Externalities and Spillovers from Sanitation and Waste Management in Urban and Rural Neighborhoods*

Evan Plous Kresch
Oberlin College

Molly Lipscomb
University of Virginia

Laura Schechter
UW Madison

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Abstract

Proper sanitation and waste management has important health benefits, both directly for the household making the decision and indirectly for its neighbors due to positive externalities. Nevertheless, construction and use of improved sanitation systems in much of the developing world continues to lag. Many recent interventions such as Community Led Total Sanitation (CLTS) have attempted to harness the power of social interactions to increase take-up of improved sanitation. Most evidence to date mobilizes social pressure in rural areas, yet evidence is more scarce in urban neighborhoods where high population density may lead to larger externalities from poor sanitation decisions. We review the recent literature on how sanitation decisions are inter-related within neighborhoods: the health externalities that sanitation decisions have on neighbors and the social decision spillovers that drive take-up. We explore potential explanations for the low take-up and maintenance of sanitation systems, including the possibility of non-linearities and thresholds in health externalities; the roles of social pressure, reciprocity, learning from others, and coordination in decision spillovers; and differences between urban and rural contexts.

*Kresch is assistant professor of Economics at Oberlin College; Lipscomb is associate professor of Economics and Public Policy at University of Virginia's Batten School and the Department of Economics; Schechter is professor of Agricultural and Applied Economics and Economics at UW Madison. Corresponding author: Laura Schechter `lschechter@wisc.edu`. The authors thank Radu Ban, Lisa Cameron, Diane Coffey, Oliver Cumming, Barbara Evans, Matthew Freeman, Craig Gundersen, and Subhrendu Pattanayak for comments on an earlier draft. First submitted June 25, 2019. Accepted July 29, 2019. Editor in charge of submission: Craig Gundersen.

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1 Introduction

The lack of proper sanitation has important impacts on health and welfare, yet sanitation lags other key development goals in terms of the amount of resources devoted to it and the progress being made to increase access. The 7th Millenium Development Goal included the objective of halving the world's population without access to basic sanitation. This goal was not met: 2.1 billion people gained access to improved sanitation, but 2.6 billion remain without access to basic sanitation as of 2015 (United Nations 2015).[1] As of 2015, 68% of the world's population had access to at least basic sanitation; this represents a substantial improvement over the past two decades. The rates of people primarily practicing open defecation has gone down from 20% to 12% between 2000 and 2015. Access to basic sanitation is not enough, since only 39% of sanitation waste was safely managed in 2015 (Joint Monitoring Programme 2017).[2] These averages disguise substantial heterogeneity in latrine and sewage disposal access across regions of the world and between urban and rural areas. For example, in Southern Asia 7.5% of urban sewage is treated, but only 0.45% of rural sewage is treated. In sub-Saharan Africa, 7.5% of urban households engage in open defecation while 32% of rural households engage in open defecation (Joint Monitoring Programme 2017). Urban sanitation issues are often somewhat different from rural problems: while rural areas struggle with open defecation and a lack of sanitary latrines, urban areas are more likely to have high coverage of latrines, but struggle with the safe disposal of fecal sludge when the latrines are full.

Sanitation and waste removal lead to externalities on health and human capital. Lack of improved sanitation is one of the leading causes of diarrheal outbreaks, which

[1]The Millennium Development Goal for sanitation was arguably more ambitious than the one for water as many countries started with lower baseline coverage for sanitation. In addition, the goal essentially required individual household sanitation services and not shared ones.

[2]This is a very loose estimate given how little data there are. Many countries are showing 0% access to safely managed sanitation, particularly in urban areas, largely because they have no data.

account for an estimated 1,656,000 deaths of all ages and 466,000 deaths of children under 5 globally each year, making it the 5th leading cause of death of children under 5 (Troeger et al. 2018). In addition, lack of improved sanitation has been linked to childhood stunting, presenting a possible policy path towards improving the welfare of the more than 150 million stunted children worldwide, predominately in South Asia and Sub-Saharan Africa (Cumming & Cairncross 2016). While lack of improved sanitation is prevalent in both rural and urban areas, expanding urban sanitation is increasingly important. The proportion of urban residents with access to safe water and sanitation is actually *falling* as investment in sanitation does not keep pace with urban population growth (WHO & UNICEF 2015).

Given that sanitation and waste management leads to externalities, they will be under-provided, making government intervention necessary. The design of government or NGO programs to increase sanitation and improve health outcomes should take into account the shape of these externalities and the fact that health externalities may cause decision spillovers.

Throughout this review we use the terms externality and spillover to refer to two different effects. Each individual makes a waste management decision and that decision can have direct effects on both the health and the waste management decision of his neighbors. We refer to health *externalities* such that one person's decision affects the health of others. On the other hand, we refer to decision *spillovers* such that one person's decision affects the decisions made by others. When the decision spillovers are positive, they may also be called a multiplier effect or a social multiplier.

These health externalities may be linear, with each additional neighbor who uses a latrine increasing a household's health by the same marginal amount. But, they might be non-linear, with greater health improvements due to increases in sanitation starting from a low baseline or starting from a high baseline. They may also involve thresholds, with no health improvements seen below some minimum neighborhood level of sanitation. Health externalities may also differ between rural and urban areas due to differences in population density and access to health care.

Decision spillovers are also significant. Sanitation decisions of one individual are affected by the decisions of his neighbors (Guiteras et al. 2015). These spillovers may

be caused by social mechanisms including social pressure, reciprocity, learning from others, and coordination. They may also be caused by non-social incentives such as non-convexities and increasing returns to scale in the health externality caused by neighbors' improved sanitation.

Decision spillovers may differ between urban and rural areas. People in rural areas have often lived for generations in the same village and know their neighbors well. While urban areas have higher population density, they are also more socially heterogeneous, transient, and anonymous; not necessarily good characteristics for community-based interventions (Delea et al. 2018, McGranahan 2015). Duflo et al. (2012) discuss the importance of understanding differences between urban and rural areas when designing policies, especially given the rapid migration and urbanization of developing countries. Fifty-four percent of the world's population currently lives in cities, and cities are growing quickly as a percentage of world population (United Nations 2014).

Taken as a case study, Community Led Total Sanitation (CLTS) is one of the most extensively tested sanitation interventions. It aims to harness social pressure and shame to improve sanitation. While there is evidence that CLTS can effectively reduce open defecation in rural villages (Pickering et al. 2015), it is not obvious that what works well in a rural environment will necessarily have success in an urban environment. Preliminary evidence suggests CLTS is less effective in more urban and less cohesive environments.

While this paper primarily focuses on the health impacts of improved sanitation, poor sanitation has numerous policy and welfare implications. One relevant area is global food security, particularly in developing countries. Wastewater is commonly used in developing countries in irrigated agriculture due to both its high nutrient content and the lack of conventional alternative water sources (Thebo et al. 2017, United Nations World Water Assessment Programme (WWAP) 2017). The use of untreated wastewater in crop irrigation may pose an increased infection risk, both directly on farm workers and indirectly on individuals that consume the contaminated crops (Drechsel et al. 2010).

In Section 2, we explore health and human capital externalities due to sanitation,

their shape, and how they differ in rural versus urban environments. We devote Section 3 to a focused exploration of CLTS and its differential effectiveness in urban versus rural settings. In Section 4 we look at other non-CLTS interventions and the mechanisms which may cause these interventions to lead to decision spillovers: social pressure, reciprocity, learning from others, and coordination. Section 5 concludes with a discussion of areas ripe for future research.

2 Externalities and Non-Linear Returns

Improved health is a fundamental externality inherent to the utilization of sanitation systems (Freeman et al. 2017). As an illustration, John Snow's landmark epidemiological study demonstrating cholera to be a waterborne disease led to the disabling of the Broad Street Pump; later investigations of the contaminated well on Broad Street identified the source as a forgotten cesspit three feet away that had begun to leak fecal bacteria (Klein 2013).

Standard economic theory implies that in the presence of positive externalities, goods will be under-utilized and there is a role for policymakers to encourage the construction and use of sanitation systems. Proper cost-benefit analysis of such programs requires an understanding of the types and sizes of benefits due to sanitation systems. In this section we analyze the various health externalities that arise from sanitation systems and waste management more generally, as well as the possibility of non-linearities and thresholds in the shape of these externalities. This section will deal with externalities related to health and human capital. Decision spillovers, by which increased sanitation adoption by one person affects the adoption of others, are discussed in Section 4.

A number of papers referenced in this paper study the impacts of India's Total Sanitation Campaign (TSC). The TSC was a large-scale program rolled out from 2001 to 2012 by the Indian government in rural areas across the country promoting the construction of low-cost latrines. The 10-year project was extremely large in scope - building on average one pit latrine per 10 rural residents at a total cost of over $1.5 billion. Because of the massive scope and roll-out of the program, it has

been a valuable resource for researching the effects - both biological and behavioral - of improved sanitation in rural areas.

2.1 Health Externalities

Improved sanitation systems and waste management are associated with a variety of positive health externalities, in particular a reduction in infectious diseases. We consider recent evidence for externalities on various outcomes including diarrheal outbreaks, infant mortality, and child height. Many of these health improvements are exhibited among infants and young children under five years of age. Young children are the most vulnerable population as they are especially susceptible to water-borne diseases and parasitic infections, due both to a less developed immune system and insufficient knowledge of avoidance behavior tactics (He & Perloff 2016).

Acute diarrheal infections resulting from contaminated water are one of the leading causes of mortality in developing counties, especially among young children (Bauza et al. 2019). Of the 842,000 global deaths from diarrheal diseases in 2012, 33% were directly attributed to inadequate sanitation (Hutton & Chase 2016). In Indonesia, Garg et al. (2018) find that water pollution due to individuals using a river for hygienic and sanitary practices can explain a large share of diarrhea-related deaths in downstream villages using the river as their primary source for drinking water.

Increasing access to improved sanitation systems presents the potential for large reductions in diarrheal diseases worldwide. These gains can arise both from the direct effect of a household gaining access to the sanitation system as well as the indirect effect of the *neighborhood* accessing the system. Deutschmann et al. (2018) conduct an intervention in urban Senegal randomizing prices for sanitary latrine desludging (emptying). The more of a household's neighbors who choose the sanitary technology, the lower the incidence of diarrhea in that household. Once one controls for the neighborhood's aggregate technology choices, the household's own technology choice has no impact on diarrhea in that household. Andrés et al. (2017) find similar results in rural India. A child in a household and neighborhood with poor sanitation

will have higher diarrhea prevalence than a child in a household and neighborhood with better sanitation. A quarter of that impact can be attributed to the direct benefit of access to sanitation, with the remaining three quarters accruing from the indirect effect of neighbors utilizing improved sanitation.

The relationship between the share of the village with improved sanitation and diarrheal prevalence appears nonlinear. There is almost no externality in villages with low sanitation take-up. The existence of potential non-linearities and thresholds in health externalities will be discussed in more detail in Section 2.3.

In systematic reviews of the literature on the impact of improved water and sanitation systems on diarrheal incidence, Fewtrell et al. (2005), Wolf et al. (2014), and Prüss-Ustün et al. (2019) find that improved sanitation tends to decrease the incidence of diarrhea by a magnitude of 30-40%. These papers point to a lack of randomized control trials on improved waste management programs as a limitation to their meta-analyses.

Geruso & Spears (2018) analyze the relationship between sanitation and infant mortality in India. Cultural differences lead Hindus to be more likely to defecate outside than Muslims. This difference in open defecation can explain the differing rates of infant mortality. By age one, an additional 11 per 1000 Muslims infants survive compared to Hindu infants, despite the fact that Muslims in India have lower wealth, educational attainment, and access to public services. Moreover, there are significant externalities, as Hindu infants living in predominantly Muslim communities have higher survival rates.

Another health externality from improved sanitation and waste management is increased height among children. Reduction in child stunting has been widely recognized as a proxy for increased human capital accumulation in prepubescent populations (Fuller et al. 2016, Spears 2019). We review evidence on externalities on human capital accumulation in Section 2.2. Increases in child height as a result of improved sanitation may arise via numerous mechanisms. First, diarrhea can cause stunting as a result of the loss of nutrients consumed during each episode (Cumming & Cairncross 2016). Second, the presence of intestinal parasites as a result of contact with fecal matter can divert resources away from a child's growth and development.

For example, repeated exposure to fecal contaminants may lead to environmental enteric disfunction (EED) in which frequent inflation of the small intestine reduces its ability to absorb nutrients (Cumming & Cairncross 2016, Humphrey 2009).

Multiple papers show a positive relationship between improved sanitation and child height. Gertler et al.'s (2015) large-scale randomized intervention on sanitation in rural Mali, India, and Indonesia provides evidence of a significant negative relationship between the prevalence of open defecation in a village and the average child's height-for-age z score. Pickering et al.'s (2015) study of Community-Led Total Sanitation (CLTS) programs[3] in Mali find that children in program villages were significantly taller than children in non-program villages. Hammer & Spears (2016) and Dickinson et al. (2015) study randomized sanitation interventions in rural India and find increases in height-for-age z-score for children in treatment villages. Fuller et al. (2016) show a strong relationship between sanitation and child height in Ecuador, finding that children in villages with 100% sanitation coverage had a 67% lower prevalence of stunting compared to those with no coverage.

Briceño et al. (2017) is a notable exception to the studies finding a link between improved sanitation and improved health outcomes. They study two large-scale government campaigns to promote hygiene and sanitation (one to improve handwashing, and another to increase the coverage of latrines) in rural Tanzania and find no impact on either diarrheal outbreaks or stunting. The sanitation intervention involved both a marketing campaign to promote latrine use and a CLTS intervention to increase latrine construction.[4] While the campaign did change attitudes towards sanitation, with significant increases in latrine construction, utilization, and decreases in open defecation, these improvements in sanitation were not substantial enough to generate significant health externalities.

In addition to diarrhea, infant mortality, and stunting, sanitation has also been shown to decrease the prevalence of anaemia, respiratory infections, and intestinal parasites. Coffey et al. (2017) exploit the rapid improvement in sanitation across

[3]More information on CLTS can be found in Section 3.

[4]Even before the intervention latrine ownership in the study area was high relative to other parts of East Africa, with approximately 50% of households already owning an improved latrine.

Nepal from 2006 to 2011 and find that a ten percentage point decrease in the share of nearby households defecating in the open is associated with a 0.13 g/dL increase in hemoglobin levels.[5] Watson (2006) studies the impact of the federal program investing in sanitation infrastructure on U.S. Indian reservations, and finds that increased access to improved sanitation led to a sharp decrease in infectious respiratory disease among Native American infants, as well as among nearby white infants. Cameron et al. (2019) analyze the impact of a large-scale, randomized sanitation intervention across rural Indonesia and find that the intervention led to a significant decrease in roundworm infestations in children in non-poor households when led by NGOs.

2.2 Human Capital Accumulation Externalities

In addition to improved health outcomes, access to sanitation may lead to increased human capital accumulation. Researchers have measured the human capital externality through increases in cognitive test scores and educational outcomes. The most comprehensive paper on the impact of sanitation on childhood cognitive ability is Spears & Lamba (2016). The authors exploit the variation in within-district trends in India's Total Sanitation Campaign (TSC) implementation in a difference-in-differences framework to estimate the impact of latrine access on early childhood development. They find that exposure to TSC significantly increased cognitive ability, with children exposed in their first year of life much more likely to recognize letters and numbers. Effects are seen to persist, as Orgill-Meyer & Pattanayak (2019) find higher analytical ability due to improved sanitation ten years later, especially among girls.

There are many plausible mechanisms for how improved sanitation can lead to increases in human capital, of which we will focus on two. First, improved sanitation leads to a reduction in the prevalence of intestinal parasites caused by exposure to contaminated water or walking barefoot through fecal matter. Intestinal parasites such as hookworm and roundworm have a significant impact on a child's educational

[5]For comparison, nutritional supplement programs have been shown to increase hemoglobin levels by 0.20 to 0.41 g/dL.

development due to decreased energy, ability to focus, and classroom participation (Baird et al. 2016, Miguel & Kremer 2004). Bleakley (2007) finds a hookworm eradication program in the American South in the early 1900s led to increases in school enrollment and literacy. In a more contemporary setting, the work of Cameron et al. (2019) documenting decreases in roundworm infestations due to improvements in sanitation could imply gains in education in a manner similar to Miguel & Kremer (2004), although the authors did not explicitly study educational outcomes in the paper.

A second pathway for sanitation to effect schooling outcomes is by encouraging attendance. Adukia (2017) finds that latrine construction in schools as part of India's TSC program led to significant increases in attendance by pubescent girls. This effect was predominantly present when schools constructed sex-specific latrines, whereas construction of unisex latrines benefitted younger girls and boys equally. Adukia posits that this differential effect is driven at least in part by privacy and safety concerns. This finding is corroborated by Ray & Datta (2017) who analyze the same TSC program and find construction of separate female toilets led to gender parity in participation only in the upper primary level. Some researchers have posited that the lack of sex-specific facilities may cause a decrease in school attendance by girls during menstrual periods (Freeman et al. 2012, Lidonde 2004), although it should be noted that a (small-scale) randomized evaluation in Nepal found an intervention directly related to menstruation had little to no impact on school attendance (Oster & Thornton 2011).

2.3 Non-linearities and Thresholds in the Externality

We now focus on the possibility of non-linearities and thresholds in the externalities from improved sanitation. A threshold would imply that there was some level of latrine coverage below or above which additional marginal coverage had no impact on neighbors' health. A non-linearity would imply that the effect of adding another latrine might differ when a village had 25% coverage compared to when it had 75% coverage. Non-linearities would suggest that sanitation investments may exhibit

increasing or decreasing returns to scale. As a neighborhood becomes cleaner, the marginal benefit to a household from improving its own sanitation may increase or decrease (Andrés et al. 2017, Fuller et al. 2016, Garn et al. 2018, Oswald et al. 2017).

Understanding the shape of the returns to improved sanitation is important for designing policies which can improve health outcomes at a lower cost. There is currently no consensus on whether the impacts of increasing sanitation on health outcomes are linear in nature. The lack of consensus is more than likely due to the small sample sizes and insufficient variation in sanitation coverage in existing studies, the short time horizon over which outcomes have been measured, a sparse literature with few replicated papers, or a combination of the three.

In the study by Spears & Lamba (2016) on the effects of India's TSC on children's cognitive ability, the authors do not find evidence of a non-linearity in the relationship between cognitive achievement on latrine intensity. Gertler et al. (2015) performs a similar exercise for the relationship between percent of households practicing open defecation and average child height-for-age z-scores. The plotted local polynomial suggests the relationship is close to linear, but slightly concave, with higher marginal impacts when village-level open defecation is high (or village-level sanitation is low). There is no threshold for the health benefits.

Spears (2019) presents evidence of a non-linear relationship between open defecation density (per square kilometer) and average child height-for-age among the pooled African and Indian Demographic and Health Surveys (DHS). The effect of open defecation density on child height is slightly convex in Africa and slightly concave in India. Thus, in Africa higher marginal impacts from improved sanitation occur in places that have better sanitation (lower open defection density) to start, whereas in India higher marginal impacts from improved sanitation are found in areas where sanitation is poor to start. Because the shape found in Africa is derived from cross-country regressions, the usual caveats apply.

The nonlinearity documented in the African data in Spears (2019) appears to be due to a threshold. The impact of open defecation on child stunting occurs only when open defecation is low; average child height remains constant above the threshold. Similarly, Augsburg & Rodríguez-Lesmes (2018) show that the relationship between

the percent of households that use toilets and child height is linearly positive until the 30% threshold, at which point average height-for-age stops increasing with higher latrine utilization. In addition, Guiteras et al. (2019) show positive externalities with a threshold: "latrine adoption decisions may become strategic substitutes once you go beyond 60% adoption share in the community, which happens to be exceedingly rare in our data." This evidence suggests there exists an upper threshold above which transmission is interrupted.

Fuller et al. (2016) posit that there also likely exists a lower threshold below which a few households switching to improved sanitation will have little to no effect. Andrés et al. (2017) calculates that in rural India this threshold is 30%. A study of community latrine coverage found a higher threshold, with prevalence of trachoma in children (Oswald et al. 2017) only decreasing when latrine prevalence hit 60%, with continued decreasing returns from there.

Finally, many studies find no effect at all of increased latrine access on health outcomes.[6] Null effects may be due to a combination of a high lower threshold that is not reached and low utilization rates. Authors of articles with null effects such as Patil et al. (2014) and Clasen et al. (2014) attribute the absence of positive externalities to the low rates of ownership and usage of latrines, as well as the high continued prevalence of open defecation. Barnard et al.'s (2013) study of the TSC finds that, despite a large increase in latrines, many people do not utilize them.

2.4 Differences in Externalities in Rural and Urban Settings

Most of the papers discussed thusfar study health externalities in rural contexts. A few papers utilize data that covers both rural and urban settings (Augsburg & Rodríguez-Lesmes 2018, Coffey et al. 2017, Geruso & Spears 2018), while a few others focus on the externalities present for sanitation systems in strictly urban settings (Deutschmann et al. 2018, Johnson & Lipscomb 2019).

Deutschmann et al. (2018) study a latrine desludging campaign in urban Senegal and find a significant externality: when a household chooses to empty (desludge)

[6]See Wolf et al. (2019) for a meta-analysis of the heterogenous impacts on diarrheal outbreaks.

its latrine in the more sanitary manner, diarrhea incidence among its neighbors decreases. Similarly, in urban Burkina Faso, Johnson & Lipscomb (2019) show that access to subsidized sanitary desludgings for poor households significantly decreases diarrhea among neighborhood children. As poor households are more likely to use inferior sanitation practices in the absence of external support, successfully targeting subsidies to them has strong impacts on neighborhood health.

In a non-experimental setting, Barreto et al. (2007) conduct a longitudinal study on the effect of a city-wide sanitation program in urban Salvador, Brazil. Comparing households before and after the roll-out of a new municipal sanitation system, the authors find that the program was accompanied by a 22% reduction in diarrheal prevalence across the city. Moreover, the size of the impact was nearly twice as large in higher risk areas. In an earlier study on Salvador's sanitation system focusing on poorer neighborhoods, Moraes et al. (2003) found a one-third reduction in childhood diarrheal outbreaks in neighborhoods with proper drainage and sanitation compared to neighborhoods that lacked this infrastructure.[7]

There are reasons to believe that health externalities may be larger in urban areas, including the increased population density and lack of permeable surfaces for fecal matter to be disposed in a sanitary matter (Duflo et al. 2012). On the other hand, thick soils and impermeable surfaces may protect groundwater from fecal contaminants. Bennett (2012) tests this filtration mechanism in the urban Philippines. Instrumenting for geological variation across the city to account for the endogenous consumption of groundwater, he finds that areas with the thickest soil have 10-13% less sanitation coverage than households in areas with the thinnest soil, but does not find a significant difference in diarrheal prevalence due to this sanitation gap. This suggests that soil thickness insulates groundwater from surface contamination and decreases the impact of the sanitation practices of one's neighbor.

Hathi et al. (2017) perform a cross-country analysis of child mortality and height from 172 rounds of the Demographic and Health Survey and find that open defecation

[7]Genser et al. (2006) similarly finds strong effects of neighborhood and household sanitation on childhood diarrheal incidence in urban Brazil.

affects children in urban areas[8] more steeply than their rural counterparts. The authors posit that the steeper effect for urban populations is largely due to the significantly higher population densities.

Spears (2019) attributes India's greater population density, even in rural areas, in explaining the height gap between children in India and Sub-Saharan Africa. Estimating a counterfactual height for Indian children re-weighted with the population density of Africa would more than close the observed gaps in height-for-age between the two regions.

Augsburg & Rodríguez-Lesmes (2018) study the effects of sanitation coverage on child height in a mix of urban and rural areas in Northern India. Using survey data from households in the slums and peripheral villages around Gwalior, the authors find that increased sanitation coverage led to significant increases in height during the first year of life.

On the other hand, neither Coffey et al. (2017) nor Geruso & Spears (2018) find a significant difference between urban and rural populations in the size of the impact of improved sanitation on anemia prevalence and infant mortality respectively. One plausible explanation for the divergence in findings is the imperfect comparability of the study populations. Hathi et al. (2017) and Spears (2019) are primarily concerned with the interaction of sanitation use and population density, which is only one of the many differences between urban and rural settings. For example, urban residents may have easier access to health care facilities, which may compensate for the greater neighborhood health externality.

3 Community Led Total Sanitation

Given the large externalities imposed on neighbors by poor sanitation choices, policymakers have looked to harness community action to improve sanitation. Community Led Total Sanitation (CLTS) is arguably the most common such intervention. CLTS programs have increased substantially since they were first developed in Bangladesh

[8]The DHS defines an urban area relative to the national statistic office of the respective country.

in 1999 (Kar & Pasteur 2005). They are now conducted in Asia, Africa, Latin America, and the Pacific and they have been promoted by the World Bank's Water and Sanitation Program (Cameron et al. 2019). Proponents of CLTS argue that they have helped thousands of villages to become open-defecation free and helped to meet the Millennium Development Goals (Kar & Pasteur 2005), while others question the long-term persistence of the effects of the programs (Crocker et al. 2017). Further discussion of CLTS and related programs is also available in Rosenboom & Ban (2017).

CLTS programs are dedicated to reducing open defecation by convincing households to build toilets and to use them consistently. While more traditional programs focus on inducing households to build toilets by using subsidies, CLTS works through providing the village with information about the drawbacks of open defecation. CLTS then harnesses social pressure and shaming, encouraging households to report on their neighbors who continue to engage in open defecation. Social pressure is emphasized through continued community-level monitoring after the CLTS team has left (Kar & Pasteur 2005).

CLTS typically takes place in three phases. In the "mobilization" phase, the CLTS team works with local officials in order to identify ways in which to garner interest in the program and to improve attendance for a community meeting to discuss sanitation. The community meeting takes place in what is called the "triggering" phase, where a team from the NGO executing the project holds a village-level meeting and provides the community with information about sanitation, maps the village and where people openly defecate, and discusses the mechanisms for the spread of parasites through flies. There is typically a disgust element in which they discuss transmission of diseases through flies landing on food after feeding on human waste. Finally, in "post-triggering" there is periodic monitoring both through encouraging the community to self-monitor and through repeated visits to the community (Kar & Pasteur 2005).

CLTS may reduce the acceptability of open defecation within communities, particularly those that have higher levels of social capital. However, the reliance on shaming and social pressure can also have negative consequences and raise ethical

concerns. Poor households who do not have the means to construct toilets may face social consequences and a deterioration of their social network that they can ill-afford, further alienating them from the rest of the community. Bartram et al. (2012) cites examples of poor households being fined, having stones thrown at them, being excluded from access to clean water supplies, and even being raped when caught openly defecating.

It may be surprising that governments and policy-makers find it desirable and ethically justifiable to resort to encouraging individuals to shame one another, and especially to shame the poor and vulnerable. There are a few potential explanations for the continued popularity of CLTS and reasons that policymakers might find it excusable to leverage shame in the context of sanitation interventions, of which we will discuss three. First, as externalities in sanitation are thought to be extremely large (see Section 2), improving sanitation may produce a net increase in social welfare, even if it ends up exerting a cost on the poorest members. Second, unhygienic sanitation may impose larger costs on poorer households that have fewer resources for avoidance and adaptation mechanisms. Third, in many developing countries a primary difficulty for improved sanitation use is convincing people who already own latrines to actually use them. As many of these latrine-owners are not among the poorest households, shaming people who have sanitary options but choose traditional open defecation may be a way to change social norms rather than an attack on the poorest members of the community.

In addition to potential ethical issues, the reliance on social pressure may help to maintain the effects of the program over time, but the lack of subsidies may reduce the opportunity for such programs to help the poorest households. Despite the proliferation of CLTS programs, we lack a firm understanding of the role which each of the components of CLTS plays in the success of the program as a whole. We review the literature on the impacts of CLTS relative to subsidies, the social mechanisms through which CLTS may work, and the difference between the efficacy of urban and rural CLTS programs.

3.1 Social Pressure versus Subsidies

The difference between CLTS and subsidy programs emphasizes the dichotomy between programs relying on social pressure and those relying on monetary inducements to increase the use of toilets. Proponents of subsidy programs argue that the poorest households may have trouble covering the up-front costs of sanitation systems, and the only way to achieve full take-up of improved sanitation is to subsidize the costs for the poorest (Trémolet et al. 2010). This may be particularly important in cases in which there are convex benefits to improved sanitation: wealthier households who can afford improved sanitation may not purchase it if their neighborhood has multiple other households who don't already use improved sanitation.

On the other hand, the CLTS community eschews subsidies based on the concern that households which expect future subsidies for sanitation services may hold off on constructing toilets if they believe that subsidized toilets will arrive in the future. The proponents of CLTS believe that the information and shaming components of the CLTS program are so strong that they can overcome the difference in monetary incentives with the potentially stronger and longer lasting shaming and disgust social incentives (Kar & Pasteur 2005). However, as may be expected in programs requiring households to make substantial investments without subsidies, Cameron et al. (2019) find that while CLTS does appear to have an impact on the number of households building toilets, this impact comes entirely from the relatively wealthier households. Poor households can not afford to invest in improved sanitation technologies without subsidies.

While the majority of the literature finds that subsidies are important to inducing increased purchases of sanitation goods, several studies suggest that CLTS-type[9] programs which increase social pressure may increase the willingness to pay for improved sanitation. Gertler et al. (2015) compare the results of CLTS-based programs in four countries (India, Indonesia, Tanzania, and Mali), in some cases combining subsidy programs with the CLTS program. They find that the largest impact on

[9]Because the founders of CLTS believed there should not be subsidies, we refer to programs which include the social pressure and shaming components of CLTS, but also include subsidies, as "CLTS-type" programs.

sanitation use resulted from increased levels of latrine installation. The impact of subsidies on installation depends on the price elasticity of demand. The social pressure created through the CLTS program can increase the price elasticity of demand, thereby increasing the take-up rate for improved sanitation at a given subsidy rate.

There is increasing evidence that subsidies may add an important dimension to CLTS programs, increasing their impact particularly among the poorest. Pickering et al. (2015) find that a program combining CLTS and subsidies had an important impact on children's health and height. When the subsidies program was left out and CLTS was implemented on its own there was no statistically significant improvement in child health, even though reported open defecation decreased.

The combination of CLTS with subsidies has been found to be effective in India's Total Sanitation Campaign (TSC). Barnard et al. (2013) shows that TSC increased latrine availability. The Total Sanitation Campaign treatment villages experienced a 50 percentage point higher increase in latrine coverage over time than the control villages. Treated households above the poverty line (who experienced the social components but were not eligible for the subsidy) saw an impact around half the size of the impact seen by those below the poverty line (who experienced the social components and were also eligible for subsidies). As mentioned in Section 2, Hammer & Spears (2016) and Dickinson et al. (2015) use randomized controlled trials and find CLTS-type programs in India lead to gains in height-for-age z-scores for children. Dickinson et al. (2015) also find substantial gains in satisfaction with local sanitation and reduction in walking time as people no longer have to walk to the fields to defecate when they have latrines near their households.

When subsidies are separated from the CLTS program, the impacts of the CLTS programs are more uncertain. Guiteras et al. (2016) test the relative effectiveness of a CLTS-type program focusing on social pressure relative to subsidies and a supply-side intervention making latrine installers more readily available in villages where they may otherwise have been difficult to find. They find that only the subsidies had a significant impact on latrine ownership, and that subsidies impacted both the poor who were targeted directly by the subsidies and their wealthier neighbors who may have been induced by the improved sanitation environment to take up better

sanitation practices. Pattanayak et al. (2009) test which is a stronger motivator, shame or subsidies. While the impact of the subsidy treatment may be somewhat confounded with the poverty status of the household (only poor households in treatment villages had access to the subsidy), the authors find that the combination of shame and subsidies is highly effective in harnessing social pressure and monitoring while allowing the poorest households to overcome barriers in access to improved sanitation. They find that one third of the impact of the program is caused by the subsidy treatment while two-thirds is caused by the shame treatment.

3.2 Differences in CLTS's Success in Rural and Urban Settings

CLTS was developed with rural Bangladeshi villages in mind. It is typically believed to work best in homogeneous rural communities (see the meta-review in Venkataramanan et al. (2018)), although it has been tried in urban environments with mixed success. However, to reach large swaths of the population most affected by poor sanitation, population-dense cities and peri-urban areas which may be more affected by externalities will need to be targeted. Additionally, many of the poorest households in urban areas lack access to both formal and informal credit markets, rendering traditional cash subsidies for sanitation less effective (Trémolet et al. 2010), and making non-monetary interventions a promising policy solution.

What community characteristics aid in the success of CLTS? Hathi et al. (2016) find that Indian villages with more inter-caste and inter-religious conflict have inferior sanitation practices. They suggest that villages with more caste conflict are likely to be less successful in improving sanitation through CLTS programs. Even in relatively homogeneous communities, the ability of CLTS to induce social shaming may vary depending on the implementer and the local context. To the extent that the CLTS program fits into a wider culture of social engagement and community meetings, it may be more successful. Abramovsky et al. (2016) find limited evidence suggesting that communities with more village meetings have more success with CLTS programs.

Increased availability of latrines following CLTS programs may not translate

directly into health and sanitation gains. A meta-review of CLTS programs by Venkataramanan et al. (2018) finds that CLTS programs increase latrine construction (by 9-32 percentage points), but the resulting reduction in open defecation is typically much lower. Key factors in the success of such programs include community participation, strong village leadership, social cohesion, and a sense of community responsibility. In many cases, these factors are exactly those which are less prevalent in urban settings.

Abramovsky et al. (2016) show that a CLTS program in Nigeria had some impacts in rural areas, but that in urban environments (of over 20,000 people) the program had no impact. They suggest that this is due in large part to the fact that in many of the urban environments they were not able to complete all of the phases of the program. Crucially, many of the facilitators sent to the larger urban environments were unable to complete the "triggering" component of the intervention, commonly seen as the most important part of CLTS interventions. The most common reason for non-completion of the "triggering" component appears to be that the facilitators were unable to gather a sufficient proportion of the population. This would be particularly difficult in urban environments where many commute to work in other neighborhoods.

The literature provides several potential mechanisms through which CLTS may be more effective in rural areas. Cameron et al. (2019) show that CLTS-type programs are more effective in imposing social sanctions in areas where there is more social capital, which in many cases may be smaller and more homogeneous communities. Crocker et al. (2017) show that CLTS programs are more effective in areas where the baseline level of sanitation is particularly poor, and where there is more potential for social cohesion (as measured by the community being smaller and the people having lived together longer). Venkataramanan et al. (2018) find that smaller and more homogeneous communities are more likely to have successful CLTS programs.

3.3 Maintaining Gains in Sanitation from CLTS

The long term success of CLTS is determined in large part by the persistence of outcomes such as toilet use and maintenance. To the extent that CLTS creates shame or social pressure related to open defecation, we may expect new social norms to develop following a CLTS program and this may increase the likelihood that improvements in sanitation persist. Crocker et al. (2017) use quasi-experimental methods to show that in most communities gains persist after one year. Persistent gains are found primarily in villages that had very high rates of latrine use following the CLTS program, and they argue that this suggests CLTS led to a new social norm. In a study of CLTS across four African countries, Tyndale-Biscoe et al. (2013) found a relatively small rate of reversion by villages back to open defecation, with social pressure being one of the primary motivators to maintaining the improved sanitation system. To the extent that these may be wealthier villages in which households can afford to invest in improved sanitation without subsidies, it may be that the primary and persistent gains are focused in wealthier villages.

In contrast, the longer-term follow-up in Orgill-Meyer et al. (2019) showed some persistence over the medium term of 4-5 years, but the long term follow up of 10 years showed no persistent gains in open defecation or latrine ownership in the treatment communities. In part, this was due to catch up by control communities, but there was also a lack of maintenance of the latrines and a lack of persistent community norms around use of the latrines.

As CLTS emphasizes the importance of the community building the toilets themselves without outside subsidies, this commonly results in latrines which are not well constructed (Cavill et al. 2014). Crocker et al. (2017) found a very high incidence of CLTS latrines failing; in one study site the failure rate was 45%. They did find that in most cases latrines were eventually repaired, but continued high failure rates could induce lower persistence in the long run.

Expanding sanitation coverage through CLTS depends in large part on the ability of the government or NGOs to scale up programs. Cameron et al. (2019) investigate the relative ability of NGOs versus the government of Indonesia to increase rates of

toilet ownership and child health through CLTS programs. Programs run by the local government can not match the benefits induced by programs run by smaller-scale NGOs. NGOs were able to increase latrine ownership among non-poor households by much more than the government-run programs. Similarly, when an NGO ran the program, villagers were 12 percentage points more likely to have heard about the "triggering" event, and were 13 percentage points more likely to know about the program. These results put into question the scalability and potential for long-term success of these programs.

4 Social Spillovers and Sanitation

We move on from looking at health externalities to study decision spillovers. We will look at each of the social mechanisms behind decision spillovers in turn. These are social pressure, reciprocity, learning from others, and coordination. If a paper involves multiple interventions testing distinct mechanisms, each intervention is discussed in the corresponding sub-section, rather than discussing the paper in its entirety at once. For some interventions their place in the categorization is quite clear, while for others their placement is more subjective. The final mechanism, coordination, acted as a catch-all for interventions which didn't neatly fit into one category.

For each social mechanism that follows we first define what we mean by it. Then we look at evidence for the effect that mechanism has on sanitation and waste management decisions in rural areas. Finally we look at evidence regarding how the effect differs or is similar in urban settings.

4.1 Social Pressure

Decisions are made due to social pressure when a person's desire to be seen in a certain light by some reference group, in other words their social image concerns, affects their decision-making. Such concerns may be strong in rural areas where individuals know each other well and have lived for generations. Social pressure may not be as effective at motivating behavioral change in an urban setting.

In Bursztyn & Jensen's (2017) framework, an individual's utility incorporates social image as the disutility from acting against a social norm. This disutility is composed of three terms: how much the individual cares about being perceived by the reference group as a good type, the reference group's posterior expectation of the individual's type after observing his action, and the perceived desirability of being of that type. According to this framework, social pressure may be less effective in affecting waste removal decisions made in the home in urban settings for three reasons related to each of the three terms. First, while geographic neighbors are the people who view and are affected by one's sanitation choices, in urban areas an individual's reference group does not necessarily consist of his neighbors. Second, actions may be less observable in urban environments. Finally, individuals may not have a clear sense of what is socially desirable sanitation behavior in an urban environment. We focused on Community Led Total Sanitation (CLTS), arguably the most well-known sanitation intervention seeking to harness shame and social pressure, in Section 3. Here we discuss non-CLTS interventions, or the more social pressure related elements of CLTS interventions.

Cameron et al. (2019) present descriptive evidence that rural Indonesian villagers use their existing non-sanitation social capital to harness shame and social pressure with the goal of improving sanitation in their community. Their measure of social pressure comes from survey questions asking "whether building a toilet reduces the likelihood of being a target of gossip; whether those who defecate in the open will not be accepted by the community; and whether the community imposes social sanctions on those who defecate in the open." Villages with higher levels of social capital are more likely to impose sanctions for unsanitary choices.

Given that rural villagers already make use of their existing social capital to pressure neighbors into improving sanitation, can researchers design interventions harnessing that social pressure to improve sanitation even more? In rural Bangladesh, Guiteras et al. (2015) randomly assign subsidies and randomly assign a latrine promotion program. They find that the latrine promotion program has no impact on latrine ownership so it does not seem to induce social pressure.

On the other hand, the random assignment of subsidies to particular individuals

can induce social pressure, as analyzed in a follow-on paper (Guiteras et al. 2019). Using social network data, the authors chose some clusters in which they gave community leaders (those mentioned most often by others as being someone they would consult for help resolving a dispute) and socially central households (those mentioned most often by others as being someone with whom they interact most frequently) a higher likelihood of drawing the subsidy.

Contrary to what the authors were expecting, they find that the social multiplier effect is actually quite small when leaders and central individuals receive the subsidies. Larger social multiplier effects are found when subsidizing less central, or more socially marginal, households. The authors take this as evidence of the impact of shame. If even the less well-connected individuals of lower social standing are making more sanitary decisions, it becomes shameful to be seen as the last hold-out. The authors hypothesize that villagers don't think it is surprising when wealthy households purchase a latrine and encouraging wealthy households to adopt expensive sanitary techniques will not help in shaming others into adopting.

In rural India, Pattanayak et al. (2009) conduct an intervention which is designed to more directly and viscerally invoke feelings of shame. The authors call the intervention a 'walk of shame,' a community walk drawing attention to evidence of open defecation. The authors state that a local organization helped 'establish systems of fines, taunting or social sanctions to punish those who continued to defecate in the open." The authors find a strong effect of shame and social pressure.[10]

Overall, these three experiments show that harnessing social pressure can be quite effective, albeit arguably ethically challenged, at increasing latrine ownership in rural areas. We will next see that the results for interventions meant to harness social pressure in urban areas are much less encouraging.

Deutschmann et al. (2018) conducts an intervention which attempts to harness

[10]One caveat to the interpretation that this entire effect is due to social pressure, is the fact that treated households below the poverty line received the shame treatment and additionally received a subsidy to purchase a latrine. In Section 4.4 we will see that subsidizing some households can lead to improved sanitation by non-subsidized households. If there is a social multiplier effect on the wealthier households due to the poorer households receiving subsidies, the effect on the wealthy combines the impact of shame and the social multiplier.

social pressure in waste management decisions in urban Senegal. When latrine pits fill up, households have two options: manual or mechanized desludging. Manual desludgings are cheaper and less sanitary, with sludge often dumped in the street in front of the house. Mechanized desludgings are more expensive but more sanitary, with sludge taken by a truck to be dumped at a treatment center. The study gives subsidies of different levels for a mechanized desludging. In some neighborhoods, the randomly subsidized price offered to a household was only told to that household, while in other neighborhoods all households were told the prices assigned to everyone else. The authors hypothesized that households which received a high subsidy and whose neighbors were told about this might feel more pressure to purchase the mechanized desludging compared to households that had received the high subsidy in secret. This is not what the authors find. The subsidy has the same effect on uptake whether or not neighbors are informed of each others' prices, and social pressure does not increase mechanized desludging.

Guiteras et al. (2016) implement interventions that attempt to harness social pressure and 'disgust and shame' to increase hand-washing in urban Bangladesh. The disgust treatment included messaging that: if you do not make sanitary choices, then your neighbors 'will know that you feed shit to yourself and your family, which is a shameful act.' The authors find very little differential impact of the shame message over a standard educational health message. The authors hypothesize that their shame intervention was not effective because social pressure from neighbors does not work as a motivator in an urban setting because people don't care what their neighbors think about them.

In sum, social pressure has proven effective as a motivator in rural areas, but this impact has not been mirrored in urban areas. Even within rural areas, social pressure and shame-based interventions are differentially more effective in smaller and more cohesive areas with high baseline levels of social capital. Moving forward, policymakers and researchers should be especially cognizant of negative repercussions and ethical issues which may arise from encouraging individuals to shame their friends and neighbors.

4.2 Reciprocity

Closely related to social pressure, is the concept of reciprocity. While the distinction between the two may be fuzzy, we differentiate reciprocity from social pressure on two dimensions. First, social pressure involves negative repercussions from making *less* sanitary choices, while reciprocity involves positive repercussions from making *more* sanitary choices. Second, and more importantly, while social pressure is based on the hedonic disutility people receive from acting against a social norm, reciprocity implies an economic return from peers to making more sanitary choices. In the terminology of Bursztyn & Jensen (2017), reciprocity implies an instrumental motive for a household wanting to appear as a sanitary type, rather than a purely hedonic motive. Reciprocity has been found to play an important role in rural areas in maintaining property rights and encouraging good behavior more generally (Schechter 2007). Here we look at evidence for its role in improving sanitation.

In rural India the government implemented a program attempting to harness reciprocity to increase latrine ownership (Stopnitzky 2017). Latrines were encouraged for instrumental reasons, in the hopes of reciprocally obtaining a better marriage outcome. The program included messages such as 'no toilet, no bride,' 'no loo, no I do,' and 'show us your loo before you woo.' These slogans encouraged families with marriageable daughters to only marry their daughters off to potential grooms who owned a latrine. The author finds that this program significantly increases latrine ownership. The impact is highest in households with sons on the marriage market and in areas where there are fewer marriageable females due to male-biased sex ratios.

In urban Senegal, the study by Deutschmann et al. (2018) mentioned above conducted an intervention to measure the impact of reciprocity on waste management decisions. The authors conducted non-anonymous dictator games in which participants decided how much money to keep for themselves and how much to give to each neighbor. If reciprocity for sanitation decisions was strong, one might imagine that respondents would increase endline giving to individuals who had made sanitary desludging decisions. This effect should be especially large for those who had made

sanitary decisions despite not receiving a high subsidy. In fact the authors do not find any impact of neighbors' sanitation decisions, or their interaction with the public announcement of the subsidy, on the amount sent to that neighbor in the endline dictator game. Participants in urban areas do not financially reward neighbors who make sanitary choices.

While there are fewer studies giving evidence on reciprocity compared to the number studying social pressure, the overall takeaways are the same. Reciprocity motivates improved sanitation in rural environments, but not in urban areas.

4.3 Learning from Others

Rural households learn from others about new agricultural and health technologies (Conley & Udry 2010, Dupas 2014). There is less evidence on learning from others specifically related to sanitation and waste management decisions. In rural India, the randomized subsidy experiment by Guiteras et al. (2019) mentioned previously finds some evidence of learning from others. The baseline social network questionnaire asked respondents to list which households they would go to for advice about a new product. The authors find that when more of the households that a participant listed as being one they would go to for advice randomly receives the subsidy, the participant is more likely to adopt the sanitary latrine. This gives suggestive evidence of learning from others regarding waste management decisions in a rural environment.

As with the previous two mechanisms, the results from urban areas appear less promising. The previously-mentioned study in urban Senegal by Deutschmann et al. (2018) additionally conducted an intervention to measure learning from others. In some neighborhoods the surveyed households were randomly divided into two groups. Enumerators approached the first group to offer them the subsidized mechanized desludging. Thereafter, the enumerators told the second half either how many households in the first half signed up, or which households in the first half signed up.

Households who are informed about their neighbors' decisions may learn more about the benefits of mechanized desludging. Yet, the study finds no effect on uptake of being told that more neighbors have signed up (even when instrumenting neigh-

bors' take-up with neighbors' high subsidy allocation). In addition, the authors use baseline social network data regarding relationships within the residential neighborhood. In contrast to the finding of Guiteras et al. (2019) in a rural neighborhood, there is no impact on adoption when either someone the household looks up to as a leader on health-related issues or someone the household is friends with adopts. This lack of effect may be due to the fact the reference group from which urban households learn is not their neighbors.

4.4 Coordination

Finally we look at coordination as a reason for decision spillovers. Coordination is often thought of as a deliberate social process such that individuals organize themselves to collectively make effective group decisions. Coordination may also take place more spontaneously, with no social interactions, based purely on environmental signals such as prices. Most papers we discuss in this section can not distinguish between purposeful and spontaneous coordination.

A common way to measure coordination is to randomly give subsidies to a subset of the population, and look at how the density of subsidies among neighbors affects the decisions made by households. Studies conducted in both rural and urban settings find evidence of this type of decision spillover, or multiplier effect. Most of these studies can not determine the precise mechanism behind the decision spillover. We tend to use coordination as a catch-all term. When a subsidy to others with whom an individual is linked in a particular way increases take-up, we may conclude that this effect is due to social pressure or learning. When the effect of subsidizing others does not depend on the manner in which the two individuals are linked in the network, we categorize that as coordination.

As with the other mechanisms, we start with the evidence from rural areas. In rural Cambodia, Ben Yishay et al. (2017) find that individuals with more neighbors who exogenously adopt the latrine, due to the neighbors' drawing lower prices, are actually less likely to adopt latrines themselves. This is the only study we have seen that finds a negative multiplier effect from subsidies. The authors posit that this

negative spillover is not due to households learning that latrines are less beneficial than previously thought. They hypothesize that the health impacts of owning a latrine decrease in neighbor's latrine ownership. This may be due to non-linearities or thresholds in the health production function or due to the fact that neighbors commonly share latrines with one another.

The other studies offering randomized subsidies for waste management technologies in rural areas all find positive, rather than negative, decision spillovers. The study by Guiteras et al. (2015) in rural Bangladesh mentioned earlier conducts an intervention in which differing shares of households in a neighborhood received a subsidy for a latrine. When three quarters of the villagers are offered a subsidy, unsubsidized neighbors' ownership also increased by 8.5 percentage points compared to the control villages even though the price they faced was the same as the price faced by households living in control villages. This is evidence of a large multiplier effect.

In terms of non-linear multiplier effects, increasing the share of households receiving the subsidy from 25% to 50% has a large effect on demand for sanitation. The multiplier effect levels off after that point, with smaller additional improvements in adoption of latrines by subsidy non-recipients when 75% of households receive a subsidy.

Guiteras et al. (2019) use the same data to estimate a structural model of demand that allows the benefits of adopting to vary with the share of other households adopting. The optimal subsidy plan involves tradeoffs between giving large subsidies to a few individuals or small subsidies to many people. In their particular setting, offering a smaller subsidy to more households is shown to have a larger impact than using the same budget to offer larger subsidies to fewer households.

Gautam (2018*b*) uses a related structural model to estimate the multiplier effects of subsidizing externality-inducing sanitation decisions. Gautam (2018*a*) takes this model one step further and adds liquidity constraints on top of the externalities. Using data from both rural and urban areas in India, she compares the effects of two policies - a subsidy and a loan. She finds that loans and subsidies are more effective in different situations. Subsidies are most effective in villages with mid-level initial

sanitation since the externalities generate large amounts of feedback. On the other hand, loans are more cost effective in villages with very little initial sanitation since the potential for feedback due to externalities is lower in such a setting. This work highlights that the optimal policy should take into account both health externalities and decision spillovers.

Contrary to what we have found for social pressure, reciprocity, and learning from others, decision spillovers due to coordination in urban areas seem to be as strong as those found in rural areas. While the study by Deutschmann et al. (2018) mentioned earlier does not find evidence of social pressure, reciprocity, or learning from others, they do find evidence of a decision spillover. When the share of households receiving the subsidy increases by 25 pp, the share of households purchasing a more sanitary mechanized desludging (while controlling for the household's own subsidy) goes up by 2 pp. This magnitude is in line with the magnitude found in Guiteras et al. (2015).

We mention one final paper in the urban Philippines which looks at coordination but does not randomly assign subsidies (Bennett 2012). The author finds that a sanitary decision made by one household is beneficial for that household's neighbors. This externality leads to the, at first unexpected, finding that the spread of piped water leads to decreases in sanitation. As adoption of piped water increases, the household that has adopted piped water decreases its sanitation level (increases its open defecation) since the household expects that the water it consumes will be clean regardless. This decrease in sanitation by one household will have effects that reverberate through the community on households which do not have piped water as other households decrease their sanitation level in response. The availability of clean piped water interrupts the positive multiplier effect of one person's sanitation choice on that of his neighbor.

In sum, there is evidence of decision spillovers in both rural and urban areas. As more households adopt sanitary technologies, it becomes more worthwhile for other households to adopt as well. The non-linearities and threshold effects in health externalities discussed in Section 2 may lead to a spontaneous multiplier effect, or the spillovers may be due to deliberate social coordination.

5 Conclusion

We have highlighted the literature showing that sanitation and waste management, including latrine building, latrine use encouragement, and mechanized latrine desludging, have important externalities on health and education outcomes, especially among children. It is not only the household's own decision which affects their children, but also the decisions of neighboring households. Sanitation externalities may be particularly important in more population dense settings.

We suggest two areas where more research is needed related to sanitation externalities. First, understanding whether there are increasing or decreasing returns to neighborhood levels of sanitation, and whether there is a lower threshold below which improved sanitation has no effect and/or an upper threshold above which improved sanitation has no effect are open questions with substantial relevance for public policy. Second, more research is needed to understand how the production function for neighborhood sanitation and health differs across rural and urban settings. Figuring out the shape of the sanitation-health production function is important for targeting policy and funding towards settings where it can have the most impact.

Given that there are health and human capital externalities from improved sanitation, we might suspect there to also be decision spillovers from improved sanitation. Research in both urban and rural areas show that one person's sanitation decision does affect the decision of his neighbors. We explored four mechanisms which might be behind decision spillovers. These are social pressure, reciprocity, learning from others, and coordination. We reviewed the evidence for Community Led Total Sanitation (CLTS), one of the most well-known and commonly conducted interventions attempting to harness social pressure and shame to improve sanitation. While decision spillovers are found in both rural and urban settings; social pressure, reciprocity, and learning from others are all found to be less effective in urban than in rural settings. Decision spillovers in urban settings may arise due to the shape of the sanitation-health production function, and not due to social interactions.

This leaves open another area for future research. Why are social interactions and peer effects less effective for improving sanitation in urban areas? One potential

dimension is to explore who is an individual's reference group in an urban area (those from whom they learn, and those who have the power to shame them). It seems likely that the reference group is much more geographically dispersed and less overlapping in urban environments than in rural environments. Future research could first identify the relevant reference group, and then try out interventions designed to work well with such dispersed social networks.

A second dimension is to explore - both theoretically and empirically - what happens when the group which causes the externality differs from the reference group. In rural areas, neighboring households' sanitation choices impose externalities on one another and neighbors also act as each other's reference group. In urban areas, neighboring households' sanitation choices still impose externalities on one another yet the reference group may consist, for example, of work colleagues rather than residential neighbors. It may be much more difficult to harness the power of shame as imposed by work colleagues for sanitation decisions which do not affect them and which they do not directly observe.

The sanitation literature has focused in large part on rural sanitation, yet the welfare consequences of poor sanitation choices may be much larger in urban areas. While the literature suggests social pressure and shame treatments such as CLTS increase the take-up of sanitation in small cohesive homogeneous villages, there is little evidence that the lessons from rural sanitation carry over to an urban setting. While the base levels of sanitation in urban areas are higher, much remains to be done in improving urban sanitation, particularly as urban centers become more population dense and peri-urban areas of developing countries spread. Finding answers for improvements in sanitation for these areas would help to increase global health and reduce child diarrhea and mortality.

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