

Digital Health Support in Treatment for Tuberculosis

By Erez Yoeli, Jon Rathausser, Syon P. Bhanot, Maureen K. Kimenye, Eunice Mailu, Enos Masini, Philip Owiti, & David Rand

Improving support for patients with tuberculosis (TB) is a major priority for governments and development agencies around the world, and digital health interventions have the potential to address shortfalls in the current standard of care. Although access to the Internet, smartphones, and other forms of technology is still limited in areas with a high tuberculosis burden, mobile “feature” phones (i.e., phones that lack the advanced functionality of smartphones but can be used to make calls, send text messages, and access some simple Internet features through a text-based interface) are ubiquitous. Therefore, our team developed a digital health platform that was compatible with feature phones to provide support for patients with tuberculosis.

TB is curable and preventable yet it kills 1.6 million people a year (or 4,000 people a day) making it one of the top ten causes of death worldwide, according to the [World Health Organization \(WHO\)](#). In fact, it is the number one killer amongst infectious diseases, killing more people than HIV and Malaria, combined. Community stigmas, as well as adhering to a formal treatment regime are key reasons this extremely infectious disease is still a huge risk.

TB IS CURABLE AND PREVENTABLE YET IT KILLS 1.6 MILLION PEOPLE A YEAR (OR 4,000 PEOPLE A DAY) MAKING IT ONE OF THE TOP TEN CAUSES OF DEATH WORLDWIDE, ACCORDING TO THE WORLD HEALTH ORGANIZATION (WHO).

According to the WHO, a patient must take four antimicrobial drugs for at least six months to cure the disease. But health officials across the globe say that without supervision and support, many TB patients will not finish their medications.

STUDY METHODOLOGY

To conduct the study and find solutions, we teamed up with 17 health care clinics in Nairobi, the capital of Kenya, to create a randomized trial. There were 569 patients who participated in the intervention which granted support via our mobile phone platform, and 535 patients in the control group who did not receive any extra support, but continued to receive treatment according to the usual standards of care. The study was approved by the institutional review boards of Kenyatta National Hospital and the University of Nairobi.

IN THIS BRIEF

- Investigators assessed an interactive digital health intervention that motivated and reminded Kenyan patients with active tuberculosis to take their medication and complete treatment.
- Nonadherence to treatment regimens is a major medical problem that leads to serious negative health outcomes. Critically, the challenge is often behavioral, not medical.
- In a 1,200-patient randomized controlled trial at 17 clinical sites in Nairobi, 96 percent of the patients achieved successful outcomes with the digital health support.
- Patients with the digital health support were two-thirds less likely to fail to complete treatment than a control group that did not receive support via the mobile platform.

Our researchers, in collaboration with Keheala, an Israeli mobile health company, developed a health platform for tuberculosis patients. It works on “feature” phones, (a.k.a. “dumb” phones) that are relatively common in areas most prone to contagious disease outbreaks, like Sub-Saharan Africa, Southeast Asia, and Eastern Europe.

The program created interactive communication between patients and a team of supporters – rather than, one-way reminders about medication – and also used behavioral-science insights to help motivate patients to continue their recovery regimens.

We applied two of Keheala’s key behavioral principles to change patient behavior: “increased observability” of treatment adherence, and “eliminating plausible deniability,” that is, denying patients the opportunity to make excuses for missed treatments.

Individuals were randomly assigned to either receive the standard of care plus access to our mobile phone platform (intervention group) or the standard of care alone (control group). We employed block randomization within each of

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the 17 clinics, so that half the individuals in each clinic were assigned to each group.

THE PROGRAM CREATED INTERACTIVE COMMUNICATION BETWEEN PATIENTS AND A TEAM OF SUPPORTERS — RATHER THAN, ONE-WAY REMINDERS ABOUT MEDICATION

Patients were eligible for the study if they: (1) had been clinically diagnosed or bacteriologically confirmed to have TB; (2) were not diagnosed with a drug-resistant strain of TB; (3) could communicate in either Kiswahili or English; (4) owned or had access to a mobile phone on the Safaricom network, the dominant network operator in Kenya; and (5) had at least two months of TB treatment remaining.

Each day, patients received a text message asking them to verify adherence to treatment. Such interactive messaging approaches have shown more promise for promoting adherence than one-way reminders. If the patient did not verify adherence, two additional messages were sent at one-hour intervals, followed by messages and then phone calls from study team members who had personal experience of successful completion of treatment for tuberculosis. If there was still no response, a notification was sent to the clinic. This approach ensured that nonadherence was addressed in a timely fashion and presented patients with a resource for overcoming barriers such as challenges in accessing care, stigma in the community, and lack of information, motivation, or support. It also made patients feel accountable to others for their adherence or nonadherence. Social science research suggests that such accountability, also referred to as observability, motivates cooperative behavior.

The digital health platform also provided educational information about tuberculosis to patients. Weekly motivational messages such as “Taking your pills will help you get better and keep you from infecting family and friends” were sent by text message. Additionally, patients participated in an “adherence contest” in which they could compare their reported compliance with that of others and could qualify for a “winner’s circle” if their adherence was 90% or higher. These features further

enhanced accountability, helped to establish a norm of adherence, and emphasized the benefits to the community – all of which motivated patients to cooperate. All platform content was developed in conjunction with local study team members to ensure that it would be comprehended by and appropriate for the study population.

Individuals assigned to the control condition did not receive access to the platform; they simply received the usual care provided by their clinic. Upon consenting, they were sent a single SMS thanking them for participating, and informing them they would not receive any further messages.

RESULTS

Treatment outcomes were recorded by clinicians in the clinics’ TB registers following WHO guidelines. The primary trial outcome was an unsuccessful treatment outcome, which was defined as a composite of death during treatment for tuberculosis, treatment failure (i.e., the patient’s sputum smear or culture was positive at month five, or later), or loss of follow-up (i.e., the patient interrupted treatment for more than two consecutive

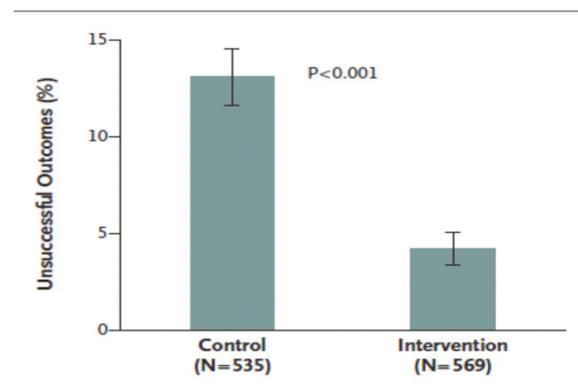


Figure 1

We excluded patients who had received a misdiagnosis or were transferred out of their clinic, as is standard when analyzing data involving TB patients. A total of 1,104 patients remained: 535 in the control group and 569 in the intervention group. The key result is that, of these patients, unsuccessful treatment outcomes occurred in 70 patients

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(13.1%) in the control group and 24 patients (4.2%) in the intervention group (See Figure 1).

In our online appendix, we also show that our results in the two groups were similarly large and significant when: loss of follow-up was considered; when patients with bacteriologically confirmed infection were included, or after adjustment for individual characteristics.

EXTRAPOLATING TO ALL OF KENYA, OUR INTERVENTION HAS THE POTENTIAL TO LEAD TO 12,291 ADDITIONAL SUCCESSFUL TREATMENTS PER YEAR.

Our results suggest behaviorally informed digital interventions can help address shortfalls in the current standard of care for TB treatment. Extrapolating to all of Kenya, our intervention has the potential to lead to 12,291 additional successful treatments per year. Based on current estimates, this would result in 329 fewer cases of drug-resistant TB, 1,553 fewer deaths, and savings of USD \$24.4 million in healthcare, household, and social costs. More broadly, this intervention could be adapted to other diseases, with HIV as a particularly compelling candidate. In ongoing research, we are testing our platform at scale in a randomized trial involving nearly 20% of Kenya's TB patient population. We are also using machine learning to develop interventions that provide differentiated support for individuals who would benefit from extra attention and care.

REPORT

Read the full *New England Journal of Medicine* article [here](#).

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REFERENCES

1. World Health Organization. The End TB Strategy. 2015 (<https://www.who.int/tb/strategy/end-tb/en/>).
2. Communications Authority of Kenya. Second quarter sector statistics report for the 2018 financial year 2018/2019 (October-December-2018). <https://ca.go.ke/wp-content/uploads/2019/03/Sector-Statistics-Report-Q2-2018-19.pdf>
3. Metcalfe JZ, O'Donnell MR, Bangsberg DR. Moving beyond directly observed therapy for tuberculosis. *PLoS Med* 2015; 12(9): e1001877.
4. Wald DS, Butt S, Bestwick JP. One-way versus two-way text messaging on improving medication adherence: meta-analysis of randomized trials. *Am J Med* 2015; 128(10): 1139.e1-1139.e5.
5. Rand DG, Yoeli E, Hoffman M. Harnessing reciprocity to promote cooperation and the provisioning of public goods. *Policy Insights Behav Brain Sci* 2014; 1: 263-9.
6. Collins D, Njuguna C. The economic cost of non-adherence to TB medicines resulting from stock-outs and loss to follow-up in Kenya. The Systems for Improved Access to Pharmaceuticals and Services (SIAPS) Program. 2016.

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