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Village sanitation and child health: Effects and external validity in a randomized field experiment in rural India

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ABSTRACT

Over a billion people worldwide defecate in the open, with important consequences for early-life health and human capital accumulation in developing countries. We report a cluster randomized controlled trial of a village sanitation intervention conducted in rural Maharashtra, India designed to identify an effect of village sanitation on average child height, an outcome of increasing importance to economists. We find an effect of approximately 0.3 height-for-age standard deviations, which is consistent with observations and hypotheses in economic and health literatures. We further exploit details of the planning and implementation of the experiment to study treatment heterogeneity and external validity.

1. Introduction

Height has emerged as an important marker of human capital, attracting wide-ranging attention from economists (Steckel, 2009). This is because children who are able to grow to their height potentials are also able to develop towards their cognitive and other human capital potentials (Case and Paxson, 2008). One large threat to early-life growth in developing countries is poor sanitation, especially open defecation. More than one billion people worldwide defecate in the open without using a toilet or latrine. Open defecation is particularly widespread in India, and it has been suggested that this fact can help explain why children in India are among the shortest in the world (Spears, 2013). Especially because the public good nature of sanitation suggests an important economic policy role, it is therefore important to better understand any causal effect of exposure to poor sanitation on child health (Cutler and Miller, 2005).

This paper makes three contributions to the literature. The first and main contribution is to present results of a cluster randomized controlled experiment designed to estimate effects of rural sanitation on child height. In 2004, the government of Maharashtra in partnership with the World Bank conducted a randomized village-level sanitation promotion intervention. We document evidence indicating that the intervention caused a modest improvement in sanitation and an increase in child height. An effect of sanitation on child net-nutritional outcomes is consistent with evidence and theories from the medical and epidemiological literature, especially in India where high rural population density may worsen disease externalities.

A second contribution of the paper is to document evidence suggestive of externalities: we find apparent effects of neighbors' latrine use even on households whose members continued to defecate in the open; a quantitative bounding exercise allows us to largely rule out that the latrine use of a child's neighbors did not, on average, matter for her height. Finally, the history of this experiment permits a third contribution to the economics of randomized field experiments, as they can applied in practice with the ability to critically analyze our experimental result and estimate its external validity where the experiment *did not* happen. Due to institutional features of the partnership between the World Bank and the government of Maharashtra – unrelated to the internal validity of our experiment – comparable data were simultaneously collected in other parts of Maharashtra where the government *considered* conducting an experiment, but where no attempt at an experiment was ultimately made. Although we, of course, cannot use these data to

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know what the effect of the experiment would have been in other parts of Maharashtra, variation within the district that we can study predicts that the effect might have been much smaller in the places which narrowly missed being selected for the experiment.

This paper proceeds in sections. Section 3 details the experimental method and empirical strategy, and Section 4 presents results. These estimates are important not only for assessing the impact of a part of a large government development program as implemented, but also for documenting that an improvement in sanitation can cause an improvement in child height. Next, Section 5 considers the external validity of this result, taking advantage of comparable data collection in two districts where the experiment did not occur. Section 6 concludes with a discussion of these results.

2. Sanitation, health, and early-life human capital

According to joint UNICEF and WHO (2012) estimates for 2010, 15% of the world population and 19% of people in developing countries defecate in the open without using any toilet or latrine. Of these 1.1 billion people, nearly 60% live in India, which means they make up more than half of the population of India. People in India are much more likely to defecate in the open than even people in much poorer sub-Saharan African countries, on average, and open defecation in India has declined little despite rapid economic growth (Coffey et al., 2014).

On average, Indian children are exceptionally short; because height is an important indicator of human capital, the puzzle of widespread stunting in India has attracted the recent attention of many economists (*e.g.* Deaton, 2007; Tarozzi, 2008; Jayachandran and Pande, 2013). Although stunting is commonly referred to as an indicator of "malnutrition," evidence is accumulating for an important role of the disease environment in shaping nutritional outcomes (Smith et al., 2013). For example, the economic history literature has shown a large association between average population-level heights and the disease environment, as reflected in mortality rates (Bozzoli et al., 2009). Hatton (2013), studying the historical increase in European height, concludes that "the most important proximate source of increasing height was the improving disease environment as reflected by the fall in infant mortality."

Medical and epidemiological literatures describe at least four pathways by which disease from environmental fecal pathogens could reduce early-life growth: loss of nutrients due to diarrhea, energy expenditure fighting disease, worm and parasite infections, and malabsorption due to inflammatory responses of the intestine to repeated infection (Checkley et al., 2008). Most recently documented in detail in the medical literature, but perhaps very quantitatively important, is the possibility of chronic but subclinical "environmental enteric dysfunction," which would reduce nutrient absorption and could cause stunting without causing diarrhea (Humphrey, 2009).[1]

Non-experimental econometric evidence is consistent with an important effect of poor sanitation on early-life health and child human capital (*e.g.* Galiani et al., 2005). For example, Cutler and Miller (2005) find a large effect of water filtration and chlorination on mortality in major U.S. cities in the early 20th century. Bleakley (2007) documents that eradicating hookworm infection – one of the several mechanisms by which poor sanitation impacts health – improved learning and increased incomes in the American South. Spears (2013) has recently observed that heterogeneity across developing countries in open defecation rates can explain a large fraction of the variation in average child height. Geruso and Spears (2015) exploit a difference in demand for latrine use between Hindus and Muslims within India to document an effect of local open defecation on infant mortality.

It is therefore of high importance to both economists and policymakers to make well-identified estimates of the causal effect of sanitation on child height. This study presents what was, to our knowledge, the first randomized controlled trial of the effect of village sanitation on child height. We study data from a village-level sanitation program, implemented in 2004 in the context of Maharashtra's phased roll-out of the Indian government's national Total Sanitation Campaign (TSC). A senior official of the Maharashtra government chose to collaborate with the World Bank to exploit the initial phase-in of the TSC to conduct an impact evaluation. Alok (2010), in his memoirs as an administrative officer responsible for the TSC, describes Maharashtra as an early and rapid adopter of the TSC. The period that we study is therefore very early in the implementation of the TSC, when there would have been a national sanitation *policy*, but this would not yet have been widely effectively implemented in *programs*. The period we study would also have been effectively before the Clean Village Prize, a part of the TSC which is exploited in Spears' (2012a) identification strategy. Because this was the initial implementation of TSC programs in these districts of Maharashtra, despite the existence of a written national sanitation policy, there was little risk of "contamination" of the control group during the period studied.

3. Empirical strategy

In 2004, the government of Maharashtra, in collaboration with the World Bank Water and Sanitation Program, conducted a sanitation promotion intervention, randomly allocated at the village level. We use the experiment to learn about the effect of rural sanitation on early-life human capital accumulation. The timeline of this experiment contained four events: the experimental intervention in early 2004 and three survey rounds.

- February 2004: baseline survey data collection,
- Shortly thereafter: village-level sanitation "triggering" intervention,
- August 2004: midline survey data collection,
- August 2005: endline survey data collection,

Therefore, about 18 months elapsed between the experimental intervention and the final observations of outcomes.

3.1. The program: latrine construction and village sanitation promotion

The experimental program studied here was conducted in the context of the initial introduction of India's Total Sanitation Campaign (TSC) by the Maharashtra state government. The TSC was a large government effort throughout rural India, partially funded by the central government, but implemented by state governments.[2]

[1] Environmental enteric disfunction would be caused by repeated fecal contamination which, through an inflammatory response, increases the small intestine's permeability to pathogens while reducing nutrient absorption. This inflammation is hypothesized to have direct effects on growth-regulating hormones (Prendergast et al., 2014). If so, such inflammation could cause apparent malnutrition of various forms, stunting, and cognitive deficits, even without necessarily manifesting as diarrhea or otherwise observable illness (*see also* Petri et al., 2008; Mondal et al., 2012; Korpe and Petri, 2012). Lin et al. (2013) show that children in Bangladesh who are exposed to more fecal environmental contamination are more likely to exhibit biological markers of enteropathy, and in turn suffer impaired growth. In longitudinal data from field sites in eight countries, Kosek et al. (2013) show that environmental enteropathy is associated with subsequent deficits in growth.

[2] It is not the purpose of this paper to conduct a "program evaluation" of the TSC overall; for an impact evaluation demonstrating that the TSC overall improved infant mortality and child height, on average, see (Spears, 2012a). For a study of the