# Biometric Monitoring as a Persuasive Technology: Ensuring Patients Visit Health Centers in India's Slums

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**Abstract.** Managing chronic disease is particularly challenging in the developing world, because every trip to a health center can translate to lost time and wages on the part of the patient. This problem is especially acute for tuberculosis patients, who in India are required to visit a center over 40 times in the course of a six-month treatment period. In this paper, we explore the role of a biometric attendance terminal in persuading patients to complete follow-up health visits in slum communities of New Delhi, India. The terminal, which enrolled over 2,300 patients across 25 centers during our 2 years of observation, uses biometric fingerprint scanning to ensure that tuberculosis patients receive and take medications on the right schedule. We evaluate the perceived impact of the terminal via interviews with 8 health workers, 4 center owners, and 23 patients. Our findings suggest that the biometric terminal helps to draw patients to the center, both by incentivizing health workers to convince patients to come, and by persuading patients that in-person visits are important.

## 1 Introduction

Persuading patients to comply with prescribed treatment can often make the difference between life and death. This is especially true for tuberculosis, a disease that remains the largest infectious killer of adults, claiming nearly 1.8 million lives annually [5]. In India, which is responsible for nearly one fifth of the global TB burden [5], these deaths are especially tragic because there are free and effective antibiotics available from the government. However, in order to be cured, an infected patient needs to take the drugs (initially 7 pills at a time) on a strict schedule: three days per week continuously over a 6- to 8-month period. Failure to complete this regimen can lead to drug resistance, which is typically deadly – not only for the patient, but also for others he or she might infect.

In order to persuade patients to adhere to tuberculosis treatment regimens, India and other countries have adopted a program known as Directly Observed Therapy, Short Course (DOTS). In this program, patients ingest each dose of medication under direct observation. The observers, known as medication *providers*, keep the medications with them in order to closely control their distribution and administration. Patients are therefore required to travel to a DOTS center to receive each dose. While the DOTS program has had a significant impact on tuberculosis control in India, it also introduces a new

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challenge, which is to persuade patients to make regular visits to the center. Due to myriad factors spanning education, travel, work schedules, side effects, and forgetfulness, it remains difficult to convince patients to visit the center regularly, thereby jeopardizing their treatment outcome.

To address this problem, we designed and deployed a biometric attendance terminal that uses fingerprinting technology to record every visit that a patient makes to a health center. Every day, the visitation log is uploaded via SMS to a central location, where program managers can analyze the data and offer targeted counseling or supervision for patients who have missed their dose. We deployed this terminal across 25 tuberculosis treatment centers in slum communities in urban India. To date, our deployment spans 2 years and encompasses over 2,300 patients. We evaluated the impact of the terminal via interviews with health workers, center owners, and patients.

Our results indicate that health workers perceive the biometrics platform as improving patient attendance at the health center, thereby improving their medication adherence and prospects for recovering from TB. One of our key findings is regarding the impact of biometrics on the social dynamics between health workers and patients. While we expected the terminal to strain the trust of this relationship, due to the vigilant monitoring introduced, our anecdotal evidence suggests the opposite. In their conversations with patients, health workers describe the biometric platform as a common adversary to which they are also bound, thereby creating empathy in the patient and persuading them to make regular visits out of solidarity with the health worker. While some health workers and patients acknowledge that biometrics can cause inconvenience, and not all patients are able to explain the purpose of the system, these drawbacks are minor compared to the benefits cited. Overall, our findings suggest that biometric attendance tracking can play a positive role in promoting healthy behaviors in low-income settings.

## 2   Related Work

Ensuring that patients adhere to prescribed medication is a pressing global problem that has been studied extensively [9]. A review of interventions seeking to improve adherence found 17 programs that had statistically significant effects on treatment outcomes [6]. Successful interventions were usually complex, incorporating more convenient care, information, counseling, reminders, self-monitoring, reinforcement, family therapy, and other forms of additional supervision or attention. However, none of these studies addressed adherence to TB medications in a developing-country context.

Even under directly-observed treatment regimens, it is recognized that many factors prevent adherence to tuberculosis medications [2]. A study focusing specifically on the Indian context found that men dropped out of treatment because the visits jeopardized work and earning opportunities, while women dropped out due to housework and the strain of keeping their condition secret, particularly when women's movement outside of the home is questioned [8]. Prior researchers have worked to improve DOTS therapy using videophones in place of in-person visits [3], a strategy that is judged to save costs in the United States but is still prohibitively expensive in the context of slum communities in India. Researchers have also worked to reduce the need for DOTS by using medication monitors to log self-administered doses [7], though this approach remains

controversial amongst policymakers due to the difficulty of monitoring treatment and also the potential resell of government-funded TB medications. Prior work in persuasive technology has also explored the design of an electronic medication monitor [13].

Biometric technologies are receiving increasing attention as a means to verify the delivery of social services to underprivileged populations. This dialogue is especially relevant in India, where the UID (Unique Identification) project aims to provide a unique biometric identity to each of the 1.2 billion citizens of the country. Proponents of UID point to numerous benefits for poor communities, including increased access to bank accounts, decreased waste due to undeserved welfare payouts, and, recently, increased access to healthcare. The UID authority goes so far as to say that "health related development schemes could offer a killer application for the UID" [14]. However, this claim is not without controversy. Critics from academia, the media, and the public sphere have been vocal in questioning the role of biometrics in healthcare delivery. One researcher concludes that "the UID scheme has thus little to offer for improvement in the public health situation in the country" [11].

While the debate regarding the role of biometrics in healthcare delivery is becoming increasingly relevant, and increasingly polarized, there is surprisingly little scientific evidence regarding the impact of biometrics on real-world health programs. Research on biometric identification in the developing world has focused on health clinics in South Africa [12], anti-retroviral therapy in Malawi [16], clinical trials in Vietnam [4], and tracking of nomadic pastoralists in Chad [15]. However, to the best of our knowledge, there is no prior study that examines the interplay of biometrics and healthcare delivery for low-income populations in India. This paper seeks to fill this gap by examining a large-scale deployment of biometric technologies in health clinics in slum communities.

## 3  Biometric Attendance Tracking

The context for our project is a tuberculosis treatment program run by Operation ASHA (OpASHA), one of the premier TB treatment organizations in the world. OpASHA serves over 8,000 patients across 11 Indian states, including a longtime focus on slum communities in Delhi. They utilize a highly innovative model that includes all the elements of government DOTS programs, as well as some additions. In an OpASHA DOTS center, there are two actors: a *provider* and a *counselor*. The provider is a member of the local community who offers physical space for use as a DOTS center throughout the day. The counselor is a full-time OpASHA employee who administers medication for several hours per day from the provider's location, and also delivers doses to patients' homes when they fail to come to the center. Since patients visit centers only 3 days per week, counselors typically are responsible for two centers, which they visit on alternate days. While OpASHA's model has been highly successful, they sought to improve the transparency of DOTS center operations to enable them to scale across India and other countries.

### 3.1  Technology Design

Our approach in this project is to utilize a biometric fingerprinting terminal to provide a transparent and tamperproof record of which doses of TB medication are administered
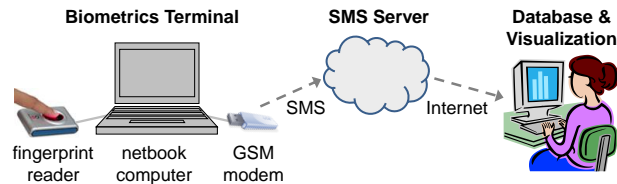
**Fig. 1.** Overview of our biometric attendance system.

to a patient under supervision of a health worker. While similar records are recorded on paper today, they are widely regarded as being unreliable and unrepresentative of daily operations; also, they are difficult to promptly aggregate and analyze. Using a biometric terminal with daily uploads to a central location, it becomes possible for program managers to identify missed doses as soon as they occur, and to respond with improved counseling or supervision.

The technical details of our system have been described in a prior publication [10]. Briefly, the system consists of three components: a netbook computer, a biometric fingerprint reader, and a GSM modem (see Figure 1). When patients visit the center, they scan their fingerprint, and the system logs their visit. At the end of the day, the history of visits is uploaded via SMS to a server, where it becomes available for visualization and analysis by program managers.

### 3.2 Technology Deployment

The biometric terminal was deployed to all 17 of Operation ASHA's centers in Delhi and, starting in October 2011, to 8 centers in Jaipur (see Figure 2). In this process, the terminal was taken up by 13 counselors and enrolled over 2,300 patients. Since there is a separate terminal for each counselor and provider, we deployed a total of 38 terminals.

Deploying a new technology at this scale in a resource-poor environment is no small feat. Training the counselors and attaining their commitment to the system was the first hurdle. During training, we dispelled fears, such as the counselors being replaced by the computers or being micro-monitored by the management. As counselors had limited exposure to computers, they thought they might damage the system and were hesitant to use it. We needed to hold multiple training sessions, and offered on-site help for initial patient enrollment, before counselors were comfortable using the system on their own.

The second hurdle that emerged over time was the recognition accuracy of the fingerprint reader. Though we used a state-of-the-art device (the Digital Persona U.are.U4500), our conditions were very demanding, as our low-income clientele often had calloused fingers, and we were also using the reader to identify them without any assistance (i.e., the system *identified* patients based on their fingerprint, rather than *verifying* their fingerprint relative to another form of identification.) Though mis-recognitions were relatively rare, we aimed to eliminate them entirely. We accomplished this by requiring two fingerprint scans per patient. If the system matches the print to the same person on both trials, then they are logged in as that person. Otherwise, the patient is asked to try again until two successive scans are consistent.

The final challenge in our deployment was dealing with various software and hardware failures of the laptops, spanning computer viruses, power surges, physical damage,
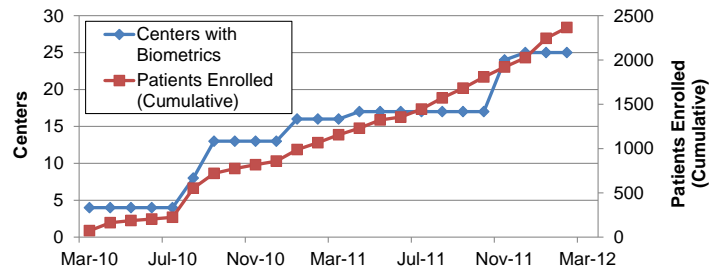
**Fig. 2.** Deployment timeline of the biometrics terminal.

and bugs in our initial platform. Of these, computer viruses proved to be the biggest challenge. Despite its intended use as a healthcare platform, we learned the laptops were frequently used for entertainment purposes during off hours, introducing viruses via USB thumb drives. While antivirus software proved insufficient to curb the issue, we eventually stabilized the systems by using Windows Steady State to prohibit most types of changes from being stored to disk.

## 4 Perceived Impact of Biometrics

Our goal in this study was to evaluate the potential of biometrics to improve health outcomes in a tuberculosis treatment program. While the ideal methodology for such a study would be to conduct a randomized controlled trial and measure the impact of biometrics on missed doses, default rate, and cure rate, such a trial is beyond the scope of our initial investigation. While we did examine these outcomes across the centers studied, the sample size was too small, and there were too many confounding factors, to identify any statistically significant effect of the intervention. While we look forward to conducting a more rigorous trial in the future, in this work we focus on qualitative feedback as an indicator of the potential impact of the biometric system.

### 4.1 Methodology

To understand the perceptions of the biometrics technology by various stakeholders in the treatment program, we conducted semi-structured interviews with 8 counselors, 4 providers, and 23 patients. Interviewers were conducted by the first author, a technology officer of Operation ASHA, who had led the deployment of biometrics over the previous 15 months and was already known to the counselors and providers. While the interviewer made every effort to remain impartial, some participants' responses may have been biased by a desire to please the interviewer. We revisit this issue in Section 5.

Interviews were conducted over two months (Jul-Aug 2011) and took place in either the DOTS center or the Operation ASHA office. Interviews were done in Hindi and typically lasted between 10 and 45 minutes. The audio was recorded and later transcribed and translated to English. The authors then analyzed the (anonymized) English transcripts for common themes and patterns, which are summarized below.
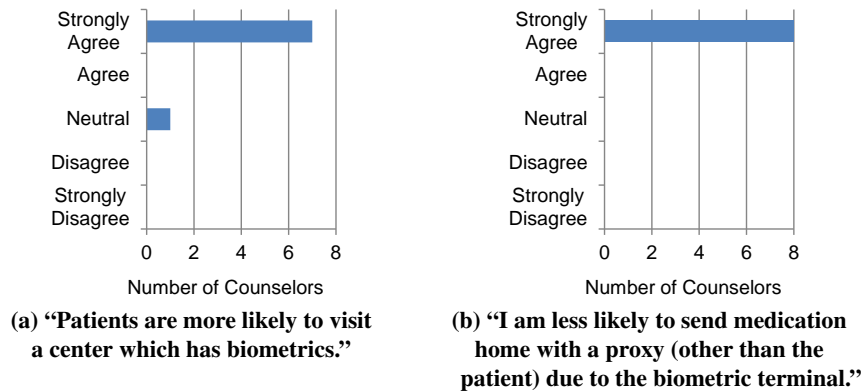
(a) "Patients are more likely to visit a center which has biometrics."



(b) "I am less likely to send medication home with a proxy (other than the patient) due to the biometric terminal."

**Fig. 3.** Counselors' agreement with interview statements.

## 4.2 Perceptions of Counselors

We interviewed eight counselors, spanning all of Operation ASHA's active centers in Delhi. Counselors were predominantly female (one was male), had an average age of 27, and had an average household income of Rs. 14,500 ($295) per month. Counselors were relatively well-educated, with all completing 12th standard and three holding a B.A. Most counselors (5 out of 8) had some training with computers, usually via a 3 to 12 month course. However, only a fraction of counselors (3 out of 8) had any real-world experience with computers. All counselors owned a mobile phone, as well as a TV. Counselors were employed with Operation ASHA for an average of 1.6 years (min 6 months, max 3.3 years) at the time of our interviews. They had been using biometrics in their centers for an average of 7 months (min 4 months, max 1.1 years).

*Biometrics helped to persuade patients to come to the center.* Of all the points cited in favor of biometrics, counselors were most vocal about the benefits in drawing patients to the centers. Ensuring regular meetings between patients and counselors is the corner-stone of the DOTS treatment protocol. However, these meetings often break down. In the words of one counselor, "Many patients want unsupervised doses and when I refuse they even offer me money. They don't want to come to the center, but send someone else in their place."

As illustrated in Figures 3a and 3b, counselors are almost unanimous in feeling that the biometrics caused more patients to visit the centers, and also reduced the likelihood of sending medication home with a different person (the 'proxy'). One counselor explains this benefit as follows:

> Earlier someone else would come with some excuse and pick the medicine. We could not argue too much because the patients would threaten to quit the treatment or worse skip medication. Now even they realize that it's a rule from the government and they can't avoid it. The patients have become more active and we have also become more alert and vigilant.

We gathered numerous anecdotes in which counselors believed that certain patients would not have visited the centers if it weren't for the biometric devices. For example:

N. was pulmonary positive and was also very sick. He lived very far off and was not ready to come to the center. I went to his house for first counseling session and registered him in the laptop. I motivated him, giving the reason of biometrics. So for almost a month till he was too sick to walk, he came with an attendant on a rickshaw. He was excited to see biometrics and kept coming in regularly to give his fingerprint. He was fit to move about within 2 months.

Even when patients are in better health, obligations such as work can prevent them from visiting the centers. The biometric devices have also been effective in drawing such patients in. As noted by one counselor, "A patient goes on motorcycle to Noida for work [consuming his entire day] and wanted someone else to collect his doses. When I showed him the fingerprint device and told him that it would not be possible, he took half day off on 3 days of the week."

In other cases, it is the counselor who takes extra measures to ensure that medication is delivered. For example, one counselor took regular trips to a patient's residence to ensure that their interaction was logged: "There is a handicapped patient who is unable to come to the center. And he wants unsupervised doses. Since I can't give it to a proxy but still I want to give him DOTS, I go myself every time and take his fingerprint."

The biometrics also had an interesting and unexpected impact on counselor-patient interactions. Previously, counselors alone were responsible for enforcing the DOTS protocol, and if patients disliked the protocol, they directed their negative feelings at the counselors. However, upon introducing the biometrics, it became clear to patients that both counselors and themselves were subject to monitoring by a higher authority (the central office), thereby reducing tensions between counselors and patients. In the event of a dispute, counselors can 'blame' the biometrics for enforcement of the protocol, while retaining good relations with the patient. In the words of one counselor, "All patients come to the DOTS center, some out of consideration for me as I have told them that I get scolded if scans are not taken." Another counselor confirms, "If a patient doesn't want to come and gives the excuse of going for duty, I tell them that this is important and that this record goes to the office. This becomes a reason for them to visit the center."

*Counselors viewed biometrics as improving the treatment program.* Overall, the counselors were in broad agreement that the biometric attendance terminals were improving the main activities of the treatment program, namely 1) enforcing adherence to DOTS, as patients were more likely to visit the centers themselves instead of sending a 'proxy', and 2) helping counselors to identify and follow-up with patients who had not yet visited on a given day. Together, these benefits also imply that counselors had more interaction with patients, further improving care. Figure 4a illustrates that 7 out of 8 counselors felt strongly about the overall improvement to the program.

One of the key benefits is ensuring that patients retrieve their own medication, as summarized by one counselor: "It has benefited us. Our interaction with the patient increases because the patient is forced to come to the center." Another counselor emphasizes the book-keeping benefits of biometrics: "I would be lost without biometrics. I would not know how many patients to expect that day, how many and who have already visited the center."

The counselor responsible for the neutral reply in Figure 4a was frustrated by some technical difficulties in registering and recognizing patients on the terminal. However,

(a) **"Biometrics is improving the treatment program."**



(b) **"Biometrics enables me to do my job faster."**
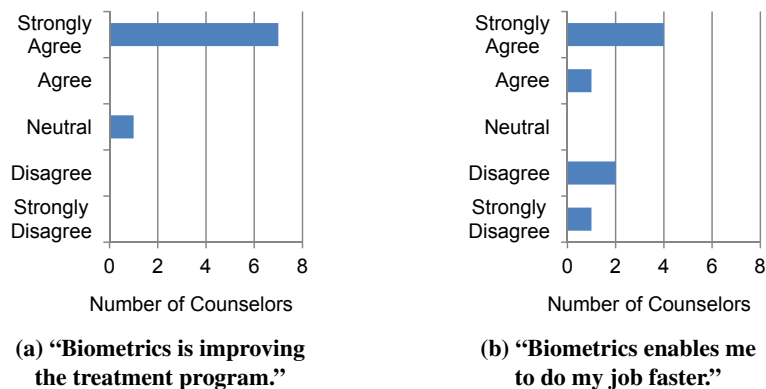
**Fig. 4.** Counselors' agreement with interview statements.

this same individual "strongly agreed" that medication was less likely to be sent by proxy when using the biometrics.

*Counselors earned more respect using biometrics.* In addition to benefiting the treatment program, the biometric devices also offered auxiliary benefits to counselors. As summarized by one counselor, "I have started getting more respect from all" since the introduction of the laptops. Another counselor explained, "Now that I have this laptop the patients give me double respect. When I go into the field even the neighbors of the patient flock around and think I am coming from a big hospital because I carry a laptop. So they listen carefully and even ask questions."

Two counselors noted increased respect within their families, as well. One counselor said, "In my family, now my value has increased. My hubby did not like that I was working among TB patients. They feel good now that I have been given this responsibility [of a laptop]."

While these perceptions do not directly impact patients, they are important for the uptake of biometric devices within the organization. The success of the biometric program ultimately rests with the counselors, who are the main mediators of the technology. As it often requires patience and perseverance for them to learn how to use the technology, the respect gained can provide an important incentive and reward for carrying through with the program.

*Biometrics increased the amount of work for some counselors.* While the feedback from counselors was largely positive, our discussion would not be complete without considering the possible drawbacks of biometrics. One area that could be improved further is the efficiency of counselors with the technology. As illustrated in Figure 4b, counselors had mixed opinions as to whether the biometric devices enabled them to do their jobs more quickly.

There are several explanations for this result. First, as the biometric technology is in a pilot stage, we are currently requiring counselors to maintain *both* paper and electronic records, so that the paper records can serve as a backup in the event of any unexpected behavior from the biometrics software. As stated by one counselor, "Biometrics has doubled my work as I have to maintain both the records now."

Another potential challenge to the acceptance and sustainability of the biometrics is that it holds counselors accountable for very strict adherence to the treatment protocol. When asked if she would be happy if the biometric system is withdrawn, one counselor replied, "I will be happy because I am under a lot of tension that if patients are not given unsupervised doses, they will quit and come in default and if I give unsupervised then they will come in the missed dose list." While adherence to the protocol is critical for successful implementation of DOTS, counselors who were previously unaccustomed to monitoring could find it more stressful to be subject to constant auditing via biometrics. We expect that this feeling may prove to be different amongst new counselors, who did not have prior experience in an unmonitored treatment scenario.

### 4.3   Perceptions of Providers

We interviewed four providers. Providers were male, had an average age of 36 (min 30, max 43) and had an average household income of Rs. 17,500 ($389) per month. All providers had a health diploma. Half had some background with computers, while half had some informal knowledge; none had received formal training. All providers owned mobile phones and TVs. Providers had worked with Operation ASHA for an average of 1.5 years (min 6 months, max 4 years) and had been using biometrics in their centers for an average of 11 months (min 5 months, max 1.25 years).

*Providers believed that patients were more likely to visit due to biometrics.*  Like the counselors, providers perceived that the presence of biometrics increased the likelihood that patients would visit their DOTS center. Three out of four providers strongly agreed with this idea, while one was neutral. One provider said, "I think it a very good initiative. This has helped us convince more patients to come to the DOTS center. Initially the counselor went to some patients' homes to take the fingerprints. Now the patients understand that it is important that the records in the laptop are up-to-date. So they come without much ado."

Because more patients visit the DOTS center during the daytime, there are fewer after-hours visits for the provider to handle. One provider said, "The counselor makes sure that she gets most of the fingerprints when she is on duty and there are fewer patients that are left pending for the day."

*Providers preferred to have the biometrics in their centers.*  Overall, providers were strong advocates of the biometrics program. Three out of four providers strongly agreed that they prefer to keep the technology in their centers, while one was neutral. It is not obvious that providers would have this sentiment, since they are held liable for a laptop that is kept on the premises at all times. They were responsible for keeping it safe from theft and tampering.

### 4.4   Perceptions of Patients

We interviewed 23 patients (11 male), who were members of slum communities. Seven were illiterate, while the rest had completed an average of 9 years of schooling. The majority of female patients (9 of 12) were housewives. Other patients were students (n=4) or employed in small jobs such as selling vegetables or helping in an office. The

average household income amongst patients was Rs. 8300 ($184) per month. Almost all of the patients (21 out of 23) owned a mobile phone, and most (17 out of 23) owned a TV. They were enrolled with OpASHA's treatment program for an average of 3.9 months (min 2 months, max 8 months).

*Patients had varied understandings of the purpose and benefit of biometrics.* While the intent of the biometric system was explained briefly to patients by the counselor, the purpose and benefits of biometrics were not understood in all cases. This may have been compounded by the patients' unfamiliarity with biometric technology. Only two patients had used biometrics before (one for attendance in an office, and one for registering for an insurance scheme).

We asked patients to explain why the biometrics were in use. Sixty-one percent of respondents understood well, for example, saying that "it is for my benefit so that I come every day and give my fingerprint." However, 39% of respondents could not articulate the intent of the system. About half of patients (52%) expressed positive feelings for the biometrics, saying that it was "good" or similar, while the remaining patients did not offer an opinion.

When asked if the biometrics was helping the treatment, some patients perceived an impact. For example: "It is definitely helping the patients. Because of laptops the patients are coming to the center, and when they are here they will take their medicine also." However, others were not clear on how the system helps the patient. Several said that they "can't say" whether the biometrics helps the patients, while one patient, perhaps in an attempt to please the interviewer, said "Yes [it helps], but I can't say how."

When asked if the biometrics helped them personally, one patient said that her primary motivation in visiting the DOTS center was not due to biometrics, but due to better health: "I don't know [if the system helps me]. I would have come even if this device wasn't there because I want to get well." At the same time, another patient admitted that the biometrics changed her behavior in visiting the DOTS center: "I think so. If laptop wouldn't have been here I may not have come to the center so regularly but would have sent my husband."

Several patients were impressed that the organization was investing expensive resources in their treatment, and in turn felt more motivated to visit centers. A counselor recounted a story in which one patient encouraged another by saying, "The government and organization is doing so much to treat us – free medicines, free tests, even facility of attendance system to ensure that we get well. In spite of this if we can't come to the center to treat ourselves then we don't deserve to be treated!"

At the same time, some patients acknowledged that due to the biometric monitoring, they were under increased pressure to visit the DOTS centers, and this could sometimes lead to inconvenience. One counselor recalled, "The drivers have a problem coming to the center as they have erratic hours of duty. Earlier they could come on non-schedule day and take their medicine. Now they are under compulsion to come themselves and on the scheduled day. Such patients don't like this system." We view this sentiment as evidence that the biometrics is having its intended effect. While the treatment protocol may be inconvenient at times, when followed closely it ensures that all patients are cured.

## 5    Study Limitations

One limitation of our study is that responses of participants may have been biased due to *demand characteristics*, which is the tendency for participants to adjust their responses to conform with the investigator's expectations. Since our interviewer was a known champion of the biometric terminals, and also held an influential position in the organization, respondents could have felt pressure to speak positively about the technology.

To account for this contingency, we performed a second round of (shorter) interviews in which a different interviewer posed one of the same questions to the counselors. This interviewer (the second author) also contributed to the biometrics project, but had less interaction with the counselors to date and was thus less of an authority figure in their eyes. He asked counselors, "would you be disappointed if biometrics was removed from the program?" While 7 counselors responded similarly to before, one counselor reversed her stance, confessing that she was "a little scared" to admit to the first interviewer that she didn't want the terminal. She said the terminal was heavy and difficult to carry. This experience prompted us to study demand characteristics in more detail, culminating in an independent demonstration of dramatic response bias when working with underprivileged populations in India [1].

Unfortunately it is too late for us to precisely characterize or compensate for the influence of response bias on the results reported in this paper. We believe that most of the sentiments are genuine, especially those supported by concrete anecdotes. However, an independent assessment using interviewers that are not associated with the project, and not of greater social status than the counselors, could help to corroborate our findings.

## 6    Conclusions

This paper examines the potential benefits and hazards of deploying a biometric attendance terminal in a real-world healthcare setting. Unlike prior studies, our work focuses on low-income communities in India, where the role of biometrics is currently an active subject of scrutiny and debate. While our findings are preliminary, and based only on the opinions of stakeholders in the program, they do suggest that biometrics can play a positive role in persuading patients to adhere to a treatment protocol – in this case, ensuring regular consumption of tuberculosis medications.

Our interviews suggest two primary mechanisms by which biometrics is affecting behaviors. First, it persuades the counselor: by offering a transparent and tamperproof record of attendance, it makes counselors more accountable and thus more incentivized to attract patients to the center. Second, it persuades the patient: as most patients understand that the biometrics system cannot be fooled, they come to the center to avoid causing any negative repercussions for the counselor, or for themselves. There may also be a third element of persuasion, that we have yet to study, which is the influence on program managers as they start to incorporate biometric reports into their daily supervision of staff.

Future research could further investigate the relative role and interplay of these mechanisms. However, our goal in this paper was not to isolate the mechanisms of persuasion, but rather to understand whether biometrics, on the whole, can make a real tu-

berculosis treatment program more likely to succeed. In the future, more study is needed to rigorously assess the impact of biometrics on patient health outcomes, preferably via a controlled trial.

## Acknowledgments

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