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Frontline Worker Compliance with Transparency Reforms: Barriers Posed by Family and Financial Responsibilities

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Abstract

Significant development funding flows to informational interventions intended to improve public services. Such "transparency fixes" often depend on the cooperation of frontline workers who produce or disseminate information for citizens. This article examines frontline worker compliance with a transparency intervention in Bangalore's water sector. Why did compliance vary across neighborhoods, and why did workers exhibit modest rates of compliance overall? Drawing on ethnographic observation and an original dataset, this article finds that variation in workers' family responsibilities and financial circumstances largely explains variation in compliance with the intervention. Furthermore, workers often prioritize longstanding responsibilities over new tasks seen as add-ons, leading to modest rates of compliance overall. Perceptions of "core" jobs can be sticky—especially when reaffirmed through interactions with citizens. This study represents one of the first multi-method companions to a field experiment, and illustrates how the analysis of qualitative and observational data can contribute to impact evaluation.

Introduction

More information for lay citizens, cheaply provided and easily accessed, is at the heart of global efforts to "make services work for poor people" (World Bank 2004). The underlying assumption is that transparency improves citizens' experience with service delivery; information about services positions citizens to make better use of them. In addition, citizens armed with information about service provider performance are better placed to press for improvements and to demand accountability. Improved transparency, in other words, promotes a virtuous cycle leading to improved service delivery. Development institutions, telecommunications companies, and national governments have channeled significant funding into informational interventions to improve the quality of public services. A growing body of scholarship in Public Administration, Development Economics, Political Science, and Development Studies now evaluates the efficacy of such policies (Pande 2011; Lieberman, Posner, and Tsai 2014). This article is part of an impact evaluation of an informational intervention in Bangalore's water sector.

"Transparency fixes" to long-standing problems with service delivery often hinge upon the cooperation of human intermediaries who ultimately supply information to citizens. This is particularly the case in low- and middle-income countries where automated information production and dissemination are not common. For instance, some utilities can afford the technologies to monitor water flows and consumption, and to compile and publish information on these. Others, however, do not possess reliable information on the water they distribute and how much is consumed versus lost in transit. In these situations, utility workers have to manually spot-check flow and pressure along the piped network, and turn in log-books to their superiors. Even interventions with information and communications technologies at their center, such as government-subsidized computer kiosks or cell-phone based price retrieval programs, have human intermediaries connecting the "last mile."

Frontline workers in public services are frequently the weak link in the information delivery chain. Researchers and journalists have reported on the reluctance of frontline workers to accept information collection and dissemination reforms, for example in the utilities, transport and banking sectors, because such reforms threaten low-level jobs or cut down opportunities for graft.

In some cases, implementing informational reforms have been too time-consuming or costly for frontline workers. In other instances, workers have been enthusiastic and entrepreneurial, acting as a liaison between citizens and the state, or actively promoting health and educational reforms.

Our study focuses explicitly on this theme: we examine why frontline workers do not comply with orders to provide information for transparency initiatives, even when doing so would require little additional time or effort. We analyze a new informational intervention in the urban water sector in India. With insufficient water to meet current needs and inadequate carrying capacity of the water infrastructure, almost all Indian cities provide water intermittently. Households receive water for a few hours a day a few times a week, often at unpredictable times. To reduce the coping costs associated with unpredictable water, NextDrop, a social enterprise, pioneered a text-message based system whereby households were given real-time information on when (or whether) to expect their water on a given day. NextDrop's system relied upon the cooperation of the city's water valvemen, or street-level utility workers, who physically turn water valves on and off, releasing water to small clusters of households at a time. In Bangalore, where NextDrop partnered with the water utility, calling the company to report whenever valves were adjusted became an official part of the valvemen's job description.

Our goal in this article is to explain both modest rates of, as well as variation in, frontline worker compliance with this attempt to make water schedules more transparent to Bangalore's residents. The article represents a companion to an experimental evaluation of the household-level impacts of NextDrop's services (AUTHOR Under review). Impact evaluation research for development interventions has increasingly turned to the rigor of experimental research for a credible answer to the question of what works and what does not work. However, experimental research designs cannot provide insights into *why* an intervention succeeded or failed. Our impact evaluation identified non-complying frontline workers as the primary reason for the failure of NextDrop's system. This article goes beyond evaluation to explain *why* the frontline workers, Bangalore's water valvemen, frequently did not comply. It represents one of the first examples of a multi-method study designed explicitly as a companion to a

field experiment, rather than as an after-the-fact effort to understand null findings.[i]

Drawing on months of ethnographic fieldwork and analysis of an original dataset collected for this project, we find that to understand the overall modest levels of compliance with the system, we must understand how street-level bureaucrats (SLBs) rank new, relative to existing, responsibilities. We argue that prioritization is often tied to how SLBs perceive their jobs. If the new task, for instance an information-oriented reform, is seen as peripheral to the core job, it may not get done. Job perceptions on the ground can be "sticky," especially if these perceptions are reaffirmed through interactions with citizen-clients. In theoretical terms, as we discuss below, this finding affirms the model of the SLB as a "citizen-agent" from the literature on street-level bureaucracy, as opposed to the "state-agent" figure more common to the principal-agent literature.

We find that to understand variation in compliance rates across neighborhoods, we must consider the individual circumstances of the workers who service them. When financial circumstances and family responsibilities constrain the flexibility and attention that SLBs can devote to their work, new tasks can be the first to go. Yet informational interventions are often designed precisely as add-on tasks to SLBs' existing jobs. SLBs are inevitably embedded in particular financial and familial situations, but how these affect their work performance is seldom discussed in the principal-agent and street-level bureaucracy literatures.

In the rest of the article, we review the strands of these literatures that are particularly relevant for our project; we highlight their contributions to understanding organizational, community, and individual-level influences on compliance. We discuss the text-message based transparency initiative analyzed here, documenting the modest overall levels of compliance we observed among water valvemen as well as significant individual-level variation. We describe our mixed-methods study design, review our findings, and conclude with the implications of our results.

Frontline Workers: From Compliance to Understanding

The dominant approaches to studying how frontline workers might react to additional responsibilities are principal-agent theory and street-level bureaucrats

theory. Asymmetric information and its implications are central to both these literatures.

The principal-agent literature is mainly concerned with "Weber's asymmetry" (Miller 2005), where the principal has the policy-making authority but only the agent has the information needed to implement the policies. The principal therefore has to wrest compliance from frontline workers despite asymmetric information and policy uncertainty. Performance-based incentives or the threat of penalties tend to dominate analyses within this framework (Gailmard and Patty 2012; Shapiro 2005). The SLB literature prioritizes the point of view of the agent; Lipsky's path-breaking work showed that frontline workers exercise discretion in order to, in effect, shape policy from the bottom up (Lipsky 1980). Access to street-level information that their superiors do not have enables such "pragmatic improvisation" (Maynard-Moody and Musheno 2012). Skilled workers such as doctors and veterinarians use their knowledge to navigate between their clients and their superiors (Schott, van Kleef, and Nordegraaf 2016), but experiential knowledge or *mētis* (cf. Scott 1996, 74–75), born of long practice, gives even SLBs with little formal education the confidence to go against their principals. These literatures show that the extent to which information asymmetries and credible threats act as countervailing forces can help explain both compliance rates as well as their variation across neighborhoods and individuals.

We categorize additional explanations of frontline worker behavior into organization-, community-, and individual-level factors. This categorization is implicit in most studies (but see Riksheim and Chermak 1993), and allows us to systematically investigate factors that may explain modest rates of, as well as variation in, compliance with transparency interventions.

Oberfield (2014) defines *organizational influences* as coming from "intra-organizational systems, processes, and dynamics" that shape how SLBs act. Feasible levels of monitoring (Banerjee and Duflo 2006; Miller 2005); robustness of the accountability mechanisms among principal, agent, and citizen (Caseley 2003); corruption within the organization (Bussell 2013); and organizational "culture" (Crook and Ayee 2006); all determine the extent and nature of discretion. Monetary incentives matter, but can backfire if they are too large or too small (Kamenica 2012); non-monetary incentives, such as uniforms, may

work to affirm worker identity qua worker and keep the agent from acting against the principal's interests (Akerlof and Kranton 2005). Routines also shape worker behavior, including discretion (Hasenfeld 2000). These studies indicate that levels of compliance are jointly determined by incentives and habitual behaviors. Organizational factors influence overall levels of compliance within an organization, and help explain variation in compliance between organizations.

Community influences stem from the localities in which SLBs work and include neighborhood characteristics and social norms. Norms are particularly well-recognized in the literature on police behavior (Epp, Maynard-Moody, and Haider-Markel 2014; Shannon Portillo and Rudes 2014; Willis and Mastrofski 2011). SLBs may collectively set norms in the absence of organizational directives (Hupe and Hill 2007), or the community (i.e. the SLB's ecosystem) may signal its priorities and send SLBs "clues" about what is or is or not important (Kamenica 2012). SLBs also make judgments about community characteristics and about what is "normal" to each context; at worst, they may provide low-quality work in low-income neighborhoods and internally justify this by labeling the residents as "undeserving" (Hastings 2009). These arguments suggest that compliance levels may vary with the socio-economic character of the community served, even for the same frontline worker.

Individual characteristics can explain variations in worker performance on the same job and in the same communities (Oberfield 2014). The most obvious of these are education and experience (e.g. Moynihan and Pandey 2007). But social identity such as age, ethnicity, and gender – of the agent and of the principal – significantly determines an SLB's view of which "rules" must be followed (Akerlof and Kranton 2005; S. Portillo 2012). Dispositional traits such as conscientiousness and open-mindedness (Callen et al. 2015) are predictors of high performance (from the principal's perspective), while professional traits such as the trained instincts of home nurses or teachers (Harrits and Møller 2014) may support or go against the principal's interests. Compliance, in these studies, is explained by a complex combination of personal and contextual factors.

We draw on these studies to outline our predictions regarding when frontline workers will comply with transparency interventions (and possibly other informational reforms). We expect overall compliance levels to be modest

because frontline workers' perceptions of their core job responsibilities are sticky. These perceptions will partially derive from the organizations where they work and the communities that they serve, and will be reinforced through frequent interactions with those communities. Any new task, unless seen by the agent as a core element of the job, may be neglected. Because many informational interventions are designed as add-on tasks for the frontline worker—e.g. sending notifications, or showing citizens how to access government data—they will likely take a back seat to core responsibilities if unaccompanied by high-powered incentives or high community demand. Moreover, threats of dismissal if workers do not comply will lack teeth because of information asymmetries; SLBs are integrated into informational interventions precisely *because* they possess information their organizational superiors do not.

We expect variation in compliance across local contexts to stem from community and individual-level factors. First, as the literature building on Lipsky (1980) suggests, street-level bureaucrats interact differently with different types of clients, for example, across neighborhoods of different socio-economic or ethnic character. Consistent with the literature, we expect lower levels of compliance in low income neighborhoods. Variation in the individual characteristics of SLBs, such as education, disposition or motivation will also drive variation in compliance; we expect more educated and motivated SLBs to perform better. We suggest that additional individual-level factors will affect workers' "capacity to cope" (Schott, van Kleef, and Nordegraaf 2016, 603): financial pressures or family obligations, such as the number of children a worker supports or the flexibility of his or her spouse's occupation, will distract SLBs during the workday, particularly when workloads are already heavy. Family and financial responsibilities have been underemphasized relative to other individual characteristics in the SLB literature. Understanding SLB behavior in informational interventions as a combination of how SLBs understand their work and their personal constraints highlights the challenges of incentivizing compliance with such tasks.

Compliance with NextDrop's Water Notification System in Bangalore

Our study focuses on a cell-phone based system intended to help households cope with intermittent water supply by providing them with advance

notifications of water arrival times. Over 100 million people in South Asia live with intermittent water supplies (Kumpel and Nelson 2016) with a mean supply duration of 7.2 hours a day (www.ib-net.org). In many cities, water arrives every third or fourth day, for just a few hours at a time. This is because, as cities have expanded, the water supply and/or piped network has been unable to keep up with demand. Furthermore, water supply timings are unpredictable due to erratic electricity supplies. Unpredictable and intermittent water supply is stressful because households have to wait for water to arrive and then quickly fill up every available storage container while it is still on. If they miss a supply period, they must turn to more expensive sources such as water vendors. From the utility's perspective, intermittency also makes it difficult to track and manage the city's flow of water in real time.

In urban India, intermittent water supplies are allocated via frontline utility workers who manually turn the water valves on and off, controlling water flows into "valve areas" of 20 to 200 households. Without flow sensors installed throughout the water system, the valveman assigned to each valve area is the best informed on when to expect the actual water supply, or whether to expect water that day at all (see also Björkman 2015). There is always an information gap between the valvemen and the utility, and between the valvemen and residents.

NextDrop, a social enterprise, aimed to close this information gap and provide utilities and city residents with something they have never had previously—real-time digital information on municipal water flows across the city. NextDrop reasoned that households would be better able to cope with intermittent water supply were they to receive advance notification regarding water arrival times and supply cancellations. To do this, they created digital maps of the valve areas (Figure 1), collected GPS coordinates for households who wanted these notifications, and placed the households within specific valve areas. The valvemen, after every valve adjustment, were asked to input these data through NextDrop's interactive voice response (IVR) system. NextDrop processed this information and sent a text message (or SMS) to residents telling them when their water would arrive (e.g., "Your water will arrive in 30 minutes"), or if it would be delayed or cancelled. NextDrop piloted their system in the city of Hubli-Dharwad (population ~1,000,000), adjusted their software,

and then rolled out their services in Bangalore (~8.4 million) and Mysore (~900,000).

[INSERT FIGURE 1 ABOUT HERE]

The research described here focuses on valveman compliance with the NextDrop system in Bangalore. At an average supply duration of four hours a day, Bangalore has one of the lowest reported water supply durations among Indian megacities (McKenzie and Ray 2009). While an economically vibrant city, it has numerous low-income settlements and widely varying qualities of public services.[ii] So there was reason to expect the system to be of use to households. Starting in 2013, and with a Memorandum of Understanding (MOU) with the Bangalore Water Supply and Sewerage Board (BWSSB) in place by 2014, NextDrop started signing up residents to receive real-time water supply notifications on their mobile phones. The service was free because the utility paid the company directly. Because of the MOU between the company and the utility, sending notifications became part of the valvemen's official job description.

From the start, the NextDrop staff knew that the valvemen might be reluctant to comply with their notification regime. The entire set up – one in which the BWSSB had administrative authority and the valvemen had knowledge – reflected "Weber's asymmetry." During their pilot in the smaller twin cities of Hubli-Dharwad, NextDrop garnered a workable level of cooperation from the valvemen. The company tried various incentives for them: a point-reward system, social incentives such as recognizing the "valveman of the quarter," and personal assistance such as replacing worn footwear. The company never kept data on incentive-specific performance but believed that the combination of individual and social incentives was effective. Scaling up this highly personalized system to the megacity of Bangalore proved challenging, so NextDrop relied upon BWSSB's hierarchy to encourage valvemen to submit the required data. In effect, the Bangalore rollout substituted the reliance on valvemen's individual incentives for reliance on the utility's organizational structure – arguably a more scalable proposition.

Adding NextDrop notifications to the job description proved only partially successful in Bangalore. Valvemen did not submit notifications all the

time and rates of compliance varied substantially by valveman. Figure 2 presents data for one of the utility's subdivisions (to protect valveman anonymity, we call it Subdivision A). It reports the number of notifications sent when opening water valves relative to the number expected based on the utility's official supply schedule.[iii] Each bar represents the ratio of actual to expected reports for an individual valveman. We observe notification ratios between 0.42 and 0.81, or moderate levels of compliance overall. We also observe variation across valvemen within the subdivision and within the same service stations[iv] (the different shades represent the five service stations covering Subdivision A). Therefore, even when controlling for organizational factors, the variation in compliance across valvemen is prominent.

[INSERT FIGURE 2 ABOUT HERE]

Study Design and Data

Our study adopts a mixed-methods approach to understanding why valvemen complied at only modest levels with the NextDrop intervention, and why rates of compliance varied across neighborhoods. We paired extensive qualitative research with water valvemen with the compilation and analysis of an original dataset on the timing and frequency of valvemen's notifications, the characteristics of individual valvemen, and the communities they served. We drew on our qualitative data to understand the overall rates of compliance with the intervention, and on our qualitative and quantitative evidence to understand variation in compliance across neighborhoods.

BWSSB has divided Bangalore into 32 subdivisions for administrative purposes. Our study focuses on Subdivision A, where the company felt that they had resilient relationships with the valvemen. Subdivision A is also far enough from where our research team was conducting the impact evaluation of NextDrop's intervention (AUTHOR Under review) that the studies could not influence one another.

We measured levels of valveman compliance using NextDrop's notification data for valve openings (Figure 2; see Online Appendix, Section A3 for NextDrop's method of counting notifications and our analysis of their data). To understand why compliance was modest overall, we employed an

ethnographic approach; the lead author (with a local translator) conducted open-ended interviews and extended observations of valvemen, as well as dozens of interviews with utility staff, residents, and NextDrop employees in neighborhoods across Bangalore. This gave us a sense of the physical and institutional structure of the municipal water system in which the valvemen carry out their duties. We selected nine out of the 17 valvemen within Subdivision A, who varied significantly in terms of compliance, for further analysis.[v] The bulk of our study focused on these nine – their work histories, their aspirations and frustrations, and their familial and financial circumstances. We took our cue from Maynard-Moody and Musheno's (2000; 2012) influential work on street-level bureaucrats, paying close attention to the valvemen's own narratives about their job. Through these observations and interviews we came to understand the ways in which valvemen saw their job, how NextDrop's notification system fit into their ecosystem, and the power dynamics between themselves and the utility. We accompanied each of these valveman on his rounds through his assigned valve areas and his meal breaks at home. We took extensive notes and photographs during these sessions.[vi]

We complemented our ethnographic research by collecting and analyzing an original dataset on valvemen, service station, and valve area characteristics in Subdivision A, mirroring the literature's focus on individual, organizational, and community factors. For individual-level factors, we collected information from all nine valvemen on their employment status (permanent or contract), the number and gender of their children, their wives' employment type (coded by the inflexibility associated with the job; housewives were most flexible and babysitters were most inflexible), the vehicle they used for work, their age, and the number of valves for which they were responsible. Our interviews were semi-structured, with potential independent variables systematically collected for all the valvemen, but with enough flexibility to let them discuss their work, lives and constraints on their own terms. (Online Appendix, Section A1).

For community-level factors, we visited every valve area (N=233) served by the nine valvemen to code the socio-economic status of the neighborhood, water infrastructure, and street activity: the community-level factors that could influence levels of, and variations in, valveman compliance (see Online Appendix, Section A2). We categorized the valve areas as (primarily) low,

medium, high, or mixed socio-economic status (SES) (Online Appendix, Section A2 and Figure A4 for details). A "low SES" area had a high level of domestic activity on the streets (cooking or washing clothes and dishes), narrow roadways, high noise levels, and few trees. A "high SES" area had little noise, high tree coverage, well-maintained homes, and no visible domestic activity. In addition, we counted (non-commercial) cars per five households, number of overhead water tanks through a visual assessment of the area, and the visible residents on the main street of the valve area, usually around mid-day on a weekday. More cars indicated higher SES, more overhead tanks implied less work for the valvemen, while more residents could potentially distract them.

We used these quantitative data to analyze whether factors that appeared important in our observations and interviews also explained variation in compliance across valve areas. We first carried out a principal components analysis to determine the extent to which our (potential) explanatory variables were correlated with one another (Vyas and Kumaranayake 2006) (see Online Appendix, Table A5). We then ran linear regressions to see which independent variables were associated with valveman compliance within each valve area. These simple regressions allowed us to establish whether or not individual-level characteristics that seemed to influence compliance from our ethnographic research appeared to hold once we controlled for the valve area context.

Empirical Findings

In this section, we review our ethnographic evidence from Subdivision A to understand why overall rates of compliance with NextDrop's system were modest. We then turn to our qualitative and quantitative findings to explain variation in these rates across the valve areas.

Explaining Modest Compliance Levels

Our research found empirical support for three main explanations of the modest rates of overall compliance. First, valvemen perceived their jobs principally as responding directly to "the public"—rather than to the utility's hierarchy—and the public pressed them to perform long-standing water management tasks rather than send NextDrop notifications. Second, valvemen already felt

overworked, and viewed the NextDrop notification task as an additional, non-core responsibility. Third, valvemen had privileged knowledge of the water infrastructure, and therefore did not take seriously the threat of dismissal for not submitting notifications.

Valvemen's Perceptions of Their Job: "I Work with the Public." Our interactions with the valvemen made it clear that they placed more emphasis on responding to pressure from the public than on their formal job description. BWSSB defined their jobs as opening and closing water valves at particular times and fielding residents' complaints. Though valvemen agreed that their job was to adjust water valves, their overriding description was: "My main work is working with the public." This sentiment was a recurrent theme. In explaining why his work was good, one valveman asserted: "I have shown what kind of work I do, how I work with the public." Another claimed: "When I work I forget about my family and friends. These people are my family and friends." This attitude closely reflects a "citizen-agent" meta-identity (Maynard-Moody and Musheno 2000), where frontline workers, while acknowledging the state, perceive themselves as actually working for citizens.

What, then, do valvemen claim they do for the public? "From morning I wake up, I do the work and I take care of complaints." A good valveman is "someone who attends to the problems and stays up day and night until the problems are solved." A bad valveman is someone about whom the public could complain: "He leaves the valves on whenever he wants. He's not punctual." If "the public" complained to the councillor (the elected ward representative), especially at election time: "the councillor complains to the valveman's superiors. His superiors ask him, 'Well? Are you fooling around and wasting time?'"

Consideration of (and pressure from) citizen-clients was particularly evident when valvemen talked about why they, at times, gave their clients extra water. Residents regularly negotiated with the valvemen for water or for repairs to leaky pipes through phone calls and appeals to common decency. If for some reason there is no water supply at the scheduled time, the practice at BWSSB is for valvemen to skip that turn and not hold up the supply for the valve areas to follow. However, valvemen do not always heed this rule: "If I'm supposed to give them an hour of water, and due to power cuts they only get a half hour,

then I will give them another half hour." One valveman said succinctly: "I sympathize with these people." We regularly observed this sympathy in practice while following the valvemen on their weekly routes, but we never observed members of the public mention NextDrop. A valveman taking his cue from his clients would not have prioritized NextDrop's notifications.

Valvemen's Perceptions of NextDrop's System: "It's Just an Additional Job." Our field observations also clarified the extent to which valvemen juggled multiple job responsibilities, which made a seemingly simple new task feel onerous. While some valvemen claimed that sending notifications had gradually become standard practice, others expressed annoyance: It is "not helpful for valvemen;" "It's just an additional job;" It "hampers my work." One valveman said that if NextDrop wanted him to make notification calls then they should be there when the valves break in the middle of the night. These attitudes prevailed even in the service stations where NextDrop had the most established relationships with the valvemen.

These reactions must be understood in light of the many and varied tasks that make up the valvemen's formal and informal roles. Valvemen convey information between the utility and residents; they negotiate with supervisors, residents, and even state politicians regarding water timing and system repairs. Some of these negotiations are clearly a form of rent seeking, but some are necessary for providing water services ("They need at least two buckets of drinking water; it's just a matter of 10 more minutes"). We were told that the valvemen, who know the water system best, are often called in to perform repairs, even at night, though this is not part of their official job description. In addition, contracted valvemen who are not permanent employees regularly moonlight for odd jobs, such as plumbing work at residential complexes. NextDrop's requirements fell to the bottom of this long list of competing demands.

Valvemen's Perceptions of Threats and Incentives: "I Don't Worry about Being Fired." Significant information asymmetries meant that both NextDrop and the utility had difficulty monitoring valveman compliance with the NextDrop system, and that threats of dismissal lacked credibility. NextDrop delivered

reports to service station managers each week informing them of the valvemen's notification ratios, but had more trouble monitoring notification accuracy. Valvemen had the freedom to submit inaccurate information: in following valvemen for hours at a time, we rarely observed them sending notifications to NextDrop, even after adjusting dozens of valves. Sometimes they sent off a series of notifications during tea breaks. Valvemen should have sent messages soon after they had physically adjusted the valves so that the company could send accurate announcements to its clients.

Though most valvemen are contracted out through a private company, they understood their ultimate principal to be BWSSB. As a result of the MOU between the BWSSB and the company, they readily related NextDrop's authority with that of their supervisors. When asked why they complied with the NextDrop system, valvemen would usually say that they did not want to get fired. However, information asymmetries meant that the threat of removal was not completely credible. Valvemen know the location of every pipe and water valve, which the utility does not, because the system maps are incomplete. They know how many rotations particular valves require (see Björkman 2015), how each valve is threaded, and where to check for adequate flow. Valve-specific information is passed on between valvemen without the mediation of a supervisor. With frequent desk-staff changes at BWSSB service stations, such institutional memory is held only by the valvemen. At one station, one of the two valvemen talked back to his supervisors and even to NextDrop's employees. "I don't worry about being fired," he said; he would be difficult to replace because he holds so much tacit information about the water system. A Service Station employee agreed: "The office needs him."

Meanwhile, few valvemen considered NextDrop's sporadic incentive schemes, such as mobile phones for the best valvemen, or a "bonus" of free talk time, as motivating. Some were incredulous at NextDrop's ranking of "best" performance. Others considered the rewards to be paltry, even insulting. Several valvemen said that relational connections with NextDrop were more important than monetary compensation. Contract valvemen wanted NextDrop to treat them more like their government-employed permanent counterparts.[vii] They wanted uniforms like the khaki-colored ones that permanent workers wore. Or they wanted NextDrop to provide employee-type identification cards; contracted

valvemen had no IDs. Ambiguity with respect to their social category was one of the valvemen's main work-related struggles, with identity-affirming incentives having high symbolic value.

In sum, our research showed that valvemen's perceptions of their roles were sticky and not easily amenable to redefinition. Valvemen saw their roles in terms of their relationship with the public, and the public was not clamoring for notifications. NextDrop notifications were just an additional responsibility; they viewed as more fundamental the tasks of operating the creaky water system and responding to the needs of (often) poor residents. Moreover, the main incentive the utility and NextDrop possessed to promote compliance—the threat of dismissal—was not effective; information asymmetries protected the valvemen.

Explaining Variation in Compliance

We observed significant variation in compliance across valvemen and valve areas. We draw on two types of data to understand this variation. Our qualitative observations and interviews suggested that characteristics of the neighborhoods where valvemen worked, as well as individual valvemen's family circumstances, helped explain this variation. Our quantitative analysis suggests that rates of compliance were lower in areas serviced by valvemen shouldering greater financial and familial burdens.

Results of Qualitative Analysis: Community and Individual Influences. Our rounds with the valvemen showed that community-level factors influenced both the time and inclination that valvemen had to send NextDrop notifications. Low-income areas proved more difficult to work in because of poor infrastructure and more frequent interactions with citizens, as we might expect based on the Indian politics literature.[viii] Narrow and unpaved roads were hard to navigate. Chickens and dogs had to be avoided. Residents milled around and confronted the valvemen with water-related complaints. Valvemen sometimes had to enter residents' homes to see if the water was actually flowing through their taps. In the midst of all this activity they constantly took phone calls – from the residents, the engineers, the BWSSB staff. When, the valvemen asked, were they going to send off NextDrop's notifications?

While valvemen also checked water pressure in middle-class areas, they could spot check underground tanks and faucets without encountering residents. But clients in poorer areas depended on face-to-face encounters to know when their water would turn on and to negotiate water supply amounts and timings. Valveman V attests to this: "The higher class people call our superiors and the superiors tell the valvemen the problem. The lower class people come to me directly, and I have to explain to them directly…I lose a lot of time talking to people." These observations suggest that valvemen who serviced predominantly low-income neighborhoods would have sent supply notifications less regularly; they are consistent with the data on compliance rates for individual valvemen (shown in Online Appendix, Figure A4).

Accompanying valvemen on their rounds and discussing their workdays also revealed many individual-level factors affecting compliance. In brief, valvemen under the double pressure of financial need and family duties sent notifications less regularly. Less compliant valvemen had more children at home, and in particular more daughters. More children indicate increased financial need, and, for many Indian families, having a daughter means that the family must save for (future) dowry expenses. Every non-permanent valveman with three or more young children sought outside jobs, generally plumbing or driving, which could force him to deviate from his valve adjustment schedules (and concomitant notifications). A low-scoring valveman with three daughters was matter of fact about it: "We ask our relatives for help – if you help us now, we'll help you when your daughters get married." We also observed that less compliant valvemen had wives in low-wage low-flexibility jobs, such as dishwashing or babysitting in other people's homes. This indicates a valveman's need for additional income and also time constraints on his wife; domestic service, especially babysitting, demands long hours away from home. The valveman is then left with more family-related responsibilities, especially if there is a sick child or minor emergency at home. On several occasions, we observed valvemen picking up sick children from school, or going home to take the laundry off the clothesline before the rains came, right in the middle of the workday. Contract workers faced particular difficulties with these sorts of burdens because their salaries were almost 40% lower than permanent workers'

salaries. For a moonlighting valveman with three children but no spouse at home, NextDrop's notifications were not a priority.

Results of Quantitative Analysis: Individual-Level Factors. To complement our qualitative research, we created a dataset including a range of individual and valve area characteristics (described above). We conducted a preliminary covariate analysis with PCA (Online Appendix Table A5) and then ran linear regressions of the dependent variable (actual / expected notification ratio for each valve area) against the community and valveman characteristics that we observed to be associated with compliance in our qualitative research.

We regressed valve area compliance rates against each individual-level independent variable, controlling for the socio-economic class of the valve area (233), with the standard errors clustered by the nine valvemen (Table 1). We then ran two separate omnibus models, with the number of children and number of daughters, respectively. The regressions suggest that the number of children, and in particular girl children, is strongly associated with compliance. One additional child is associated with a seven percent decrease in compliance, while an additional girl is associated with an 11% decrease (Table 1, Models 1 and 2). These individual-level characteristics are statistically significant despite the small number of cases. Having a wife working in an inflexible occupation is also associated with lower rates of compliance in some specifications. Coefficients for valveman characteristics are comparable if we substitute alternative measures of valve area socio-economic status, such as the number of cars per five households for the general class score.

[INSERT TABLE 1 ABOUT HERE]

Our data analysis highlights the importance of specific family and financial constraints that have received little attention in SLB or principal-agent literatures thus far, but that may be quite common in rapidly growing cities that are under economic pressure to outsource their street-level workers. Given the limited number of valvemen we could shadow and our reliance on observational data, however, we do not claim causality; rather, these associations suggest hypotheses worthy of further exploration.

Discussion and Implications

Informational interventions intended to improve the quality of public services have been promoted for both efficiency and transparency. Such "transparency fixes" to long-standing service problems often depend upon the cooperation of public sector workers who ultimately produce or disseminate information for citizens. This study analyzed a text-message based intervention in the urban water sector, through which the utility's customers could get advance notifications of when their water supply would be turned on. This was meant to reduce the cost of waiting and stress that intermittent and unpredictable water supplies typically entail. The entire intervention hinged on the cooperation ("compliance") of the valvemen, the frontline workers of the urban water system.

We draw on months of ethnographic fieldwork and analysis of a new dataset compiled for this project to understand the overall modest levels of compliance with the system, as well as variation in compliance across neighborhoods. We find that how SLBs rank new "add-on" tasks relative to existing responsibilities may be critical to the success of informational interventions. Prioritization is tied to how frontline workers see their job. We find that Bangalore's valvemen perceive themselves as serving "the public" ("*I sympathize with these people*"), even though they are fully aware of the power of their employers, the water utility. Their knowledge of the systems they maintain serves as a countervailing power; they know that even if they deviate from their narrow job descriptions they cannot be easily replaced ("*The office needs him*"). Similarly, while NextDrop viewed compliance with rules and targets as an important facet of their jobs, the valvemen themselves took their cues from the citizens, none of whom pressed them for NextDrop's notifications ("*It hampers my work*"). Our ethnographic data suggested that the citizen-agent over state-agent role was most pronounced when valvemen worked in densely populated lower socio-economic status communities ("*I lose a lot of time talking to people*"). Valvemen appear to internalize such communities as more needy of extra services and more likely to complain directly to them, which in turn makes it more time-consuming to serve them.

Because valvemen serve at the frontline of the water system, they are besieged by instructions at every turn, from citizens, engineers, councillors, and members of the legislature. These stakeholders could be seen as contributing to a

"multiple principal" problem (Shapiro 2005), but the valvemen's overall reaction was one of "coping toward clients" (Tummers et al. 2015). This complicates the conventional incentive design / information asymmetry narrative that still underlies much principal-agent theory and organizational practice. It supports a "citizen-agent" narrative for frontline workers (Maynard-Moody and Musheno 2000; 2012) that could well lead to low performance measures from the principal's point of view.

There is no inherent contradiction between this finding and the literature on rent-seeking behavior. SLBs have often resisted reforms aimed at streamlining and disseminating information to the public for government-provided services. The literature on petty corruption has argued that such resistance stems from the potential loss of rent-seeking opportunities (because customers can directly access information, bypassing the SLB), or the threat of job losses. Rent-seeking undoubtedly occurs in Subdivision A, but the valvemen that we observed did not seem to fear that NextDrop's system would reduce their rent-seeking opportunities. The giving and taking of small amounts of money to keep a valve open longer, or to enter a house to examine the plumbing, would have little impact on a valvemen's incentive or ability to notify NextDrop. Pipe leaks or temporary power outages could easily explain any deviations from the scheduled openings and closures. As Meyers and Vorsanger (2003) argue, multiple and co-existing motives reflect complexity rather than contradiction.

Given how valvemen understood their core jobs, whom they understood to be their main clients, no public pressure to submit notifications, and the utility's limited ability to offer credible threats, NextDrop's notification system fell to the bottom of the priority list. Our analysis of variation in compliance suggests that this was particularly the case for those with significant family responsibilities. Variation in the number of dependent children, and in the nature of their wives' outside employment, was associated with variation in compliance. More children and less help at home led to more moonlighting for side jobs and more domestic responsibilities competing with formal responsibilities. Our work points to the usefulness of looking not only at individual characteristics, as the SLB literature has done, but also to workers' family and financial constraints. Our observations also revealed associations between the socio-economic status of citizens, the interactions between anxious citizens and their valvemen, and the

modest compliance of the valvemen by the phone-based metric that tracked them. Circumstantial heterogeneity made for heterogeneous compliance among Bangalore's water valvemen.

Our study had three limitations that must moderate our conclusions. First, all observation-based work suffers from the Hawthorne Effect: in our case, the possibility that valvemen will not speak rudely to their clients or accept bribes in the presence of an outsider. However, given the convergence of our ethnographic observations and our regression results, we are confident that the effect was small at best. Second, our sample size of nine is small and purposive, so we cannot argue that our observations in Subdivision A can be generalized to all of Bangalore. Third, we could not compare the impacts of the other individual-level factors, such as cognitive abilities or attitudes, which have featured prominently in the SLB literature, to the family and financial factors we investigated. Rather, we argue that the individual-level drivers of action (or inaction) that we highlight are worth investigating in Bangalore and beyond, as they may help to make sense of observed variations in frontline worker performance in other cities and for other public services.

Conclusion

Since Lipsky's (1980) groundbreaking work, SLB studies have revealed many community- and individual-level factors that shape frontline worker behavior. We add two specific insights to this literature. First, our valveman case highlights the difficulty of an added informational task becoming part of the routine, because of the stickiness of workers' perceptions of their own jobs. Many transparency-oriented interventions are add-ons to established routines. Worker perceptions will be even stickier when they are reinforced by the communities in which the workers are embedded; in effect, the job is co-produced by the SLB and the citizen-clients and rather than just by the SLB and his superiors. Informational tasks may be especially vulnerable to worker non-compliance in such contexts, especially when clients do not affirm the importance of submitting information. This suggests that those designing transparency initiatives implemented by frontline workers should ensure that information collection directly (and visibly) benefits workers themselves, or their clients. Moreover, threats to punish workers for not submitting information may not be credible,

because information asymmetries can provide even relatively uneducated SLBs with significant leverage. More broadly, our findings suggest that all studies of transparency interventions should pay attention to how frontline worker compliance was obtained (AUTHOR Under review).

Second, we highlight the importance of financial and family burdens as constraining the capacities of frontline workers. These life burdens can take frontline workers away from their jobs, physically and mentally, and have been underemphasized in the SLB literature. Our analysis shows that individuals in highly varying personal circumstances will "comply" to highly varying degrees, and this is a genuine challenge for incentive design. Our analysis also offers a counter to the popular imagination, at least in India, in which frontline workers are thought of (if at all) as people who will only work if given a "tip."[ix] As our valvemen lamented: "The public wants their work to be done, but nobody knows our problems." This suggests that positive incentive schemes—particularly if they are large enough to substantially reduce workers' financial burdens—may improve compliance rates among those facing challenging family circumstances.

More broadly, our study suggests that scholarship on local public goods provision pay greater attention to street-level bureaucracy. Frontline workers are ubiquitous in the water, electricity, telecommunications, medical, and transportation sectors, especially in the global South, where systems are less automated. Future work on understanding (and incentivizing) these workers should pay particular attention to how they, rather than just the public agencies, see their jobs. It should pay attention to their family and financial circumstances, as these may play a significant role in their job performance. This would be important for all research on public goods provision, well beyond informational interventions or water. In agreement with several scholars on whose work we draw, we recommend moving beyond a compliance framework to an understanding framework in all such studies. Frontline workers should no longer be analyzed as complying with or deviating from a "system" that they should service. Rather, they should be analyzed as integral components of (in our case) the urban water system, which, in addition to having disposition and agency, also have their cracks and their fissures.

Notes

[i] See also Ananthpur, Malik and Rao (2014) for an impact evaluation involving a substantial parallel, ethnographic component. See Dunning (2008) and Kaspizewski, MacLean and Read (2015) on how qualitative methods can inform field experimental design and explanations of *why* interventions have the effects that they do.

[ii] On variation among low-income settlements in Bangalore, see Krishna, Sriram and Prakash (2014).

[iii] Because there were many fewer valve closed and supply cancelled notifications, and the valve opening time information was most useful for NextDrop's notification system, we focused our analysis on the valve opening notifications.

[iv] Service stations are water utility offices run by engineers overseeing two to ten valvemen. There are 97 service stations across Bangalore.

[v] The compliance ratios for our case study valvemen ranged from 0.45 to 0.81, covering the full range of compliance observed in Subdivision A.

[vi] Sessions with the valvemen were not tape recorded, so as to ensure anonymity and not put our subjects at risk. See Section A.1, Online Appendix, for further detail.

[vii] What these workers wanted most of all was to be made permanent, with the almost 40% higher salaries and the pensions that accompanied permanent status. Some held out hope that this would happen one day, though others were more resigned.

[viii] Scholars contend that the urban poor must pressure politicians and government officials to obtain services, whereas the middle class have privileged access to the state via associations and other channels (see Harriss (2005) and Ghertner (2011) for reviews).

[ix] See, for instance, the Indian website http://www.ipaidabribe.com

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FIGURE 1

Example of BWSSB Valve Areas (from Subdivision E3, the site of the NextDrop impact evaluation)

FIGURE 2

Notification Compliance: Actual/Expected Valve Opening Reports per Valveman, Aug. – Dec. 2014, Subdivision A

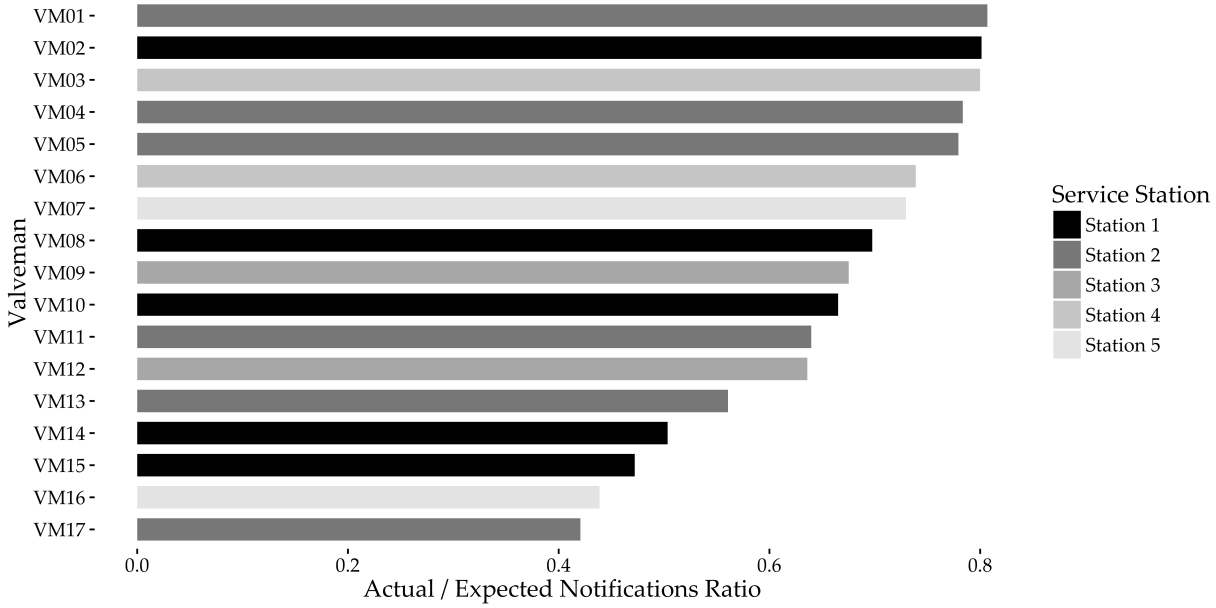

TABLE 1
Valvemen Compliance with NextDrop Notification System, Aug. – Dec. 2014, Subdivision A

Dependent Variable: Valvemen Compliance per Valve Area									
	M1: Girls	M2: Children total	M3: Wife employment	M4: Employment status	M5: Vehicle	M6: Age	M7: Valves	M8: Full model	M9: Full model
Individual characteristics									
Number of girls	-0.11 (0.02) ***							-0.13 (0.05) ***	
Number of children total		-0.07 (0.01) ***							-0.14 (0.06) **
Wife's employment			-0.05 (0.03) *					0.03 (0.04)	0.05 (0.05)
Employment status				0.05 (0.04)				0.03 (0.04)	-0.11 (0.09)
Vehicle					0.05 (0.04)			0.06 (0.03) *	0.08 (0.02) ***
Age						-0.01 (0.00)		0.01 (0.01)	0.01 (0.00) ***
Number of valves							-0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Valve area characteristics									
Middle class valve areas	0.02 (0.06)	0.05 (0.05)	0.04 (0.04)	0.04 (0.04)	0.01 (0.06)	0.03 (0.04)	0.03 (0.04)	-0.02 (0.07)	-0.02 (0.07)
High class valve areas	-0.02 (0.07)	0.02 (0.06)	0.05 (0.07)	0.09 (0.05)	0.03 (0.06)	0.05 (0.05)	0.07 (0.03)	-0.07 (0.07)	-0.07 (0.07)
Mixed class valve areas	-0.06 (0.01)	-0.02 (0.09)	-0.05 (0.09)	-0.03 (0.08)	-0.06 (0.08)	-0.05 (0.07)	-0.05 (0.08)	-0.07 (0.10)	-0.07 (0.10)
N	233	233	233	233	233	233	233	233	233
Multiple r^2	0.21	0.16	0.09	0.03	0.06	0.04	0.02	0.24	0.24
Adjusted r^2	0.19	0.15	0.07	0.01	0.00	0.03	0.00	0.21	0.21

Notes: Results of linear regressions with standard errors clustered by nine valvemen. Results that are significant here remain significant when clustered standard errors are omitted. *: p<0.1; **: p<0.05; ***: p<0.01.

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Online Appendix:
Frontline Worker Compliance with Transparency Reforms: Barriers Posed by Family and Financial Responsibilities

A1. Valvemen Data Collection and Analysis

Individual-level information about the characteristics and motivations of the valvemen in our study were collected in Summer 2014, January 2015, and finalized during the Summer of 2015. We partnered with NextDrop to make initial contact with the water utility and the valvemen. We chose to focus on the valvemen of the Bangalore water utility's Subdivision A, where NextDrop had been working the longest. NextDrop had not fully rolled out across the city, so Subdivision A valvemen would have been farthest along the learning curve and most regular in their use of NextDrop's system. Additionally, a close study of these more experienced valvemen would not have been disruptive to NextDrop's relationship with them. In contrast, valvemen in other subdivisions, who were less familiar with NextDrop, might have felt our research team to be "watching" them on behalf of NextDrop. Subdivision A was an ideal site for analysis for other reasons: it possesses neighborhoods of varying socio-economic status and is geographically removed from the subdivision where we conducted our evaluation of the household-level impact of NextDrop services

We combined shadowing with semi-structured interviews, which allowed us to both collect qualitative information on factors affecting compliance and to compile a dataset on the valvemen characteristics and employment conditions. The first author initially shadowed NextDrop's field staff on their rounds with various valvemen and at water utility meetings, gaining an overall perspective of how NextDrop, the utility, and valvemen operated and related to one another. Then (as explained in the main paper), nine valvemen were selected from Subdivision A; according to our data analysis, they complied at high, medium, and low rates with NextDrop's system. The first author, without NextDrop staff but with a local translator, shadowed each valveman on his regular rounds for a full working day, and often more than one day; this included following them to their homes for tea if invited. During these rounds, observation notes were handwritten in a notebook and then transcribed into Word documents. The rounds were also tracked with Google MyTracks and photos were taken of public areas. The data were stored in a laptop with a locked code and secured in

accordance with the rules of UC Berkeley's Office for the Protection of Human Subjects (OPHS).

The first author also conducted semi-structured interviews with each of the valvemen, during which both structured and open-ended questions were asked. These were conducted during the shadowing if there was time, or during a valveman's day off at his home, at the local utility service station, or in the valve areas where he worked. Typical open-ended questions included:

- What did you do before becoming a valveman?
- How did you get this valveman job?
- What are the sources of income in your household?
- Describe your typical work day.
- What do you think a valveman's main job is?
- How would you describe a good valveman versus a bad valveman?
- Who is your boss?
- Who talks with you the most during a work day?
- What type of people seem to complain to you the most and why do think that is?
- How did you feel when your started working with NextDrop?
- Why do you follow what NextDrop tells you to do?

For our quantitative data collection, the responses to structured questions are outlined below in Table A1. As with the shadowing observations, the interview notes were originally handwritten in a notebook and then transcribed in Word and compiled in Excel in a laptop with a locked code and secured in accordance with OPHS rules.

For our qualitative analysis, the shadowing observation and interview notes were analyzed without software, but using standard means of content analysis from which emergent themes were documented, following Atkinson and Coffey's chapter on "Concepts and Coding."[1] The data were compiled in a table that included the valvemen ordered by their level of compliance. It contains observations regarding their observed working speed and style, their socio-economic data, their years of working as valvemen, their "beat" characteristics, and their family composition. In addition, we compiled their responses to key structured and open-ended questions, which we coded by overt as well as

[1] Coffey, A. and Atkinson, P., 1996. *Making sense of qualitative data: complementary research strategies*. Sage Publications, Inc.

emergent themes. These included: children, assets, other jobs, other income earners in the home, becoming a permanent worker, looking for other jobs, working with NextDrop, working with their customers, observed customer interaction, complaints, extra water, supervisors, salary, on being a valveman, and their teams at local service stations.

Quotes were selected for the main paper according to two criteria: (1) they were representative of sentiments or opinions that were widely repeated, and / or (2) they were reflective of opinions or sentiments that our independent observations or quantitative analysis also found. We use these quotes mainly to corroborate our observations and analysis, and to give "voice" to the respondents directly.

For the quantitative analysis, the responses to the structured questions were compiled into a dataset that includes the personal and household characteristics of the nine valvemen we focused on, as well as their employment conditions. The data sources were semi-structured interviews, informal discussions, and field observations.

Variables included:

- Personal: Age of the valveman at the time of the interview; years of formal education; and marital status (single, married, widowed).
- Household: Number of adults in the household; total number of children; number of sons; number of daughters; children's ages at the time of the interview; married or single; wife's income sources (none, tailoring, maid, cook, baby-sitting, other).
- Employment conditions: Number of valves in the area(s) worked; average number of calls per day from residents (self-reported); number of years working as a valveman; whether contract laborer or permanent employee; the vehicle used for work (bicycle, scooter, motorbike); and outside income sources (none, plumbing, driving, other).

TABLE A1

Data Sources and Variable Type for Individual-Level Independent Variables

Variable	Type	Source	Min	Max	Mean	SD
Number of girls	Integer	Interview / observation	0	3	1.40	0.95
Number of children	Integer	Interview / observation	0	4	1.94	1.21
Flexibility of wife's employment	Integer[1]	Interview	0	4	1.87	1.17
Security of	Integer[2]	Interview	0	1	0.17	0.37

employment						
Vehicle used at work	Integer[3]	Interview / observation	1	4	2.58	1.01
Age	Integer	Interview	28	46	39.5	5.79
Number of valves managed	Integer	NextDrop database / valveman interview	15	43	30.9	9.80

Note: Data presented for nine valvemen.

[1]: Coded by flexibility where housewife is coded 4 and baby-sitting is coded 0

[2]: Permanent worker is coded 1 and contract worker is coded 0

[3]. Vehicle used at work is coded 4 for a motorcycle and 0 for bicycle

A2. Valve Area Survey Data Set and Coding

The unavailability and imprecision of government census data compelled us to independently collect primary data at the valve area scale. This data set was compiled in Summer 2015 based on systematic observations in the field. The same pair of researchers/surveyors observed all 233 VAs. We started by uploading the KML files for each valve area into Google My Maps. Figure A2.1 shows an example:

FIGURE A2.1

Valve Areas and Points of Observation in Google My Maps

An example of the valve areas plotted in Google My Maps for on-field observation. Each pin drop represents the point of observation for each valve area. The street names and GPS coordinates have been removed to maintain anonymity for the subdivision and its valvemen.

We then set a point of observation within each valve area, usually at a point along the longest stretch of road in the area. This was usually the main street. We dropped a pin for each point of observation and recorded its GPS coordinate. From this observation point, we counted visible residents, cars, overhead water tanks etc., for the specific valve area. We considered these variables to be clear markers of the overall socio-economic status (SES) of neighborhoods. For potential community-level variables such as the condition of the piped water network, sewage, roads and homes, we conducted extended visual assessments by traveling through all 233 valve areas.

We made three types of observations for each valve area (i.e. community-level) variable: actual counts (e.g. residents visible at the time of observation), an ordinal scale of 1 – 3 (e.g. for infrastructure condition) where 1 signified low SES and 3 signified high SES, and a descriptive category for when the variables could be neither scored nor counted (e.g. overall character of the valve area).

Our first indicator of valve area SES was the prevalence of non-commercial four-wheel vehicles, a common marker of upper-middle class households in India. From our observation point, counting the *number of cars visible* per five houses: a valve area with 0 – 1 cars visible was coded 1, 2 cars visible was coded 2, more than 2 cars visible was coded 3. If a significant portion of the area included commercial buildings and activity, we designated the area as mixed residential / commercial.

Infrastructure condition is another marker of SES in India. Therefore we counted *overhead water tanks* visible from our observation point as a measure of both robustness of the structure of the home and ability to cope with water intermittency. We coded this variable as 1 if we saw no or few overhead tanks and as 3 if we saw many. Several low-income homes with connections to piped water have taps outside their homes; we counted *outside taps* and coded these as 1 if most homes appeared to rely on outside taps, as 2 if only some homes had outside taps, and as 3 if no outside taps could be seen. Water pipes and taps that are common to several households on a street also indicate SES; we coded *common pipes* as 1 if the area had any and as 3 if there were none (i.e. all pipes led to private household taps). We also checked for the condition of the *sewage infrastructure*, as many low-income neighborhoods in India have open drains. We found no open sewage in Subdivision A.

We looked to street activity as another marker of SES, hypothesizing that densely populated neighborhoods could signal lower-income valve areas. To capture the level of street activity in a given valve area, we counted the *number of residents visible* from our observation point, always at approximately mid-day on weekdays, so that our codes would be consistent across valve areas. We counted only those people that appeared to live in the area (i.e. they were performing household chores, talking with other residents, watching their children, etc.) as opposed to those who were shop owners or were just passing by. We did not count this variable for streets that were mixed commercial / residential in character. We also made a note of the *primary languages* we heard spoken. Mostly Kannada indicated a population mostly native to Karnataka, but significant use of Tamil or Telugu indicated migrant populations. Migrant- or minority-dominated areas are often lower income.

In addition, without counting or scoring, we observed the *materials used for constructing the street* (concrete, asphalt, gravel or dirt), as well as its condition (clean or broken up). We observed and noted the *building types* in the area; "large" homes had more than two habitable stories and were wide enough to hold two rooms. We noted the mix of houses versus multi-household apartments, and whether the buildings were of mixed residential / commercial nature or were predominantly residential. We noted if there were large *religious structures* within the area (as opposed to small street-corner temples or mosques); large religious structures may be associated with a better level of water service. For similar reasons, we also noted if there were *large institutions* -- commercial, academic or government -- within or right next to a valve area boundary. These observations were not explicitly coded, but we used them as validating and contextual information when classifying the SES (or general class) of the valve areas.

Taking into account all these observations, both from our designated observation points as well as from a visual inspection while traveling through all 233 valve areas, we qualitatively categorized the valve areas by *general class*. General class, therefore, is a composite reflection of our observations, and represents our judgment of the overall socio-economic character of the neighborhood. Low socio-economic status valve areas were coded as 1, middle-level SES areas were coded as 2, and upper SES areas were coded as 3. We did not code the mixed commercial / residential valve areas. Principal components analysis to estimate correlations of the independent variables showed that general class was strongly and positively correlated with number of cars visible and number of overhead tanks, and strongly and negatively correlated with

number of residents visible (Table A.5, below). Figure A2.2 shows examples of low, middle and high SES areas:

FIGURE A2.2 (a)
Low Socio-Economic Status Areas in Bangalore, 2015

Note that even low SES areas have some "middle income" homes.

FIGURE A2.2 (b)

Middle and High Socio-Economic Status Areas in Bangalore, 2015

A3. NextDrop Notification and Supply Schedule Datasets, Subdivision A

Whenever a valveman called NextDrop's interactive voice response (IVR) system, he was identified through his phone number and the call was immediately time-stamped. The valveman entered the code for the just-adjusted valve and indicated the type of notification that the customer should receive (valve opening, valve closing, supply delay, or supply cancellation). NextDrop compared these calls to their database on the expected frequency of water supply in each valve area (e.g. every two, three, or four days). They then calculated a ratio of actual notifications to the frequency of expected notifications as a performance measure for each valveman. This measure did not indicate notification accuracy – for instance, the valveman could call in to NextDrop before or after he actually opened a valve – but it was a simple tool to let NextDrop know if the valvemen were broadly complying with their notification regime.

We downloaded the valve adjustment notification data from NextDrop's dashboard in January 2015. It includes notification data for all of Subdivision A from August to December 2014. The data fields included are date and time of notification, employee (valveman) name, call type (valve open, valve closed,

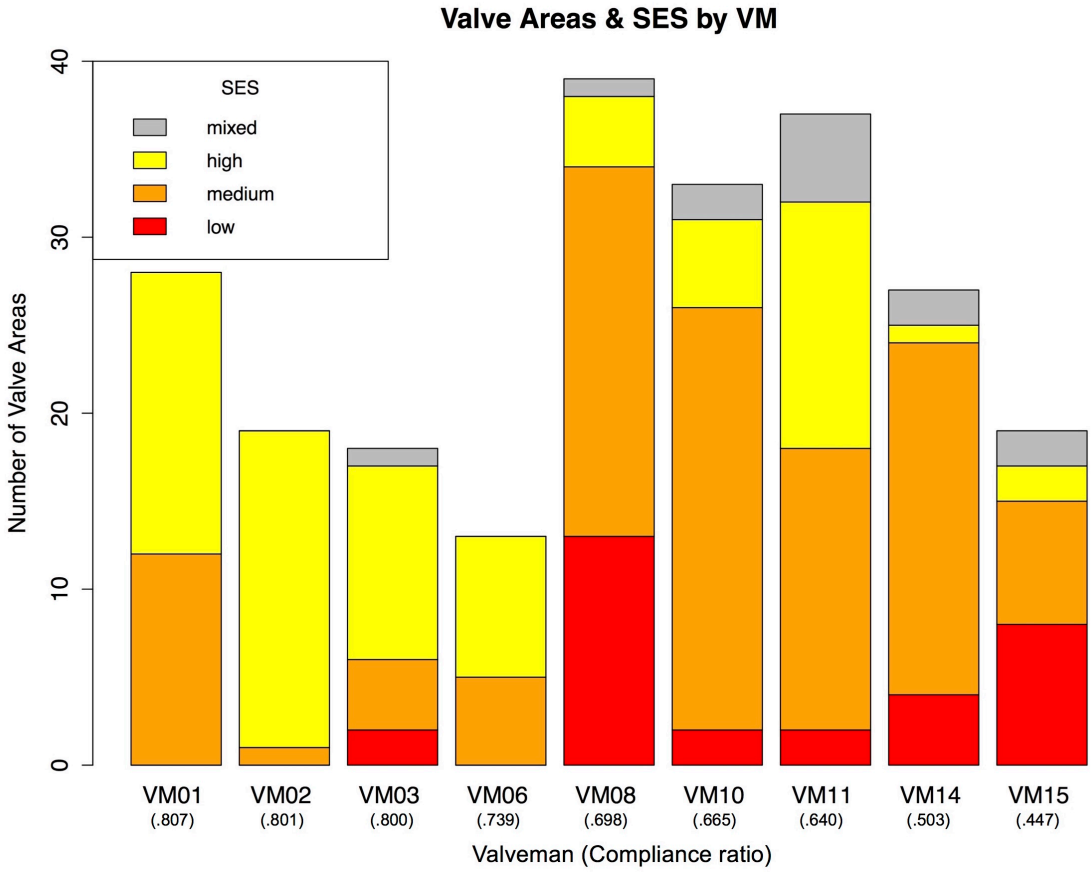
supply cancelled), city area name, valve ID number, and associated service station name. There were many fewer valve closed and supply cancelled notifications, so the valve opening time information was most useful for NextDrop's notification system; we focused our analysis on the valve opening notifications.

The water supply schedule was originally downloaded from the NextDrop dashboard in Fall 2014. It includes the valve area ID number, city area name, supply time duration, actual supply date, and supply frequency. Supply frequency is recorded as the number of days between one supply period and the next (e.g. "2" means water is supplied every 2 days). NextDrop employees originally compiled this information through contact with local service station managers, and told the research team that this was a difficult dataset to put together, since service station supervisors were hesitant to share this information with them. These two datasets were used to establish compliance levels for each valveman using the program R.

A4. Valvemen's Compliance by General Class of Valve Area

Looking more closely at community-level factors, we can analyze the general class of the valve areas serviced by each valveman. Figure A4 shows bars for each valveman ordered by level of compliance, measured as the ratio of number of notifications sent to number of notifications expected. The leftmost bar represents the valveman with the highest compliance. The Y-axis shows the number of valve areas serviced by each valveman. Each bar shows the number of valve areas managed from each general class category. The four most highly compliant valvemen (with a notification ratio above 0.70) have a majority of their valve areas categorized as "high SES" and a small number of, or no, "low SES" valve areas.

FIGURE A4
SES of Valve Areas by Valveman



Note: Nine valvemen in order (left to right) from high to low "compliance."

TABLE A5

PCA Table with Correlations among Independent Variables

Variable	PC1	PC2	PC3	PC4
Valve area compliance	-0.230	-	-	-
Overhead tanks	-	0.449	-	-
Cars	-	0.507	-	-
Residents visible	-	-0.379	-0.172	-
General class	-0.130	0.473	-0.150	-
Age	-	0.103	0.189	0.600
Valveman vehicle	-	-	0.205	-0.710
Employee status	-0.375	-0.247	0.230	0.290
Wife employment	0.425	-	-0.223	0.216
Children total	0.506	-	0.144	-
Children girls	0.473	-0.162		-
Children boys	0.338	0.249	0.402	-
Valves total	-	-	0.761	-

Notes: Loadings are after varimax rotation of the first four components of PCA analysis of the variables. The first four components have eigenvalues above one and in combination account for 75% of the cumulative variance.