Sanitation and health externalities: Resolving the Muslim mortality paradox

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Abstract

In India, Muslims face significantly lower child mortality rates than Hindus, despite Muslim parents being poorer and less educated on average. Because observable characteristics would predict a Muslim *dis*advantage relative to Hindus, previous studies documenting this robust and persistent pattern have called it a "puzzle" of Muslim mortality. This paper offers a simple solution to the puzzle in the form of an important sanitation externality. Most of India's population defecates in the open, without the use of toilets or latrines, spreading fecal pathogens that can make children ill. Hindus are 40% more likely than Muslims to do so, and we show that this one difference in sanitation can fully account for the large (18%) child mortality gap between Hindus and Muslims. Building on our finding that religion predicts infant and child mortality only through its association with latrine use, we show that latrine use constitutes an externality rather than a pure private gain: It is the open defecation of one's neighbors, rather than the household's own practice, that matters most for child survival. The gradient and mechanism we uncover have important implications for child health and mortality worldwide, since 15% of the world's population defecates in the open. To put the results in context, we find that moving from a locality where everybody defecates in the open to a locality where nobody defecates in the open is associated with a larger difference in child mortality than moving from the bottom quintile of asset wealth to the top quintile of asset wealth.

1 Introduction

In India, Muslim children are substantially more likely than Hindu children to survive to their fifth birthday, despite Muslim parents being poorer and less educated on average than Hindu parents. This phenomenon, which has been documented by Shariff (1995), Bhat and Zavier (2005), Bhalotra and Soest (2008), and Bhalotra et al. (2010), is hard to reconcile with the well-developed literature on the importance of income and education in explaining health and mortality differences between racial, ethnic, or religious groups.[1] Nonetheless, by age five, mortality among Muslims is about 18 percent lower than among Hindus, with an additional 1.7 children per 100 surviving to age 5. Bhalotra et al. (2010) named this robust and persistent pattern a "puzzle of Muslim child mortality advantage," and carefully demonstrated that education, wealth, family demographics, state trends, cohort effects, development expenditure, and village-level health services and health infrastructure could together account for *none* of the Muslim mortality advantage, which has existed since at least the 1960s. In fact, the variables known to have the strongest mortality gradients would predict a mortality *disadvantage* for Muslims. Even including health behaviors that are more proximate, such as breastfeeding, antenatal care, or place of delivery had little to no power to explain the disparity. In this paper we identify a solution to this puzzle, with implications for child health and survival within and outside of India.

We show that the entire gap between Muslim and Hindu child mortality can be accounted for by a particular kind of sanitation externality. More than half of Indian households defecate in the open without using a toilet or latrine, introducing pathogens into the environment that cause disease. Bacteria and worms contained in feces get transmitted via contact with skin and via ingestion, leading to both acute and chronic illness. Recent medical and epidemiological research (see, e.g., Mondal et al., 2011) suggests that consistent exposure to the disease environment created by open defecation can result in chronic intestinal problems

[1] See, for example, Geruso (2012) for an accounting of racial mortality differences in the US.

that block the absorption of nutrients in food. In India, Muslims are about 40 percent more likely than Hindus to use pit latrines or toilets, which serve to safely dispose of excreta. More importantly, Muslims are more likely to have Muslim neighbors who follow the same practice. We show that differences in these sanitation behaviors can account for the entire mortality gap between Hindus and Muslims.

The ultimate roots of this behavioral difference are difficult to trace, but longstanding. We discuss below the unique history and context of open defecation among Hindus, the earliest evidence of which can be found in ancient Hindu religious texts. The issue was brought to the forefront of public attention by Gandhi in the 1920s, and nearly a century later in 2012 has been revived as a topic of pressing public policy concern by both conservative and liberal Hindu politicians in India.

Water and sanitation have long been acknowledged to be important determinants of health outcomes (see for example Cutler and Miller, 2005, Bleakley, 2007, and Watson, 2006 for examples from the US context). Nonetheless, the health and mortality gradient in sanitation has been given relatively less research attention than the gradients in income and education. However, a burgeoning literature has refocused on the importance of sanitation, and in particular open defecation, in influencing health and mortality in the developing world. We build on the recent insight that sanitation can be as or more important than income in explaining human capital accumulation among the very poor (Spears, 2013).

We begin by replicating the main result of Bhalotra et al. (2010). Using several National Family Health Surveys from India, we show that neither wealth, demographics including birth order by gender, nor a host of other theoretically relevant variables can account for the large and statistically significant infant (under 1) and child (under 5) mortality gaps between Hindus and Muslims in India. We then show that including a measure of open defecation can completely account for the gap, with or without the inclusion of an extensive set of controls. Further, we show that it is latrine use by neighbors, rather than the households' own use of latrines, that is associated with the largest mortality gradient. In our preferred specification, village-level average open defecation has an effect about twice as large as own latrine use on child survival. As we discuss below, this is consistent with an environmental health externality, in which neonates and children are exposed to the pathogens introduced by neighbors' open defecation.

Why can open defecation account for so much? First, the gradient in local sanitation is large. For example, our findings indicate that moving from a locality where everybody defecates in the open to a locality where nobody defecates in the open is associated with a larger difference in mortality that moving from the bottom quintile of asset wealth to the top quintile of asset wealth. Second, the group differences are large. At any level of asset wealth or consumption, Muslims are 15-20 percentage points more likely to use latrines or toilets. Therefore, there is a large component of sanitation practice that is both uncorrelated with income and highly correlated with being Muslim.

The solution to the Muslim mortality puzzle provides broader insight into the importance of sanitation in health and human capital accumulation. Although our analysis is primarily aimed at solving the Muslim mortality puzzle—that is, showing that sanitation differences between Hindu and Muslims can explain mortality differences in an accounting sense—we also perform a series of supplemental analyses that are supportive of a causal pathway in which children and infants in localities with high levels of open-defecation are exposed to fecal pathogens.

First, to address the possibility that our open defecation variables may be confounding the effects of other correlated hygiene differences, we show that there are no systematic Hindu-Muslim differences in practices like hand washing with soap, hand washing after defecating, or water purification.

Second, in order to partially address the possibility that Hindus and Muslims are systematically different in other unobserved ways, we exploit the fact that the size and even sign of differences in latrine use between Hindus and Muslims varies across the vast geography of India. We show that in the Indian states where open defecation is similar between Hindus and

Muslims, the infant and child mortality rates are also similar. And in the rare places where Hindu are *less* likely to defecate in the open than Muslims, the well-documented Muslim advantage reverses. This result implies that if Hindu-Muslim differences in unobservables were driving our results, then these unobservables would have to track the geographic differences in differences between Hindu and Muslim latrine use, narrowing the field of plausible alternative explanations.

Next, to rule out the possibility that the sanitation effect we observe is reflecting any unobserved behavior that is associated with religion of the respondent household, we show that Hindu households residing in villages that are predominately Muslim (and therefore have, on average, neighbors more likely to use latrines) experience lower infant and child mortality rates than Hindus living amongst other Hindus. The results are symmetric when considering the neighbors of Muslims. If the Hindu-Muslim mortality gap were due to something about the household's religion, rather than the local externality we suggest, we would expect one's own religion to matter, but not the religion of one's neighbors.

And finally, we exploit variation in whether an infant was breastfed. The hypothesis that sanitation is affecting mortality via fecal germs would predict differential impacts of the externality according to whether a child was breastfed. This is because breastfeeding creates a natural barrier against germs, even if the nursing mother ingests those germs. Therefore, infants who consume water and other food are more likely to be exposed to and ingest fecal pathogens introduced by neighbors than those who exclusively breastfeed. We show that in the infant mortality regressions, there is a significant interaction between neighbor's open defecation and whether a mother breastfed her child. Breastfeeding significantly counteracts the negative impacts of poor local sanitation.

Our paper makes three important contributions. First, we solve the Muslim mortality puzzle posed by Bhalotra et al. (2010). Bhalotra et al. concluded that unobservable behaviors or endowments associated with religion were influencing Muslim health. By showing that sanitation differences fully account for the mortality gap, not only do we unpack the "religion" or "culture" explanation, we also cast the mortality gap in terms of a more general phenomenon rather than an idiosyncratic difference between Hindus and Muslims in India. Although India, which is home to around one third of the world's poor,[2] is certainly important in its own right, our results have implications that may be broadly applicable throughout the developing world. Over a billion people worldwide (15 percent of people in the world) practice open defecation.

Second, we complement the recent literature on health and sanitation in several ways. Ours is the first paper to examine the impact of local open defecation on child mortality. Previous studies have focused on the effect of open defecation on human capital accumulation reflected in height, or have used alternative explanatory variables such as aggregate variation in government programs that were introduced to improve sanitation (see Spears, 2012). In addition, a potential concern with other studies that have examined sanitation and health using variation over time is that sanitation improvement might be correlated with other unobserved local changes such as economic development. The Hindu-Muslim comparison here offers a unique opportunity to examine variation in sanitation practices that arise from historical and religious institutions and is, as we show, not positively correlated with general indicators of economic well-being across the groups. Our setting is one in which Hindus are advantaged in terms of material well-being and are disadvantaged in the sanitation practices of their neighbors.

Finally, our study is important in highlighting the potential external nature of the problem. Establishing that open defecation is largely an externality, rather than a consequence of own household behavior, is an important starting point for justifying any policy intervention on economic efficiency grounds and for properly designing such interventions.

The remainder of the paper is organized as follows. Section 2 provides further context on open defecation in India, as well as evidence from the literature on its important consequences for early-life health. Section 3 outlines our empirical strategy and describes in detail the

[2]By the World Bank definition of $1.25 per day.

econometric decomposition techniques that we use. Section 4 first replicates the Bhalotra et al. (2010) finding of a Muslim child mortality advantage, and then demonstrates that sanitation can fully account for this gap. Section 5 presents evidence supportive of a causal, external effect of sanitation. Section 6 concludes.

2 Open defecation in India

Muadh reported God's messenger as saying, "Guard against the three things which produce cursing: relieving one self in watering-places, in the middle of the road and in the shade."

–Mishkat-al-Masabih (Muslim sacred text) P:76

Far from his dwelling let him remove urine and excreta

–The Laws of Manu (Hindu sacred text), Chapter 4 verse 151

More than half of the Indian population, over 600 million people, defecate in the open, without the use of a latrine or toilet. The prevalence of open defecation (hereafter OD) is particularly high among India's Hindu majority. Data from the most recent wave of the National Health and Family Survey of India show that as of 2005, 67% of Hindu households defecate in the open—e.g. in fields, near streets, or behind bushes. In comparison, only 42% of the relatively poorer Muslim households do so.

The roots of this difference are difficult to trace. Different sanitation practices may have evolved between the largely segregated Muslim and Hindu communities for purely secular reasons. Or differences may have arisen due to some institutional features of the religions *per se*. Or secular differences in sanitation traditions, established long ago, may have been reinforced by the creation of religious texts that codified existing norms.

In the Hadith (i.e. teaching of Mohammad) quoted above, open defecation is expressly prohibited to Muslims. In particular, the passage warns against relieving oneself near places epidemiologists would recognize as having special potential to spread fecal pathogens, either by contaminating water or transmitting disease via contact with bare feet in heavily trafficked areas. In contrast, the Hindu tradition views excreta as something to be kept away from one's home.

The high prevalence of OD among Hindu Indians was brought into public focus by Gandhi, who said famously in 1925 that "Sanitation is more important than independence." Gandhi was particularly concerned with the plight of "scavengers"–low caste Hindus traditionally tasked with manually removing human waste from open or "dry" latrines.[3] He urged upper-caste Hindus to take responsibility for their own sanitation and lamented, "Our lavatories bring our civilization into discredit. They violate the rules of hygiene." Much more recently, Hindu politicians from both major political parties in India have echoed this sentiment with the slogan: "Toilets are more important than [Hindu] Temples."[4]

Ramaswami (2005) and Bathran (2011) attribute the modern persistence of OD among Hindus in India to the persistence of the Hindu caste system: the ritual avoidance of excreta is maintained not only be keeping defecation away from the home, but also by relegating its cleanup to the untouchables. Although it is beyond the scope of this econometric paper to evaluate, cultural scholars have claimed that this link between human waste and the "polluted" castes reinforces the norms in which sanitation problems are ignored by even upper caste Hindus (Ramaswami, 2005).

Therefore, perhaps contrary to intuition, the prominence of OD among Hindus is not merely a matter of the affordability of toilets. Instead, there is relatively less demand among

[3]Dry latrines are importantly different from pit latrines, because the former require someone to manually remove feces from them on a regular basis–a task traditionally left to low caste Hindus. The construction of new dry latrines has officially been outlawed since 1993 by The Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act, though their construction and use continues.

[4]Union Rural Development Minister Jairam Ramesh of the Congress party made the statement in October 2012. Gujarat Chief Minister and BJP candidate for Prime Minister Narendra Modi made an identical statement in October 2013.

Hindus at any price to relieve oneself in or near the home, compared to Muslims. Toilets constructed or paid for by the government often remain unused or repurposed by Hindus (Ramaswami, 2005). Summary statistics from the NHFS (tabulated in Table 1 below) show that Hindu–but not Muslim–households are much more likely to have electricity than to own or use a private or public latrine. Our estimates from the NHFS also show that even relatively wealthy Hindus who own large assets such as motorcycles often opt for open defecation rather than latrine use.

How could OD contribute so dramatically to infant and child mortality differences between Hindus and Muslims? Bacteria and parasites such as worms live in feces, and feces on the ground get onto feet and hands and into mouths and water. These pathogenic processes have been documented since at least the 19th century (Freedman, 1991). More recent epidemiological evidence suggests that years of exposure to fecal pathogens could lead to enteropathy—a chronic intestinal problem that prevents the proper absorption of calories and micronutrients (Humphrey, 2009; Petri et al., 2008; Mondal et al., 2011; Lin et al., 2013).

The transmission of serious disease via open defecation has historically not been unique to the developing world. Between 1910 and 1915, the Rockefeller Foundation spent millions in the US South to eradicate hookworm infections, which caused anemia and stunting in children (Bleakley, 2007). At the time, the prevalence of hookworm infections among southern school-aged children was around 40 percent. Unlike the modern Indian context, these infections were rarely fatal. But similar to the Indian context, the infection vector was human feces. Barefoot children in the US South were routinely exposed to worms while working or walking in fields fertilized with human feces and while using unsanitary outhouses.

Despite strong epidemiological evidence of a connection between OD, and health and mortality, the potential impact of OD on nutrition and human capital accumulation in the developing world has only recently attracted significant research attention in economics. In a comparison of 65 developing countries, Spears (2013) showed that international variation in sanitation could account for over 60% of the international variation in children's heights. Focusing on India, Spears (2012) evaluated a large sanitation project by the Indian government which reported building one pit latrine was per ten rural persons from 2001 to 2011 and offered local governments incentives to promote their use. By comparing better and worse performing districts, the study found significant improvements in child height and mortality among post-construction cohorts in districts where more latrines were reported being built. Note that the districts Spears (2012) studied were about 1,000 times more populous than the local areas defined in this study. This allows us to more narrowly measure the local open defecation externalities to which a child is exposed.

In short, the long-noted association between fecal pathogens and disease, along with more recent studies of open defecation's effects on human capital accumulation, lend plausibility to the idea that sanitation differences might be an important piece of the Muslim mortality puzzle.

3 Data and Framework

3.1 Data

Following Bhalotra et al. (2010), our analysis sample consists of data from three rounds of the National Family Health Survey (NFHS) of India: 1992/1993, 1998/1999, and 2005/2006. The NFHS (India's version of the Demographic and Health Survey) is a large, nationally representative survey that collects data from women aged 13 to 49, with survey modules focused on reproduction and health. Female respondents report birth histories, including deaths and stillbirths, as well as information on the health and health behaviors of their children.

We organize our analysis at the level of the child, constructing mortality rates from birth history information on around 310,000 Hindu and Muslim children in India over the three survey rounds.[5] We include every live birth within the past 10 years before the survey. Our primary outcomes of interest are the infant mortality rate (IMR) and the child mortality rate (CMR), defined respectively as the number of deaths among children less than one year old and less than five years old, scaled per 1,000 live births over the same period. We also examine the neonatal mortality rate (NMR), defined as deaths in the first month of life, again scaled per 1,000 live births over the same period.

The NHFS is also includes information on household assets, household physical infrastructure, and health behaviors of other residents. With respect to disposal of excreta, the respondents are asked about the type of toilet facility, if any, the household usually uses. We code a household as openly defecating if they report using no facility, a bush, or a field.

Importantly for investigating sanitation externalities, we can construct a measure of local area open defecation for each household in the survey. The DHS is a two-stage random sample, with households chosen from local primary sampling units (PSUs). The median survey PSU contains observations on 27 households.[6] This allows us to calculate a local OD rate: the fraction of surveyed households in a child's PSU who defecate in the open. We use this local area measure of OD to distinguish the effects of neighbors' use of latrines and toilets from the household's own use of a latrine or toilet.

3.2 Mortality and sanitation differences

Table 1 tabulates summary statistics for Hindus and Muslims in the NFHS 1, 2, and 3. Note that children (live births) are the observations in our data, so these averages are representative of young children and their households, not of all of India. Child mortality is high across India, and consistent with previous studies, there is a large and significant Muslim advantage. For every hundred live births, 1.7 fewer Hindu children will survive to age 5, implying child

[5] Bhalotra et al. (2010) exclude the states Andhra Pradesh, Madhya Pradesh, Tamil Nadu, West Bengal, and Himachal Pradesh. We do not do so, but our results are completely robust to imposing this restriction.

[6] Our data do not contain the sampling frame, but according to the DHS (NFHS-3) report, rural PSUs are villages of "usually about 100 to 200 households." Large villages above 500 households were split into three possible PSUs. Urban PSUs are census enumeration blocks (approximately 150-200 households).

mortality is 18.6 percent higher among Hindus than Muslims. Infant and neonatal mortality show similar patterns, with 17.0 percent and 19.0 percent survival deficits, respectively. In all cases these differences are highly significant, and this Muslim advantage occurs despite Muslims being significantly less likely to own large assets (the primary measure of wealth in this survey), and despite having lower education on average. Given these patterns, it is perhaps unsurprising that that previous studies have shown that none of the variables that typically are associated with large health gradients, such as wealth and education, can account for these morality gaps.

We argue that one area in which differences in observable characteristics might plausibly explain differences in health outcomes is sanitation, in which Muslim children are significantly advantaged. Hindus are 40 percent more likely to defecate in the open than Muslims. Moreover, Table 1 shows that Hindus tend to live in PSUs with other Hindus, and Muslims with other Muslims. This reinforces differences across individual households, and creates a correlation between own religious identity and the sanitation practices of neighbors, which is key to understanding the externality channel we argue for.

Figure 1 shows that in addition to being more likely to use latrines themselves, Muslims are more likely to have neighbors who do so. In panel A, the dependent variable is open defecation in the household's local area (PSU). In panel B, the dependent variable is whether the household itself practices open defecation. By both measures, children in Muslim households face less exposure to fecal germs. They tend to be located in PSUs where fewer of their neighbors defecate in the open, by a margin of 20 percentage points.

Panels C and D of Figure 1 remove any mechanical correlation between the toilet facilities of the respondent household and its neighbors by conditioning on whether the members of the respondent household use a latrine or toilet themselves. Irrespective of whether the own household practices OD (Panel C) or does not (Panel D), Muslim households are significantly more likely to have neighbors who use a latrine or toilet. These patterns are robust to controlling for assets, parental education, urban residence, and state fixed effects (full regression results presented in the Appendix).

3.3 Empirical Framework

We use two complementary techniques to demonstrate the extent to which the sanitation differences highlighted above can explain mortality differences between Hindus and Muslims.

3.3.1 Regressions

To begin, we regress mortality rates on an indicator for being Muslim (with or without additional controls) and note how the coefficient on the Muslim indicator attenuates when further controls for sanitation are added to the regression. Thus, we estimate:

$$mortality_{ip} = \beta_0 + \beta_1 Muslim_{ip} + \beta_2 sanitation_p^{PSU} + \beta_3 sanitation_{ip}^{HH} + X_{ip}\theta + \varepsilon_{it}, \quad (1)$$

where i indexes live births and p places, or more precisely survey PSUs. *Mortality* is an individual-level mortality indicator: either 0 if a child survived to the specified age or 1,000 if she did not.[7] *Muslim* is an indicator for being Muslim. X is a vector of SES and demographic controls that will be variously included to demonstrate robustness. We cluster standard errors by PSU.

The key explanatory variables are $sanitation_p^{PSU}$ and $sanitation_{ip}^{HH}$, which are, respectively, the fraction of households in a child's PSU who defecate in the open and an indicator for whether the child's own household defecates in the open. These will allow us to capture the private and external mortality benefits of sanitation use. We will interpret exposure to open defecation to be able to account for the Muslim mortality paradox to the extent that including these two variables reduces or eliminates the coefficient β_1 on the Muslim indicator.

[7] This construction merely scales mortality rates and coefficients to match the standard of expressing rates per 1,000.

3.3.2 Non-parametric reweighting decomposition

Our second method of accounting for the Hindu-Muslim gap follows the approach in DiNardo et al. (1996) and its application to demographic rates in Geruso (2012). We non-parametrically reweight observations in order to match the Hindu and Muslim subsamples on observables, most importantly with respect to sanitation. Using a reweighed Hindu subsample, we construct a counterfactual: what would Hindu mortality rates be if Hindu children were exposed to the same levels of open defecation as Muslim children?[8]

In particular, we follow four steps:

1. Divide both samples into 22 bins b of exposure to open defecation: 10 bands of local area (PSU) open defecation $(0.0, 0.1), [0.1, 0.2), \ldots, [0.9, 1.0)$ interacted with household open defecation, plus a bin for households in PSUs where no households defecate in the open and a bin for households in PSUs where all households defecate in the open.

2. Within each sample $s \in \{Hindu, Muslim\}$ and each bin b, compute ω_b^s, the fraction of sample s in bin b, using survey design weights.

3. For each observation in the Hindu sample, create new counterfactual weights by multiplying the observation's survey sampling weight by the ratio $\frac{\omega_b^{Muslim}}{\omega_b^{Hindu}}$ for the bin b of which it is a member.

4. Compute a counterfactual mean Hindu mortality rate under the Muslim distribution of sanitation using these new weights.

This approach has the advantage of allowing explicit consideration of how heterogeneity along other dimensions of observables shapes the Hindu-Muslim gap to be explained. In particular, we can first reweight a sample according to a partition based on other variables (e.g., what would Hindu mortality rates be exposed to the Muslim distribution of asset ownership?) and then further reweight according to a finer partition that interacts groupings of

[8]Spears (2013) uses a similar method to estimate the fraction of the India-Africa height gap that can be explained by sanitation.

these variables with the sanitation levels (here, matching the joint distribution of Muslim asset ownership and sanitation exposure). The advantage of this method, compared to the linear Blinder-Oaxaca decompositions, is that it forces the full joint distribution of characteristics between the groups to be equalized, as opposed to just the marginal means, which more flexibly allows for correlation between sanitation and other observables.

4 Results

This section presents evidence in three stages that open defecation accounts for the Hindu-Muslim mortality gap. First, nonparametric regression plots confirm a Muslim advantage in mortality throughout the SES distribution; this advantage vanishes when we condition on open defecation. Second, applying the regression framework of Bhalotra et al. (2010), we show that there is no Muslim mortality advantage holding constant sanitation. Third, nonparametric decompositions document an explanatory power of open defecation that is, if anything, greater than in the linear decompositions.

4.1 Nonparametric regression plots

Panels (a) and (b) of Figure 2 illustrate the puzzle documented by Bhalotra et al. (2010): at all levels of socioeconomic status, infant mortality is lower among Muslim children than among Hindu children. Although DHS data do not include economic variables such as income or consumption, we follow the demographic literature (see for example Filmer and Pritchett (2001)) in using asset ownership to proxy wealth in Panel (a).[9] In Panel (b), we plot mortality against mother's height. There is a long literature connecting adult height to

[9]We cannot use the principal component asset index included in the DHS because it is constructed including measures of sanitation. Therefore, we construct a household's asset rank by (1) partitioning the sample into $128 = 2^7$ bins of indicators for ownership of seven assets; (2) ranking the bins by the average child mortality rate in each bin; (3) assigning each household the median rank within the sample of its bin. Thus the household of child 200,000 has more and better assets than 200,000 of the approximately 300,000 children in our sample. Unlike a principal component index, this measure has units with a clear interpretation.

economic well-being (Case and Paxson, 2008; Steckel, 2009). A mother's height, in addition to being a summary measure of her own well-being in early life, may be correlated with child health through many channels (Ounsted et al., 1986; Spears, 2013). As expected, using either asset ownership or mother's height as the proxy for economic well-being, children in higher-SES households experience lower mortality. More importantly, a substantial Muslim advantage remains at every level of material well-being.

Panels (c) and (d) of Figure 2, which replace the vertical axes of the panels above them with measure of sanitation, suggest a potential explanation the mortality paradox. In these bottom panels, the dependent variable is the local fraction of households living near a child who defecate in the open. Visually, the associations of sanitation with asset wealth and mother's height strikingly resemble the associations of mortality with asset wealth and mother's height. Similar to the panels above them, there is a clear Muslim advantage at all levels of material well-being in terms of sanitation, and the confidence intervals for Hindu and Muslim children's environments do not overlap.

Figure 3 offers an initial, visual answer to the question of whether sanitation can account for the Muslim mortality paradox. The figures plot nonparametric regressions of mortality rates on local area sanitation coverage separately for Hindu and Muslim children. Infant mortality is plotted at the top (panels (a) and (b)), and child mortality at the bottom (panels (c) and (d)). In the left-side panels no controls are included. The right panel adds controls.[10] To create the plots that include controls, we first regress both mortality and sanitation on the controls, and then plot the nonparametric association between the *residuals* from these regressions.

Unsurprisingly, mortality rates are lower for children exposed to a smaller fraction of neighbors who defecate in the open: all lines slope down. More importantly, the large Hindu-

[10]These controls are state fixed effects; indicators for survey round, urban residence, birth year, and birth month; and a full set of sex-by-birth order indicators, which Pande and Jayachandran (2013) have recently shown to importantly predict early life health in India. For completeness in following Bhalotra et al. (2010), we also include state-specific linear time trends for year of birth, which will flexibly account for much of the heterogeneity in economic and human development in India over this time period.

Muslim gap in mortality is nowhere apparent in this figure. Three conclusions emerge. First, unlike in Figure 2, the Hindu and Muslim lines are very close to one another, crossing in all cases at least once. This indicates that, conditional on exposure to local open defecation, Hindu and Muslim mortality rates are not very different. Second, from visual inspection of the group means, it is clear that the within-group gradient between sanitation and mortality, reflected in the curves, is sufficient to account for the across-group differences in group means, reflected in the dots. In other words, the mean sanitation and mortality rates for *both* groups lie on the empirical sanitation-mortality curves, and these curves are identical across groups.

Third, the versions of the plots in panels (b) and (d), in which the dependent variable is the residual from an OLS regression, rule out that any of the controls used in the regression is an omitted variable in the sanitation-mortality association. After adjusting for controls, the ability of sanitation to account for the mortality differences is only clearer, as the mortality rates conditional on sanitation become only closer for the two groups.

4.2 The puzzle, solved: Regression results

Bhalotra et al. (2010) report that a wide range of economic, social, and demographic observables cannot explain the Muslim mortality puzzle. In particular when they regress mortality indicators on an indicator for being Muslim, this indicator remains negative and significant even after many controls are added. In this section, we repeat their procedure, but show that exposure to open defecation is alone sufficient to eliminate the coefficient on the Muslim dummy.

Table 2 presents results from estimating regression equation (1), and the main finding of our analysis. Whether introducing the sanitation variables to regressions with no controls beyond indicators for the DHS survey round, as in Panel A, or to regressions with a wide set of demographic and socio-economic controls,[11] as in Panel B, local and household open

[11] Our list of controls includes factors other papers have found to predict early-life health in India: a full set of birth order by sex effects (Pande and Jayachandran, 2013); a count of household ownership of seven assets asked about throughout DHS survey rounds, the standard strategy for controlling for SES using these data

defecation are together able to reduce the Muslim dummy to zero.[12]

Comparing the coefficients on local and own household open defecation highlights the critical *externality* of open defecation. The gradient between local open defecation and mortality is almost always steeper than the gradient between mortality and a household's own open defecation, in some cases twice as steep or more. Previous accounts of the Muslim mortality paradox in India may have missed the explanatory power of open defecation precisely because they omit to focus on this externality.

A natural question in this context is whether differences in son preference between Hindus and Muslims could confound results. To address the possibility that mortality gaps across religious groups—and the ability of OD to account for them—could differ by the child's gender, we replicate a subset of Table 2, splitting the sample by gender. Table 3 presents results on infant mortality rates for boys and girls separately. Not only are the Hindu-Muslim gaps in infant mortality similar across boys and girls, but the gaps attenuate to zero in exactly the same pattern as in the main table once measures of open defecation are included.

4.3 Nonparametric decomposition

Table 4 reports counterfactual Hindu mortality rates, computed by reweighting the sample of Hindu children to match the distribution of Muslim observables. We replicate our results for both CMR and IMR. Panels C and D further reweight the Hindu sample to match the distribution of Muslim children into Indian states; dimensions of human development can vary considerably across the states of India.

(Filmer and Pritchett, 2001); child's birth month (Doblhammer and Vaupel, 2001); indicators for mother's relationship to the head of the household (Coffey et al., 2013); mother's age when the child was born; an indicator for being a multiple birth; and an urban dummy fully interacted with household size.

[12] Bhalotra et al. (2010) exclude the Indian states of Andhra Pradesh, Madhya Pradesh, Tamil Nadu, West Bengal, and Himachal Pradesh. If we similarly exclude these states, our results are, if anything, quantitatively stronger. The coefficient on the Muslim coefficient predicting CMR is -15.6 ($t = 6.03$) without the sanitation controls and +2.5 with; the coefficient on IMR is -9.6 ($t = -5.87$) without sanitation and +1.3 with.

The first rows of Panel A and Panel B present the main result of this table: reweighting the Hindu sample to match the Muslim sample only in terms of exposure to open defecation yields counterfactual child and infant mortality rates among Hindus that are *lower* than the Muslim mortality rates. The fact that sanitation can nonparametrically account for 118 percent of the CMR gap and 108 percent of the IMR gap is, again, consistent with the fact that Hindu children come from richer families, on average, and would therefore be expected to have lower mortality.

The rest of the table explores the explanatory power of open defecation when added sequentially after other reweighting factors, many of which *widen* the gap to be explained. The need to create regions in the joint distributions that include support in both the Hindu and Muslim subsamples limits the number of dimensions over which we can simultaneously jointly reweight.[13] Therefore, we focus on three variables for which there is wide consensus on their importance for early life health: SES, here operationalized as ownership of seven DHS assets; mother's age at the birth of the child, here split in to five-year bins; and a categorization of mother's height, which correlates with the SES of her family of origin, the quality of the intrauterine environment, and her adult health and cognitive achievement.

After controlling for characteristics in rows (2) through (6) of each panel, a large mortality gap persists. But like the first rows that do not include controls, adding sanitation to the set of reweighting variables has a large incremental effect on the counterfactual mortality gap. In 13 out of 28 cases the mortality gap is reversed, with the counterfactual Hindu mortality rate becoming lower than the true Muslim mortality rate. Across all 28 specifications over both child and infant mortality rates, the fraction of the gap explained by open defecation has a mean of 92 percent, or essentially all of the mortality paradox, even after reweighting for the controls that increase the gap to be explained.

Beyond the Hindu-Muslim mortality differences that motivate this decomposition, these

[13] See Geruso (2012) for a fuller discussion of this limitation. Because of the joint support problem in cases of very narrow cells or many dimensions, we cannot include a specification that jointly reweights on survey round, mom's age, assets, mom's height, and sanitation without dropping observations.

results emphasize the potential for the wellbeing of poor children living anywhere in which OD is practiced to be dramatically affected by their neighbors' sanitation behavior.

5 Validation and Mechanisms

The main goal of this paper is to resolve the Bhalotra et al. (2010) Muslim mortality paradox in the accounting sense of Oaxaca-Blinder. Nonetheless, in this section we go further to provide evidence that the sanitation-mortality gradients we observe are consistent with a causal relationship.

Before performing additional tests, we begin with two observations. First, the general concern that sanitation might be correlated with other unobservable local features such as economic development, unobserved neighborhood infrastructure, or health services is less of an issue here than in other contexts because of the nature of the idiosyncratic religious difference we exploit. Our setting is one in which the Hindu majority is considerably advantaged compared to the Muslim minority in terms of material wellbeing, social status, and in access to state services, but disadvantaged in the sanitation practices of their neighbors. This allows us to exploit variation in sanitation that is negatively, rather than positively, correlated with education, wealth, and local factors. Second, the puzzle motivating the paper is that no observables (prior to examining the open defecation of neighboors) could explain the Muslim advantage; indeed it was Bhalotra et. al's contribution to the literature to carefully document this. Therefore, there is already considerable evidence against our result reflecting an omitted variable. Nonetheless, we supplement our analysis with several pieces of supporting analysis that are strongly suggestive of a causal pathway from OD to infant and child mortality.

5.1 Toilets or Other Hygiene Behavior?

Our main dataset allows us to construct good measures of OD, but contains very limited information other hygiene practices. Because group differences in human waste disposal could plausibly be correlated with other unobserved differences in hygiene, the issue is an important one. Indeed, experimental evidence by Luby et al. (2005) has shown that hand washing impacts diarrhea and pneumonia in the specific context of South Asia. To address this we turn briefly to the India Human Development Survey (IHDS) of 2004-2005, which contains better measures of hand washing and the treatment of water, but for which we cannot construct similarly reliable mortality rates.[14] Our goal with the IHDS is therefore to examine whether Hindu-Muslim differences exist in these other behaviors. We regress indicators for several hygiene and water variables the IHDS on an indicator for being Muslim.

Table 5 lists the results in two panels, with the top panel simply displaying differences in the unconditional means and the bottom panel controlling for log household consumption and whether the household is urban. In the first column, we replicate the result from the NHFS that Muslims are dramatically less likely to OD. However, column (2) shows that there is no association between religious identity and hand washing after defecating. Column (3) shows there is no association between religious identity and hand washing with soap. Column (4) shows Muslims are no more likely to purify their water. Finally, column (5) shows the only economically large or statistically significant difference besides OD: Muslims are significantly less likely to have water piped to their homes. Note that this would generally be considered a Muslim disadvantage with respect to health, operating against our findings of the correlated OD effect. It likely reflects the inferior access to state services faced by Muslims. In sum, the table shows that differences in human waste disposal between Hindus and Muslim appear not to carry over to advantages in even a single other category of hygiene or water. The practice of OD among Hindus, therefore, is not merely a marker for differences in other

[14] Specifically, we are limited by the smaller sample size of the IHDS and the fact that complete birth histories were not recorded for all women of childbearing age.

important sanitation practices.

5.2 Geographic Heterogeneity

In order to partially address the possibility that other unobserved variables beyond hand washing and water quality are driving the patterns in our main results, we exploit the fact that the size and even sign of differences in latrine use between Hindus and Muslims varies across the vast geography of India. In particular, while Hindus are less likely to use latrines overall, the degree of difference in this practice between Hindus and Muslims varies across Indian states. Our conjecture that OD causally impacts infant and child mortality suggests that in places where the OD gap is smaller, so should be the mortality gap. On the other hand, we would not expect such a pattern under the alternative explanation that Muslims are simply different along some other unobserved dimension.

Figure 4 plots differences across Indian states using our main NHFS sample, all three rounds. Each Indian state appears up to three times in the graph, with markers proportional to population size.[15] The top and bottom panels, respectively, plot the difference in infant and child mortality between Hindus and Muslims against the difference in OD between Hindus and Muslims. In states where the OD gap is small or zero, the infant mortality gap is similarly small or zero. In both panels, the linear regression line crosses the zero mortality difference precisely where the OD difference is zero. And in the rare cases where Hindus are *less* likely to defecate in the open than Muslims, the Muslim advantage reverses, and Muslim infant and child mortality is higher than among Hindus.

5.3 Externalities: Own Versus Neighbors' Religion

Muslim children are less likely to die in childhood. However, if open defecation is the explanation, then it is not only *being* Muslim which promotes survival, but also *living near*

[15] Each state doesn't appear exactly three times because some states split between the 2nd and 3rd round of the DHS.

Muslims, and even then only because of the association between neighbor's religion and neighbor's sanitation. We have seen two pieces of evidence consistent with this: In Table 1, the average Muslim child lives near a population that is ten times more Muslim in its composition than the population near the average Hindu child. In Table 2, the gradient is almost always steeper on community open defecation rates than on one's own household's behavior. Note that PSU-level OD is likely measured with more error than household OD, being typically computed from less than 30 observations in each community. This suggests that at least part of the coefficient on own household OD actually reflects its correlation with true underlying PSU-level OD. This recognition makes the pattern of stronger effects on PSU-level OD than household OD even more striking.

To bolster the argument that a sanitation externality is driving our results, rather than religion or some unobserved correlate of religion, we introduce Figure 5. The figure plots mortality rates against the religion of one's neighbors, but conditions on the household's own religion, which would otherwise be correlated with that of the neighbors due to *de facto* religious segregation across villages. We compute, for each child, the fraction of surveyed households that are Muslim in the PSU where that child lives. For both IMR and CMR, the graphs show that Hindu and Muslim children alike experience less mortality if they live in places where more of their neighbors are Muslim. The fact that there is vertical space between the lines could reflect an additional private benefit of a household's own safe sanitation.

Are these associations statistically significant and robust to alternative specifications? Table 6 indicates that they are. The table presents a three-stage pattern of regression results: First, in column (1), regressing mortality on an indicator for being Muslim reproduces the Muslim mortality advantage. Then, in column (2), adding a control for the fraction of a child's PSU who is Muslim eliminates the statistical significance of the Muslim indicator: the advantage accrues not to Muslims *per se*, but to those who live near Muslims. Finally, in column (3), adding the same controls for household and local open defecation that were used in Table 2, eliminates in turn the statistical significance of the fraction of the PSU that is Muslim, demonstrating that sanitation factors can account for the advantage of Muslim neighbors.

Recall that we cannot include hand washing directly as a control in our main dataset. However if—despite our finding of no differences in hand washing between Hindus and Muslims—this were a relevant omitted variable, hand washing effects would only be expected to show significance in estimates of the mortality gradient with respect to the household's own religion. In fact, it is neighbors' religion where we the find largest effects, making the alternative explanation of hand washing less plausible, as our estimates would then imply that it is neighbors', rather than one's own, hand washing behavior that matters most. Further, such an explanation would be inconsistent with the nearly identical OD-mortality gradient between Muslims and Hindus (evident in the slopes of the Hindu and Muslim curves in Figures 2 and 3). The finding in this section—that the Muslim advantage accrues to Hindus and Muslims alike who live near Muslims—points clearly towards an explanation based on disease externalities.

5.4 Interaction of sanitation and breastfeeding

If open defecation is indeed *causing* many of the infant deaths we study—rather than merely being spuriously correlated—then the association between sanitation and mortality should be greatest for children most likely to be exposed to fecal germs. Water and food are two key pathways through which poor sanitation causes infections in children. Breastfeeding is, therefore, known to be protective, by interrupting this pathway of disease transmission.[16] In effect, breastmilk is a natural prophylactic to germs in water and food, even those consumed by the breastfeeding mother.

Following this logic, Table 7 shows that in our sample local open defecation matters most

[16]Spears (2012), in an analysis similar to this section, shows that a government sanitation program in India had a greater effect on children who had non-breastmilk food earlier.

for the mortality of children who are not exclusively breastfed. We use two operationalizations of proper breastfeeding: an indicator that a child was exclusively breastfed for the first six months, and an indicator that a child was breastfed at all in the first six months. Note breastfeeding, as a property of children, varies *within* local PSUs.

The coefficients on the main effects for breastfeeding show that it is associated with infant mortality as expected. The negative coefficients on the interactions of OD and the breastfeeding variables indicate that breastfeeding is associated with a much larger decline in mortality in PSUs where many households defecate in the open than in PSUs where fewer households defecate in the open. This is consistent with the notion that breastfeeding is filtering out the fecal pathogens that would otherwise be ingested by babies. In the context of the sum of the evidence presented above, it would be unlikely that sanitation and breastfeeding would statistically interact in this way if there were not a pathway from open defecation to mortality operating via the externality channel we describe.

6 Conclusion

Various authors have documented a puzzle in the literature: Muslim children in India, despite being poorer, on average, than Hindu children, suffer lower rates of infant and child mortality. Bhalotra et al. (2010) show that a wide range of standard socioeconomic, demographic, and health observables are entirely unable to account for this difference. We have shown that open defecation alone can fully statistically explain the paradoxical Muslim mortality advantage, if both private and external benefits of sanitation are taken into account.

Of course, sanitation differences between Muslims and Hindus are not randomly assigned. Nonetheless, in terms of understanding the broader relationship between sanitation and health, our study has the advantage—in stark contrast to the small existing sanitation literature that uses variation in sanitation over time—that sanitation is negatively, not positively, correlated with other determinants of good health in our context. This is because the Muslim minority is generally poorer and attains lower educational levels, despite better sanitation practice. Further, by identifying variation in sanitation exposure that arises from the religious composition of one's neighbors, we have introduced a novel source of variation in sanitation exposure that may be used in future studies.

Our finding is important, first and foremost, because child mortality is important: a 17 per 1,000 births difference in child mortality, implied by the sanitation discrepancy between Hindus and Muslims, is profound. If there are about 30 million live births per year in India, about 70 percent of which are Hindu, then bringing Hindu children to the Muslim child mortality rate by matching their level of open defecation could imply hundreds of thousands more children living to be five years old, among those born each year.

Finally, we have highlighted the *externalities* of open defecation. It is not merely using a latrine that is protective; it is living near other households that use latrines. Much of the benefit of safe sanitation is not private to your household; it is also, and largely, external to those who live nearby. This understanding advances the economic case that sanitation is a public good which may therefore be under-supplied.

In sum, the results here point to a potentially important determinant of child well-being that has been under explored in the literature on the determinants of health and human capital accumulation in the developing world. Indeed, we find that the health-sanitation gradient is substantially larger than the health-wealth gradient in our context, highlighting the need for more investigation into this relationship.

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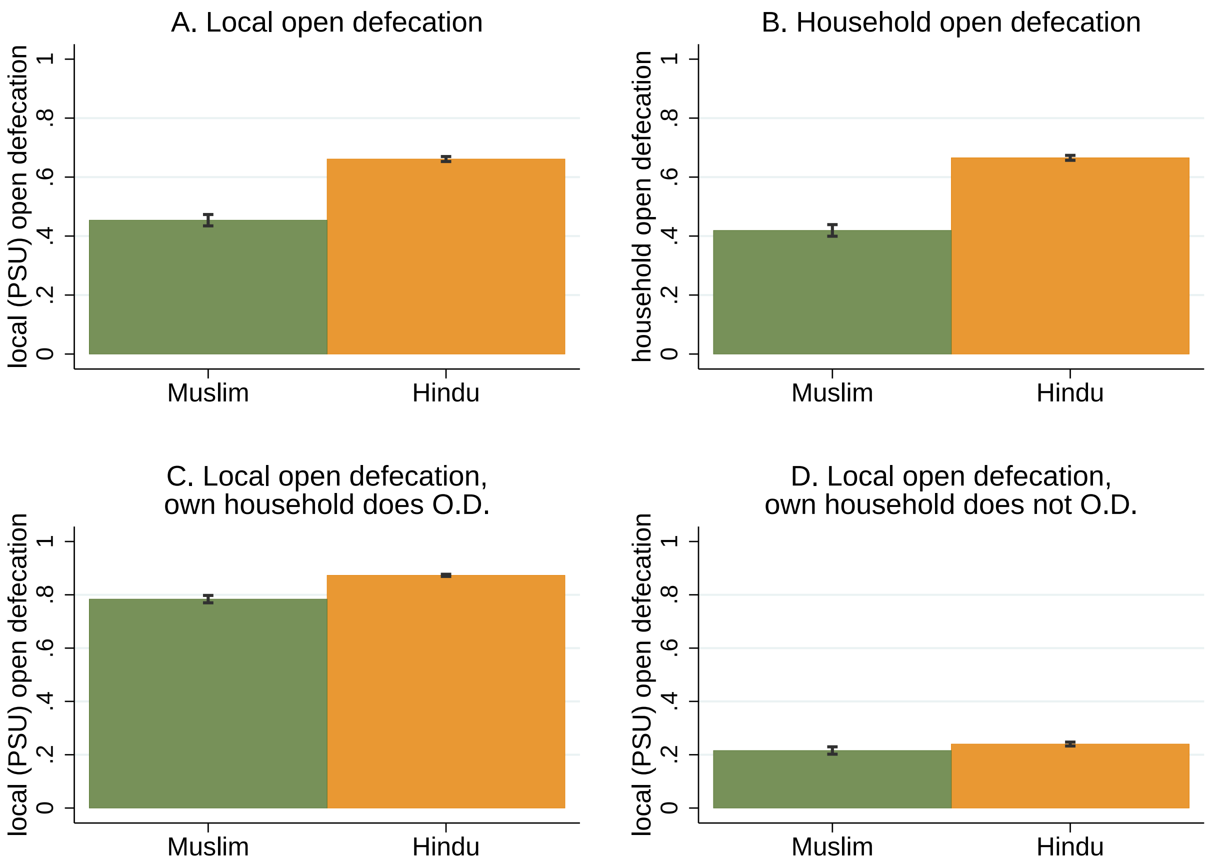

Figure 1: Muslim children are exposed to less open defecation externalities.

Mean differences in household and neighborhood open defecation between Hindus and Muslims. In Panels A, C, and D the outcome is the local area open defecation for the neighborhood in which the household resides, defined as the fraction of households in the PSU that report using no facility, a bush, or a field. The dependent variable in Panel B is whether the household itself practices open defecation. Standard errors of means clustered by survey PSU are plotted as whiskers. In each panel, group means are significantly different.

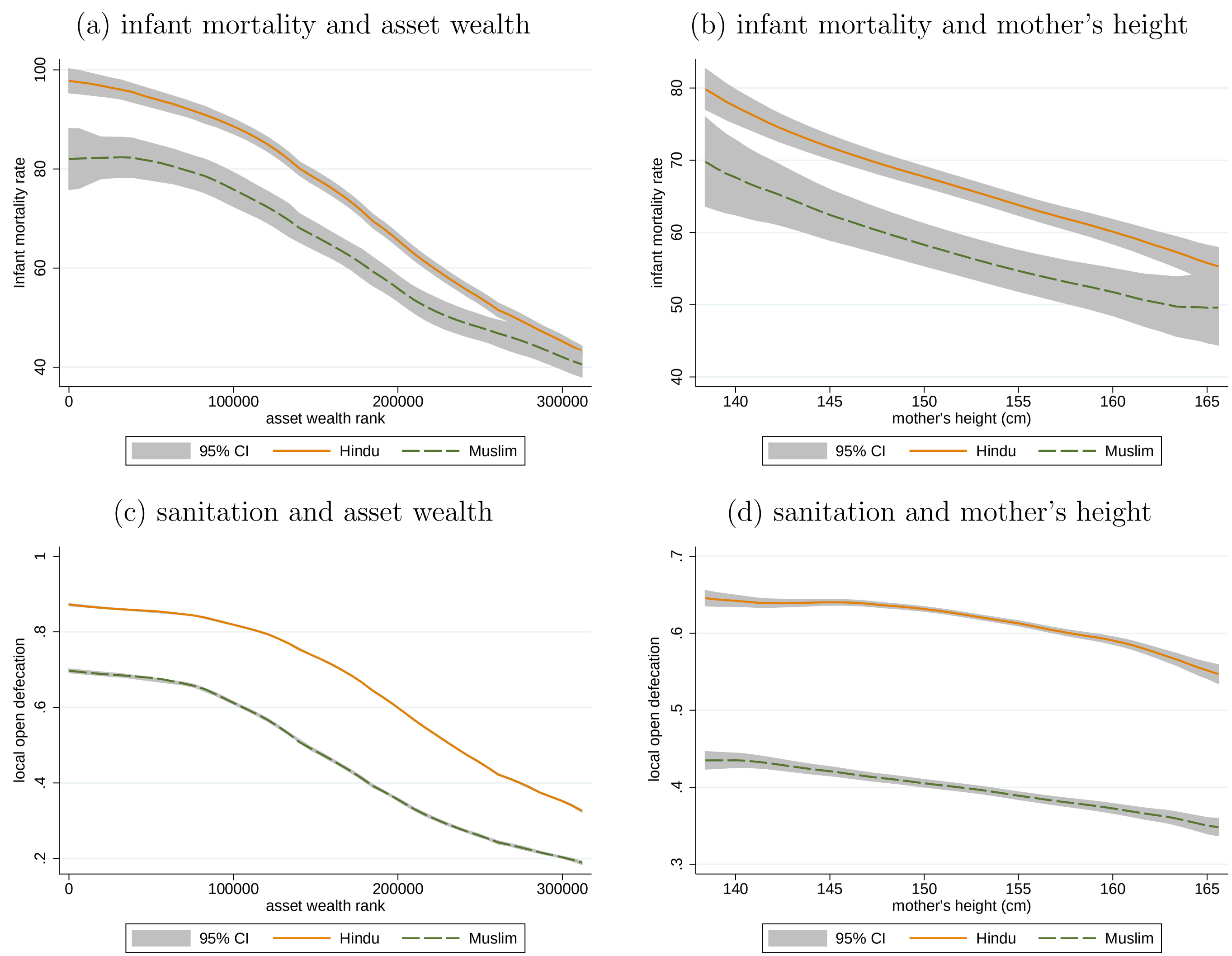

Figure 2: Muslim children suffer lower mortality and are less exposed to open defecation

Figure plots local linear regressions and 95% confidence intervals. In Panels A and B the outcome is the IMR. In Panels C and D the outcome is the local area open defecation for the neighborhood in which the household resides, defined as the fraction of households in the PSU that report using no facility, a bush, or a field. The left panels plot outcomes against asset wealth rank, described in the text. The right panels plot outcomes against mother's height. Standard errors of means clustered by survey PSU.

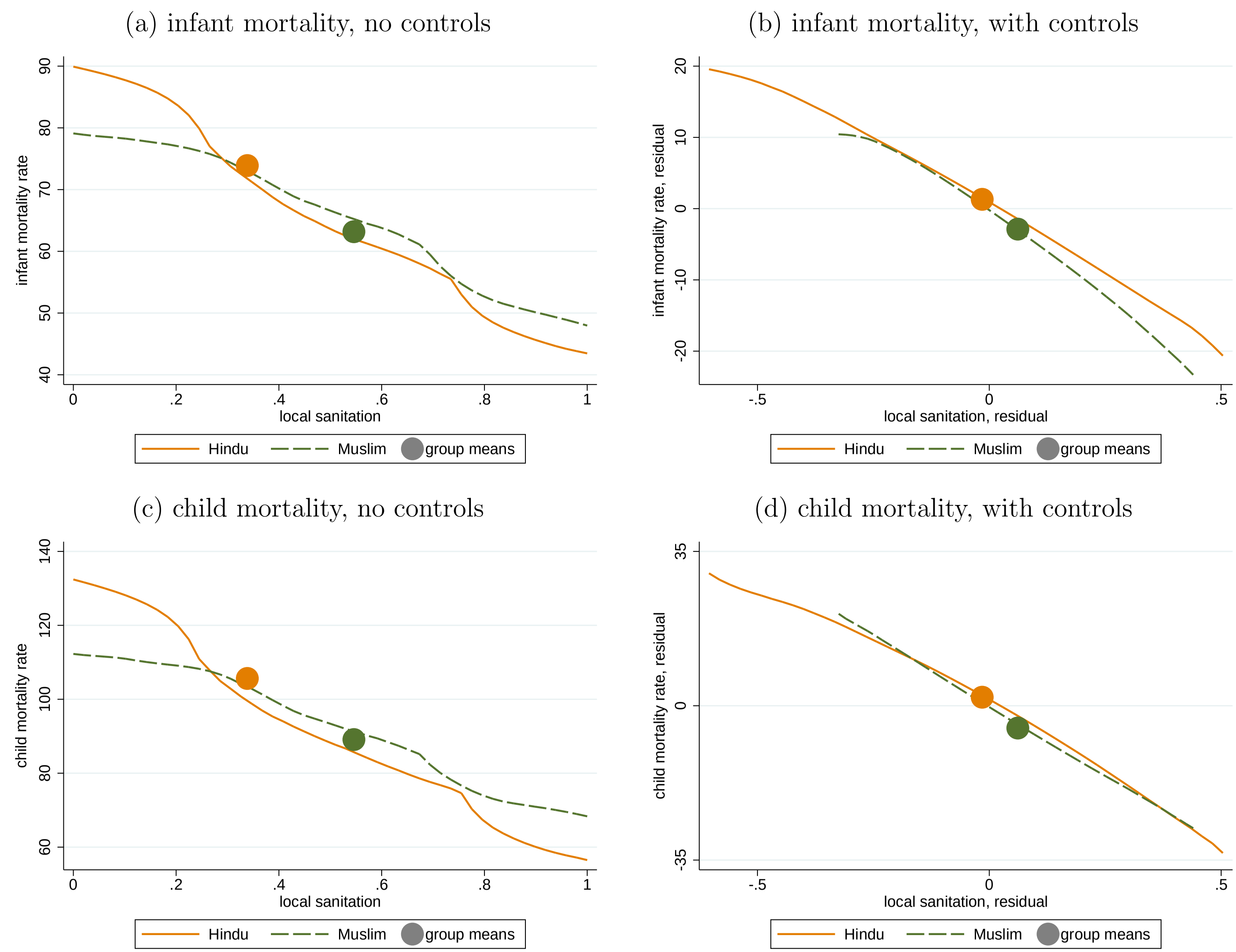

Figure 3: Sanitation differences can account for Hindu-Muslim mortality differences

Figure plots local linear regressions of mortality rates on local area open defecation as defined in the Figure 2 notes. The right panels residualize both mortality and local sanitation by first regressing the independent and dependent variables on our extended controls as defined in the Table 2 notes.

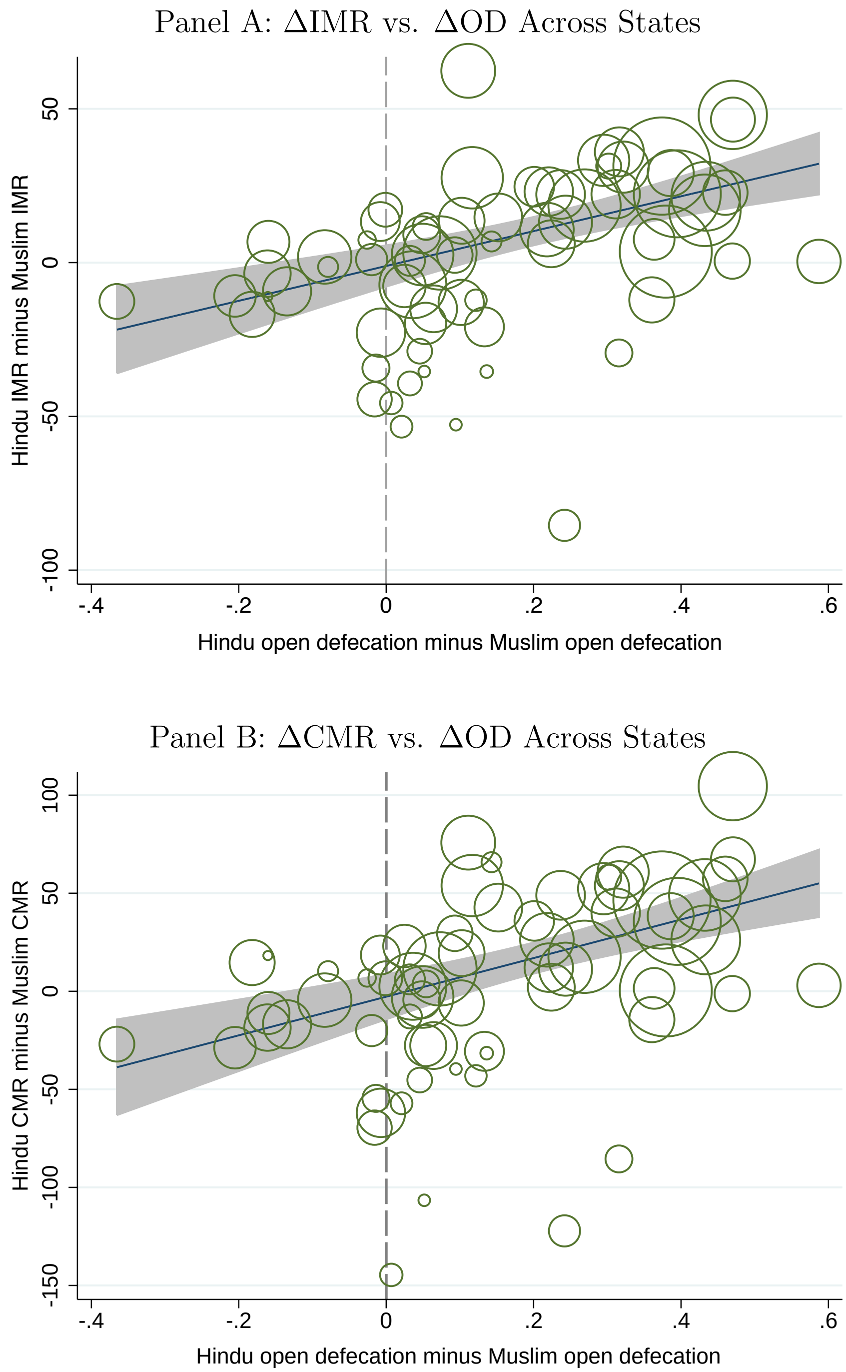

Figure 4: Geographic variation in the Hindu-Muslim mortality gap tracks geographic variation in the Hindu-Muslim OD gap.

Figure plots differences in mortality against differences in OD between Hindus and Muslims. The horizontal axes list the difference in OD prevalence in a state-year. The vertical axes plot the difference in infant mortality (per 1000 births) and child mortality in that state year. Each observation is an Indian state from one of the three NHFS survey rounds that comprise our main estimation sample. The linear regression line (no controls) and 95% confidence interval are plotted. Marker sizes proportional to state population.

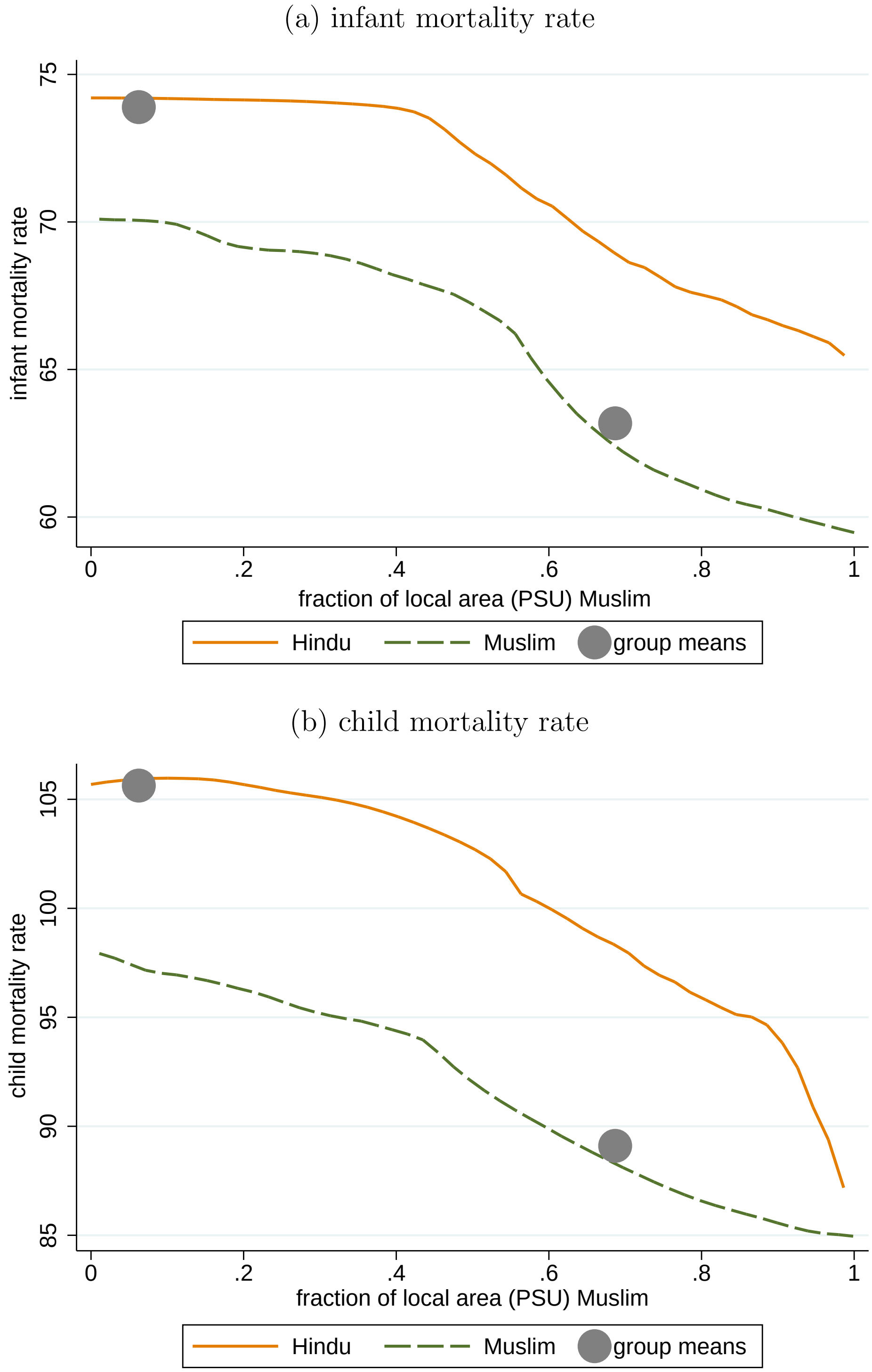

Figure 5: Positive externalities of Muslim neighbors

Figures plot local linear regressions of infant and child mortality against the fraction of the PSU that is Muslim. Raw data from the main estimation sample, no controls.

Table 1: Summary statistics: Hindus and Muslims, NFHS 1, 2, & 3

	Hindu	Muslim	t-statistic
child mortality rate (CMR), years 0-5	105.63	89.10	-6.89
infant mortality rate (IMR), year 1	73.89	63.18	-7.04
neonatal mortality rate (NMR), month 1	46.90	39.40	-6.58
post-neonatal mortality rate (PNMR), months 2-11	27.77	24.17	-3.88
household open defecation	0.665	0.419	-23.84
local (PSU) open defecation	0.661	0.454	-20.67
local (PSU) fraction Muslim	0.063	0.687	84.50
household has electricity	0.593	0.593	0.05
household has radio	0.362	0.364	0.31
household has television	0.331	0.305	-3.14
household has refrigerator	0.101	0.098	-0.54
household has bicycle	0.464	0.409	-7.80
household has motorcycle	0.122	0.098	-6.15
household has car	0.019	0.015	-3.22
urban household	0.280	0.398	9.22
mother's height (cm)	151.53	151.98	5.30
mother's age at birth	24.15	24.63	9.19
mother no education	0.570	0.626	6.84
mother some primary	0.147	0.159	2.82
mother some secondary	0.193	0.167	-5.14
mother completed secondary	0.089	0.046	-15.55
child ever breastfed	0.959	0.961	1.01
child breastfed for at least 6 months	0.809	0.807	-0.67
child's birth order	2.44	2.72	26.57
child is female	0.481	0.490	3.71
n (children born alive)	260,303	52,083	

Summary statistics for our main analysis sample, rounds 1, 2, and 3 of the NFHS. Observations are children, not households. Neonatal, infant, and child mortality are defined, respectively, as the number of deaths among children less than one month old, less than one year old, and less than five years old, scaled per 1,000 live births over the same period. Post-neonatal mortality is death in months 2-11. t-statistics computed from standard errors clustered by survey PSU.

Table 2: Difference in open defecation account for mortality differences between Muslims and Hindus, OLS

	child mortality (CMR)		infant mortality (IMR)		neonatal mortality (NNM)	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Survey Round FEs only						
Muslim	-14.52***	1.514	-9.484***	0.241	-7.002***	-1.085
	(2.365)	(2.334)	(1.503)	(1.489)	(1.135)	(1.133)
household OD		28.71***		17.12***		10.66***
		(2.585)		(1.725)		(1.314)
local (PSU) OD		44.66***		28.77***		17.37***
		(3.431)		(2.267)		(1.715)
n (live births)	164884	164884	283741	283741	312386	312386
Panel B: Extended controls						
Muslim	-12.20***	-2.526	-7.156***	-0.793	-4.368***	-0.134
	(2.279)	(2.319)	(1.465)	(1.498)	(1.124)	(1.151)
household OD		12.29***		8.059***		6.135***
		(2.623)		(1.738)		(1.331)
local (PSU) OD		42.39***		28.77***		18.35***
		(4.054)		(2.687)		(2.045)
extended controls	✓	✓	✓	✓	✓	✓
n (live births)	164884	164884	283741	283741	312386	312386

OLS regressions of mortality on religion and sanitation. Dependent variables are listed at the column heads. Neonatal, infant, and child mortality are defined, respectively, as the number of deaths among children less than one month old, less than one year old, and less than five years old, scaled per 1,000 live births over the same period. All regressions include indicators controlling for DHS survey rounds. Extended controls in Panel B include a count of assets, household size, an urban dummy fully interacted with household size, birth order by sex effects, child's birth month, indicators for mother's relationship to the head of the household, mother's age when the child was born, and an indicator for being a multiple birth. Standard errors clustered by survey PSU in parentheses. Two-sided p-values: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3: Open defecation explains similar IMR gaps for boys and girls

	(1)	(2)	(3)	(4)	(5)	(6)
sample:	All	All	Boys	Boys	Girls	Girls
Muslim	-7.156***	-0.793	-5.607**	0.460	-8.796***	-2.113
	(1.465)	(1.498)	(1.989)	(2.022)	(1.926)	(1.972)
local (PSU) OD		28.77***		26.05***		31.67***
		(2.687)		(3.571)		(3.518)
household OD		8.059***		8.695***		7.390**
		(1.738)		(2.326)		(2.435)
extended controls	✓	✓	✓	✓	✓	✓
n (infants born alive)	283,741	283,741	147,008	147,008	136,733	136,733

OLS regressions of infant mortality on religion and sanitation, performed separately by sex. Columns (1) and (2) repeat earlier results. Columns (3) and (4) and (5) and (6) split the sample by the gender of the infant. Extended controls described in the Table 2 notes. Standard errors clustered by survey PSU in parentheses. Two-sided p-values: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4: Reweighting decomposition: Counterfactual Hindu mortality rates, matching Muslim observables

Controls, prior to adding sanitation				Panel A: Hindu CMR, across states			Panel B: Hindu IMR, across states		
				M: 89.1	H: 105.6	Gap: 16.5	M: 63.2	H: 73.9	Gap: 10.7
round	mom's age	assets	mom's height	Reweight without OD	Reweight with OD	incremental effect	Reweight without OD	Reweight with OD	incremental effect
				105.6	86.3	-19.4	73.9	62.3	-11.6
✓				103.5	86.0	-17.5	72.6	62.1	-10.5
✓	✓			104.5	87.5	-17.0	73.3	63.4	-9.9
✓		✓		105.5	92.2	-13.3	74.1	65.9	-8.3
✓			✓	103.5	92.1	-11.4	72.6	65.7	-6.9
✓	✓		✓	104.1	92.6	-11.5	72.9	66.2	-6.7
✓	✓	✓		106.3	92.8	-13.5	74.6	66.9	-7.7

Controls, prior to adding sanitation				Panel C: Hindu CMR, within states			Panel D: Hindu IMR, within states		
				M: 89.1	H: 98.2	Gap: 9.1	M: 63.2	H: 69.0	Gap: 5.8
round	mom's age	assets	mom's height	Reweight without OD	Reweight with OD	incremental effect	Reweight without OD	Reweight with OD	incremental effect
				98.2	85.9	-12.3	69.0	61.6	-7.3
✓				96.6	87.9	-8.7	68.4	61.3	-7.2
✓	✓			97.1	86.2	-10.9	68.8	61.3	-7.5
✓		✓		97.5	92.2	-5.3	69.4	64.7	-4.7
✓			✓	97.7	90.8	-6.9	69.3	64.4	-4.9
✓	✓		✓	97.5	92.3	-5.2	69.3	64.8	-4.4
✓	✓	✓		97.2	88.5	-8.6	69.3	62.8	-6.5

The table presents a nonparametric decomposition of the extent to which sanitation differences can account for mortality differences between Hindus and Muslims. Columns labeled "Reweight without OD" present mortality rates for Hindu children ($\times 1000$), using the empirical Hindu distribution of exposure to open defecation; columns labeled "Reweight with OD" reweight the sample of Hindu children to compute a counterfactual in which Hindu children matched the Muslim exposure to open defecation. Checkmarks in the first four columns indicate that the Hindu sample is reweighted to match the Muslim distribution by three survey rounds, eight categories of mother's age at the child's birth, eight categories of a count of owning assets asked about in DHS surveys, or six categories of mother's height, prior to reweighting according to sanitation. Panels C and D additionally reweight to match the distribution of Muslim children across the Indian states.

Table 5: Differences in Other Hygiene Practices and Water Treatment, IHDS

	(1) Open Defecation	(2) Hand Washing after Defecating	(3) Hand Washing with Soap	(4) HH Purifies Water	(5) HH has Piped Water
Panel A: Unconditional Differences in Means					
Muslim Difference	-0.164**	-0.00293	0.0286	0.0305	-0.0730**
	(0.0231)	(0.00646)	(0.0212)	(0.0196)	(0.0216)
Hindu Mean	0.605	0.995	0.432	0.302	0.413
Panel B: with Controls					
Muslim Difference	-0.148**	-0.00301	0.0139	0.0220	-0.105**
	(0.0205)	(0.00644)	(0.0175)	(0.0196)	(0.0175)
Log Per Capita Consumption	-0.218**	0.00285*	0.191**	0.107**	0.108**
	(0.00780)	(0.00129)	(0.00811)	(0.00830)	(0.00733)
Urban	-0.325**	0.00297^{+}	0.294**	0.167**	0.411**
	(0.0154)	(0.00172)	(0.0160)	(0.0155)	(0.0183)
n (households)	40701	40701	40701	40701	40701

OLS regressions of open defecation (OD), hand washing, and water quality on an indicator for being Muslim. Sample comes from the 2004-2005 IHDS and includes Hindus and Muslims only. Standard errors clustered by survey primary sampling unit (PSU) in parentheses. Two-sided p-values: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 6: Externalities of Muslim neighbors: Effect on infant mortality rate, OLS

	(1) IMR	(2) IMR	(3) IMR
Muslim household	-7.156***	-3.581	-2.417
	(1.465)	(2.278)	(2.278)
local (PSU) fraction Muslim		-5.816*	2.725
		(2.889)	(2.928)
local (PSU) open defecation			29.09***
			(2.701)
household open defecation			8.055***
			(1.738)
extended controls	✓	✓	✓
n (live births)	283741	283741	283741

OLS regressions of infant mortality (per 1,000) on religion and sanitation. Standard errors clustered by survey primary sampling unit (PSU) in parentheses. Extended controls described in the Table 2 notes. Two-sided p-values: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 7: Evidence for an effect of sanitation on IMR: Interaction with breastfeeding

	(1) IMR	(2) IMR
Local (PSU) OD	49.66***	21.69***
	(4.377)	(3.639)
Breastfed in first 6 months × local (PSU) OD	-246.1***	
	(13.38)	
Breastfed in first 6 months	-256.3***	
	(5.813)	
Breastfed exclusively in first 6 months × local (PSU) OD		-246.0***
		(22.60)
Breastfed exclusively in first 6 months		-472.5***
		(8.894)
HH OD	7.232**	6.112*
	(2.550)	(2.415)
extended controls	✓	✓
n (live births)	86343	87227

OLS regression with infant mortality per 1,000 as the dependent variable. Extended controls described in the Table 2 notes. Standard errors clustered by survey primary sampling unit (PSU) in parentheses. Two-sided p-values: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.