

99DOTS: Using Mobile Phones to Monitor Adherence to Tuberculosis Medications

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Background: The WHO estimates that even in developed countries, less than half of chronic disease patients take medication as directed. This problem is especially dire in the case of tuberculosis (TB), where non-adherence to medication contributed to an estimated 450,000 drug-resistant cases in 2013. To bolster adherence, countries such as India have long embraced Directly Observed Therapy, Short course (DOTS), where patients travel to clinics to take doses under the observation of a care provider. However, DOTS has proven to be costly, difficult to implement, and inconvenient for patients. These factors greatly limit its reach and effectiveness.

Purpose: In this work, we propose 99DOTS: a new model of delivering tuberculosis medications that utilizes basic mobile phones and augmented blister packaging to provide real-time adherence monitoring without the burden of direct observation. As illustrated in Figure 1, our approach utilizes a custom envelope, or *blister card*, into which each pack of medication is inserted and sealed by the provider. When the patient dispenses medication from the blister pack, the pills also break through perforated flaps on the blister card. On the back side of each flap is a hidden number. Patients submit these numbers by sending a free missed call¹ as evidence that they have dispensed medication. The beginning of the phone number is printed on the outside of the card, while the remaining digits (unpredictable to patients) are hidden behind the pills.



Fig 1: 99DOTS prototype.

Methods: To understand the feasibility and acceptance of 99DOTS, we have conducted three pilots spanning over 40 patients in India. In Bangalore, we worked with St. John's Medical College to track new patients through the first two months of treatment. Patients were sent home with one month of free medications at a time. In Moradabad, Uttar Pradesh, we worked with Operation ASHA to use 99DOTS for two months in existing DOTS centers. And in Patna, private chemists are enrolling patients on 99DOTS; patients collect free medications with 99DOTS labels, and we track them through the course of treatment. In all these pilots, 99DOTS patients receive a series of daily reminders (via SMS and automated calls). Missed doses trigger SMS notifications to care providers, who follow up with personal, phone-based counseling. Real-time adherence reports are also available on the web.

Results: Results from the pilots are very encouraging. Over 90% of all doses were reported correctly using 99DOTS. All patients were able to use the system, even if they had not received any formal education. Rigorous qualitative interviews found that patients expressed gratitude for the implicit attention of a remote care provider who was always “looking over their shoulder”.

Conclusions: We believe that 99DOTS represents a promising approach for improving the delivery of tuberculosis medications. If a patient shows regular adherence under traditional DOTS, they could gradually transition to 99DOTS, improving convenience to patients and also allowing providers to focus their attention on less adherent patients. We are working with several institutions to scale up deployments of 99DOTS, and are planning a randomized controlled trial to evaluate its effectiveness.

¹ A *missed call* is when one calls a number and hangs up before the call is answered.