TUBERCULOSIS TREATMENT IN THE AGE OF DIGITAL HEALTH AND AI

A Scoping Review of TB medication adherence monitoring techniques

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PROJECT OVERVIEW

Identify and describe clinical trials published on the technology options for remotely monitoring TB medication adherence.

Scoping review: synthesizes research evidence and is used to categorize or group existing literature in a given field in terms of its nature, features, and volume
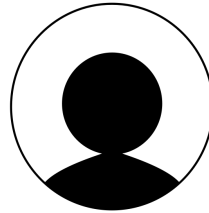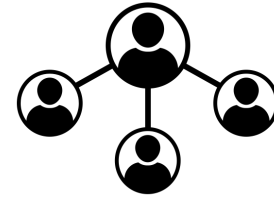
TUBERCULOSIS

MYCOBACTERIUM TUBERCULOSIS
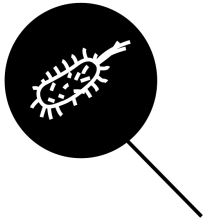
- Often affects the lungs
- Spread person to person from those with **active TB**
- spread when someone with lung TB coughs, sneezes or spits

LATENT TUBERCULOSIS

- Carry the bacteria, but cannot transmit the disease
- Affects about ⅓ of the world
- Lifetime risk of becoming ill
- **6-12 month** treatment

ACTIVE TUBERCULOSIS

- Bacteria kills tissue
- Symptoms: coughing, fever, night sweats
- 85% of cases from reactivation of latent TB
- **6-12 month** treatment

Estimated TB mortality rates excluding TB deaths among HIV-positive people, 2017

Mortality per 100 000 population per year

- 0–0.9
- 1–4.9
- 5–19
- 20–39
- ≥40
- No data
- Not applicable
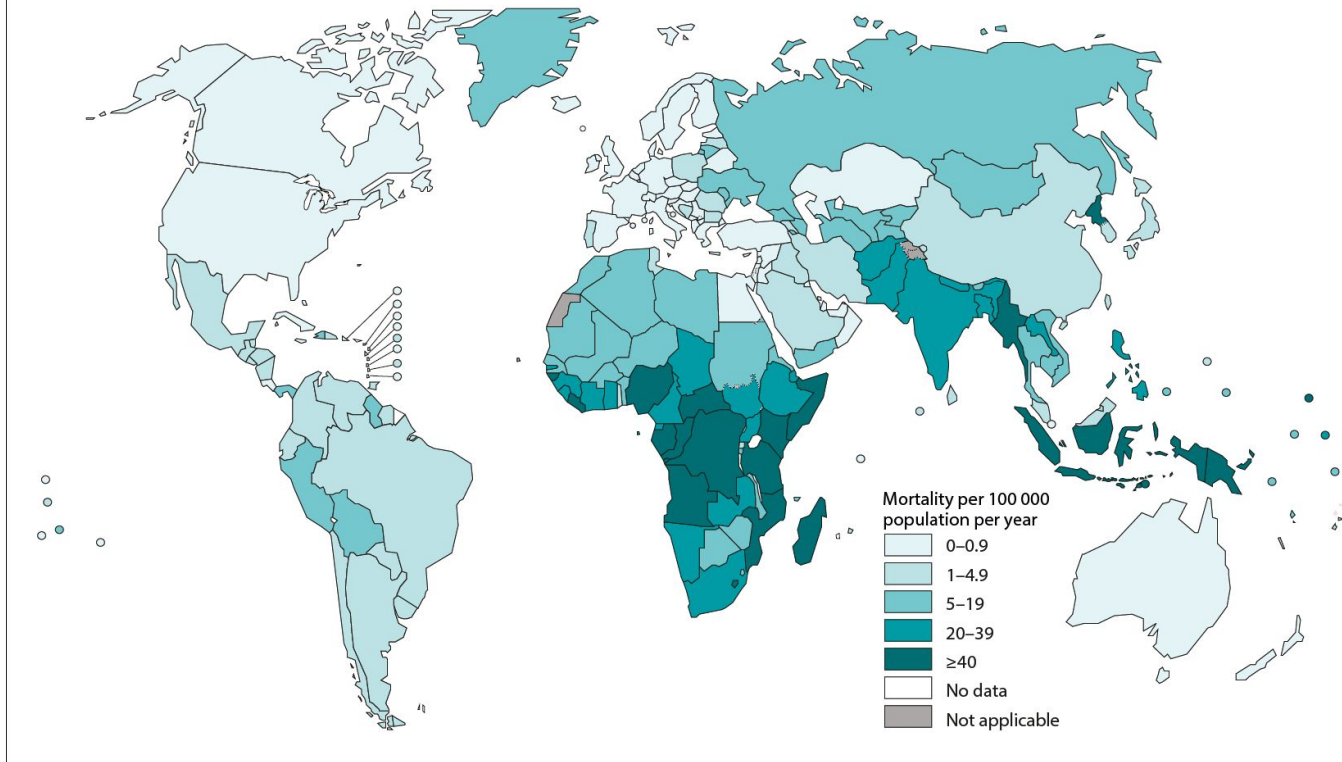
The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: *Global Tuberculosis Report 2018*. WHO, 2018.

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World Health Organization

Number of tuberculosis cases and TB incidence by national origin in the US, 2010-2018
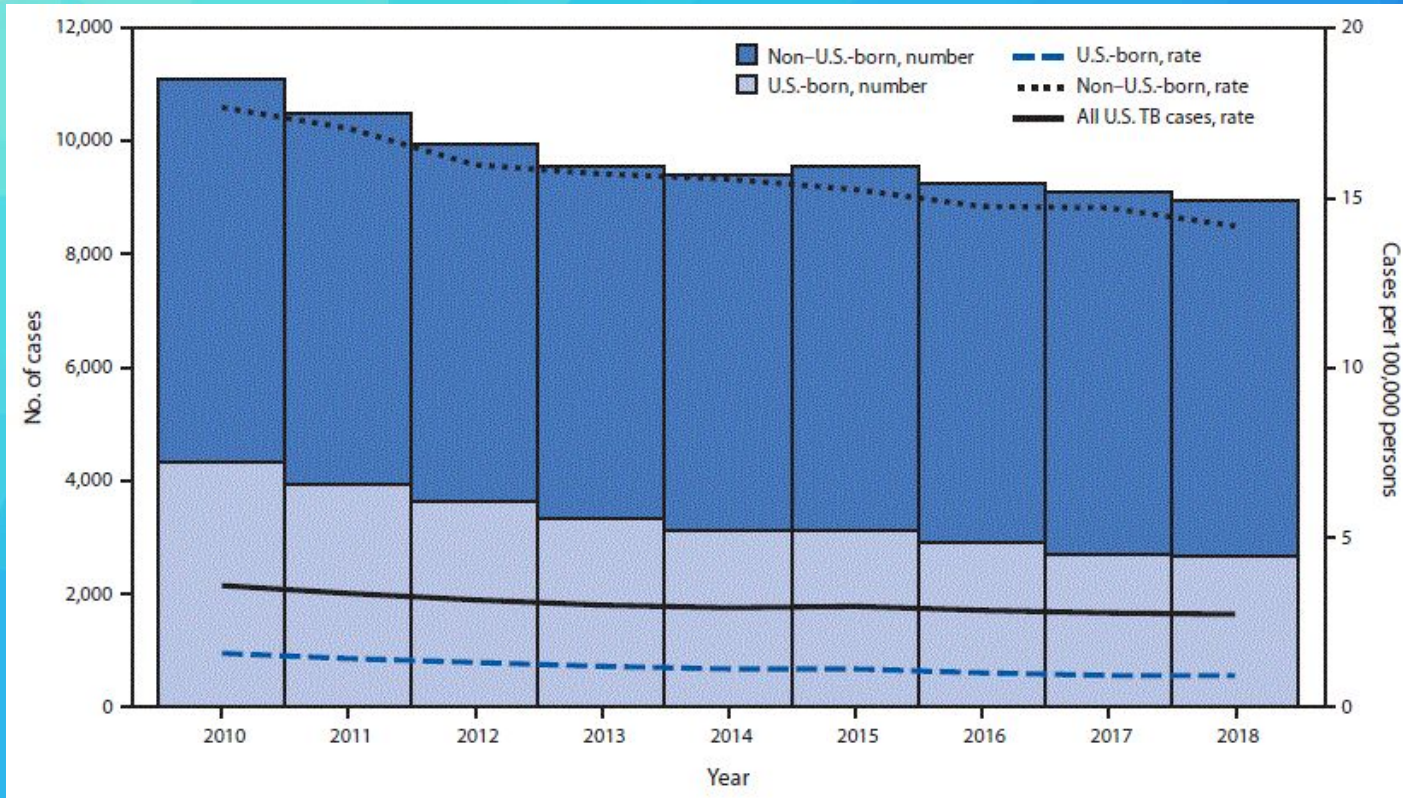
ENDING TB IS ON THE GLOBAL AGENDA

UN SDG 3: Ensure healthy lives and promote wellbeing for all at all ages
- 3.3 by 2030, end the epidemics of AIDS, **tuberculosis,** malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases

By 2035, WHO aims for a **95% reduction in TB deaths,** a **90% reduction in TB incidence** and for **no families to be facing catastrophic costs due to TB**

Pillars:
- Patient-Centered care and prevention
- Bold policies and supportive systems
- Intensified research and innovation

AIMS

Review and classify adherence monitoring alternatives in TB:

- What **patient populations** are studied?
- What number of potential participants **refuse** study?
- What amount of participants **dropout** of study?
- What parties is adherence information **shared** with?
- Do studies include a **qualitative assessment** of acceptability by users or other stakeholders? If yes, what frameworks are used?

Focused analysis was done on the *scalability, ethics,* and *effectiveness* highlighted in the included studies.
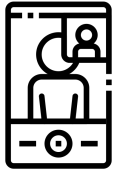
What methods are out there?

CURRENT PRACTICE
-Latent: Provider asks patient about medication use
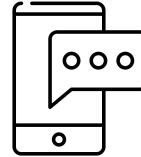-Active: Provider directly observes patient taking medication

SIGNALING PILL BOTTLE
-Bottle flashes when pill should be taken
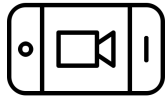-message sent to computer once pill bottle has been opened

LIVE VIDEO DOT
-Provider calls and observes patient taking pill on video platform

TEXT MESSAGES
-Provider asks patient if they have taken medication via text
-Patient reports adherence

RECORDED VIDEO DOT
-patient records video of themselves taking pill and uploads
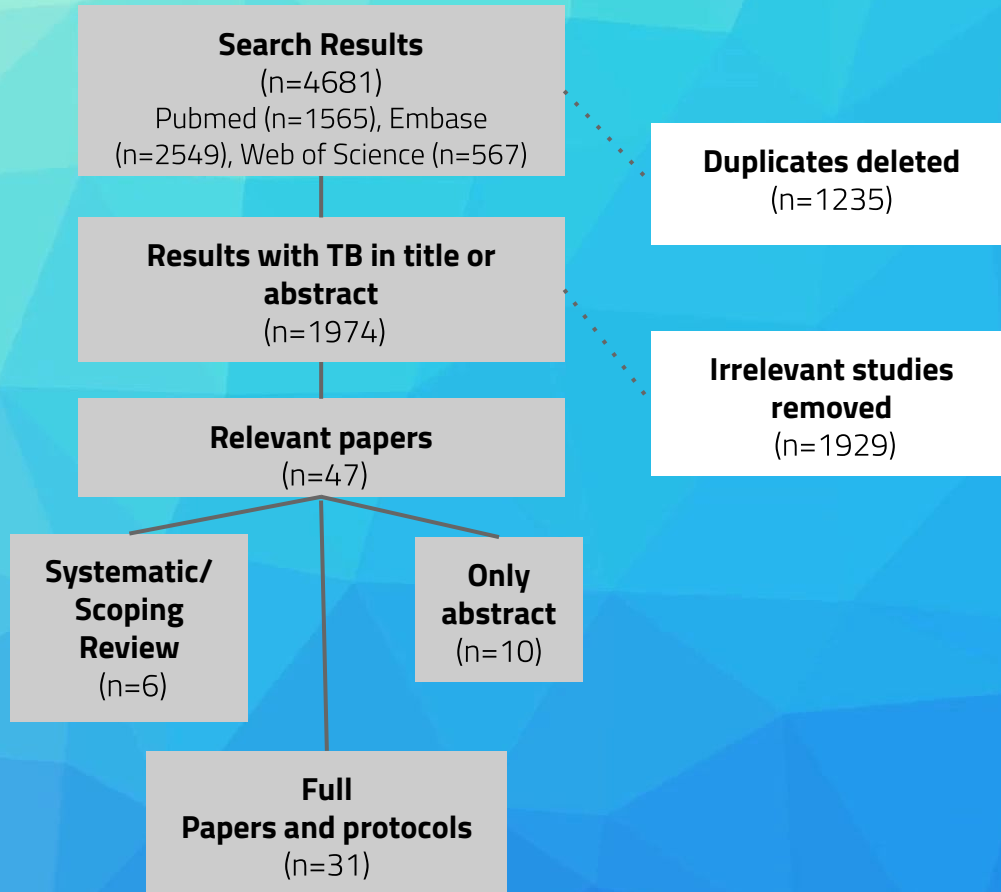-program has face and pill detecting AI technology

SIGNALING PILL
-signal released when pill reaches stomach, which sends notice to receiving device

METHODS

Scoping review in accordance with PRISMA guidelines. Three queries with identical search terms were conducted using *PubMed*, *Web of Science*, and *Embase*.

SEARCH RESULTS AND SCREENING PROCESS

Search Results
(n=4681)
Pubmed (n=1565), Embase
(n=2549), Web of Science (n=567)

Duplicates deleted
(n=1235)

Results with TB in title or abstract
(n=1974)

Irrelevant studies removed
(n=1929)

Relevant papers
(n=47)

Systematic/ Scoping Review
(n=6)

Only abstract
(n=10)

Full Papers and protocols
(n=31)

A title-abstract review was conducted to determine articles relevant to the research aims, followed by a review of the full papers (if available).

The articles will be screened by and independent reviewer and discrepancies will be resolved.

FINDINGS

31 STUDIES INCLUDED

4 STUDY PROTOCOLS

14 COUNTRIES

*include studies that took place in multiple countries

	Number of Studies
Country	
USA*	10
China	6
Tanzania	3
India	2
Australia	1
England	1
Haiti	1
Kenya	1
Mexico*	1
Morocco	1
Pakistan	1
Singapore	1
South Africa	1
Vietnam	1
Study Design	
Pilot evaluation	12
Randomized control trial	7
Mixed-methods study	4
Prospective cohort study	2
Retrospective cohort study	2
Data Sharing Parties	
Healthcare worker	21
Other	6
Physicians	2

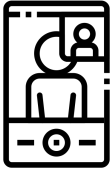# APPROACHES USED
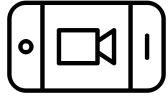
8
STUDIES USED RECORDED VIDEO DOT
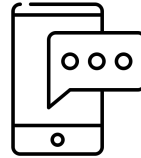
5
STUDIES USED A PHONE SYSTEM

6
STUDIES USED LIVE VIDEO DOT

1
STUDY USED A SIGNALING PILL

6
STUDIES USED A SIGNALING PILL BOTTLE

10
USED A COMBINATION OF THESE METHODS

KEY STUDY FEATURES

10753

TOTAL PARTICIPANTS

9662

PARTICIPANTS IN STUDIES REPORTING REFUSALS AND DROPOUTS

1237

OF THESE PARTICIPANTS REFUSED TO PARTAKE IN STUDY

636

OF THESE PARTICIPANTS DROPPED OUT OF THE STUDY

OTHER KEY STUDY FEATURES

19

STUDIES CONDUCTED QUALITATIVE WORK

4 INCLUDING PROVIDER PERSPECTIVES

7

STUDIES REPORTED COST SAVINGS FROM TECH ADHERENCE MONITOR

CONCLUSIONS

- **Patient populations**: most studies conducted in US, other high regions included SE Asia and Africa, most did not specify if treating latent TB
- **Amount of study participants/ study refusers:** 1237/9662 refused
- **Amount of study dropouts**: 636/9662 dropped out

- **Adherence data sharing:** most patient data shared with DOT/ other TB devoted health workers, some with providers, some with study research assistants
- **Qualitative assessments of acceptability**: 19 studies included qualitative assessments of acceptability with users, 4 of these 19 included other stakeholder perspectives

LESSONS LEARNED

STUDY LESSONS

- No set list of terms to capture the world of adherence monitoring tools
- Some articles may have been left out because of this
- Will have to go back through results with reviewer to verify data

PERSONAL LESSONS

- Had to wrap my head around the issue at hand
- Had to lean on resources of Penn to correctly conduct search
- Confirmed belief that global issues are local issues and local solutions are global solutions

THANK YOU!

QUESTIONS?

Appendix 1

Pubmed/Web of Science

(tuberculosis OR TB) AND ("99DOTS" OR "bracelet- and self-directed observational therapy" OR "BSDOT" OR "digital adherence technology" OR "digital health feedback system" OR "digital medicine" OR "digital pill" OR "digital pillbox" OR "drone observed therapy system" OR "DrOTS" OR "drug monitoring" OR "eDOT" OR "eHealth" OR "electronic direct observed therapy" OR "electronic pillbox" OR "ingestible biosensor" OR "ingestible event monitor" OR "ingestible sensor" OR "ingestion sensor" OR "medical electronics" OR "medical telemetry" OR "medication adherence" OR "medication adherence sensor" OR "medication adherence technology" OR "mHealth" OR "monitoring technology" OR "real time monitoring" OR "reminder systems" OR "sensor embedded medication" OR "sensor embedded pill" OR "smart pill" OR "telemedicine" OR "treatment compliance technology" OR "vDOT" OR "video recording" OR "videoconferencing" OR "virtual direct observed therapy" OR "wirelessly observed therapy" OR "WOT")

*Embase was identical, but used single quotation marks