in bacterial contamination due to water supply inside A’s house, and \( \Delta E_3 W_A \) denotes the reduction in B due to water supply inside A’s house.
(via encouraging water latrines). Also $XW_A$ denotes the expenditure on $W_A$. For the rest of FOCs, we will treat the discrete choices as continuous.

If A only considers the effect of water supply on his own utility, he/she will ignore the positive externality of water supply inside his/her house on B. This is (since the agents are identical) equal to:

$$\left[ \frac{\partial U}{\partial S} - \frac{\partial U}{\partial t} + \lambda \frac{\partial O}{\partial t} \frac{\partial k}{\partial S} \right] \frac{\partial S}{\partial E} \left[ -\frac{\partial g5}{\partial L} \frac{\partial L^W_A}{\partial W_A} \right]$$

(11)

The increase in latrine use inside A’s house by A reduces bacterial exposure of B through the function $g5$ in (11). This lower bacterial exposure reduces B’s sickness and affects B’s utility directly, through increased leisure and through greater productivity when B works on his/her farm.

The FOC arising out of the choice of latrines is similar to (9), and these choices are also going to generate externalities similar to (11).

$$\frac{\partial J}{\partial L^{NW}_A} = \left[ \frac{\partial U}{\partial S} - \frac{\partial U}{\partial t} + \lambda \frac{\partial O}{\partial t} \frac{\partial k}{\partial S} \right] \frac{\partial S}{\partial E} \left[ -\frac{\partial g2}{\partial L^{NW}_A} \right] - \lambda p_{LNW} = 0$$

(12)

$$\frac{\partial J}{\partial L^W_A} = \left[ \frac{\partial U}{\partial S} - \frac{\partial U}{\partial t} + \lambda \frac{\partial O}{\partial t} \frac{\partial k}{\partial S} \right] \frac{\partial S}{\partial E} \left[ -\frac{\partial g3}{\partial L^W_A} \right] - \lambda p_{LW} = 0$$

(13)

The FOC for choice of $D_A$ is:

$$\frac{\partial J}{\partial D_A} = \left[ \frac{\partial U}{\partial S} - \frac{\partial U}{\partial t} + \lambda \frac{\partial O}{\partial t} \frac{\partial k}{\partial S} \right] \frac{\partial S}{\partial E} \left[ -\frac{\partial g6}{\partial D_A} \right] - \lambda p_D = 0$$

(14)

The choice of $D_A$ is far more likely to suffer from sub-optimal provision than that of water supplied in A’s house or latrine inside A’s house, because A will be tempted to free-ride on B’s provision of $D_B$, a tendency that will be strengthened if the number of agents is large.
Finally, we have the conditions relating to choice of how much time is spent in earning wages or in agricultural production.

\[
\frac{\partial J}{\partial t_w} = -\frac{\partial U}{\partial t_L} + \lambda p_w = 0 \tag{15}
\]

In (15) there is a loss of utility from less leisure, while the benefit is income earned.

\[
\frac{\partial J}{\partial t_w} = -\frac{\partial U}{\partial t_L} + \lambda \left[ \frac{\partial O}{\partial t_w} k(S) \right] = 0 \tag{16}
\]

In (16) the income earned is affected by the level of sickness, and the cost is the loss of utility from reduced leisure.

3 Context and Data

The Uttarakhand is the 27th state of India and was carved out of Uttar Pradesh (geographically the largest state in India) on November 9, 2000. The state has two Divisions (Garhwal and Kumaun), with 13 Districts, which can be grouped into three distinct geographical regions: the High mountain region, the Mid-mountain region and the Terai region. It is spread over an area of 55,845 square kilometers having 78 Tehsils, 95 blocks and 7,227 Gram Panchayats. It has a total of 16,826 inhabited villages, 86 cities/towns and only five are major cities with population over 100,000. Its population is 8.5 millions with average density of 159 persons per square kilometer, which varies from as high as 612 in Haridwar and 414 in Dehradun districts to as low as 37 in Uttarkashi. 89% of the villages have population less than 500. The decadal population growth rate is 20.41% (against 21.54% for the country) and the infant and maternal mortality rates are 42 and 517 respectively, which are higher than the national averages. The sex ratio in the state is 962 as compared to 933 for the country.
Only half of the state is estimated to be fully covered by functioning water supply schemes. In addition, the state faces severe water shortages. Nearly 30% of the schemes suffer from a decrease in the availability of water, especially during the summer months, because of depletion of water sources. This causes some of the villagers to spend one to three hours per day collecting water for domestic uses. While water-related diseases are a major health problem for the rural areas in the state, particularly for infants and children. For instance, at any given time, 18% of all children suffer from diarrhea. Therefore, the state government prioritized rural water supply and sanitation as a key area of its development agenda in its Tenth Plan (2003-7).

In terms of socioeconomic characteristics, Uttarakhand is not very different from the other states of India. But what distinguishes it from other states of India, is its geographical features wherein 93% of the area of the state is hilly and 63% of the land is covered with forests. Being primarily a hilly state, it has starting disadvantages for the prosperity of agriculture, and easy accessibility of clean drinking water vis-a-vis other states of India. Thus, some of the factors that affect the incidences of ill-health and economic status of households in the state are expected to be distinctively different from the factors of poverty and ill-health incidences in other states.

We use the survey data of 1,530 households from rural regions of Uttarakhand. The data was collected as the part of an exercise to develop a Strategy for Sanitation and Hygiene promotion conducted by The Energy and Resources Institute (TERI), New Delhi, with support from the World Bank. The primary survey involved 39 gram panchayats, the smallest administrative unit at the rural level spread across all thirteen districts of rural Uttarakhand. The 39 gram panchayats (three per district), were selected based on multiple criteria. Gram panchayats were selected from a list of representative gram panchayats provided by State Water and Sanitation Mission. In addition, villages were selected to ensure representation from villages with varying characteristics. The sample villages were also chosen from villages
both with and without the Swajal program\textsuperscript{2} an earlier the World Bank and the Government of India funded program for ensuring safe water access to some of the villages in the state. More specifically, 12 out of 39 Gram Panchayats were covered under the Swajal program; and 9 out of 39 villages were in plains. A structured questionnaire was used to collect both the quantitative and qualitative data on family characteristics, income and expenditures, poverty status, health, sanitation, and hygiene behavior. The survey was implemented during 2004-05.

3.1 Measures of Household’s ill-Health

We use two measures of a household’s ill-health. The first one captures a household’s incidences of ill-health, and it is defined as the number of household members with incidences of ill-health (i.e. diarrhea, cholera, typhoid, dysentery, worm infestation and jaundice). To arrive at this measure of health at the household-level, for each member of the household a value of 1 is assigned if he/she had suffered from any (or some or all) of the ailments in the six months preceding the survey date. Then members of the household having suffered from any of the ailments are counted. Thus, this measure is a count variable. Hence, count data models of ill-health, implied by the theoretical model, are specified and estimated. The second measure of ill-health is an index variable, obtained by dividing the first measure by household size. So it is a continuous variable that takes the values between 0 to 1 and, accordingly, Tobit models are specified and estimated.

3.2 Potential Determinants of Households’ ill-Health

The list of potential determinants of household’s ill-health are presented in Table 1. It includes household size, poverty status of the household, educational achievements of the

\textsuperscript{2}Swajal program is a World Bank assisted project between 1996-2002 to improve water supply and environmental sanitation services in some of the water scarce regions of the state
head (male or female) of household, household’s hygiene behavior, and community hygiene behavior.

We use household size as a control variable because a large household is more likely to have higher number of total ill-health incidences than a small household. The socioeconomic status of the household is captured by inclusion of a measure representing the household’s poverty status. In the survey households were to asked to identify their poverty status. Thus poverty status is self-reported by households. In India, poverty is officially linked to a nutritional intake as measured in calories. The Planning Commission of the Government of India defines poverty lines as a per capita monthly expenditure of Rs. 49 for the rural areas and Rs. 57 in urban areas at 1973-74 all-India prices. These poverty lines correspond to a total household per capita expenditure sufficient to provide, in addition to basic non-food items - clothing, transport - a daily intake of 2,400 calories per person in rural areas and 2100 in urban areas (WB, 1997). Individuals who do not meet these calorie norms fall below the poverty line. The Government of India issues differential ration cards which entitles households to some government supplies at subsidized prices (e.g. rice, sugar, and Kerosene oil). Poor households, below the poverty line, are entitled to some special benefits.

One of the most important components of human capital endowments of households’ is educational achievements of their household heads. Many studies including Pritchett and Summers (1996) have shown that the income of an individual is positively associated with his or her educational achievements. Moreover, we can reasonably expect that a household’s hygiene behavior is also determined by it’s level of education. In particular, a household with an educated (or with higher level of educational achievement) household head is expected to have better hygiene behavior than a household with an uneducated (or less educated) head. To account for education, we define four dummy variables representing if the head of the household is illiterate (no formal schooling at all), primary school educated, high school educated, and college educated respectively. However, in order to avoid “dummy
variable trap” we drop the dummy variable representing household head with no formal schooling. Consequently, marginal effects of included education variables convey the relative contribution of a particular education level compared to no schooling at all.

We measure the household’s hygiene practice and sanitation by a variable representing whether the household has access to latrine inside the house. It is a binary dummy variable that takes the value of 1 if the household has access to latrine inside the house; otherwise it takes the value of zero.

The neighborhood hygiene and sanitation is captured by a binary variable that takes the value of 1 if the a household’s neighborhood drainage is clean and in good environmentally sanitary conditions.

Table 2 presents corresponding summary statistics of the defined data characteristics. From Table 2 we find that approximately 59% of the households are below poverty line (or in poverty status); 39.4% of the household heads are illiterate, 31.2% of the household heads have the primary schooling as their highest education, 22.6% have high school education, while only 6.0% of the all household heads have college education. 38% of villages are located in plain terrain. As far as the households’ hygiene is concerned, we find from Table 1 that approximately 51% of the households in the village have latrine availability inside their houses, and 41% of the households have water availability inside the house. Regarding community hygiene, we find that on average only 51% of the households in a village have access to latrine inside their houses, and approximately 8% of drains in the village are environmentally clean.

4 Empirical Models and Estimation Strategy

4.1 Determinants of Households’ ill-Health

...to be revised and explained
We focus on providing a better understanding of the causal factors of the recurring ill-health incidences of the households. Following our theoretical model in Section 2, the household’s ill-health is affected by five sets of factors: first, the true underlying unobservable economic status, \( Poverty Status_i^* \), which we interpret as the household’s propensity to be poor; second, ill-health is also affected by other household specific observable personal characteristics, such as the household size and education (PS); third, hygiene practices of the households, such as availability of latrine and water inside the house (HP); fourth, community level hygiene practices, such as percentage of households in the village that have latrine and village cleanliness, measured by percentage of reported clean drains in the village (CHP)\(^3\) and fifth, the region specific heterogeneity, captured by district dummies and a plain dummy, defining whether the village is characterized as a plain or hilly terrain (RE).

Mathematically, ill-health incidences of households can be expressed as follows:

\[
H_i = H(Poverty Status^*, HC, HP, CHP; RE) \tag{17}
\]

where \( H_i \) for the household \( i \) is defined as earlier (see Section 3.1).

The health production function in equation (17) is empirically operationalized by estimating the different versions of the following regression equation:

\[
H_i = \beta_0 + \beta_1 * Poverty Status_i^* + \beta_2 * HC_i + \beta_3 * HP_i + \beta_4 * CHP_{village} + \beta_5 * RE_{district} + \epsilon_i \tag{18}
\]

\(^3\)Ill-health incidences of the household is not only determined by its own hygiene practices, but is also influenced by village level hygiene practices. Its own hygiene practices are not enough for the household to prevent or escape from recurring ill-health incidences. If the village as the whole is hygiene-wise conducive for frequently occurring ill-health incidences, then the household still might suffer from temporary illness. Thus, there is both positive and negative externality of hygiene behavior in determination of the household’s incidences of ill-health. That is, collective village level hygiene practices are as important as the household’s own hygiene practices in determining the household’s ill-health status.
4.2 Estimation Strategy

In estimating the regression equation in (18), we face two estimation related issues: (a) the explanatory variable, poverty status, is potentially endogenous.\footnote{There is large body of empirical literature documenting economic effects of health (Strauss, 1986; Fogel, 1994; Strauss and Thomas, 1998; Glick and Sahn, 1998; Schultz, 1999, 2001, 2002; Thomas and Frankenberg, 2002; Case, Lubotsky and Paxson, 2002; Bloom and Mahal, 1997; Bloom and Sachs, 1998; Bloom and Canning, 2000; Bhargava et al., 2001; Bloom, Canning, and Sevilla, 2001). Using the Health and Retirement Survey (HRS), a multiyear random sample of households in the US, Smith (1999) found people with disease onset tend to draw down on household wealth in a range of 3,620 to 25,371 dollars, depending on onset of severity and income levels.} Thus, in order to obtain consistent and efficient parameter estimates of the model in (18), we correct for the endogeneity of poverty status. This is accomplished by estimating the model in (18) by IV estimation procedure; (b) our dependent variable, $H$ is defined in two alternative ways. The first one refers to the household’s ill-health, and it is a count variable. For count data the natural choice of probability model is a Poisson regression model. However, Poisson probability model implicitly assumes the equality of it’s mean and variance. Therefore, first we test for the validity of this assumption. Our statistical test suggests that the Poisson regression model is not appropriate for our data. Hence, we estimate a Negative Binomial model that allows for overdispersion. This model is estimated by GMM methods to correct for the endogeneity of poverty status. The second measure of $H$ is ill-health status index, which is a continuous variable but censored at zero. Accordingly, a Tobit model is estimated by IV procedure.

4.3 Instrument for Poverty Status

The first stage regression for IV strategy is:

$$ Poverty \ Status^*_i = \pi_0 + \pi_1 \ast Caste_i + \pi_2 \ast X_i + \mu_i $$  \hspace{1cm} (19)
where \( Caste_i \) is the instrumental variable, which takes the value of 1 if the household is identified to be Scheduled Caste or Tribe; otherwise it takes the value 0; and \( X_i \) are other control variables (mainly geography). The \( Poverty Status^* \) is the household’s unobserved poverty status, or propensity to be poor. What we observe is a binary variable, \( Poverty Status \), indicating whether the household is poor (or in poverty status):

\[
Poverty Status_i = \begin{cases} 
0 & \text{if } Poverty Status^*_i \leq z \\
1 & \text{if } Poverty Status^*_i > z 
\end{cases}
\]

The results of this regression in Table 2-3 show that \( Caste \) is statistically significant predictor of \( Poverty Status^* \).

5 Empirical Findings

...to be revised and explained

Tables 3-6 present the estimates of count data models of households’ ill-health status.

Table 6 presents the results of Tobit model.

Tables 8-9 contains results on instruments for households’ poverty status.

In Tables 10-11, results of IV estimation of count data and Tobit models are presented.

Tables 12-17 are about the correlates of households’ hygiene and sanitation and water availability.

We noted in the preceding section that Poisson model is not suitable for our data. Therefore, we simply present the results here for the sake of comparison with the results obtained from the estimation of the negative binomial model, but will not discuss it here.

The results of alternative specifications of the negative binomial model are presented in Table . From Table we observe that poverty status of households has a strong and positive effect on their ill-health status. That is the households in poverty status have higher ill-
health incidences, compared to the households who are not in the poverty status. We find that hygiene practices of households play a critical role in determining their ill-health status. As we can notice from Table 5, that latrine availability inside the house—a leading indicator of households’ hygiene practices inside the house—has negative and statistically significant effect on ill-health incidences of households. In other words, the households with good hygiene have lower incidences of ill-health, compared to the households with poor hygiene.

We discussed in Sections 2 and 4.1 that ill-health incidences of households are not only determined by their own hygiene practices, but they are also determined by community-level hygiene practices. Thus, there is both negative and positive externalities associated with hygiene practices. In order to test for the health externality of hygiene behavior, we included two variables representing the levels of latrine availability in villages and the cleanliness of village drainage respectively. From Table 5, we find that the village-level hygiene play a more powerful role in determining households’ ill-health than households’ own hygiene, which becomes obvious from comparing their respective coefficients. The coefficient associated with village drain cleanliness (-0.786) is statistically significant and much larger than the corresponding coefficient for the latrine availability inside the house. This implies that if the overall village-level hygiene improves, every household in the village will derive positive benefits in terms of decrease in ill-health incidences from such improvement. Similarly, we note from Table that the coefficient associated with village latrine availability (-0.558) is statistically significant and has expected sign.

One can reasonably argue that it is not the hygiene practices of households that determines their ill-health status but the real determinants are their poverty status and the levels of the educational attainments. That is, if the household is non-poor and educated, it will have better hygiene practice, and therefore the households’ hygiene is not an independent factor in the determination of their ill-health status, and it is simply capturing the effects of income and education. Our results suggest the opposite: (1) we control for poverty status
of the households, and even after the inclusion of poverty status variable, the variable representing the latrine availability inside the house is independently significant (see Tables ). Moreover, as we will argue in the next section that the latrine availability inside the house is not solely determined by households’ income, and education. It is also determined by the availability of clean water inside the house, which is, to a great extent, determined by factors not in control of households; and (2) further to check the robustness of the significant effects of both household and community hygiene, we controlled for the effects of educational attainments. The results for this model is also presented in Table 5. From the table we find that even after controlling for education, poverty status, household size, and community-level hygiene, the effect of the latrine availability inside the house remains statistically significant. In fact the magnitude of effect does not change much.

Finally, the role of community-level hygiene is also robust to inclusion of controls for poverty status, education, household size, plain terrain, and district effects. Thus, we have sufficient evidence to conclude that both the household’s own hygiene practice and the community-level hygiene contribute significantly in the determination of their ill-health status, over and above the effect attributable to their their poverty status. Thus, there is large health externality of households’ hygiene behavior.

In Table 6 we present the IV estimates of different specifications of the Tobit model. A careful examination of results in Table 6 clearly confirms the results obtained from the negative binomial model. Hence, our results are not only robust to the inclusion of various control variables but also to alternative characterization of the households’ ill-status, the corresponding econometric model.
6 Correlates of Households’ Hygiene Practice and Water Availability

One of the most crucial elements of successful health improvement and poverty reduction programs is a clear understanding of mechanisms through which poverty status of households affect their health status. There is plethora of evidence documenting simultaneous relationship between income (or poverty) and health. What is missing in the existing literature is a lack of a clear understanding of the transmission mechanisms through which poverty status of households affect their health outcomes. This paper attempts to fill this gap in the existing literature by providing a better understanding of multiple pathways through which poverty status of households manifests itself in poor health outcomes in developing countries.

There are at least three such mechanisms or channels linking households’ poverty status to their ill-health. The first is poverty status–households’ investment in health and health care expenditure–ill-health. The second of these mechanisms is the poverty status–nutrition–ill health. The third of these mechanisms is the poverty status–household hygiene and sanitation–ill health. In this paper, we focus on empirically exploring the third mechanism. We postulate that poverty status influences households’ ill-health through its impacts on availability of latrine and clean water inside the house. In other words, hygiene practices (represented by availability of latrine inside the house) and water availability inside the house are two interacting and mediating variables through which poverty status influences households’ ill-health. We do not claim that latrine and water availability inside the house are solely determined by households’ poverty status. Instead what we argue is that latrine availability and availability of clean water inside the house are determined by various factors, among which some factors are household factors (such as poverty status of households), and some are not within the control of households.
6.1 Households’ Hygiene Practice

The hygiene practice of the households’ is determined by a combination of factors including their poverty status, water availability inside the house, educational attainment, occupation, social status in the society (represented by the household’s caste), household size, child dependency ratio, if the household resides in a plain or hilly terrain, and other region specific effects captured by districts (or Gram Panchayat) dummies. For the purpose of our hypothesis testing, the directly relevant variable is the poverty status of households, and other variables including water availability inside the house are treated as control variables. To test the hypothesis that poverty status of households affects their ill-health through its impact on availability of latrine inside the house, we estimate the following regression equation:

\[ \text{Latrine}_i = \delta_0 + \delta_1 \times \text{Poverty Status}_i + \delta_2 \times \text{Control Variables}_i + \epsilon_{4i} \]  

(20)

where \( \text{Latrine}_i \) is a binary variable indicating if the household has latrine inside the house. Since the dependent variable in this case is binary in nature, we estimate it as a probit regression equation. For our stated hypothesis to be true, we expect \( \delta_1 \) to be of negative sign and statistically significant.

6.2 Water Availability

The lack of access to clean water is the leading cause of different water born diseases. Thus, recurring ill-health incidences of households are causally related with the availability of clean water inside the house. The availability of water inside the house is a precondition for the availability of latrine inside the house, besides its other uses such as drinking and cooking. We argue that poverty status of households affects their ill-health through its impact on the availability of water inside the house, in addition to its impact through other channels. Thus, we hypothesize that water availability is another mediating variable linking poverty
status to ill-health of households. To test this hypothesis, we estimate different versions of the following regression equation:

\[ \text{Water Availability}_i = \lambda_0 + \lambda_1 \ast \text{Poverty Status}_i + \lambda_3 \ast \text{Control Variables}_i + \epsilon_{5i} \quad (21) \]

where \( \text{Water Availability}_i \) is a binary variable that takes the value of 1 if water is available in the house; otherwise it takes the value of, and remaining variables are defined as earlier. Since the dependent variable is binary in nature, we estimate a probit model. For our stated hypothesis to be true, we expect \( \lambda_1 \) to be of negative sign and statistically significant.

6.3 Results

Table 8 presents the estimated results of probit model for the determinants of latrine availability inside the house. The corresponding marginal effects of explanatory variables are given in Table 9. From these tables, the following result can be inferred: the households in poverty status are less likely to have latrine inside the house, compared to households who are not in poverty status. This result is obtained after controlling for the effects of household characteristics, such as education, occupation, caste, family size, child dependency ratio, distance from the main road, and district-specific heterogeneities. In the preceding section, we presented a conclusive evidence suggesting that ill-health incidences of households are causally determined by both the households and the community(village) hygiene behavior. This result along with the result from Table 8 suggest that latrine availability inside the house is one of the many mechanisms through which poverty status manifests itself in the poor health outcomes for households.

Also from Table 8, we note that latrine availability inside the house is determined by the availability of water inside the house which, in turn, is partly determined by poverty status. The later is evident from the results presented in Tables 10-12 for the determinants of water
availability inside the house. From both Tables 10-12, we observe that the households in poverty status are less likely to have access to clean water inside the house, as opposed to households who are not in poverty status. However, we emphasize that whether a household is poor or not-poor matters for determination of water availability inside the house, only when the village itself has access to clean water supply. This shows that availability of water inside house is another significant mediating variable linking poverty status of the households to their ill-health status.

In sum, hygiene practices and water availability inside the house are two interacting and mediating variables through which poverty status influences households’ ill-health.

7 Policy Implications

In this paper we examined the determinants of households’ ill-health status. We presented a simple theoretical model of health externalities of hygiene behavior, demonstrating how both the household and community hygiene can impact households’ incidences of ill-health. Then using a micro-level survey data of 1,530 households collected in 2005 in rural Uttarakhand, a northern state of India, we tested the empirical implications of the theoretical model. The implied econometric models essentially consisted of a count data model and a Tobit model, with an endogenous regressor (i.e. poverty status of the households). These econometric

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5It is evident from epidemiological literature that one of the causes of ill-health (particularly water-borne disease) is the lack of access to adequate sanitation facilities and clean drinking water (Esrey, 1996). Latrine availability for household members mitigates exposure to various bacteriological contamination from open defecation, besides affording more sanitary practices like washing hands with soap or ash. Therefore availability of latrines impacts the health of the household and is in turn determined by several household and regional factors. For instance awareness of diarrhea amongst household members and higher education level of the household may lead to appreciation of the benefits of latrine construction. The results that these are significant positive determinants of latrine availability besides poverty status, which is negatively significant. Water availability inside the household is a positive determinant of the households choosing to have latrines. This can be explained by the fact that lack of access to water inside the premises preempts latrine construction, because it is very difficult for household members to fetch water for sanitation facility inside the household. It is rather easier to use open defecation spots closer to water sources when there is no water available within the house. This exposes the individuals to contamination through the oral-faecal route as well.
models were estimated by the GMM and IV procedure to correct for an endogenous regressor.

Our major findings are: first the community and individual hygiene behavior are strong predictors of households’ ill-health status, over and above effects attributable to households’ socioeconomic status such as household size, poverty status, and educational achievements; and second hygiene practices and water availability inside the house are two interacting and mediating variables through which poverty status influences households’ ill-health.

One implication of our findings is that in order to improve health status of both poor and non-poor households in rural India, there are additional policy choices that have not been clearly delineated by the past studies: first, any program targeted towards poverty reduction is expected to improve households health status; second, poverty status influences households’s ill-health through its impact on latrine and water availability inside the house, which implies that for improvements in households’ health, the later two mediating variables are directly more relevant than poverty status in itself. This suggests that the desired improvements in health outcomes for households can be effected by ensuring availability of latrine and clean water inside the house.

It is in this context our finding that availability of latrine inside the house is causally determined by water availability assumes significance for at least two reasons: (1) it suggests to us that if clean water is ensured in villages, the likelihood of latrine availability inside the house will dramatically improve for all households in the village. This, in turn, will lead to decrease in frequently occurring ill-health incidences of households; and (2) with the availability of clean water to every household in the village, community-level hygiene will significantly improve which, in turn, will result in health benefits for all households due to positive externality associated with community hygiene.

Given that the availability of clean water inside the house is a critical precondition for improvements in both households’ own hygiene practices as well as community-level hygiene, the issue of policy response narrows down to the provision of clean water to all households
in the village. Clean water can either be privately or publicly provided. However, given our findings of large health externality of households' hygiene behavior, we argue that a private provision of water services may not produce an optimal improvements in health outcomes. It is primarily because of the recognition that a market provision of water services will not ensure an universal access to clean water in the community, even though it might result in an expanded access to clean water. Even if water is available in the village, some of the poor households will not be able to afford to have water inside the house. Thus, in the presence of large health externality of the household’s hygiene behavior, for an optimal improvement in health outcomes, either the public provision or a regulated market provision of water services may be required.

8 Concluding Remarks
References


   *Journal of Human Resources*.


   *Journal of Political Economy*, 80, No. 2, pp. 223-255.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition</th>
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</thead>
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<tr>
<td><strong>Measures of ill-Health:</strong></td>
<td></td>
</tr>
<tr>
<td>Household’s ill-Health</td>
<td>Number of members in the family with incidence of illness in the last six months</td>
</tr>
<tr>
<td>Household’s ill-Health Index</td>
<td>Members with incidence divided by total family members</td>
</tr>
<tr>
<td><strong>Socioeconomic Characteristics of Households:</strong></td>
<td></td>
</tr>
<tr>
<td>Poverty Status</td>
<td>Household is below the poverty line</td>
</tr>
<tr>
<td>Male-Headed Household</td>
<td>Head of the Household is Male</td>
</tr>
<tr>
<td>Age of Household Head</td>
<td>Age of the household head (in years)</td>
</tr>
<tr>
<td>Household Size</td>
<td>Total members in the household</td>
</tr>
<tr>
<td>Caste</td>
<td>Scheduled Caste or Scheduled Tribe Household</td>
</tr>
<tr>
<td>No Formal Schooling</td>
<td>No Formal Schooling of the household head</td>
</tr>
<tr>
<td>Primary School</td>
<td>The household head has primary school education</td>
</tr>
<tr>
<td>High School</td>
<td>The household head has high school education</td>
</tr>
<tr>
<td>College and Above</td>
<td>The household head has atleast college education</td>
</tr>
<tr>
<td>Agriculture</td>
<td>The primary occupation of the household is agriculture</td>
</tr>
<tr>
<td>Casual Labor</td>
<td>The primary occupation of the household is casual labor</td>
</tr>
<tr>
<td>Services</td>
<td>The primary occupation of the household is Services</td>
</tr>
<tr>
<td>Others</td>
<td>The primary occupation of the household is Others</td>
</tr>
<tr>
<td>Land Ownership</td>
<td>Household owns some amount of land</td>
</tr>
<tr>
<td>Distance to Road</td>
<td>The distance between the household and the main road is greater than 1 km</td>
</tr>
<tr>
<td><strong>Hygiene Behavior:</strong></td>
<td></td>
</tr>
<tr>
<td>Latrine Availability</td>
<td>Household has a latrine in the house</td>
</tr>
<tr>
<td>Village Latrine Availability</td>
<td>Percentage latrine availability in the village</td>
</tr>
<tr>
<td>Neighborhood Clean Drain</td>
<td>Neighborhood drainage is clean or is in good sanitary condition</td>
</tr>
<tr>
<td>Water Source away from Latrine</td>
<td>Household’s water source is 10 meters away from latrine</td>
</tr>
<tr>
<td>Covered Drinking Water</td>
<td>Household covers stored drinking water</td>
</tr>
<tr>
<td>Water Availability</td>
<td>Water is available inside the house</td>
</tr>
<tr>
<td><strong>Others:</strong></td>
<td></td>
</tr>
<tr>
<td>Plain</td>
<td>The terrain of the village is plain</td>
</tr>
<tr>
<td>Swajal Program</td>
<td>The village had the Swajal program</td>
</tr>
</tbody>
</table>
Table 2: SUMMARY STATISTICS

<table>
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<td>Household’s ill-Health</td>
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<td>0.113</td>
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<td>College or Above</td>
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<td>0.251</td>
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<td>Services</td>
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<td>0.377</td>
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<td>Village Latrine Availability</td>
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<td>0.268</td>
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<td>Toilet Scheme</td>
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</tr>
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</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Poverty Status</td>
<td>0.386**</td>
<td>0.260+</td>
</tr>
<tr>
<td></td>
<td>(2.77)</td>
<td>(1.73)</td>
</tr>
<tr>
<td>Latrine Availability</td>
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<td>-0.441**</td>
</tr>
<tr>
<td></td>
<td>(-3.09)</td>
<td>(-3.02)</td>
</tr>
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<td>(-1.70)</td>
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<td>(6.05)</td>
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<td>(0.57)</td>
<td>(0.47)</td>
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<td>(-1.99)</td>
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<td>0.360*</td>
</tr>
<tr>
<td></td>
<td>(2.06)</td>
<td>(2.07)</td>
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<tr>
<td>Services</td>
<td>0.0586</td>
<td>0.0521</td>
</tr>
<tr>
<td></td>
<td>(0.28)</td>
<td>(0.25)</td>
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<td>0.413*</td>
</tr>
<tr>
<td></td>
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<td>(2.00)</td>
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<td>(0.01)</td>
<td>(0.04)</td>
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<td>-0.301</td>
</tr>
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<td>(-1.43)</td>
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<tr>
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<td>-0.243</td>
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</tr>
<tr>
<td></td>
<td>(-1.40)</td>
<td>(-1.35)</td>
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<td>Male-Headed Household</td>
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<tr>
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<td>(0.05)</td>
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<tr>
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<td>Yes</td>
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<td>Constant</td>
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t statistics in parentheses
+ p < 0.10, * p < 0.05, ** p < 0.01
Table 4: Households’ Ill-Health Incidences: Poisson vs. Zero-inflated Poisson Models

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<th>(1)</th>
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<td>0.232</td>
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<td>(2.77)</td>
<td>(1.73)</td>
<td>(1.61)</td>
<td>(1.16)</td>
<td>(1.48)</td>
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<td>(1.05)</td>
<td>(0.95)</td>
<td>(1.03)</td>
<td>(1.04)</td>
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<td>-0.352*</td>
<td>-0.347*</td>
<td>-0.421*</td>
<td>-0.357*</td>
<td>-0.417*</td>
<td>-0.340*</td>
<td>-0.375*</td>
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<td>(-3.09)</td>
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<td>(-2.24)</td>
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<td>(-2.17)</td>
<td>(-2.40)</td>
<td>(-2.10)</td>
<td>(-2.05)</td>
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<td>Neighborhood Clean Drain</td>
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<td>-0.691+</td>
<td>-0.740+</td>
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<td>-0.952*</td>
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Notes: All coefficients are statistically significant at * p < 0.10, ** p < 0.05, *** p < 0.01.
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Table 8: Instruments for Poverty Status: First Stage Regression, Probit Model

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* t statistics in parentheses

+ p < 0.10, * p < 0.05, ** p < 0.01
### Table 9: Instruments for Poverty: First Stage Regression, Probit Model, Marginal Effects

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* $t$ statistics in parentheses

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<td>-0.00031</td>
<td>-0.00031</td>
<td>-0.00031</td>
<td>-0.00031</td>
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<td>Latrine Availability</td>
<td>-0.00040</td>
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<td>-0.00031</td>
<td>-0.00031</td>
</tr>
<tr>
<td>Neighborhood Clean Drain</td>
<td>-0.00078</td>
<td>-0.00078</td>
<td>-0.00078</td>
<td>-0.00078</td>
<td>-0.00078</td>
<td>-0.00078</td>
<td>-0.00078</td>
<td>-0.00078</td>
<td>-0.00078</td>
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</tr>
<tr>
<td>Primary School</td>
<td>0.00155</td>
<td>0.00155</td>
<td>0.00155</td>
<td>0.00155</td>
<td>0.00155</td>
<td>0.00155</td>
<td>0.00155</td>
<td>0.00155</td>
<td>0.00155</td>
<td>0.00155</td>
</tr>
<tr>
<td>High School</td>
<td>-0.0121</td>
<td>-0.0121</td>
<td>-0.0121</td>
<td>-0.0121</td>
<td>-0.0121</td>
<td>-0.0121</td>
<td>-0.0121</td>
<td>-0.0121</td>
<td>-0.0121</td>
<td>-0.0121</td>
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<tr>
<td>College and Above</td>
<td>-0.0146</td>
<td>-0.0146</td>
<td>-0.0146</td>
<td>-0.0146</td>
<td>-0.0146</td>
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<td>-0.0146</td>
<td>-0.0146</td>
<td>-0.0146</td>
<td>-0.0146</td>
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<tr>
<td>Plain</td>
<td>-0.00899</td>
<td>-0.00899</td>
<td>-0.00899</td>
<td>-0.00899</td>
<td>-0.00899</td>
<td>-0.00899</td>
<td>-0.00899</td>
<td>-0.00899</td>
<td>-0.00899</td>
<td>-0.00899</td>
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<tr>
<td>Casal Labor</td>
<td>0.00115</td>
<td>0.00115</td>
<td>0.00115</td>
<td>0.00115</td>
<td>0.00115</td>
<td>0.00115</td>
<td>0.00115</td>
<td>0.00115</td>
<td>0.00115</td>
<td>0.00115</td>
</tr>
<tr>
<td>Services</td>
<td>-0.00037</td>
<td>-0.00037</td>
<td>-0.00037</td>
<td>-0.00037</td>
<td>-0.00037</td>
<td>-0.00037</td>
<td>-0.00037</td>
<td>-0.00037</td>
<td>-0.00037</td>
<td>-0.00037</td>
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<td>Toilet Scheme</td>
<td>0.00231</td>
<td>0.00231</td>
<td>0.00231</td>
<td>0.00231</td>
<td>0.00231</td>
<td>0.00231</td>
<td>0.00231</td>
<td>0.00231</td>
<td>0.00231</td>
<td>0.00231</td>
</tr>
<tr>
<td>Water Source away from Latrine</td>
<td>-0.00143</td>
<td>-0.00143</td>
<td>-0.00143</td>
<td>-0.00143</td>
<td>-0.00143</td>
<td>-0.00143</td>
<td>-0.00143</td>
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<td>-0.00143</td>
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<tr>
<td>Covered Drinking Water</td>
<td>-0.00142</td>
<td>-0.00142</td>
<td>-0.00142</td>
<td>-0.00142</td>
<td>-0.00142</td>
<td>-0.00142</td>
<td>-0.00142</td>
<td>-0.00142</td>
<td>-0.00142</td>
<td>-0.00142</td>
</tr>
<tr>
<td>Male-Headed Household</td>
<td>-0.0172</td>
<td>-0.0172</td>
<td>-0.0172</td>
<td>-0.0172</td>
<td>-0.0172</td>
<td>-0.0172</td>
<td>-0.0172</td>
<td>-0.0172</td>
<td>-0.0172</td>
<td>-0.0172</td>
</tr>
<tr>
<td>Age of Household Head</td>
<td>-0.00012</td>
<td>-0.00012</td>
<td>-0.00012</td>
<td>-0.00012</td>
<td>-0.00012</td>
<td>-0.00012</td>
<td>-0.00012</td>
<td>-0.00012</td>
<td>-0.00012</td>
<td>-0.00012</td>
</tr>
<tr>
<td>GP Dummies</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Constant</td>
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<td>0.00027</td>
<td>0.00027</td>
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<td>0.00027</td>
<td>0.00027</td>
<td>0.00027</td>
<td>0.00027</td>
<td>0.00027</td>
</tr>
</tbody>
</table>

Table 12: Households’ Ill-Health Incidences: IV Estimation of Tobit Model

*5 statistics in parentheses. 
+1 statistics in parentheses, p < 0.10, *p < 0.05, **p < 0.01.
Table 13: Correlates of Latrine Availability inside the House: Probit Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>(Std. Err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.096**</td>
<td>(0.255)</td>
</tr>
<tr>
<td>Poverty Status</td>
<td>-0.405**</td>
<td>(0.091)</td>
</tr>
<tr>
<td>Household Size</td>
<td>0.070**</td>
<td>(0.020)</td>
</tr>
<tr>
<td>Primary School</td>
<td>0.043</td>
<td>(0.092)</td>
</tr>
<tr>
<td>High School</td>
<td>0.117</td>
<td>(0.108)</td>
</tr>
<tr>
<td>College and Above</td>
<td>0.507**</td>
<td>(0.186)</td>
</tr>
<tr>
<td>Casual Labor</td>
<td>-0.135</td>
<td>(0.111)</td>
</tr>
<tr>
<td>Services</td>
<td>0.323**</td>
<td>(0.117)</td>
</tr>
<tr>
<td>Others</td>
<td>0.341**</td>
<td>(0.123)</td>
</tr>
<tr>
<td>Caste</td>
<td>-0.171†</td>
<td>(0.095)</td>
</tr>
<tr>
<td>Water Availability</td>
<td>0.705**</td>
<td>(0.097)</td>
</tr>
<tr>
<td>Diarrhea Awareness</td>
<td>0.328**</td>
<td>(0.104)</td>
</tr>
<tr>
<td>Swajal Program</td>
<td>0.998**</td>
<td>(0.155)</td>
</tr>
<tr>
<td>Plain</td>
<td>-1.293**</td>
<td>(0.257)</td>
</tr>
<tr>
<td>Distance to Road</td>
<td>-0.256***</td>
<td>(0.097)</td>
</tr>
<tr>
<td>District 2</td>
<td>1.305**</td>
<td>(0.269)</td>
</tr>
<tr>
<td>District 3</td>
<td>0.853**</td>
<td>(0.249)</td>
</tr>
<tr>
<td>District 4</td>
<td>0.058</td>
<td>(0.260)</td>
</tr>
<tr>
<td>District 5</td>
<td>0.421†</td>
<td>(0.249)</td>
</tr>
<tr>
<td>District 6</td>
<td>1.443**</td>
<td>(0.367)</td>
</tr>
<tr>
<td>District 7</td>
<td>1.587**</td>
<td>(0.279)</td>
</tr>
<tr>
<td>District 8</td>
<td>0.633**</td>
<td>(0.238)</td>
</tr>
<tr>
<td>District 9</td>
<td>0.708**</td>
<td>(0.239)</td>
</tr>
<tr>
<td>District 10</td>
<td>0.612*</td>
<td>(0.260)</td>
</tr>
<tr>
<td>District 11</td>
<td>-0.541*</td>
<td>(0.247)</td>
</tr>
<tr>
<td>District 12</td>
<td>1.574**</td>
<td>(0.329)</td>
</tr>
<tr>
<td>District 13</td>
<td>-0.291</td>
<td>(0.253)</td>
</tr>
</tbody>
</table>

Likelihood Ratio Chi (28) 490.37  
Prob > chi2 0.0000  
Pseudo R square 0.2524  
Number of observations 1402

+ p < 0.10, * p < 0.05, ** p < 0.01
Table 14: Correlates of Latrine Availability inside the House: Probit Marginal Effects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>(Std. Err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.509**</td>
<td>(0.153)</td>
</tr>
<tr>
<td>Poverty Status</td>
<td>-0.412**</td>
<td>(0.086)</td>
</tr>
<tr>
<td>Household Size</td>
<td>0.046*</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Primary School</td>
<td>0.085</td>
<td>(0.089)</td>
</tr>
<tr>
<td>High School</td>
<td>0.210*</td>
<td>(0.100)</td>
</tr>
<tr>
<td>College and Above</td>
<td>0.573***</td>
<td>(0.176)</td>
</tr>
<tr>
<td>Casual Labor</td>
<td>-0.463**</td>
<td>(0.100)</td>
</tr>
<tr>
<td>Services</td>
<td>0.107</td>
<td>(0.105)</td>
</tr>
<tr>
<td>Others</td>
<td>0.162</td>
<td>(0.110)</td>
</tr>
<tr>
<td>Caste</td>
<td>0.115</td>
<td>(0.087)</td>
</tr>
<tr>
<td>Water Availability</td>
<td>0.654**</td>
<td>(0.089)</td>
</tr>
<tr>
<td>Diarrhea Awarness</td>
<td>0.290**</td>
<td>(0.099)</td>
</tr>
<tr>
<td>Swajal Program</td>
<td>0.884**</td>
<td>(0.086)</td>
</tr>
<tr>
<td>Plain</td>
<td>-0.209*</td>
<td>(0.096)</td>
</tr>
<tr>
<td>Distance to Road</td>
<td>-0.128</td>
<td>(0.082)</td>
</tr>
</tbody>
</table>

Likelihood Ratio Chi (28) 354.77
Prob > chi2 0.0000
Pseudo R square 0.1826
Number of observations 1402

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$
Table 15: Correlates of Latrine Availability inside the House, with controls for Gram Panchayats: Probit Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (Std. Err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.516† (0.312)</td>
</tr>
<tr>
<td>Poverty Status</td>
<td>-0.498** (0.098)</td>
</tr>
<tr>
<td>Household Size</td>
<td>0.056** (0.022)</td>
</tr>
<tr>
<td>Primary School</td>
<td>0.133 (0.100)</td>
</tr>
<tr>
<td>High School</td>
<td>0.161 (0.117)</td>
</tr>
<tr>
<td>College and Above</td>
<td>0.559** (0.208)</td>
</tr>
<tr>
<td>Casual Labor</td>
<td>-0.113 (0.122)</td>
</tr>
<tr>
<td>Services</td>
<td>0.319* (0.136)</td>
</tr>
<tr>
<td>Others</td>
<td>0.333* (0.143)</td>
</tr>
<tr>
<td>Caste</td>
<td>-0.193† (0.112)</td>
</tr>
<tr>
<td>Water Availability</td>
<td>0.697** (0.109)</td>
</tr>
<tr>
<td>Diarrhea Awareness</td>
<td>0.372** (0.115)</td>
</tr>
<tr>
<td>Swajal Program</td>
<td>0.992* (0.457)</td>
</tr>
<tr>
<td>Plain</td>
<td>0.007 (0.467)</td>
</tr>
<tr>
<td>Distance to Road</td>
<td>-0.295* (0.122)</td>
</tr>
<tr>
<td>gp_dum2</td>
<td>-1.004* (0.484)</td>
</tr>
<tr>
<td>gp_dum3</td>
<td>-0.285 (0.367)</td>
</tr>
<tr>
<td>gp_dum4</td>
<td>0.381 (0.373)</td>
</tr>
<tr>
<td>gp_dum5</td>
<td>1.565** (0.550)</td>
</tr>
<tr>
<td>gp_dum7</td>
<td>-0.373 (0.385)</td>
</tr>
<tr>
<td>gp_dum8</td>
<td>0.158 (0.400)</td>
</tr>
<tr>
<td>gp_dum9</td>
<td>1.228** (0.391)</td>
</tr>
<tr>
<td>gp_dum10</td>
<td>0.620† (0.354)</td>
</tr>
<tr>
<td>gp_dum11</td>
<td>-1.465** (0.449)</td>
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<tr>
<td>gp_dum12</td>
<td>-1.155* (0.580)</td>
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<tr>
<td>gp_dum13</td>
<td>-0.406 (0.367)</td>
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<tr>
<td>gp_dum14</td>
<td>-0.988** (0.350)</td>
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<td>gp_dum15</td>
<td>-0.348 (0.384)</td>
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<tr>
<td>gp_dum16</td>
<td>-0.074 (0.571)</td>
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<tr>
<td>gp_dum17</td>
<td>-1.222* (0.574)</td>
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<tr>
<td>gp_dum18</td>
<td>0.099 (0.563)</td>
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<tr>
<td>gp_dum19</td>
<td>1.793** (0.392)</td>
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<tr>
<td>gp_dum20</td>
<td>-0.476 (0.321)</td>
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<tr>
<td>gp_dum22</td>
<td>0.657† (0.362)</td>
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<tr>
<td>gp_dum23</td>
<td>-0.375 (0.376)</td>
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<tr>
<td>gp_dum24</td>
<td>-0.242 (0.361)</td>
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<tr>
<td>gp_dum26</td>
<td>0.364 (0.504)</td>
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<tr>
<td>gp_dum27</td>
<td>-0.536 (0.455)</td>
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<tr>
<td>gp_dum28</td>
<td>-0.564 (0.425)</td>
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<tr>
<td>gp_dum29</td>
<td>0.076 (0.445)</td>
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<tr>
<td>gp_dum30</td>
<td>0.514 (0.353)</td>
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<tr>
<td>gp_dum31</td>
<td>-1.071** (0.412)</td>
</tr>
<tr>
<td>gp_dum32</td>
<td>-1.098** (0.412)</td>
</tr>
<tr>
<td>gp_dum33</td>
<td>-1.024* (0.456)</td>
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<tr>
<td>gp_dum34</td>
<td>-1.178† (0.667)</td>
</tr>
<tr>
<td>gp_dum35</td>
<td>0.106 (0.565)</td>
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<tr>
<td>gp_dum36</td>
<td>-0.174 (0.324)</td>
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<tr>
<td>gp_dum37</td>
<td>-1.444** (0.425)</td>
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<tr>
<td>gp_dum38</td>
<td>-1.194** (0.398)</td>
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</table>

Likelihood Ratio Chi (28) 602.87
Prob > chi2 0.0000
Pseudo R square 0.3224
Number of observations 1349

+ p < 0.10, * p < 0.05, ** p < 0.01
Table 16: Correlates of Water Availability inside the House: Probit Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>(Std. Err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.761**</td>
<td>(0.204)</td>
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<tr>
<td>Poverty Status</td>
<td>-0.669**</td>
<td>(0.087)</td>
</tr>
<tr>
<td>Swajal Program</td>
<td>-0.740**</td>
<td>(0.157)</td>
</tr>
<tr>
<td>Plain</td>
<td>0.821**</td>
<td>(0.246)</td>
</tr>
<tr>
<td>Distance to Road</td>
<td>-0.456**</td>
<td>(0.105)</td>
</tr>
<tr>
<td>District 2</td>
<td>-1.447**</td>
<td>(0.267)</td>
</tr>
<tr>
<td>District 3</td>
<td>-0.777**</td>
<td>(0.246)</td>
</tr>
<tr>
<td>District 5</td>
<td>-0.145</td>
<td>(0.236)</td>
</tr>
<tr>
<td>District 6</td>
<td>-0.132</td>
<td>(0.363)</td>
</tr>
<tr>
<td>District 7</td>
<td>-0.284</td>
<td>(0.261)</td>
</tr>
<tr>
<td>District 8</td>
<td>-0.452*</td>
<td>(0.225)</td>
</tr>
<tr>
<td>District 9</td>
<td>-0.889**</td>
<td>(0.257)</td>
</tr>
<tr>
<td>District 10</td>
<td>-1.717**</td>
<td>(0.302)</td>
</tr>
<tr>
<td>District 11</td>
<td>-1.498**</td>
<td>(0.270)</td>
</tr>
<tr>
<td>District 12</td>
<td>-0.136</td>
<td>(0.316)</td>
</tr>
<tr>
<td>District 13</td>
<td>-0.733**</td>
<td>(0.240)</td>
</tr>
</tbody>
</table>

Likelihood Ratio Chi (28) 482.09
Prob > chi2 0.0000
Pseudo R square 0.2656
Number of observations 1320

+ p < 0.10, * p < 0.05, ** p < 0.01

Table 17: Correlates of Water Availability inside the House: Probit Marginal Effects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>(Std. Err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.124†</td>
<td>(0.068)</td>
</tr>
<tr>
<td>Poverty Status</td>
<td>-0.684**</td>
<td>(0.080)</td>
</tr>
<tr>
<td>Swajal Program</td>
<td>-0.701**</td>
<td>(0.089)</td>
</tr>
<tr>
<td>Plain</td>
<td>1.488**</td>
<td>(0.086)</td>
</tr>
<tr>
<td>Distance to Road</td>
<td>-0.262**</td>
<td>(0.085)</td>
</tr>
</tbody>
</table>

Likelihood Ratio Chi (28) 433.66
Prob > chi2 0.0000
Pseudo R square 0.2273
Number of observations 1402

+ p < 0.10, * p < 0.05, ** p < 0.01
Table 18: Correlates of Water Availability inside the House, with controls for Gram Panchayat: Probit Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>(Std. Err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.584*</td>
<td>(0.290)</td>
</tr>
<tr>
<td>Poverty Status</td>
<td>-0.699**</td>
<td>(0.097)</td>
</tr>
<tr>
<td>Swajal Program</td>
<td>1.799**</td>
<td>(0.421)</td>
</tr>
<tr>
<td>Plain</td>
<td>-0.404</td>
<td>(0.395)</td>
</tr>
<tr>
<td>Distance to Road</td>
<td>-0.022</td>
<td>(0.135)</td>
</tr>
<tr>
<td>gp_dum3</td>
<td>0.558</td>
<td>(0.373)</td>
</tr>
<tr>
<td>gp_dum5</td>
<td>0.328</td>
<td>(0.386)</td>
</tr>
<tr>
<td>gp_dum6</td>
<td>-2.801**</td>
<td>(0.567)</td>
</tr>
<tr>
<td>gp_dum7</td>
<td>0.571</td>
<td>(0.384)</td>
</tr>
<tr>
<td>gp_dum8</td>
<td>0.552</td>
<td>(0.399)</td>
</tr>
<tr>
<td>gp_dum9</td>
<td>-0.519</td>
<td>(0.474)</td>
</tr>
<tr>
<td>gp_dum13</td>
<td>1.796**</td>
<td>(0.387)</td>
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<tr>
<td>gp_dum14</td>
<td>-0.303</td>
<td>(0.305)</td>
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<tr>
<td>gp_dum15</td>
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<tr>
<td>gp_dum16</td>
<td>2.607**</td>
<td>(0.533)</td>
</tr>
<tr>
<td>gp_dum17</td>
<td>2.473**</td>
<td>(0.520)</td>
</tr>
<tr>
<td>gp_dum18</td>
<td>2.264**</td>
<td>(0.510)</td>
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<tr>
<td>gp_dum19</td>
<td>0.262</td>
<td>(0.392)</td>
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<tr>
<td>gp_dum20</td>
<td>-0.262</td>
<td>(0.282)</td>
</tr>
<tr>
<td>gp_dum22</td>
<td>1.970**</td>
<td>(0.345)</td>
</tr>
<tr>
<td>gp_dum24</td>
<td>-1.119*</td>
<td>(0.536)</td>
</tr>
<tr>
<td>gp_dum25</td>
<td>-2.706**</td>
<td>(0.576)</td>
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<tr>
<td>gp_dum26</td>
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<td>(0.448)</td>
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<tr>
<td>gp_dum27</td>
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<tr>
<td>gp_dum28</td>
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<tr>
<td>gp_dum30</td>
<td>-0.216</td>
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<tr>
<td>gp_dum31</td>
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<td>gp_dum34</td>
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<td>(0.547)</td>
</tr>
<tr>
<td>gp_dum35</td>
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<td>gp_dum37</td>
<td>0.430</td>
<td>(0.378)</td>
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<tr>
<td>gp_dum38</td>
<td>1.112**</td>
<td>(0.374)</td>
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</table>

Likelihood Ratio Chi (28) 494.73
Prob > chi2 0.0000
Pseudo R square 0.3066
Number of observations 1164

+ p < 0.10, * p < 0.05, ** p < 0.01