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Incentivized Peer Referrals for Tuberculosis Screening: Evidence from India[†]

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We study whether and how peer referrals increase screening, testing, and identification of patients with tuberculosis, an infectious disease responsible for over one million deaths annually. In an experiment with 3,176 patients at 122 tuberculosis treatment centers in India, we find that small financial incentives raise the probability that existing patients refer prospective patients for screening and testing, resulting in cost-effective identification of new cases. Incentivized referrals operate through two mechanisms: peers have private information about individuals in their social networks to target for outreach, and they are more effective than health workers in inducing these individuals to get tested. (*JEL* H51, I12, I18, O15, Z13)

Targeted communication of accurate, actionable information about infectious diseases is essential for protecting individuals and societies. This paper studies the role of peer networks in sharing information about tuberculosis based on referral strategies that are well understood in labor market contexts and more recently applied to technology diffusion but less commonly used in public health settings.

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Tuberculosis (TB)—a highly contagious, airborne respiratory disease—is responsible for more fatalities than any other nonpandemic infectious disease; in 2018, it caused about 1.5 million deaths (World Health Organization 2019).[1] About 10.4 million people worldwide, 3 million of them in India alone, developed active TB in 2018.[2] The disease is most common among vulnerable populations in poor countries in Africa and Asia (World Health Organization 2019). Mortality from untreated TB is high—45 percent for HIV-negative and nearly 100 percent for HIV-positive individuals (World Health Organization 2019)—and the disease is highly debilitating even among those who survive it, with serious, often devastating consequences for human productivity and well-being.

Despite the high personal cost of illness and the availability of highly effective treatment that is free to patients in developing countries, a large share of those infected with TB do not receive timely diagnoses or appropriate treatment. In India, about 40 percent of TB cases are not reported to the public health authorities (Cowling, Dandona, and Dandona 2014) as would be necessary to facilitate treatment and contact tracing. Even though the symptoms of TB are widely known in India, they are also associated with other diseases including asthma, upper respiratory infections, and cancer. The efficacy of TB treatment may not be well understood, particularly by the marginalized populations who are most at risk for the disease. This implies that many individuals who have TB symptoms may underestimate the expected benefits of formal diagnosis with and treatment for the disease. Additionally, active case finding to identify TB patients has proven very costly. One reason is that even in contexts with high TB prevalence, large numbers of individuals must be screened to identify individuals with symptoms that require testing. (Hereafter, we use the term "symptomatics" to refer to individuals whose symptoms of TB are confirmed by health workers and to distinguish them from "suspects," who are individuals identified by peers as those who would benefit from testing but who have not yet been screened by health workers for the presence of symptoms.) For example, Charles et al. (2014) report findings from a large-scale study in southern India. More than 18,000 individuals were screened, resulting in the identification of 640 individuals with symptoms consistent with TB.[3]

In this work, we study whether outreach by existing patients who are benefiting from treatment of their own TB can contribute to reducing these imperfect-information problems and improving case finding. Individuals receiving appropriate medical care have information about personal and logistical aspects of TB screening, testing, and treatment based on their own experiences as patients. They are likely to have social ties to others who would benefit from testing and treatment, both because they share risk factors and because the disease is contagious. In particular, they may have connections to at-risk people who are hard for health workers to identify and

[1] There were 1.1–1.3 million TB deaths among HIV-negative people and 223,000–281,000 TB deaths among HIV-positive people; the latter are classified as HIV deaths in official reports (World Health Organization 2017).

[2] About 1.7 billion people globally are estimated to have latent TB (Houben and Dodd 2016). These individuals are infected with *Mycobacterium tuberculosis* but do not have symptoms of the disease and cannot spread the infection to others. However, without treatment, individuals with latent TB have a 5–15 percent lifetime probability of developing active TB (World Health Organization 2017).

[3] In Charles et al. (2014), the prevalence of so-called "chest symptomatics" was 2.7 percent in rural areas and 4.9 percent in urban areas.

reach in a timely manner. Existing patients might also be able to credibly vouch for the quality of the health care provider and the benefits of treatment, providing personal testimonials that could be more compelling to some prospective patients than information from health workers.[4] Thus, peer referrals can potentially complement or supplement outreach by public health workers along two dimensions: they can increase the scope and scale of outreach and improve the ability to identify and persuade at-risk individuals. Therefore, we designed an experiment to investigate the potential of peer referrals from existing patients to resolve informational barriers to screening and case detection, much as referrals are used in labor markets to identify high-quality employees.

We partnered with Operation ASHA, a nongovernmental organization (NGO) that runs Directly Observed Treatment Short Course (DOTS) centers in several cities in coordination with the Indian government's TB control program, the Revised National Tuberculosis Programme (RNTCP), to implement a randomized controlled trial of financial incentives and peer outreach strategies for identifying and testing previously unserved individuals with symptoms of TB (Goldberg, Macis, and Chintagunta 2018).[5] We randomly assigned 122 DOTS centers treating 3,176 existing patients and located across nine cities to either a control group in which new patient intake followed Operation ASHA's standard procedures, or to one of nine active case-finding strategies. Our experimental outreach strategies varied the presence and conditionality of incentives for making referrals and whether prospective patients were approached directly by TB patients in their own social networks or by health workers following up on leads generated by current TB patients. While financial incentives have been used to shape health behaviors in other contexts,[6] introducing experimental variation in the degree and nature of existing patients' engagement in outreach is a novel contribution to the literature on referrals and allows us to disentangle the effect of private information about prospective targets from the effect of information conveyed by peers.

Our results indicate that existing TB patients have valuable information about other individuals in their social networks but outside their own households who would benefit from TB screening and testing and are effective in conveying it to their peers, particularly when they are offered financial incentives. Relative to encouragement alone, financial incentives to existing patients doubled the number of new suspects who came in for screening. On average, providing incentives resulted in 1 new patient screened for every 10 existing patients, compared to 1 new patient screened for every 22 existing patients in the absence of incentives. These additional screenings were well targeted: incentives also had statistically significant effects on other measures of case finding, including the numbers of new

[4] Conveying otherwise hidden information to prospective patients makes the peer referral mechanism we study distinct from community- or network-based targeting, where the objective is typically to aggregate information from the network to share with a third party.

[5] India launched its National Tuberculosis Programme (NTP) in 1961. Later, in order to standardize TB treatment and implement the DOTS strategy, the Revised National Tuberculosis Control Programme (RNTCP) was started in 1997. Over the next nine years, it expanded across the country.

[6] See Baird et al. (2012); Kohler and Thornton (2011); de Walque et al. (2012); Thornton (2008); Kremer, Miguel, and Thornton (2009); Miller et al. (2012); and Basing et al. (2011) for examples.

suspects sent for testing on the basis of their symptoms and of those symptomatics who were actually tested.

Direct outreach by peers was more effective in identifying prospective patients for screening and ultimately finding individuals with TB than the alternative of outreach by health workers. In fact, outreach by existing patients resulted in an average of 1 new suspect screened for every 8 existing patients and 1 new symptomatic tested for every 11 existing patients. These were more than double the levels of case finding when outreach was conducted by health workers. Further, incentives strongly complemented peer outreach: on average, incentivized peer outreach resulted in 1 new patient screened for every 5.6 existing patients and 1 new symptomatic sent for testing for every 7.4 existing patients. Incentivized peer outreach also had statistically significant effects on the number of patients with active TB who were identified, and nearly all of these patients initiated treatment immediately. Incentives appear to have increased the effort that existing patients exerted in both convincing contacts to get screened for TB and identifying those contacts who were more likely to have the disease.

Because of the effectiveness of small financial incentives and the comparatively lower cost of time for existing patients than health workers, incentivized peer outreach in TB screening is highly cost effective when compared to health worker outreach. We estimate that peer outreach results in the screening of new symptomatics at 20 percent of the cost of outreach by health workers, and it identifies new TB cases at 28–38 percent of that cost.

The reach of peers extends well beyond immediate family members (who in this study were excluded by design) to include neighbors, coworkers, and friends. Incentives and peer outreach each demonstrated the potential to increase identification of marginalized patients. The prospective patients identified by current patients who received incentives for referrals were more socially and economically disadvantaged than those identified by current patients who did not receive financial incentives, and new prospective patients identified through peer outreach were more socially disconnected than those from the health worker outreach arms.

Our study demonstrates that, in its context, the necessary conditions for large-scale, community-based referral schemes to be effective in identifying patients with TB exist. Existing patients have useful information, they are able to pass that information on and to target at-risk individuals, and they are willing to do this in return for small, cost-effective payments. We emphasize the establishment of these necessary conditions in terms of existing patients' access to information and their ability and willingness to share it rather than the ability of peer referral schemes to tackle the scale of India's TB problem. Although India has the highest TB burden in the world, infection is still a relatively rare occurrence, and it would require a prohibitively large sample to identify a large number of TB-positive individuals.

Our work contributes to large literatures in economics that consider the effects of social networks on individuals' economic outcomes and behaviors (Jackson 2011). The role of peers has been documented in the context of technology diffusion, particularly in agriculture (Beaman et al. 2021; Fafchamps et al. 2020), in the targeting of social protection programs and microfinance loans (Alatas et al.

2016; Hussam, Rigol, and Roth 2022), and in the dissemination of information about a public health insurance program (Berg et al. 2019).[7] Moreover, firms that sell goods or services often rely on referrals from current customers—who have private information about quality—to market their products to new ones (Kumar, Petersen, and Leone 2010; Godes and Mayzlin 2009). Firms also use referrals to attract and screen workers (Bryan, Karlan, and Zinman 2010; Heath 2018; Kugler 2003). The potential role of referrals in attracting candidates with specific characteristics in employment settings has been measured in experimental studies in India (Beaman and Magruder 2012) and Malawi (Beaman, Keleher, and Magruder 2018), as well as in experimental and nonexperimental studies in the United States (Burks et al. 2015; Friebel et al. 2022).

Although our application shares some features with labor or product markets and with health applications that have been studied previously, our context is distinct from the settings in which referrals have been most intensively studied. First, stigma about TB may make the cost of sharing information about treatment higher than that of sharing information about jobs or products. Second, the highly contagious nature of the disease means there are public as well as private benefits to increased identification of individuals with TB. This implies that results from marketing or employment contexts may not generalize to a health context.[8] Moreover, in the context of job market referrals, referrers typically identify targets and perform the outreach, whereas the design of our field experiment allows us to disentangle these two distinct channels through which referrals may operate.[9] Our work also complements related research by Berg et al. (2019) that studies the effect of incentives paid to agents hired to disseminate information about public health insurance in southern India. Incentive pay for agents increased potential customers' knowledge of the insurance product and increased take-up. A key distinction between this context and the one we study is that in Berg et al. (2019) the health insurance product was designed to be beneficial for the entire population, whereas TB screening and testing only benefits those with symptoms of or exposure to the disease—a relatively rare (and hard to identify) population even in a high-TB burden setting. Therefore, incentives in the Berg et al. (2019) context may increase effort in the extensive and intensive margins, while incentives for outreach to TB patients affect effort along both of those dimensions and also in targeting.

[7] A growing set of studies documents the respective effects of social interactions, networks, and peers on health behaviors including obesity (Christakis and Fowler 2007), smoking (Christakis and Fowler 2008), and the use of hygiene products (Oster and Thornton 2012), as well as choices associated with HIV treatment (Balat, Papageorge, and Qayyum 2018), hospitalization (Pope 2009), and health insurance (Sorensen 2006).

[8] In labor markets, homophily might lead to undesirable outcomes from referrals by limiting diversity in hiring (Beaman, Keleher, and Magruder 2018; Hoffman 2017) or inducing nepotism (Wang 2013), which in some cases could cause referrals to have negative net welfare effects. In our context, homophily is likely to benefit disadvantaged populations because our referrer population is marginalized and thus likely to reach out to other marginalized individuals. At the same time, it is possible that excessive reliance on a referrals mechanism might disadvantage individuals who do not enjoy large social networks. This highlights the importance of analyzing, as our study does, precisely which types of individuals are recruited through the various referral schemes.

[9] We are aware of only one marketing study that contrasts the effectiveness of outreach by current customers (analogous to patients in our context) and independent agents (Godes and Mayzlin 2009). In that study, outcomes cannot be directly associated with specific individuals on either side of the interaction since the relationship being measured is between aggregate sales in a market and the total amount of word-of-mouth content spread by customers and agents in that market.

In addition to contributing to the academic literature on networks, referrals, and incentives, our study is relevant to public health policy. It is closely aligned with and designed to study potential improvements to the strategies used to fight TB by both the World Health Organization (WHO) and India's RNTCP.[10] Furthermore, other communicable diseases such as HIV/AIDS and COVID-19 present challenges related to informational barriers that are similar to those posed by TB. These diseases also disproportionately affect vulnerable, marginalized populations and, in the case of HIV/AIDS, carry social stigma. Insights from conducting outreach to TB patients may prove useful in these contexts and may even suggest strategies for using targeted information to combat newly emerging infectious diseases.

I. Context and Experimental Design

A. *Context*

Tuberculosis is a disease caused by bacteria that spread from person to person through the air. The TB bacteria attack the body—typically, the lungs—destroying tissue. Symptoms of pulmonary TB include chest pain, persistent cough, coughing of blood and phlegm, weakness and fatigue, night sweats, and weight loss. The disease is debilitating and has a high mortality rate when untreated.

Tuberculosis can be treated and cured by multidrug regimens that have been available since the 1950s. Treatment consists of several antibiotics that kill the TB bacteria; a typical treatment course for drug-susceptible TB takes six months and patients take medicines two to three times per week. The Indian government (in partnership with the WHO) provides these medicines to patients at no cost.[11, 12]

[10] To improve outreach and reduce its cost, recent WHO guidelines encourage high-TB-burden countries to incorporate community-based outreach in national campaigns to prevent and treat TB. These guidelines, called the ENGAGE-TB approach (Haileyesus Getahun et al. 2012), include a specific emphasis on the role of communities in assisting in the detection of TB, especially in its early stages. The guidelines emphasize referrals by community health workers and volunteers; the referral strategies we test in this study are consistent with the WHO recommendations. Following the recent WHO guidelines, public health scholars and practitioners have begun to explore peer referrals as a case-finding tool. Some studies focus on HIV case finding among high-risk communities (see, e.g., Glasman et al. 2016; Gwadz et al. 2017; Shangani et al. 2017), and one study considers identification of malaria cases (Faye 2012). In the context of TB, Joshi, Sthapit, and Brouwer (2017) implement a peer-led screening project in Nepal, where 30 volunteers received intensive training to perform TB screening, collect sputum samples, accompany the newly diagnosed patients to obtain treatment, and support them during treatment. Similar strategies were implemented in the Democratic Republic of the Congo (Munyanga Mukungo and Kaboru 2014; André et al. 2018). These studies, which do not include experimental control groups and are not designed to investigate mechanisms, included intensive training of groups of selected former TB or HIV patients who deployed as community health workers, often for prolonged periods of time. Methodologically, our study differs from existing research in using an RCT to identify causal impacts of various referral and incentive schemes and to distinguish between competing barriers to information sharing. Operationally, it mobilizes existing patients during the course of their treatment and requires minimal training.

[11] Laurence, Griffiths, and Vassall (2015) report that in India the cost of a full course of medication for drug-susceptible TB was $15 per patient as of 2005; on average across low-income countries, the cost was $49 per patient.

[12] Although patients typically start to feel better after taking the medicines for a few weeks, it is important to take them as prescribed and to complete the entire treatment course in order to be cured. Failure to complete the treatment not only results in failure to be cured, but it may facilitate the growth of bacteria resistant to the medicines, leading to Drug-Resistant TB (DR-TB), Multi-Drug-Resistant TB (MDR-TB), or even rarer and harder-to-treat strains.

India has the largest number of TB cases in the world and accounts for more than one-fourth of the global TB burden. The Indian Government's TB control initiative, the RNTCP, is coordinated by TB officers appointed at the district and state levels. TB services are delivered through the existing health infrastructure in which community centers serve as treatment clinics to administer DOTS to patients and monitor treatment. Nongovernmental and private providers are systematically and actively engaged under the RNTCP.

Our study partner, Operation ASHA, operates about 200 community-based DOTS centers in several cities in 11 Indian states. Operation ASHA employs community health workers, known as "providers" or "counselors," whose job description includes detection of and outreach to new symptomatics as well as monitoring drug therapy for patients in treatment. Although Operation ASHA is an NGO, it works within the existing structure of the RNTCP. When prospective patients ("suspects") are identified by Operation ASHA's health workers as presenting symptoms consistent with TB ("symptomatics"), they are directed to a government testing center for a sputum test. Those who test positive for TB enroll in one of Operation ASHA's clinics, where their medication is dispensed at no charge to them according to DOTS standards and conforming with RNTCP guidelines and protocols.[13]

B. *Experiment Setup*

Our study consisted of a randomized controlled trial implemented in 122 DOTS centers in ten cities across three states: the Delhi National Capital Region, Madhya Pradesh, and Rajasthan (Goldberg, Macis, and Chintagunta 2018). The intervention was implemented by JPAL–South Asia in five waves between January 2016 and October 2017.

We augmented Operation ASHA's established use of community health workers and DOTS treatment by incorporating various types of referrals of new suspects by existing patients. Specifically, we used a cross-randomized design to test, respectively, three types of incentives for referrals and three types of outreach to prospective TB patients (described in detail below). The baseline sample included all Operation ASHA patients receiving treatment for drug-susceptible TB who were at least two weeks into their course of medication when the baseline surveys commenced. We expanded the sample to include patients who had completed their six-month treatment in the three months before the start of the baseline surveys. Existing patients were either in the intensive phase (IP) of treatment, when they came to the clinic three times per week, or in the continuing phase (CP) of treatment (typically following IP), which required them to come to the clinic once a week.[14] In cases where the patient was a minor, the survey questions and interventions were addressed to the legal guardian. The experiment was rolled out in five waves between March 2016

[13] Patients present at the clinic to take their medication according to treatment regimen and start date. As part of the proprietary biometric monitoring system employed by Operation ASHA, counselors verify patients' fingerprints before dispensing medication. At the end of the prescribed treatment period, all patients are tested (at government testing centers) to determine whether they have been cured.

[14] Patients suffering from MDR-TB, Extremely Drug-Resistant TB (XDR-TB), or Totally Drug-Resistant TB (TDR-TB) were not included in the sample.

and October 2017. To address the possibility of spillover effects between patients, we randomized by center.[15] A total of 3,176 patients were included in our study.[16]

For treatment and control centers, each existing patient was visited by a survey enumerator in a private location, such as the patient's home. Enumerators obtained informed consent and administered a baseline survey. Information was collected about the existing patient's socioeconomic characteristics, physical and psychological health, and TB treatment, as well as on information-sharing networks. At the end of the survey, patients at treatment and control centers were prompted to think about individuals outside their households whom they believed might be affected by TB. ("Please think of people you know who have TB symptoms.") According to RNTCP protocol, immediate family members of TB patients are automatically tested for TB and as such were excluded from our referral schemes because they were already known to the system. Then, for treatment centers only, all patients were told, "We are promoting outreach for tuberculosis to encourage more people to get tested and treated, and we invite you to join this effort." They could do this by recommending TB testing for people they knew socially and believed to have symptoms; these new suspects would receive referral cards with information about the screening process. An example of the referral card distributed by existing patients is provided in Figure 1. The cards contained information about Operation ASHA, names and addresses of local providers and treatment clinics, a list of TB symptoms, and an ID number used by Operation ASHA and the research team to link the card to the referrer and to distribute incentives according to the study design. New suspects were asked to bring these referral cards to Operation ASHA centers, where they would be screened by health providers and sent for further testing (if required) per RNTCP mandates.

This process—from a suspect's arrival at an Operation ASHA health center to testing and, if necessary, treatment—was recorded in a referral register at the center that was updated with the relevant outcome at each step, including the result of the screening, whether the new symptomatic got tested, the results of the test (for symptomatics who got tested), and whether the newly identified TB-positive individual enrolled in treatment.

New suspects were always told that they had been targeted for outreach by someone who knew them personally, and shown where their information would be recorded on the card that linked them back to the contact who provided the referral. While they were asked to bring referral cards with them to Operation ASHA, they—like any other individual—could seek care at Operation ASHA (or a public

[15] The potential for spillovers across centers was much more limited. Operation ASHA chooses where to locate its centers in order to make their location as convenient as possible for patients and to spread them out geographically to maximize their total reach and minimize possible overlap between potential patient populations.

[16] The Operation ASHA patient lists we received included 4,203 patients. Of these, 3,402 (81 percent of the total) were surveyed at baseline and enrolled in the study. Reasons why some patients were not surveyed included a move to another city or district, inability to track them after three enumerator visits, or a diagnosis of MDR-, XDR-, or TDR-TB. There was no economically or statistically significant association between the proportion of listed patients who could not be surveyed at baseline and experimental conditions (see online Appendix Table B1). The baseline included 226 patients in 10 clinics who were subsequently omitted from the analysis because a change in Operation ASHA's relationship with the leadership at the government testing center in Bhubaneshwar (Odisha) meant we were not permitted to access administrative endline data for these patients.

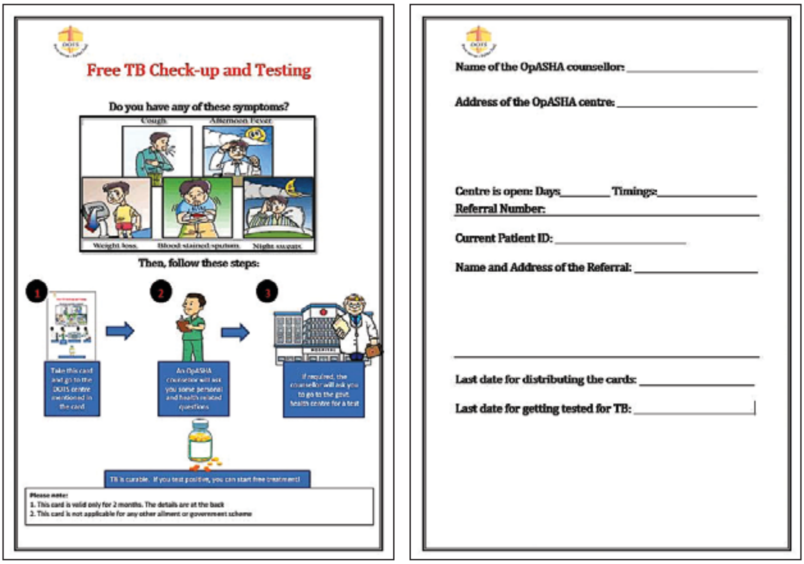

Figure 1. Sample Referral Card (English Translation)

sector facility) without providing a referral card or other documentation. Operation ASHA continued to conduct outreach, screening, and enrollment of new patients following its regular procedures throughout the duration of the study, including enrolling new patients who did not have referral cards. Any new suspect who was approached by or on behalf of an existing patient in this study but who was concerned about having their visit to Operation ASHA linked to the contact who referred them could present for screening and receive identical care without submitting the referral card.[17] To the extent that this occurred, we will underestimate the extent of case finding as a result of the outreach and incentive conditions tested in this study.

The conceptual framework that guides our experimental design is grounded in our focus on the choices of existing patients, who face potential costs and benefits from referring others for TB screening. The framework, discussed in detail in online Appendix Section A, is based on Beaman and Magruder (2012), who applied it to the more traditional context of job referrals. Here, existing patients know other people who may or may not have symptoms of TB. Existing patients decide whether to refer a given contact for screening based on the net benefit of doing so, and then the contact decides whether to respond by getting screening and following any subsequent recommendations for medical testing.

The net benefit to the existing patient has positive and negative components at the existing patient–contact dyad level, where the positive components may include the "warm glow" of helping someone improve her health, a financial exchange between the parties, or a reduction in the obligation to provide financial

[17] As described in more detail below, all new suspects were surveyed at intake by J-PAL enumerators, and the survey included questions about their perception of and experience with Operation ASHA. There were no reports of problematic interactions or negative perceptions.

support to the contact. The negative components may include stigma, time, and effort costs of making the referral. The net benefit may also include third-party financial rewards, which consist of a fixed payment for any contact who gets screened and a contingent payment if the contact is confirmed to have TB (and is therefore a high-quality referral from the perspective of the third party, which we think of as the public health sector). Both types of payments (weakly) increase the net benefit and therefore probability of referring a given contact; if the dyad-specific benefits are the same for contacts with and without TB and if symptoms of TB are at least partially observable to existing patients, then contingent payments will provide an incentive for existing patients to target contacts who have a greater probability of having TB.

Existing patients can exert effort to convince contacts of the value of TB screening, testing, and treatment. This effort increases the probability that contacts who receive referrals actually follow through by obtaining screening (and testing, if recommended by health workers). Both fixed and contingent payments increase the return to effort for existing patients, with a greater complementarity for contingent payments.

C. *Experimental Variation: Incentive Conditions*

The first type of experimental variation was in the reward offered for each new suspect who sought screening and presented a referral card linked to an existing patient. In one-third of centers there was no financial reward, only encouragement to participate for the good of the community. In another third of centers, existing patients were offered 150 rupees for each new suspect who got screened at their behest. This amount equals about $3 and is roughly equivalent to the median daily income in India.[18]

In the remaining third of centers, existing patients were offered 100 rupees for each new suspect who got screened and an additional 150 rupees if the suspect tested positive for TB. The fixed payment provided some insurance to the referrer; the size of the fixed payment and the bonus was calibrated such that the conditional and unconditional incentives were of equal expected value based on the rate of positive tests in a pilot study conducted between June and September 2012. As we will show, these turned out to be roughly the same in the full study.[19]

Our conceptual framework illustrates that while both fixed and contingent payments will increase the probability that an existing patient refers a given contact for TB screening, if the costs of referring someone with and without symptoms of TB are the same, then contingent payments will improve the quality of referrals relative to fixed payments.

[18] Diofasi and Birdsall (2016) report median daily incomes of $2.50 in rural India and $3.50 in urban India.

[19] Note that while all incentive treatments designate financial rewards to be paid to the existing patient, it is possible that existing patients and the new suspects they identified chose to divide the money between themselves according to a sharing rule of their own selection. This does not undermine our research design; such side payments are simply an element of the social reward that forms part of the expected benefit (or cost) of making a referral. The policy-relevant estimate of the effect of incentives allows for side payments to take place naturally at the discretion of existing patients and new suspects.

D. *Experimental Variation: Outreach Conditions*

The second type of experimental variation was in the modality of the referral itself. We compare peer outreach to two types of outreach facilitated by health workers. In the one-third of centers assigned to the peer outreach conditions, referral cards were given to existing patients. They were asked to approach people they knew socially and believed to have TB symptoms, inform them about TB's consequences and treatment, give them cards, and encourage them to get tested. Existing patients had up to 30 days to deliver the cards, and new suspects had an additional 30 days to present themselves at an Operation ASHA center for screening.[20] Existing patients were told they were free to request additional cards, if needed; this was done to avoid creating a perception of scarcity that might have resulted in different opportunity costs of providing cards in the various experimental conditions.

In the health worker outreach conditions, existing patients were asked to provide names and contact information for people in their social network who might benefit from getting tested for TB so that a health worker could follow up by visiting these individuals.[21] Existing patients were shown the referral cards and told that the Operation ASHA health worker would deliver the cards to the people they named. As in the peer conditions, existing patients were told they had 30 days to provide names and the new suspects were to present for screening within 30 days after receiving cards from a health worker.

Half of the health worker outreach centers were assigned to the "referrer-identified" condition, in which existing patients were told their names would be used when the health worker approached new suspects on their behalf; the specific language was, "I have come to see you because [name], who cares about you, asked me to visit." Like the peer outreach condition, the referrer-identified condition carries a risk of stigma because the current patient is revealed to be associated with a TB treatment organization, and that association would otherwise be hidden in the normal course of business because it is thought by patients and staff at Operation ASHA to raise suspicions of infection. The remaining health worker outreach centers were assigned to the "anonymous" condition, in which existing patients were told their names would not be revealed to the individuals they referred. Instead, health workers would tell the new suspects, "I have come to see you because someone who cares about you asked me to visit."

To ensure that existing patients in the peer outreach conditions received the same level of priming as those in the health worker outreach conditions, patients in the peer outreach conditions were also asked to provide names and contact information for people they knew who might benefit from getting screened for TB.[22]

[20] A new suspect who arrived outside the 60-day window would still be screened, tested, and treated if necessary, but the existing patient would not receive credit for the referral per study protocols.

[21] Contact information could be an address, instructions about how to reach a contact's home, a phone number, or other information available to existing patients that would enable health workers to visit their contacts. This flexibility was intended to reduce barriers to making referrals.

[22] Of course, patients in the peer outreach conditions were not limited to reaching out to the contacts they named. As shown in Appendix Table B6, patients in the peer outreach conditions initially listed fewer names than those in the health worker outreach arms. However, they made more referrals than the names they provided at baseline.

While effort by peers is an outcome of the study, we monitored the Operation ASHA health workers closely to ensure they visited all the contacts named by the existing patients. Compliance was high: 87.5 percent of new suspects named in the health worker outreach arms were visited by Operation ASHA staff (85 percent in the encouragement arms and 88.4 percent in the incentivized arms).

This experimental variation in outreach strategy corresponds to the social and economic costs of a referral. Peer referrals carry two types of costs: the time cost of the interaction itself and the stigma cost of revealing one's own TB status to a peer (and hinting that the peer might have TB). Referrer-identified outreach by health workers eliminates the time cost to the existing patient (and shifts it to a health worker) but, because the health worker explicitly names the peer who provided the referral, it maintains the stigma cost. Anonymous outreach by health workers carries neither time nor stigma cost at the margin for the existing patient. In both conditions, however, the new suspect might incur a psychological cost from inferring that someone in their social network (named or not) believes that they might have an infectious disease.

Making referrals may also entail a social benefit. It is unclear how to rank the treatments in terms of their social benefits to existing patients. Existing patients may experience a "warm glow" from helping others even if their contribution is anonymous. Or, they may feel greater satisfaction—or receive gratitude from their peers—for in-person or identified outreach strategies. Since peer referrals may have higher costs and benefits than identified or anonymous heath worker outreach, the question of which strategy will generate more referrals is an empirical one.

In the public health context, the quality of information conveyed to new suspects is paramount. Health workers and peers may differ in the content of the information they convey and in the credibility with which the information is perceived. On one hand, health workers may be better informed about symptoms and treatment of TB, and their expertise may be respected by prospective patients. On the other hand, existing patients are able to provide firsthand testimonials about the experience and benefits of treatment from a patient's perspective. Furthermore, because existing patients are asked to speak to people they know personally and believe to have symptoms of TB in the peer outreach condition, the personal connection may also build trust and enhance the value of the information exchanged. In the health worker outreach conditions in which the identity of the referring existing patient is revealed, some of that credibility may be recovered through the endorsement.

The final design thus randomly assigned 122 clinics to a pure control condition or one of nine treatment conditions. Table 1 summarizes the research design and indicates how many clinics and patients were assigned to the pure control condition and to each of the nine treatment conditions.[23]

[23] We had originally planned equal-sized arms both in terms of the number of centers and the average number of original patients per center. Figure 1 shows that the number of centers ranged from 10 to 14 across arms. The reason for this variation is that the randomization was done by wave and the number of centers available at the start of each wave varied. Centers also varied in size, and although we stratified on city we did not have sufficient centers in each wave to also be able to stratify on center size. The average center had 26 original patients (SD $=$ 19.4). Treated centers had about seven more patients on average than control centers ($p = 0.13$), but there were no economically or statistically significant differences in the number of original patients across incentive conditions and outreach conditions (see online Appendix Table B2). There were no differences across experimental arms in original patient

Table 1—Experimental Design and Sample Sizes

Pure control 10 clinics 189 patients	Outreach type: Health worker outreach (anonymous)	Health worker outreach (identified)	Peer outreach
Incentive type			
Encouragement	11 clinics 331 patients	13 clinics 300 patients	14 clinics 361 patients
150 rupees unconditional	11 clinics 336 patients	13 clinics 436 patients	14 clinics 252 patients
100 rupees + 150 rupees if TB positive	10 clinics 259 patients	13 clinics 352 patients	13 clinics 360 patients

E. *Incentivized Elicitation of Outreach Effort*

After responding to the endline survey (see next section for details on data collection), participants were offered the opportunity to return unused referral cards to the enumerators for a payment of ten rupees per card. This provided an incentive-compatible measure of how many cards were not distributed in contrast to simply asking respondents, who may exaggerate the number of cards distributed because of experimenter demand effects. By combining this measure of the number of cards not distributed with administrative data about the number of cards brought to Operation ASHA providers, we were able to compute the number of cards distributed by existing patients but not redeemed by suspects—information that helped us identify the nature of the barriers to referrals and testing (see Section IID below). Patients were not told about the card buyback in advance in order to prevent strategic or risk-averse behavior with regard to card distribution.

II. Data and Results

A. *Data*

Our analysis combines administrative data from Operation ASHA with two rounds of surveys of existing patients and the new suspects they identified (Goldberg, Macis, and Chintagunta 2022). The administrative data include rosters of baseline patients and new suspects (collected as part of the normal outreach and enrollment procedures), ID numbers for existing patients who referred each new suspect, and information on treatment adherence for all patients. Baseline surveys of existing patients measured their socioeconomic characteristics, physical and psychological health, risk- and information-sharing networks, and attitudes toward Operation ASHA and TB treatment. After the intervention, endline surveys were conducted

attrition at baseline (see online Appendix Table A1) and, as described in detail below, the samples are balanced on observables. Moreover, as shown in the Appendix and discussed below, the results are robust to weighing observations by the inverse of the number of original patients per center, and center-level regressions find very similar effects as at the original patient level. This suggests that there was no interaction between treatment and unobserved characteristics that are correlated with center size.

with existing patients to capture information on health outcomes and satisfaction with Operation ASHA. Intake surveys were also administered to the new suspects identified through the schemes: these measured their characteristics and history of care for TB.

B. *Patient Characteristics and Balance Tests*

Online Appendix Tables B3 and B4 provide the means and standard errors of existing patients' baseline characteristics overall as well as by incentive condition and outreach type. As a result of working with a large provider operating in multiple states, our sample is not only large but also heterogeneous on many sociodemographic dimensions. The average existing patient in the study was approximately 37 years old, and about 40 percent of baseline patients were women. (The World Health Organization [2017] reports that 65 percent of new incident TB cases are male.). Eighty-three percent of the respondents had never been treated for TB before receiving care at Operation ASHA.

Online Tables B3 and B4 show that the randomization resulted in patients having similar characteristics across experimental conditions. To formally test for balance, we implemented omnibus balance tests that compared pairs of experimental conditions using linear probability models. The p-value for the F-test for the comparison between any treatment group (pooling across the nine treatment arms) and the pure control group is 0.449. We also compared the probability of assignment to each of the three incentive treatments (separately) relative to the control group and to the other incentive treatments, and to each of the three outreach treatments (separately) relative to the control group and to the other outreach treatments. The p-values for the F-tests that the covariates included in online Appendix Tables B3 and B4 jointly predict assignment are reported in online Appendix Table B5. Of 12 tests, two p-values are less than 0.05. While our preferred specifications mirror the experimental design in including only city fixed effects, the magnitudes and statistical significance of our estimates are virtually unchanged by the inclusion of the baseline covariates from online Appendix Tables B3 and B4 or, alternatively, covariates selected using the double-lasso procedure described in Belloni, Chernozhukov, and Hansen (2014).[24]

C. *Overview of Aggregate Outcomes*

Although our experiment is designed to measure the effects of various referral schemes on individual patients' behaviors, we begin by presenting the aggregate outcomes of the study. A total of 216 new suspects were screened by Operation ASHA health workers as part of this study in the nine experimental conditions combined. (These individuals constitute the "referrals" discussed in subsequent analysis.) Of these, 170 (78.7 percent) presented symptoms consistent with TB and were sent for testing at the government testing centers; we follow Operation ASHA and

[24] Details on the double-lasso procedure are provided in Section IID, and results from these alternative specifications are reported in the online Appendix (Tables B11 and B12).

call them "symptomatics." Compared to other case-finding efforts in India, this effort identified a large number of symptomatics, especially relative to the scale of outreach. As noted earlier, Charles et al. (2010) conducted outreach to 18,417 individuals and found 640, or 3.5 percent, had symptoms consistent with TB.

In our study, 123 of these symptomatic individuals subsequently presented themselves for testing at a government center. Thirty-five were found to have active TB, of whom 34 began treatment immediately. All were previously unknown to the TB treatment system. Because of the study's stringent requirements, none were immediate family members of the existing patients who referred them, so they were not likely to be located through health worker outreach by Operation ASHA or government labs under existing protocols. Prospective patients screened in the health worker outreach conditions were neighbors (47 percent), relatives (42 percent), and friends or coworkers (11 percent) of the existing patients who referred them. The corresponding percentages in the peer outreach conditions were 46 percent, 34 percent, and 20 percent, respectively.[25] The 28 percent infection rate of the new symptomatics who were identified and tested through our referral schemes is more than twice as large as the 12 percent average TB-positive rate reported in official RNTCP statistics. (The average rates in the states where we conducted our study were 14 percent in Delhi and Madya Pradesh and 17 percent in Rajasthan.)[26]

D. *Analysis*

We study existing patients' responses to incentives and their efficacy as outreach agents by matching new suspects who were screened and tested to the existing patients who referred them through the unique ID codes embedded in the referral cards. We report four nested outcomes, each an integer value and measured at the level of the existing patient.

First, we measure the total number of new suspects who were linked to an existing patient and who presented themselves for screening at the Operation ASHA centers. Second, we measure the number of these suspects who were subsequently sent for testing (the number of "symptomatics"). This distinction is important because it indicates whether the referral strategies in this experiment resulted in targeted testing of symptomatic individuals or whether existing patients were unable (or unwilling) to distinguish between peers with symptoms of TB that warranted testing and those without. As part of its partnership with the RNTCP, Operation ASHA routinely screens prospective patients and sends those with symptoms indicative of TB for testing at government-designated microscopy centers (DMCs). It played the same gatekeeping role in screening prospective patients identified through our referral schemes. Third, we measure the number of symptomatics who actually were tested, as testing is a necessary condition

[25] The provision of incentives did not have any statistically significant effects on the relationship between referrer and referee.

[26] In a study in Nepal that used peer volunteers to identify TB cases (Joshi, Sthapit, and Brouwer 2017), 6,046 suspects were tested over a period of 16 months resulting in 287 TB diagnoses, or 4.3 percent.

to obtain treatment but requires effort by symptomatics (who have to report to a DMC) and represents a critical juncture for loss to follow-up. Finally, we measure and report the number of positive cases of TB attributed to the outreach of each existing patient in the sample.

Note that we instituted procedures to capture any peer referrals made by existing patients of pure control centers. Operation ASHA health workers at all centers kept a record of the source of each new suspect screened during the intervention period. But in practice, and in accordance with the extremely low rate of peer referrals that motivated this study, all outcomes equal zero for existing patients in the pure control group.

Note also that our outcome variables are the union of behavior by existing patients—who decide whom to approach or to have contacted by a health worker, how much effort to exert, and what information to share—with the behavior of new suspects, who decide whether to follow up to be screened and, when recommended, tested. Each of the referral modalities we consider has advantages and disadvantages to existing patients and new suspects. Our approach is to test the relative performance of each type of referral using reduced-form specifications that capture the total effects of the ways these strategies differ in costs, benefits, and information provided. Nonetheless, a comparison of the effects of various incentive types and outreach modalities provides information about the mechanisms through which referrals may (or may not) prove valuable in this context.

Financial Incentives.—To measure the effect of incentives on referrals generated by existing patients, we use OLS to estimate linear models of the form

$$(1) \qquad y_{ijc} = \alpha + \beta_1 Encouragement_{jc} + \beta_2 Conditional_{jc} + \beta_3 Unconditional_{jc} + \Gamma_c + \epsilon_j,$$

where i indexes existing patients, j are clinics (the level of treatment), and c are cities. Γ_c are city fixed effects, which absorb state and wave fixed effects (randomization was stratified by city). The omitted category in this specification is pure control clinics, so β_1 is the effect of encouraging existing patients to make referrals relative to the status quo, β_2 is the effect of offering existing patients 100 rupees for each new patient screened at their recommendation plus a 150-rupee reward for any referrals who tested positive for TB (corresponding to $f_i = 100$ and $p_i = 150$), and β_3 is the effect of offering existing patients 150 rupees for any new patient screened at their recommendation, regardless of test outcome ($f_i = 150$ and $p_i = 0$). We also report the estimated effect of financial incentives relative to encouragement (and the p-value for the tests in which $\beta_1 = \beta_2$ and $\beta_1 = \beta_3$) and compare the conditional and unconditional incentive structures (reporting the p-value for the test that $\beta_2 = \beta_3$). Recall that treatment is assigned at the center level; standard errors are therefore clustered at the center level. Additionally, we report p-values adjusted for testing 12 hypotheses (three coefficients and four outcomes) using the false-discovery-rate methodology of

Table 2—Effects of Financial Incentives on TB Screening and Detection

	Patients screened (1)	Tests recommended (2)	Patients tested (3)	Positive tests (4)
Encouragement	0.044	0.030	0.024	0.003
	(0.018)	(0.015)	(0.014)	(0.003)
	[0.090]	[0.194]	[0.274]	[0.410]
	{0.024}	{0.092}	{0.103}	{0.557}
Unconditional incentive	0.096	0.080	0.057	0.013
	(0.025)	(0.020)	(0.015)	(0.006)
	[0.002]	[0.001]	[0.002]	[0.107]
	{0.037}	{0.030}	{0.008}	{0.192}
Conditional incentive	0.102	0.078	0.058	0.005
	(0.031)	(0.028)	(0.021)	(0.006)
	[0.013]	[0.044]	[0.053]	[0.410]
	{0.135}	{0.185}	{0.169}	{0.446}
Observations	3,176	3,176	3,176	3,176
R^2	0.01	0.01	0.02	0.02
Mean of dep. var. in control group	0.00	0.00	0.00	0.00
p-value: treatments jointly 0	0.00	0.00	0.00	0.07
Point estimate of differences between treatment arms				
Encouragement-unconditional	0.052	0.050	0.032	0.010
	(0.024)	(0.020)	(0.014)	(0.006)
	{0.031}	{0.013}	{0.015}	{0.113}
Encouragement-conditional	0.058	0.048	0.034	0.003
	(0.035)	(0.031)	(0.022)	(0.007)
	{0.059}	{0.074}	{0.084}	{0.689}
Conditional-unconditional	0.007	−0.002	0.001	−0.008
	(0.033)	(0.028)	(0.019)	(0.008)
	{0.862}	{0.940}	{0.951}	{0.404}

Notes: "Patients screened" (column 1) is the number of new suspects who meet with an Operation ASHA counselor after receiving a referral card. "Tests recommended" (column 2) is the number of new suspects who are observed by Operation ASHA counselors to have symptoms of active TB and are therefore told to report to a government center for testing. "Patients tested" is the number of new suspects who obtain a test at a government testing center. "Positive tests" is the number of new suspects who have a positive sputum test result. The unit of observation is the existing patient. Linear models are estimated by OLS, including city fixed effects. The sample includes all current patients. The omitted category is patients in pure control clinics. Standard errors are clustered at the center level and reported in parentheses. Top panel: False-discovery rate corrected q-values (based on Benjamini and Hochberg 1995) are in square brackets, and randomization inference p-values (based on 2,000 random permutations) are in curly brackets. Bottom panel: standard errors for point estimates of differences between treatment arms are in parentheses, and randomization inference p-values (based on 2,000 random permutations) are in curly brackets. The randomization inference p-values were computed using the STATA command ritest (Hess 2017).

Benjamini and Hochberg (1995) and randomization inference p-values based on 2,000 permutations (Hess 2017).[27,28]

While encouragement without financial reward does increase referrals relative to the pure control condition, the results from the main OLS specifications reported in Table 2 clearly indicate that financial incentives matter. From column 1, patients at clinics assigned to the encouragement arm referred 0.044 new suspects, on average.

[27] We construct p-values for one pairwise comparison at a time, holding the assignment to other arms fixed. We implement this using the Stata command ritest provided by Hess (2017).

[28] As we discuss in Section IID, our results and conclusions are robust to a set of alternative specifications in which we include baseline covariates, weigh observations based on the size of Operation ASHA centers at baseline, or estimate our models using aggregate, center-level outcomes.

Patients eligible for conditional incentives referred 0.102 new suspects, and those eligible for unconditional incentives referred 0.096 new suspects. The p-value for the difference between encouragement and the conditional incentive is 0.09, and the p-value for the difference between encouragement and the unconditional incentive is 0.03. While money matters, conditionality apparently does not: the p-value for the test that the conditional and unconditional incentives have equal effect is 0.84. The pattern persists in other measures of referrals, including the number of new suspects recommended for testing (column 2) and the number of symptomatics actually tested for TB (column 3). In particular, note that the vast majority of suspects identified through this scheme were sent for testing, indicating that existing patients were able and willing to identify individuals with TB symptoms warranting testing. We find similar patterns when we consider positive TB tests (column 4) even though the results are less precise because this outcome variable is defined more granularly and with correspondingly lower variation. As noted in Section IIC, more than one-quarter (28 percent) of the new suspects identified through any of the treatment arms who were tested were ultimately diagnosed with TB, a higher rate than in the public sector in India during the same time period. As shown in column 4 of Table 2, existing patients in the unconditional incentive treatment group identified 0.013 new TB patients, on average, whereas existing patients in the conditional incentive treatment group identified 0.005 new TB patients. (The p-value for the test that the effect of the two incentive treatments is jointly zero is 0.04.)[29] The estimated effects of unconditional incentives remain statistically significant even after adjustment for multiple-hypothesis testing or when using randomization-based p-values for suspects screened, tests recommended, and symptomatics tested (but not for positive tests). The estimated effects of conditional incentives are statistically significant after adjusting for multiple-hypothesis testing but not significant based on the randomization-inference p-values.

These results indicate that existing patients respond to encouragement—and especially to financial incentives—to share information about screening for a communicable disease. Screening, testing, and identification of TB patients are all measures of welfare in a context with a high disease burden, where it is important to either diagnose TB or rule it out as a cause of illness. Behavioral responses by existing patients, who can identify more new suspects when offered a financial incentives to do so, translate into small but economically meaningful and statistically significant increases in case finding.

Outreach Strategies.—The second set of existing patient-level analyses focuses on the effects of peer outreach and two variants of health worker outreach, identified and anonymous, relative to a pure control condition. While the analysis in Section IID is similar to the analysis of referrals in labor market contexts, this

[29] In the encouragement group, existing patients were responsible for detecting an average of 0.003 cases of TB. The difference between the encouragement group and the unconditional group is significant at the 90 percent confidence level ($p = 0.09$), and the difference between the encouragement group and the conditional incentive group is not significant at conventional levels ($p = 0.30$).

Table 3—Effects of Outreach Type on TB Screening and Detection

	Patients screened (1)	Tests recommended (2)	Patients tested (3)	Positive tests (4)
Peer outreach	0.124	0.092	0.058	0.010
	(0.030)	(0.025)	(0.018)	(0.004)
	[0.001]	[0.003]	[0.011]	[0.061]
	{0.054}	{0.107}	{0.123}	{0.294}
Health worker outreach, identified	0.054	0.042	0.035	0.004
	(0.016)	(0.014)	(0.013)	(0.004)
	[0.011]	[0.021]	[0.053]	[0.302]
	{0.004}	{0.003}	{0.008}	{0.429}
Health worker outreach, anonymous	0.056	0.049	0.043	0.005
	(0.020)	(0.019)	(0.018)	(0.005)
	[0.040]	[0.053]	[0.061]	[0.302]
	{0.081}	{0.124}	{0.123}	{0.456}
Observations	3,176	3,176	3,176	3,176
R^2	0.02	0.01	0.02	0.02
Mean of dep. var. in control group	0.00	0.00	0.00	0.00
p-value: treatments jointly 0	0.00	0.00	0.01	0.09
Point estimate of differences between treatment arms				
Peer-identified	0.070	0.050	0.024	0.006
	(0.027)	(0.023)	(0.014)	(0.006)
	{0.033}	{0.083}	{0.217}	{0.423}
Peer-anonymous	0.068	0.043	0.015	0.005
	(0.031)	(0.027)	(0.019)	(0.006)
	{0.073}	{0.206}	{0.513}	{0.489}
Anonymous-identified	0.002	0.007	0.008	0.001
	(0.018)	(0.017)	(0.014)	(0.007)
	{0.891}	{0.652}	{0.554}	{0.901}

Notes: "Patients screened" (column 1) is the number of new suspects who meet with an Operation ASHA counselor after receiving a referral card. "Tests recommended" (column 2) is the number of new suspects who are observed by Operation ASHA counselors to have symptoms of active TB and are therefore told to report to a government center for testing. "Patients tested" is the number of new suspects who obtain a test at a government testing center. "Positive tests" is the number of new suspects who have a positive sputum test result. The unit of observation is the existing patient. Linear models are estimated by OLS, including city fixed effects. The sample includes all current patients. The omitted category is patients in pure control clinics. Standard errors are clustered at the center level and reported in parentheses. Top panel: False discovery rate corrected q-values (based on Benjamini and Hochberg 1995) are in square brackets, and randomization inference p-values (based on 2,000 random permutations) are in curly brackets. Bottom panel: standard errors for point estimates of differences between treatment arms are in parentheses, and randomization inference p-values (based on 2,000 random permutations) are in curly brackets. The randomization inference p-values were computed using the STATA command ritest (Hess 2017).

section explores a margin of referrals not discussed in the job referrals literature that is potentially especially important in a health context.

As in the previous section, we pool across treatment arms to estimate regressions of the form

$$(2) \qquad y_{ijc} = \alpha + \gamma_1 Peer_{jc} + \gamma_2 Identified_{jc} + \beta_3 Anonymous_{jc} + \Lambda_c + \mu_j.$$

We find that any peer-facilitated outreach is more effective than the status quo; 10 of the 12 coefficients reported in Table 3 are significantly different from zero, and we reject that the joint effect of the three treatment arms is equal to zero for all four outcomes. Peers are more effective than health workers at inducing the new suspects to get screened and tested, even though the suspects approached in both health worker outreach arms are identified by existing patients. The interaction between an existing patient and a suspect increases the probability of screening and testing. Existing patients who were asked to recruit new suspects directly through peer outreach induced an average of 0.124 new suspects to report for screening compared to 0.054 for those approached by health workers on behalf of a named peer ("health worker outreach, identified") or 0.056 for those approached by health workers on behalf of an unnamed peer ("health worker outreach, anonymous"). The *p*-values for the differences between peer outreach and the two health worker outreach arms are 0.01 and 0.03, respectively. The estimated effects on the number of referrals are statistically significant even after adjustment for multiple-hypothesis testing or when using randomization-inference *p*-values. There is no economic or statistically significant difference between the anonymous and identified outreach modalities. The three treatments are comparable in their efficacy in increasing the number of symptomatics tested. Peer referrals have a statistically significant effect (at the 95 percent level) on the number of TB cases found (0.010 per existing patient in the peer outreach arm), but differences with respect to the health worker outreach arms are estimated imprecisely.

Peer outreach results in the screening of twice as many new suspects as outreach by health workers, despite the additional transaction costs borne by existing patients in the peer outreach conditions. This suggests peers are more effective at conveying information about the benefits of treatment to convince suspects to seek health counseling, an intuition that is confirmed by the analysis of complementarities between financial incentives and peer outreach as well as by the discussion in Section IID.

Complementarities between Incentives and Outreach Modalities.—Next, we investigate whether there are complementarities between incentives for referrals and outreach modalities. Peer outreach is more costly to existing patients than providing names to health workers because of the time and effort required to perform outreach activities as well as the social cost of interacting with others to discuss a potentially uncomfortable subject. Therefore, we hypothesize that incentives might be more effective under the peer outreach modality.

Because the results in Section IID indicate no economically or statistically meaningful differences in the conditionality of incentives or the anonymity of health worker outreach, we test for complementarities between financial incentives and peer outreach by pooling the two incentive types and the two health worker outreach variants to estimate the following regression:

$$y_{ijc} = \alpha + \psi_1 no\$Peer_{jc} + \psi_2 no\$Health\ worker_{jc} + \psi_3 \$Peer_{jc} + \psi_4 \$Health\ worker_{jc} + \Gamma_c + \epsilon_j, \quad (3)$$

where *no*\$ denotes conditions with no incentives and \$ indicates groups with incentives.

The results from this exercise, shown in Table 4, indicate strong complementarities between financial incentives and peer outreach. Each existing patient in the peer

Table 4—Complementarities between Peer Outreach and Financial Incentives on TB Screening and Detection

	Patients screened (1)	Tests recommended (2)	Patients tested (3)	Positive tests (4)
Peer outreach, no financial incentive	0.036	0.023	0.017	−0.001
	(0.023)	(0.020)	(0.016)	(0.003)
	[0.623]	[0.623]	[0.623]	[0.846]
	{0.081}	{0.158}	{0.142}	{0.786}
Health worker outreach, no financial incentive	0.048	0.034	0.028	0.005
	(0.020)	(0.017)	(0.016)	(0.004)
	[0.169]	[0.381]	[0.562]	[0.623]
	{0.079}	{0.208}	{0.194}	{0.535}
Peer outreach, financial incentive	0.178	0.135	0.084	0.017
	(0.044)	(0.038)	(0.026)	(0.007)
	[0.001]	[0.008]	[0.017]	[0.170]
	{0.029}	{0.052}	{0.044}	{0.142}
Health worker outreach, financial incentive	0.063	0.054	0.046	0.006
	(0.017)	(0.016)	(0.015)	(0.004)
	[0.006]	[0.011]	[0.030]	[0.623]
	{0.005}	{0.010}	{0.019}	{0.313}
Observations	3,176	3,176	3,176	3,176
R^2	0.02	0.02	0.02	0.02
Mean of dep. var. in control group	0.00	0.00	0.00	0.00
Point estimate of differences between treatment arms				
Peer incentives − peer encouragement	0.142	0.112	0.067	0.018
	{0.015}	{0.034}	{0.037}	{0.055}
Health worker outreach incentives − health worker outreach encouragement	0.015	0.020	0.017	0.001
	{0.399}	{0.211}	{0.248}	{0.894}
Peer encouragement − health worker outreach encouragement	−0.012	−0.011	−0.012	−0.005
	{0.688}	{0.734}	{0.658}	{0.459}
Peer incentives − health worker outreach incentives	0.115	0.080	0.038	0.011
	{0.002}	{0.014}	{0.072}	{0.150}

Notes: "Patients screened" (column 1) is the number of new suspects who meet with an Operation ASHA counselor after receiving a referral card. "Tests recommended" (column 2) is the number of new suspects who are observed by Operation ASHA counselors to have symptoms of active TB and are therefore told to report to a government center for testing. "Patients tested" is the number of new suspects who obtain a test at a government testing center. "Positive tests" is the number of new suspects who have a positive sputum test result. The unit of observation is the existing patient. Linear models are estimated by OLS, including city fixed effects. The sample includes all current patients. The omitted category is patients in pure control clinics. Standard errors are clustered at the clinic level and reported in parentheses. Top panel: False discovery rate corrected q-values (based on Benjamini and Hochberg 1995) are in square brackets, and randomization inference p-values (based on 2,000 random permutations) are in curly brackets. Bottom panel: standard errors for point estimates of differences between treatment arms are in parentheses, and randomization inference p-values (based on 2,000 random permutations) are in curly brackets. The randomization inference p-values were computed using the STATA command ritest (Hess 2017).

outreach conditions produced, on average, 0.178 new suspects (significantly different from zero in the control group at the 99 percent level) when incentives were provided, compared to 0.036 (not statistically significant) in the absence of incentives. The p-value for the test that peer outreach is equally effective with and without incentives is 0.01. Similar patterns are observed for the other outcome variables, with incentives significantly enhancing the effect of peer outreach on the number of new symptomatics recommended for testing, the number of symptomatics actually tested, and the number of new TB cases detected. The effects on the numbers of referrals remain statistically significant at the 95 percent level even after adjustment for multiple-hypothesis testing or when using randomization-based *p*-values. Existing patients in the incentivized peer outreach conditions identified, on average, 0.017 new TB patients (significantly different from zero in the control group at the 95 percent level), and the *p*-value for the test that incentivized and nonincentivized peer outreach are equally effective at identifying TB-positive cases is 0.05.

In contrast, the estimated effects of health worker outreach are similar with and without financial incentives. For example, each patient in the health worker outreach conditions resulted in 0.063 new suspects screened with incentives (significantly different from zero at the 95 percent level) and 0.048 new suspects screened without incentives (significant at the 99 percent level). For all four outcomes, we cannot reject that outreach by health workers is equally effective when implemented with and without financial incentives. Moreover, the differential effectiveness of peer outreach relative to health worker outreach is driven by the interaction with financial incentives.

Alternative Specifications.—All of the specifications described above are robust to including the patient-level covariates from the balance tests (online Appendix Tables B8 and B9) as well as covariates selected using the double-lasso procedure described by Belloni, Chernozhukov, and Hansen (2014) (online Appendix Tables B11, B12, and B13). This three-step procedure first uses lasso to select controls that are correlated with treatment assignment from among 3,067 baseline variables in our sample; second, it uses lasso to select additional controls that predict the outcome variable; and third, it estimates our models via OLS, including all of the selected controls. We implement this procedure using the Stata 16 command "dsregress," selecting controls separately for each of the four outcomes of interest and including city fixed effects as unpenalized regressors. The pattern of results from the main specifications holds. Specifically, including lasso-selected controls, financial incentives have statistically and economically significant effects on screening and testing that are statistically different from the effect of encouragement alone, and peer outreach has statistically and economically significant effects on screening and testing that are approximately twice as large as—and statistically distinguishable from—the effects of either type of health worker outreach. The complementarity between peer outreach and financial incentives also holds, with point estimates and patterns of statistical significance very similar to those in our main specification with no baseline covariates.

In the online Appendix, we also report results from weighted regressions where each observation is weighted by the inverse of the number of original patients per center (online Appendix Tables B14–B16). Further, we reestimate our models at the center level, where outcomes are center-level averages and regressions account for different sizes of clinics (online Appendix Tables B17–B19). The magnitude and statistical significance of the main estimated coefficients of interest are largely unchanged in these alternative specifications.

Effort by Existing Patients.—Existing patients could exert effort through screening potential referees, contacting them (the extensive margin), or by convincing them to get tested. While we cannot fully separate those channels, data about the number of potential contacts named at the outset of the intervention, the number of cards distributed in the peer outreach arms, and the conversion rate from screening to testing help us understand these mechanisms. At the onset of the intervention, existing patients in all outreach arms—including peer outreach—were asked to provide the names and contact information of people they would contact or who should be contacted by health workers. In the health worker outreach arms, knowing that health workers were responsible for outreach, 11.09 percent of existing patients who were not offered financial incentives and 11.35 percent of existing patients who were offered incentives provided at least one name (see online Appendix Table B6). In the peer outreach arms, 4.43 percent of existing patients who were not offered incentives and 7.68 percent of those who were offered incentives provided at least one name. This is consistent with both the previous result (that financial incentives complemented peer outreach by compensating existing patients for the required effort) and with the notion that existing patients immediately recognized that peer outreach required greater effort.

In the health worker outreach arms, all of the potential symptomatics named at baseline were contacted by Operation ASHA staff with no additional effort required by existing patients; the number of names listed corresponds to the number of potential patients who received information about testing and treatment. In the peer outreach arms, existing patients may have contacted all, some, or none of the people whom they identified at baseline; they may also have contacted people who were not on their initial lists. While we do not have perfect data about outreach attempts by existing patients, we did obtain an incentivized measure of effort in contacting suspects from existing patients assigned to the peer outreach arms. Recall that only existing patients in the peer outreach arm were given referral cards to pass on to their contacts. After the endline survey, we offered to buy back any remaining referral cards from these existing patients. The difference between the ten cards initially distributed to existing patients and the number of cards returned to the survey team provides a proxy for the extensive margin of outreach in the peer outreach arm.

Of 869 respondents assigned to peer outreach and surveyed at endline, the 195 who returned zero cards represent those who distributed ten cards and those who lost or discarded the materials. The number of cards returned is a lower bound on the number of cards not distributed to new suspects. Nonetheless, a comparison of the number of cards returned by existing patients eligible for different incentive schemes provides some information about the margin of effort. In the encouragement arm, existing patients returned an average of 7.24 cards. Existing patients eligible for unconditional incentives returned 0.05 additional cards and those eligible for conditional incentives returned 0.07 fewer cards; relative to the encouragement arm, these differences are neither statistically nor economically significant.[30] Not

[30] See online Appendix Table B7, panel A. The regression specification corresponds to equation (7) and the sample includes all patients assigned to the peer outreach arms.

only are the means similar, the distribution of the number of cards returned by the two groups is almost identical.[31]

This is striking in light of the previous result that financial incentives strongly complemented peer outreach in increasing the number of new suspects screened and tested. Now we see that this complementarity was achieved without an increase in the number of cards distributed. This pattern suggests that financial incentives increased existing patients' efforts to improve the quality of information they conveyed to new suspects or to identify suspects who had a greater likelihood of having TB. While we are not fully able to separate these two components of existing patient effort, comparing the conversation rates from screening to testing provides suggestive evidence that incentives increased effort by both improving the quality of information shared with new suspects and by targeting those most likely to have TB.

We know from the data about cards bought back that financial incentives did not change the number of outreach attempts. However, as we saw in Table 4, incentives did increase the number of new suspects who were screened, which is consistent with an effect on the quality of information conveyed by existing patients to new suspects. Although the small absolute number of new suspects who were screened and tested limits subsequent analysis, we can compare the fraction who tested positive for TB among those who were referred by incentivized and nonincentivized existing patients. Of the new suspects screened (sent for testing) as a result of referrals from existing patients in the "peer outreach, no incentives" arm, 8.33 (16.67) percent tested positive. Of those referred by existing patients in the "peer outreach, financial incentives" arm, 17.14 (30.09) percent tested positive. Since test results are only available for those new suspects who came to Operation ASHA for screening, their test results conditional on screening are a measure of the likelihood of testing positive for TB for those for whom the perceived benefits of screening were sufficiently high to show up. In this group, those who were referred by incentivized existing patients were twice as likely to have symptoms of TB and twice as likely to actually have TB as other individuals who were convinced to show up by an existing patient who did not receive incentives. Therefore, incentives appear to have improved screening as well as increasing the quality of information conveyed by existing patients to their contacts.

Quality and Characteristics of Referrals.—The results in Section IID indicate that peer outreach, particularly when incentivized, results in more referrals, more suspects recommended for testing, and more symptomatics actually tested. The increase in the number of suspects recommended for and completing testing and test positivity rates that exceed the overall positivity rates at the government testing facilities indicate that these referrals are well targeted or of high quality from the perspective of public health authorities. The investigation of existing patient effort also hints at the quality of referrals: relative to encouragement alone, incentives increased the fraction of referred symptomatics who ultimately tested positive for TB.

[31] See online Appendix Table B7, panel B. Kolmogorov-Smirnov tests give p-values of 0.993 (no incentive versus any incentive) and 0.795 (unconditional incentive versus conditional incentive).

Table 5—Effect of Treatments on Referral Quality

	Share of referrals recommended for testing			Share of referrals actually tested		
	(1)	(2)	(3)	(4)	(5)	(6)
Encouragement	0.273			0.175		
	(0.081)			(0.074)		
	{0.029}			{0.075}		
Incentive	0.474			0.382		
	(0.077)			(0.076)		
	{0.003}			{0.009}		
Peer outreach		0.420			0.306	
		(0.084)			(0.079)	
		{0.003}			{0.005}	
Health worker outreach		0.393			0.312	
		(0.079)			(0.079)	
		{0.012}			{0.032}	
Peer outreach, no incentives			0.244			0.166
			(0.094)			(0.080)
			{0.079}			{0.079}
Health worker outreach, no incentives			0.288			0.180
			(0.101)			(0.088)
			{0.049}			{0.169}
Peer outreach, incentives			0.512			0.381
			(0.103)			(0.096)
			{0.001}			{0.001}
Health worker outreach, incentives			0.450			0.384
			(0.091)			(0.090)
			{0.003}			{0.009}
Observations	122	122	122	122	122	122
R^2	0.286	0.247	0.289	0.314	0.262	0.314

Notes: Linear models are estimated by OLS including city fixed effects. The unit of analysis is the center. In the first three columns the dependent variable is the share of referrals who were recommended for testing. In the next three columns the dependent variable is the share of referrals who were actually tested. The omitted category is clinics in the pure control group. Regressions include the center-level baseline number of patients as a control. Robust standard errors are in parentheses, and randomization inference p-values (based on 2,000 random permutations) are in curly brackets. The randomization inference p-values were computed using the STATA command ritest (Hess 2017).

To further explore the targeting of referrals, we construct two measures of referrals' "quality": the share of referrals who are recommended for testing and the share of referrals who actually obtained a TB test. Since these measures are only defined for observations that have a positive number of referrals, we perform this analysis at the center level only (and define the outcomes to be zero, a lower bound on quality, for the control clinics that experienced zero referrals). We report the results of regressions of the (center-level) referrals' quality measures on our treatment indicators in Table 5. We find that incentives (pooling across outreach modalities) result in a higher fraction of referrals who test positive for TB than encouragement, peer outreach (pooling across incentive types) results in referrals of same quality as health worker outreach, and peer referrals with incentives and health worker outreach with incentives result in referrals of similar quality. This analysis confirms that, at minimum, incentives do not decrease referral quality, and it foreshadows the cost analysis that concludes this paper.

We also analyze the characteristics of the referred patients, comparing them to the existing patients (online Appendix Table B23) and across treatment arms (online Appendix Tables B24 and B25). Our focus is on whether financial incentives or outreach conditions affected targeting of disadvantaged individuals. There is no indication that financial incentives caused existing patients to identify relatively better-off suspects than when they were asked to participate for altruistic reasons only; if anything, the suspects identified by existing patients who received financial incentives had lower asset holdings than suspects identified by existing patients not offered incentives. Suspects identified via peer referrals appear more disconnected than those identified through the health worker outreach strategies. On average, new symptomatics identified via health worker outreach had 2.12 social contacts in the 24 hours preceding the survey, whereas we estimate that those identified through peer outreach had 1.77 fewer contacts (an effect statistically significant at the 95 percent level). It is striking that peer referrals resulted in the screening of suspects with statistically and meaningfully fewer social contacts than did outreach via health workers. These results suggest that peers can reach disconnected patients effectively.

Heterogeneity by Existing Patient Characteristics.—Just as network position matters in the diffusion of agricultural information (Beaman et al. 2021), it may also affect who is well positioned to spread information about public health. Banerjee et al. (2019) find that individuals nominated by their communities are better at spreading information (in this case, about immunization camps) that increases the take-up of vaccines than randomly selected individuals are. Several papers emphasize the identification of individuals who are most efficient in gathering or spreading information within their networks based on their positions within the network structures or observable characteristics. These works consider information aggregation (Alatas et al. 2016) and dissemination (Beaman et al. 2018; Banerjee et al. 2019) separately, while referrals in our context transmit information in both directions.

We do not capture full social networks, so our analysis of heterogeneous treatment effects is based on subgroup analysis of how existing patients who differ in terms of asset ownership, social connection, delay in seeking treatment for TB symptoms, phase of treatment, and gender respond to the incentive and outreach treatments. While we find differences in average levels of referrals—for example, highly connected patients and those who entered treatment promptly themselves made more referrals than patients with fewer connections or who had delayed their own treatment—we do not detect any differential response to incentives or to outreach conditions by any of the baseline characteristics we examine, including gender. In most cases, the point estimates of the interaction between treatment and baseline characteristic is close to zero. Results are available in online Appendix Tables B21 and B22, and a more detailed discussion is provided in online Appendix Section B.

Center-Level Analysis of Potential Crowding Out.—While both financial incentives and outreach strategies affect individual-level behavior in meaningful ways, the total number of new suspects screened through the outreach schemes tested here is small relative to the stock and flow of these clinics.[32] We study center-level outcomes to rule out crowding out rather than to precisely estimate an aggregate effect on the patient loads of these clinics. Crowding out could occur through competition for health workers' time, especially if they allocate a fixed-time budget to outreach activities and substitute time spent on outreach to or screening of new suspects identified through the referral schemes for their status quo outreach efforts.

Online Appendix Table B20 presents results of center-level regressions where the dependent variable is the total number of new TB patients enrolled at Operation ASHA clinics during the study period, normalized by the center-level number of patients at baseline. We estimate four specifications, aggregating the experimental conditions as in Section IID. Eight of nine estimated coefficients are positive, including economically meaningful positive effects of peer outreach, although for the reasons explained above, the study is not adequately powered to detect differences in the number of new patients at the center level. Nevertheless, the point estimates do not suggest that the intervention crowded out enrollment of new patients through other intake streams or otherwise had negative effects on new patient enrollment.

E. *Cost Analysis*

The academic research questions posed by this experiment concern the behavior of existing patients. From a policy perspective, the key parameters of interest are the costs of detecting individuals with TB symptoms (who require screening, even if negative tests ultimately rule out TB and indicate the need for different treatment) and of identifying those who have the disease. We consider four categories of recurring expenses: incentive payments made for referrals, the production of referral cards, the time costs of explaining the scheme to existing patients, and wages paid to health workers. We calculate costs per treatment arm, aggregating as in the previous sections. We calculate average costs per treatment arm by dividing the total number of symptomatics screened or new cases detected, respectively, by the total across the four categories of costs within the treatment arm.

Incentive payments are straightforward to calculate and reflect actual amounts paid to existing patients depending on the rules of the treatment arm to which they were assigned. They are zero by definition in encouragement arms.

The referral cards printed for the project cost eight rupees ($0.12) per card. In peer outreach arms, each existing patient was given ten cards, and we include the cost of all those cards even though not all were distributed to prospective patients. In the health worker outreach arms, cards were distributed to health workers based on the number of referral names provided during the baseline survey, so the cost of cards per current patient was actually lower than in the peer outreach arms.

We use administrative data captured by our computer-assisted interview interface to track the amount of time spent explaining the referral scheme to existing patients, and arrive at an estimate of ten minutes per patient to explain the scheme in both the

[32] On average, clinics in the control group added 8 patients during the two months of the study, whereas the treated clinics added 11 patients. Normalizing by the size of the center-level patient population at baseline, control clinics added 0.44 new patients and treated clinics added 0.52 new patients for each existing baseline patient.

Table 6—Cost of Detection

	Encouragement		Conditional		Unconditional	
	Cost per current patient	Total cost	Cost per current patient	Total cost	Cost per current patient	Total cost
Panel A. Costs by incentive type						
Incentive payments	n/a	n/a	11	10,500	12	12,600
Referral card printing	30	29,880	31	29,840	21	21,496
Training for existing patients	14	13,542	14	13,542	13	13,542
Payments to health workers	144	143,200	147	143,200	140	143,200
Total cost		186,622		197,082		190,838
Cost per symptomatic screened	4,552		2,119		2,327	
Cost per TB case detected	26,660		16,423		11,927	
Cost per symptomatic screened ($)	70		33		36	
Cost per TB case detected ($)	410		253		183	
	Peer		Health worker, identified		Health worker, anonymous	
	Cost per current patient	Total cost	Cost per current patient	Total cost	Cost per current patient	Total cost
Panel B. Costs by outreach type						
Incentive payments	13	12,400	5	5,300	6	5,400
Referral card printing	80	77,840	1	1,408	2	1,968
Training for existing patients	14	13,542	12	13,542	15	13,542
Payments to health workers	n/a	n/a	197	214,800	232	214,800
Total cost		103,782		235,050		235,710
Cost per symptomatic screened	887		4,897		4,622	
Cost per TB case detected	7,413		26,117		19,642	
Cost per symptomatic screened ($)	14		75		71	
Cost per TB case detected ($)	114		402		302	

Notes: Panel A: Estimated number of detections corresponds to outcome variables in Table 2, columns 1 and 7. Panel B: Estimated number of detections corresponds to outcome variables in Table 3, columns 1 and 7. All costs are in Indian rupees except where dollars are indicated. The exchange rate used is 65 rupees to 1 dollar.

peer and health worker outreach arms. Computed at the daily wage for field staff, these explanations cost 10.42 rupees ($0.15) per existing patient.

Finally, while the health workers in this study were paid regular wages by Operation ASHA, the outreach required by this project was outside their usual scope of work. Our project offered a fixed stipend of 1,800 rupees ($26.44) per month (increased to 2,000 rupees [$29.38] per month in the second year of the project) to Operation ASHA staff whose centers were assigned to the health worker outreach arms to cover time and transportation costs for outreach. The stipend was worth about 22.5 percent of their average monthly salaries and was the minimum compensation deemed acceptable by Operation ASHA's senior leadership.[33] Operation ASHA estimates that its DOTS providers allocate one-third of their time to outreach activities, though the vast majority of these efforts are devoted to tracing members of existing patients' households (a population not targeted by our intervention). This outreach is considered part of health workers' core job responsibilities and covered

[33] To implement health worker outreach for the first time also requires training the health workers. We have omitted this fixed cost from our calculations; including it would make peer outreach relatively more cost effective.

by the monthly salary, though they also receive small financial incentives and penalties for a range of activities including treatment initiation and completion.

Table 6 summarizes the results of this exercise by incentive type (panel A) and outreach type (panel B). Based on costs incurred during the study, it was less expensive to use financial incentives to identify a patient with TB than it was not to use them. Each positive case of TB identified cost $253 in the conditional treatment arms or $183 in the unconditional arms, relative to $410 in the encouragement arm. This is because while the financial incentives themselves were small relative to other costs—especially of outreach (balanced across the incentive types because of the cross-randomized design)—they were effective in increasing the number of cases detected. Costs per suspect screened are, by definition, lower: $33 using conditional incentives, $36 using unconditional incentives, and $70 without financial incentives.

The cost-effectiveness of peer outreach is even more pronounced. In peer arms, the average cost per detection was $114. Active case finding by health workers was 2.5 to 3.5 times as expensive: $402 per case detected when using the name of the referring EP and $302 per case detected when the identity of the referring EP was anonymous. Costs per suspect screened were $14 in the peer outreach arms and $75 and $71 using health worker outreach on behalf of anonymous and identified peers, respectively. The differences across treatment arms are driven by the greater number of suspects screened and detected as a result of peer outreach, as indicated in Table 3, and the higher costs of compensating health workers (via stipends) than existing patients.

We made every effort to minimize costs in all treatment arms during the study. Yet, having completed it, we recognize two areas in which future implementation of these schemes could further reduce costs. The first is to distribute fewer cards to existing patients for peer referrals. Ninety percent of existing patients in the peer outreach arms distributed five or fewer cards, so we reestimate costs assuming that five cards rather than ten were printed and distributed to each existing patient in the peer referral treatments. The second is to reduce the stipend to health workers. Our data do not offer guidance about the optimal stipend level, but as a benchmark, we consider reducing the stipend to health workers by half, to 900 rupees ($13.22) per month. Online Appendix Table B26 presents estimates for this alternate scenario, which has the biggest effect on the comparison between peer outreach and health worker outreach. While the differences between peer outreach and health worker outreach are smaller in this hypothetical than the realized costs in our study, they still clearly indicate the cost advantage of using peers for active case finding: costs would fall to $71 for each case detected through peer outreach, compared to $210 for outreach by health workers who identified the referrers and $158 for health worker outreach on behalf of anonymous peers. In fact, assuming the same detection rates as in the current study and distributing the original ten cards per existing patient, peer outreach remains more cost effective than case finding by health workers for any stipend above 560 rupees ($8.62) per month, 31 percent of the actual stipend paid to health workers in the study.

Few estimates of the cost of outreach are available in the literature. A study from South Africa estimates the cost of identifying a TB patient among a high-prevalence sample (of HIV patients, where co-infection increases patients' risk but decreases the average cost of detection) to be $381 (Kranzer et al. 2012). Although incentivized peer outreach should not replace other outreach strategies, it is clearly an effective complement to the potential to reach marginalized patients.

III. Conclusion

Underdetection of tuberculosis has serious health consequences for infected individuals, their families, and others exposed to the disease. Despite the availability of free treatment throughout India, an estimated one million people with TB have not been tested and are not receiving the necessary treatment. The value of private information may be especially high in this context: the public health system and nonprofit providers working under its auspices are often overwhelmed and unable to mount intensive contact tracing efforts. Existing outreach strategies are insufficient to overcome informational barriers that prevent some people with symptoms from seeking testing and treatment. In contrast, people who are currently undergoing treatment for TB have relatively lower time costs to identify and reach others with symptoms, and they may have particularly relevant information about the benefits of treatment. Despite this, peer referrals are virtually unheard of, partly due to the stigma associated with TB.

The results of our field experiment in India demonstrate that just as referrals are valuable for leveraging private information to identify well-qualified employees, they are highly effective for outreach to TB symptomatics. Encouragement and financial incentives, especieally, induce existing patients to refer others in need of testing, which results in the testing of new symptomatics and the detection of new TB cases. Moreover, peers are particularly effective in outreach. Our experimental design allowed us to discover that peer referrals are effective not only because existing patients have—and can be induced to reveal—useful information about members of their social network who need screening for TB, but also because of the direct role they can play in outreach to these contacts. Among peer referrers, incentives increased the number of prospective patients who were screened without affecting the number of cards distributed, suggesting that financial incentives increased the quality of information conveyed or the outreach target selected.

Our study demonstrated that incentivized, community-based referral schemes can serve as a useful complement to existing TB case-finding strategies. Both financial incentives and peer outreach are highly cost-effective at $114 for each case of active TB identified through peer outreach, compared to $300–400 for outreach by health workers. Because other diseases such as HIV/AIDS and STDs present challenges similar to TB including underdiagnosis, a reluctance to get tested, and high costs of identifying new cases, insights from this study may also prove useful in other contexts.

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