UNIVERSITY OF WITWATERSRAND

FACULTY OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

Title: Mobile health technology to improve tuberculosis contact tracing in sub-Saharan Africa: A systematic review, 2010 to 2021

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Research Report submitted for the degree: MSc Infectious Disease Epidemiology

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20 July 2022

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I hereby declare that I completed the research project titled, **Mobile health technology to improve tuberculosis contact tracing in sub-Saharan Africa: A systematic review, 2010 to 2021**, under the supervision of Prof S. Charalambous, Dr M. Black, and Mr D. Mudzengi. Complete references have been utilized to denote all of the sources that I have used or quoted. This research effort is presented in partial fulfilment of the Master of Science in Infectious Disease Epidemiology degree requirements. This document has never been submitted to any other institute for any other degree.

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ACKNOWLEDGEMENTS

First and foremost, praise and appreciation to God, the Almighty, for showering His blessings on me throughout my study effort, allowing me to successfully complete the research.

I would like to express my deep and sincere gratitude to my research supervisor Prof S. Charalambous, co-supervisors Dr M. Black and Mr D. Mudzengi for giving me the opportunity to do research and providing invaluable guidance throughout this research. Your vision, genuineness and motivation have deeply inspired me. It was a great privilege and honour to work under your guidance. I am extending my heartfelt thanks to your families.

My sincere thanks also goes to Prof Duse, head of Clinical Microbiology and Infectious Diseases at the University of Witwatersrand and NHLS for assisting with a registration fee. I would like to thank National Health Laboratory Service for financial support. I am very honoured to be the recipient of this scholarship. I appreciate the help I received from my co-workers at the TB Laboratory in Braamfontein, both directly and indirectly, in carrying out this research.

Last but not least, I would like to express my gratitude to my family: my parents Thomas and Thembi Nhleko, for their unwavering prayers, love and support in whatever I endeavours. They are the ultimate role models. I would also like to thank my siblings Ntombizefa, Scelo and Sphamandla for their support.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	Acquired immunodeficiency syndrome
App	Application
C	Credible
CHW	Community health worker
CI	Confidence interval
CSUQ	Computer System Usability Questionnaire
DOTS	Directly observed treatment short course
EM	Emergency Medicine Guidance
GPS	Geographical Positioning System
HIV	Human Immunodeficiency Virus
HSRC	Human Research Sciences Council
JBI-QARI	Joanna Briggs Institute Qualitative Assessment and Review Instrument
LTBI	Latent tuberculosis infection
MDR	Multi-drug resistant
MeSH	Medical Subject Headings
mHealth	Mobile Health
NICD	National Institution for Communicable Disease
ODK	Open Data Kits
PDAs	Personal digital assistants
PICos	Population, Phenomena of Intrest, Context and studies
PIN	Personal Identification Number
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SMS	Short Message Service
SSA	sub-Saharan Africa
TB	Tuberculosis
U	Unequivocal
Un	Unsupported

USSD	Unstructured Supplementary Service Data
WHO	World Health Organization

Abstract

Tuberculosis is a major health concern in sub-Saharan Africa, with these countries having among the highest burden globally. One of the challenges with TB is the active cases that are undiagnosed and untreated which result in continuous spread of the disease. Contact tracing is crucial to control or eliminate the spread of TB. Currently, there is growing utilization of mobile devices in the health care sector and has resulted in the increased use of mobile technologies for health interventions described as “mobile health”. Based on previous studies, there is an increase recognition that mobile health technologies may improve public health programs irrespective of the disease or setting.

In this study, we conducted a systematic review guided by Joanna Briggs Institute guidelines. The goal of this study is to evaluate the efficacy of mHealth interventions for improving TB contact tracing, describe the use of mHealth within TB contact tracing using literature from previous studies, and to summarize lessons learned regarding the use of the mHealth approach in TB contact tracing.The review considered papers that included mHealth for TB contact tracing in sub-Saharan Africa. We thoroughly searched the following databases from 2010 to October 2021: PubMed, Google Scholar, MedLine and other sources for relevant articles.

Only nine published publications out of 5101 gave data on the use of mHealth for TB contact tracing in Sub-Saharan Africa since 2010. Six investigations were undertaken in Uganda, two in South Africa, and one in Botswana,.

The study reveals that research on the availability and use of mHealth for TB contact tracing in sub-Saharan Africa is sparse. Of studies found, the review revealed that the implementation of mHealth applications were feasible and acceptable to health care providers and patients in sub-Saharan Africa. SMS text message was highly acceptable and more convenient. mHealth approaches eliminated the need of paper

forms and improved the quality of data collected. However, digital fingerprinting recorded high rates of failure due to hardware and software complications. As a result, we recommend primary studies concentrating on the use of mHealth for TB contact tracing in sub-Saharan Africa.

Keywords: mobile health, mobile phones, mobile technology, TB, Tuberculosis, contact tracing, active case identification, Index case, sub-Saharan Africa.

CHAPTER 1. Introduction

1.1 Background

Tuberculosis (TB) is a major public health concern globally, with an estimated 10 million cases and 1.5 million deaths reported in March 2020 by the World Health Organisation (WHO) [1]. While TB has generally been managed in the industrialized world, control efforts in Africa, Asia and parts of Eastern Europe have been less effective [2]. According to the WHO estimates, non-industrial nations account for over 95% of cases and mortality happen in non-industrial countries[2]. Over 25% of TB deaths occur in the African Region, fuelled by the HIV/AIDS (human immunodeficiency virus/ acquired immunodeficiency syndrome) epidemic [1]. Globally, estimates suggest 23% of the population have a latent TB infection, with the potential to develop to active TB during their lifetime[3].

One of the challenges with TB is that there are many active cases that are undiagnosed and untreated, prompting the spread of the disease [4]. In 2017, a study that was conducted in South Africa and India, found that just 64% of the estimated cases of TB were accounted for, with the remaining 36% of missing cases being either undiscovered, untreated or unreported [5]. In a year, one untreated case of TB can be passed on to 10 to 15 individuals [1]. The long-term impact of undiagnosed and untreated TB is increased morbidity, mortality, poor health status and continued transmission of infection to the communities or within families leading to unaffordable health costs. There is therefore an urgent need to control TB through early detection and treatment [1].

Contact tracing refers to the process of identifying individuals exposed to an infectious case (index case) [1]. Contact tracing is the process whereby those living with a person who has been found to have TB are identified and investigated to exclude TB disease [6]. Usually a healthcare worker will interview the patient to find out people who are

possible contacts, for instance people living in the same household or other persons such as friends, relatives, colleagues and potential social groups[1,6]. The information given to the healthcare worker is treated with confidentiality[1,6].The exposed individuals are contacted and requested to book for a check-up in the health facility. If the person presents with symptoms of TB disease further tests are conducted[6]. All exposed individuals are given information about TB[6]. If TB disease is detected, treatment for TB is initiated immediately[6]. Those with latent TB should be offered preventive treatment according to guidelines [1,7].

Contact tracing [8] enables the early detection of TB, to prevent the transmission of the disease. Studies conducted in high TB incidence settings revealed a 5% higher prevalence among contacts, most of whom are household members of TB patients [9]. In addition, contact tracing can help to identify people with latent TB who are at a high risk of developing active TB [1], for example, the individuals who are infected with HIV, whose risk for rapid progression to active TB is very high [1].

Contact tracing has not been prioritised in high burden countries despite its potential for improving early detection of TB [10]. In its current form, contact tracing poses a logistical burden on the investigation team[11]. Time and cost constraints are some of the reasons why developing countries are unable to take full advantage of contact tracing[6]. There is also uncertainty around the most optimal approach[12].

In most resource-limited settings, contact tracing uses paper-based systems for in-field data collection [8]. These systems can be less effective due to the following reasons: it can be time consuming; storage and retrieval of data is laborious; and may yield poor data quality as they are prone to transcription errors [8]. Paper-based systems may be improved by introducing digital or mobile health technologies to resolve the challenges[11,13].

Mobile health (mHealth) tool is the practice for medicine including public health enhanced by mobile devices such as cell phones, tablets, Personal digital assistants (PDAs) and wireless infrastructure as defined by WHO [1]. mHealth technology includes the utilization of cell phones for collecting local area and clinical wellbeing information, conveying and sharing of medical services data [1]. Previous studies found that mHealth intervention has the potential to improve service delivery, monitoring and reporting of health care services [2,14–16]. In low income countries, these interventions can be less effective if internet connection is poor or non-existent [8], however in some cases data can be collected without using internet and interfaced at a later stage [17]. Another advantage is remote monitoring where patients are able to use mobile devices to capture information [11]. mHealth interventions have the ability to gather and retrieve high-quality data rapidly and it can create maps that will enable to identify disease hotspots [8].

Regardless of the advantages of using mHealth, formal evaluations that provide information around the use of mHealth for TB contact tracing will be necessary for TB programmes to successfully implement the approach[18]. The accessibility of practical information on mHealth application and assessment can increase and ease the approval of mHealth in resource-limited settings.

1.2 Problem statement

Developing countries, such as those in sub-Saharan Africa, have made significant progress towards addressing the high TB burden [19]. However, the progress is too slow to reach the global target set by the WHO to end TB by 2035 [1]. The reason for the limited success of TB control measures is complications in early diagnosis and in reaching all persons at risk[4,5,20–23]. Based on the above statement mHealth interventions may enable rapid contact tracing, reach large parts of the population and allow for remote monitoring. Evaluating the effectiveness of mHealth interventions for

TB contact tracing is vital for TB health programmes and decision-making by key stakeholders to fully support and implement the approach.

1.3 Justification

Despite improvements in addressing TB, it remains a significant public health concern. The End TB strategy requires an urgent action to eradicate TB in public health by 2035. In developed countries, mHealth has been shown to be powerful tool for control of infectious diseases [24]. However, in developing countries the paper-based system for control of infectious diseases and TB contact tracing remains common. Currently, sub-Saharan Africa has not yet successfully integrated mHealth due to the lack of available information on the effectiveness of this for TB contact tracing in sub-Saharan Africa. Therefore, understanding what has already been tried and which have been successful, will greatly benefit in implementing mHealth technology for TB contact tracing in the developing countries.

1.4 Research question

What is the effectiveness of mHealth interventions designed for TB contact tracing in sub-Saharan Africa?

1.5 Objectives

1. To describe the use of mHealth within TB contact tracing using literature from previous studies.
2. To assess the effectiveness of mHealth interventions for improving TB contact tracing.
3. To summarise lessons learned regarding the use of the mHealth approach in TB contact tracing.

CHAPTER 2. Literature review

2.1 Introduction

In this section, will discuss the epidemiology of TB, the contact tracing approach , previous studies that have been done in TB contact tracing and the use of mHealth technology as an intervention in sub-Saharan Africa (SSA) [(1)]. Those include reports on strengths, gaps, challenges and lessons learned in the implementation of mHealth. The review includes perceptions and barriers in utilisation of mHealth technology.

2.2 Epidemiology of TB

Globally, the incidence rate of TB is declining, but not fast enough to meet the 2020 target of a 20% reduction between 2015 and 2020 [(1)]. Between 2015 and 2019, the overall drop was 9% (from 130 to 142 new cases per 100 000 people), with a 2.3% reduction between 2018 and 2019. Furthermore, the WHO European Region has nearly accomplished the 2020 target, with a 19% reduction in the TB incidence rate between 2015 and 2019., With a drop of 16%, the African Region has made significant progress [(1)]. Globally, the annual number of TB deaths is decreasing, but not quickly enough to meet the 2020 milestone of a 35% reduction between 2015 and 2020 [(1)].

South Africa is among the top 30 countries with high burden of TB[(23)] . Furthermore, South Africa is also among 14 countries with the highest burden of MDR-TB and HIV comorbidity[(22)]. In 2018 a TB prevalence survey was conducted according to WHO recommendations by the South African Medical Council in collaboration with the Human Research Sciences Council (HSRC) and the National Institute for Communicable Disease (NICD) [(22)]. The survey focused on individuals older than 15 years across all nine provinces of the country using a multistage cluster sampling technology [(22)].

The findings of the survey were: the prevalence of bacteriology confirmed pulmonary TB for 2018 was estimated to be 852 per 100 000 individuals; the disease was more prevalent in men (1.6 times that of females); more than two thirds of HIV negative symptomatic participants had not sought healthcare for their symptoms; a higher proportion of HIV negative people were asymptomatic compared to those living with HIV [22]. The survey findings confirmed that South Africa has a high TB burden with a high proportion of people with undiagnosed TB in the community.

2.3 TB contact tracing

Finding and treating the missing persons with TB is a priority as it is the key to ending the TB epidemic [1]. The goal of contact tracing is to shorten the time it takes to diagnose and treat a case and reduce the potential of infectious patients to spread the disease[1]. WHO advises that more than 90% of newly diagnosed TB patients' contacts be tested for TB in order to fulfil ambitious worldwide targets of lowering TB incidence and mortality with 90% by 2035[1,25].

2.3.1 Household contact tracing

Household contact tracing is performed systematically, beginning by a contact investigator in local care centres to collect the list of index patients and their addresses from TB treatment registers [26,27]. Eligible index patients are defined as having bacteriology confirmed pulmonary TB, as per guidelines[23,26,27]. The contact investigator then visits the household of the index case at a date and time previously agreed during the admission interview[23,26,28]. The contacts are screened using a questionnaire which assess their risk for TB infection or disease and the need for further laboratory investigation [26]. Sputum samples are collected and transported to TB diagnostic centres by the contact investigator [10,26].

Those who have been diagnosed with TB are referred to the health facility to start on appropriate treatment and be documented in the TB treatment register [29]. The symptomatic contacts with negative initial sputum samples are directed to the medical facility for further evaluation[26,29]. Asymptomatic contacts eligible for TB preventative therapy are counselled and referred to the health facility to be registered for this purpose[26,27,29].

The Challenge TB study conducted in Nigeria, in 2016 and 2017 on household contact tracing has shown encouraging results [26,28]. The study reported a 38% and 65% coverage of index patients, in 2016 and 2017 respectively [28].

Various studies done in sub-Saharan Africa have shown a yield of between 5-15.7% [26,27,30,31]. For example, the household screening pilot study conducted in South Africa between 1 September and 31 October 2016 showed a yield of 6.6 % newly identified TB cases among the household contacts[31]. The study conducted in Uganda, targeting contacts of newly diagnosed bacteriology confirmed TB, showed a yield of 15.7% and an Ethiopian study had a yield of 10.0% [27]. In the study conducted in South Africa, they established that non-targeted household contact tracing demonstrates a lower yield [26].

Even though the yield of contact tracing is high as demonstrated above, the implementation is not adequate [28]. Under-tracing of contacts resuls in missed opportunities for case finding and testing [25,28].

2.4 Challenges of TB contact tracing in sub-Saharan Africa

The barriers and gaps identified in TB prevention and care in the region SSA include weak TB screening strategies in targets groups, and inadequate involvement of health providers [1].

Rural settings have their own challenges. In SSA, rural areas still account for 60% of the population. Despite being less densely populated, the prevalence of tuberculosis in rural areas is comparable to that in large cities, possibly due to poverty, malnutrition, and limited access to care and poor access to care [12,27]. Long distances between healthcare institutions and villages, as well as limited transportation infrastructure, pose challenges in rural areas, making traditional home contact tracing more difficult to accomplish[8,25]. These challenges lead to under-tracing of contacts.

Care seeking was identified as a challenge in a survey conducted in South Africa in 2018 [22]. Among participants with symptoms suggestive of TB, almost two-thirds did not seek care at the time of their participation in the survey. Of these,60.2% reported that they were still planning to seek care [22]. A further 26.6% regarded the symptoms as not serious and thus did not seek care[22].

2.5 Mobile Health Technology in sub-Saharan Africa

The utilization of mobile phones on the African continent has increased significantly [32]. Telecommunication services are now available in practically every household in the world, a characteristic that was previously unavailable with fixed telecommunication systems [34–36]. The cost of infrastructure has hitherto limited the broad adoption of telemedicine, but mobile technology offers the potential to overcome this hurdle [34,36]. Wireless technologies are substantially less expensive than cable technologies, which are the foundations of telemedicine [34–36]. Furthermore, broadband wireless technologies provide increased network capacity and improved service quality [33].

The utilization of mobile devices in healthcare has increased [16,33,34]. Such devices make it possible to disseminate health information, gather intelligence on disease

outbreaks, perform remote diagnosis of diseases and provide health education to healthcare professionals as well as patients [16,34].

The decreasing costs of internet-enabled smartphones make a powerful platform for extending healthcare services to low income settings in Africa. Therefore, mobile health (mHealth) has the potential to assist African countries towards sustainable solutions to healthcare systems [35]. There are several existing initiatives to address the health challenges in Africa using mobile technologies [15,16,18]. Fortunately, tracking and monitoring health has become increasingly more engaging and effective. Mobile health represents a crucial piece of the digital health narrative and is constantly evolving to ensure critical issues are being addressed [15,16,18,33,36].

2.5.1 Application (apps) of Mobile Health technology

Currently, there are many mHealth applications already available. mHealth assists healthcare providers to collect and monitor clinical and community data in real-time [36–40]. The mHealth apps have been divided into the following categories:

2.5.1.1 Remote monitoring apps

Remote monitoring apps assist health care providers to take care of home- based patients [11] as it is not necessary to attend to all patients, in person, at the health facility [40]. The app allows the healthcare provider to track vital signs like blood glucose levels, oxygen level, heart rate, blood pressure, etc. without actually visiting the patient. In addition, remote monitoring has an effect in reducing transmission of infectious disease especially in times of outbreaks such as COVID-19 [11].

2.5.1.2 Clinical and diagnostic apps

Apps can also be used to allow healthcare workers to view laboratory results, check electronic health records, or perform digital imaging. By using such apps, the doctors can collect data from patients, evaluate and share it. Such an app also assists in

checking symptoms and diagnosing illnesses[33,34,41]. Patients may schedule appointments utilising the app.

2.5.1.3 Healthy living apps

These apps were created with the intention of encouraging people to live a healthier lifestyle. Patients with heart disease or diabetes may find the app useful because it captures data such as heart rate, nutrition, exercise, and sleep[36].

2.5.1.4 Clinical reference apps

These include references and guides everywhere[16]. In South Africa, for example, there is an app called “EM Guidance” that incorporates all of the National Department of Health`s clinical guidelines as well as medicinal information and courses.

2.5.1.5 Productivity apps

Healthcare practitioners benefit from productivity tools that help them work more efficiently. Mobile charting, home healthcare scheduling, internal corporate communication, and remote dictation are all features of the app [42].

2.5.2 Text messaging in Health care

The concurrent development of low-cost, simple-to-use mobile health applications based on SMS have numerous innovative strategies, to improve communication between patients and healthcare professionals[43,44]. SMS is a technique for text message transmission between mobile handsets[43]. Text messages are frequently sent from one mobile device to another or across many mobile devices between individuals[43]. However, utilizing SMS software, it is also feasible to send mass messages to numerous recipients[43].

2.5.2.1 SMS function

SMS functional needs will also be determined by the intricacy and complexity of the intervention program[34,43]. For instance, a task that merely calls for simple, unidirectional texting may be one that involves reminders or instructive content[43]. Contrarily, a text bidirection will be needed for an intervention that includes responses to incoming responses[43,45]. For bidirection texting, you must decide whether the incoming responses will be closed-ended or open-ended, which necessitates reading each response[43]. If more than one message will be sent, the ability to set a schedule for sending messages is necessary[43].

SMS text messaging has made this possible, in terms of patient care, it has been shown that text messages sent from mobile phones can encourage healthy behavior changes[44,45] .

Studies on health have shown varying degrees of effectiveness in improving clinical outcomes and patient satisfaction. For instance, a Cochrane systematic review of two studies by Lester at el [44,46] in Kenya revealed that text messaging is effective in boosting adherence. They experimented with a two-way SMS intervention where participants in the intervention group had to respond once per week[44,46]. They discovered a 12 % point increase in self-reported[46]. Pop-Eleches et al [47]also demonstrated the efficacy of SMS texting by reporting a 13 % point increase in the intervention group that received weekly one-way texts[47]. Singh et al findings indicated that SMS reminders can considerably increase the likelihood that a patient will follow up on an appointment date when compared to no intervention (62.26 % vs. 45.37 %)[48].

Based on these studies, it is reasonable to draw the conclusion that SMS is successful in causing a change in behavior that is good and at increasing provider connectivity[43,44,48].

2.5.3 Mobile health(mHealth) approach for the community health worker

In Africa, mHealth has been utilized to report adverse events during intense MDR-TB (Multiple Drug Resistant-Tuberculosis) treatment[37]. in Uganda and Kenya, text messaging was utilized to provide mHealth in the treatment of Acquired Immunodeficiency Syndrome (AIDS). Another study in Argentina found that utilizing a customized mHealth app to calculate patients' cardiovascular risk was beneficial [37,39,40]. In a study conducted in rural Guatemala, they developed and implemented an application for diabetes to provide algorithmic decision support to the community health worker and also serve as a data collection tool and medical record [36]. Therefore, mHealth has proven that various applications increase access to care [49]. mHealth approaches employing mobile devices in the management of tuberculosis (TB) have shown promise in terms of lowering information delivery costs and enhancing communication quality[15].

2.5.4 Mobile Health (mHealth) TB Self-screening

There has been limited use of mobile health for TB. In Tanzania they launched the TB Self-Screening and Patient Treatment mHealth app in September 2018 in an example 164,018 individuals had completed the TB self-screening evaluation over 7,657 enrolled for the TB awareness messaging service[50,51]. Furthermore, 450 healthcare providers have been trained on the app. The app enables for data disaggregation and a breakdown of presumptive versus non-presumptive situations for self-screening [51].

In South Africa(SA), the minister of health acknowledged that the CoVID-19 pandemic has forced the government to make use of technology for TB screening,

contact tracing and adherence [39]. The app called the TB Health Check was developed using the Unstructured Supplementary Service Data (USSD) code or a WhatsApp line number where the public can self-screen for TB[39]. The app guides users through a series of questions and then advises them whether they need a TB test or not. More than 9 000 people had screened themselves on the app to date and 600 of those had been referred for a test [39]. Of those that tested, 1 in 10 were found to be positive for TB and treatment was initiated [6]. The app came just after the release of a survey that was conducted by the Human Science Research Council on the prevalence of TB in South Africa [16,18,39].

This app provides an easy way for everyone to screen themselves for TB without a fear of stigma in your convenience of your own home[39]. The extensive growth of mobile phone coverage in Africa and other resource-constrained areas presents potential to use mHealth technologies to address health system shortcomings and improve healthcare service delivery.

2.6 Mobile health technology to improve TB Contact tracing

The increase in mobile phone utilization has brought the opportunity to incorporate the mobile phone as a healthcare intervention tool in TB patients [14,32]. In a Botswanan study, an mHealth approach to TB contact tracing was developed, composed of mobile phone and tablet app supported by an online database [8,13]. The approach was designed to eliminate the need for manual recording on paper contact examination forms, data entry into the database and summary report production are both manually. The mHealth approach was also created with the goal of allowing users to record the spatial coordinates of incidents. It also cut the time it took to finish each contact's TB contact tracing f and generated and emailed summary reports to designated recipients [13] . The quality of the data collected improves as a result of this method[8,13].

The application also illegibility issues were eliminated, and users were prevented from leaving fields blank or giving irrational values[8,13]. Similar to the study that was conducted in Zambia where the locations of health centres were mapped using geographically positioning system (GPS) coordinates and patterns of case detection in the area of each facility were shown [16,52].This strategy increased the quality of location data acquired using mHealth approaches that took advantage of GPS capabilities of mobile devices[18]. Users could use this app to activate the GPS function on their mobile smartphone and capture the geographic coordinates of each case's location[21].

2.6.1 Mobile health technology for TB household contact tracing

Contact tracing studies have shown that 41.3% to 61.3% of household contacts have latent TB infection, and that 3.5% to 6.5% develop active disease [17,20,53]. ETR.net (www.etrnet.info), ENRS, and e-TB manager are only a few of the electronic TB registries and monitoring systems that have been reported in recent years. The Open Data Kit (ODK) is a free open source data gathering toolkit that allows developers to create forms for their Android apps [17].

2.7 Summary

The previous studies and surveys that were conducted in SSA and in high TB burden countries have identified numerous challenges of existing traditional household TB contact tracing. The main challenges are under-reporting, poor data collection, lack of infrastructure, inadequate involvement of healthcare providers, lack of knowledge, long distance between healthcare facilities and villages, and stigmatization. Mobile based systems have the potential in overcoming these challenges.

CHAPTER 3 Research Methodology

This chapter outlines the study design, papers selected for retrieval, and inclusion criteria using the Standardized Critical Appraisal Instrument from the Joanna Briggs Institute Qualitative Assessment**.**

3.1 Registration

The protocol was registered with the (Ref: W-CBP-210826-01) Human Research Ethics Committee of the University of Witwatersrand in Johannesburg South Africa. The study was granted ethics waiver.

3.2 Literature search

This review was done according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Original literature published from 1 January 2010 to 17 October 2021 in electronic databases was included. First, a limited search to identify the keywords and index terms was utilised. Second, the keywords were used across all databases of PUBMED, MEDLINE, Cochrane, Google scholar, Web of Science and Witwatersrand Library. Thirdly, the reference list of all identified articles were searched for additional studies.

Table 1: Number of studies found and selected for retrieval

Date of search	Search Engines used	Keywords Search	Found Articles	Selected for retrieval
17/10/2021	PubMed	("telemedicine"[Mesh Terms] OR "telemedicine"[All Fields] OR ("mobile"[All Fields] AND "health"[All Fields]) OR "mobile health"[All Fields]) OR ("telemedicine"[Mesh Terms] OR "telemedicine"[All Fields] OR "mhealth"[All Fields]) OR ("cell phone"[MeSH Terms] OR ("cell"[All Fields] AND "phone"[All Fields]) OR "cell phone"[All Fields] OR ("mobile"[All Fields] AND "phones"[All Fields]) OR "mobile	1970	115

		phones"[All Fields]) AND TB[All Fields] OR ("tuberculosis"[MeSH Terms] OR "tuberculosis"[All Fields]) AND (("contact tracing"[MeSH Terms] OR ("contact"[All Fields] AND "tracing"[All Fields]) OR "contact tracing"[All Fields]) AND ("African continental ancestry group"[MeSH Terms] OR ("African"[All Fields] AND "continental"[All Fields] AND "ancestry"[All Fields] AND "group"[All Fields]) OR "African continental ancestry group"[All Fields] OR "African"[All Fields]) AND ("geographic locations"[MeSH Terms] OR ("geographic"[All Fields] AND "locations"[All Fields]) OR "geographic locations"[All Fields] OR "region"[All Fields])) AND ("2010/01/01"[Pub Date] : "2021/10/17"[Pub Date]) locations"[All Fields] OR "region"[All Fields])) AND ("2010/01/01"[Pub Date] : "2021/10/17"[Pub Date])		
	MedLine NLM	Mobile health OR mHealth apps OR mHealth applications OR mHealth devices OR Eregistry AND TB OR Tuberculosis OR Mycobacterial Tuberculosis OR smear positive TB OR Mycobacterial disease AND contact tracing OR case finding OR active case finding OR screening OR case detection AND households contact OR patients AND healthcare workers AND sub-Saharan Africa	141	15
	Other sources (google scholar and google)	Mobile health OR mHealth apps OR mHealth applications OR mHealth devices OR Eregistry AND TB OR Tuberculosis OR Mycobacterial Tuberculosis OR smear positive TB OR Mycobacterial disease AND contact tracing OR case finding OR active case finding OR screening OR case detection AND households contact OR patients AND healthcare workers AND sub-Saharan Africa	2990	302

3.3 Selection criteria

The literature was selected according to PICoS (Population, Phenomena of Interest, Context and Studies). The included criteria of the study were as follows (1) P: The subjects in these literatures should be TB patients, contacts of the TB index case and health care workers. (2) I: The studies that evaluate the use of mobile health technology for TB contact tracing. (3) C: The studies should be conducted in sub-Saharan Africa. (4) S: Cross-sectional studies, cohort studies, randomized controlled trials studies, observational studies and mixed-method studies were acceptable (5).

The language of the included studies is English. One researcher (PN) searched the literatures and compiled the eligibility list for screening. Firstly, the titles of articles were screened and then selected. Then the abstracts were further screened. Lastly, the full text of the articles was read in order to decide which studies to be included. The eligibility list was screened by two researchers (PN & DM) independently. There were no discrepancies to included studies. However, if researchers (PN & DM) had discrepancies on whether to include a certain study, the senior researcher (Prof Charalambous) was going to be consulted to make a final decision.

3.4 Data Collection and Data management

The information from each literature was extracted by one researcher (PN) including: authors, study design, nature of mHealth intervention, purpose of mHealth intervention, procedure and description country, year of publication, target population, type of mHealth device. Data was reviewed and discussed with all reviewers (Prof Charalambous, Dr Black, Mr Mudzengi) (Table 1).

The Mendeley reference manager was linked to search engines and used to store all references selected, clean and remove duplicate citations and create citations when writing up the systematic review results.

3.5 Quality Assessment

We used the Joanna Briggs Institute Qualitative Assessment, Review and Appraisal Instrument (JBI-QARI) (Table 2 and Table 3). JBI-QARI assist in assessing the trustworthiness, relevance and results of the published paper. It addresses the possibility of bias in its design, conduct and analysis. It assesses whether the studies actually address the question, process and context in relation to the intervention and the outcome.

Table 2: JBI Critical Appraisal Checklist for randomized Controlled trials

JBI CRITICAL APPRAISAL CHECKLIST FOR RANDOMIZED CONTROLLED TRIALS	Yes	No	Unclear	NA
1. Was true randomization used for assignment of participants to treatment groups?	□	□	□	□
2. Was allocation to treatment groups concealed?	□	□	□	□
3. Were treatment groups similar at the baseline?	□	□	□	□
4. Were participants blind to treatment assignment?	□	□	□	□
5. Were those delivering treatment blind to treatment assignment?	□	□	□	□
6. Were outcomes assessors blind to treatment assignment?	□	□	□	□
7. Were treatment groups treated identically other than the intervention of interest?	□	□	□	□
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	□	□	□	□

9. Were participants analyzed in the groups to which they were randomized?	□	□	□	□
10. Were outcomes measured in the same way for treatment groups?	□	□	□	□
11. Were outcomes measured in a reliable way?	□	□	□	□
12. Was appropriate statistical analysis used?	□	□	□	□
13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?	□	□	□	□

Table 3: JBI Critical Appraisal Checklist for Qualitative Research

	Yes	No	Unclear	Not applicable	
1. Is there congruity between the stated philosophical perspective and the research methodology?	□	□	□	□	
2. Is there congruity between the research methodology and the research question or objectives?	□	□	□	□	
3. Is there congruity between the research methodology and the methods used to collect data?	□	□	□	□	
4. Is there congruity between the research methodology and the representation and analysis of data?	□	□	□	□	
5. Is there congruity between the research methodology and the interpretation of results?	□	□	□	□	
6. Is there a statement locating the researcher culturally or theoretically?	□	□	□	□	
7. Is the influence of the researcher on the research, and vice- versa, addressed?	□	□	□	□	

8. Are participants, and their voices, adequately represented?	□	□	□	□	
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	□	□	□	□	
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	□	□	□	□	
Overall appraisal:	Include	□	Exclude	□	Seek further info □

3.6 Data Synthesis and Analysis

Qualitative research findings were collected using JBI-QARI. This involvement of compiling the data on the basis of similarity in meaning, which resulted in a collection of categories that reflected aggregation. These categories were then subjected to synthesis to producing a single set of synthesized findings which could be used as a basis for evidence-based practice. “Evidence-based practice (EBP) results from the integration of available research, clinical expertise, and patient preferences to individualize care and promote effective care decision-making”[(54)]. The Joanna Briggs Institute degrees of credibility were used to provide a level of credibility to each finding. The following are the three levels or degrees of credibility:

- Unequivocal (U)-evidence beyond reasonable doubt
- Credible (C)-although an interpretation, plausible in view of data.
- Unsupported (Un)-findings not supported by the data.

3.7 Study setting and context

Figure 1: Map of sub-Saharan Africa [55] where selected studies were conducted. Sub-Saharan Africa is geographically the area of the continent of Africa that lies south of the Saharan and consists of 46 of the 54 African countries

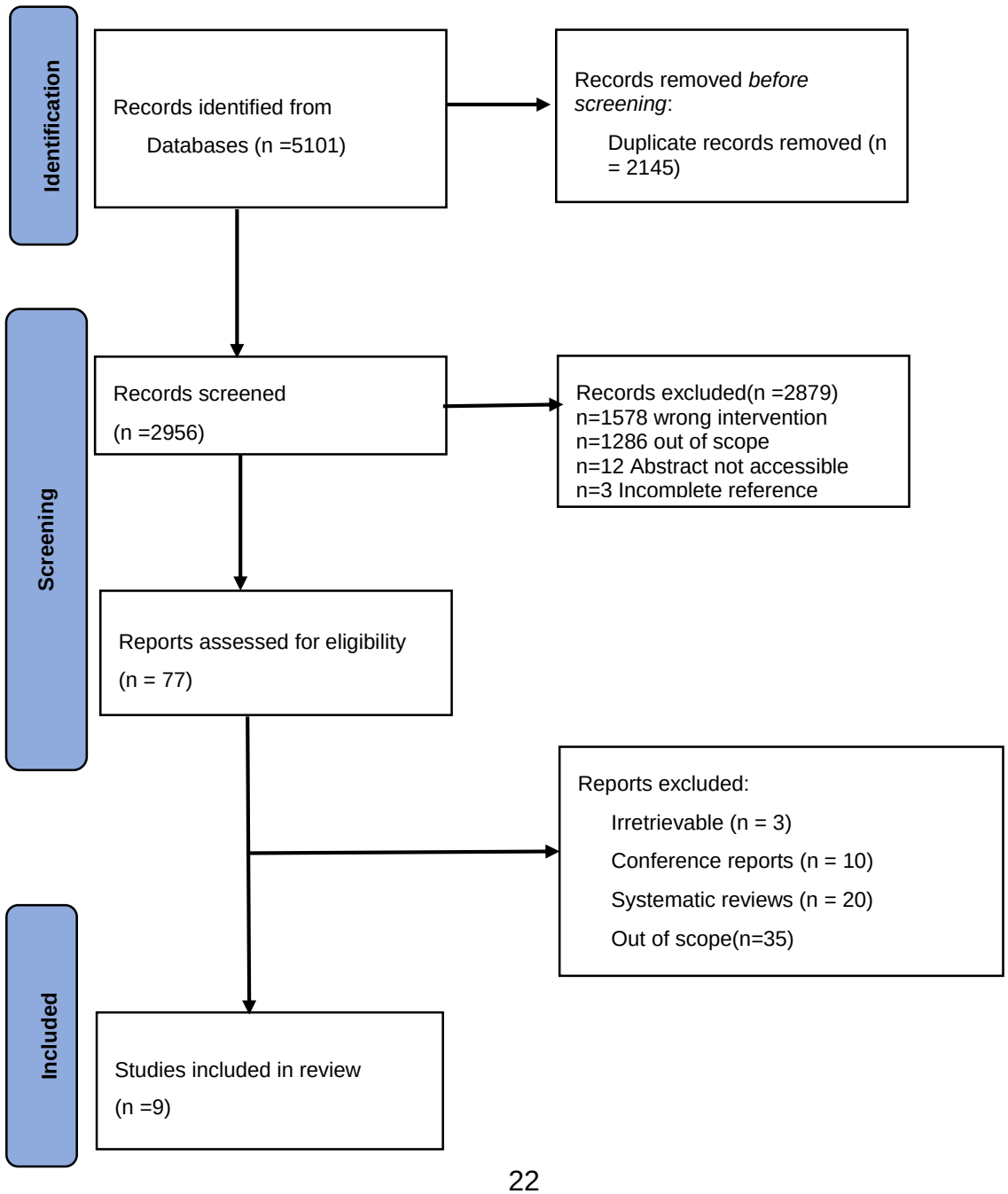
CHAPTER 4. Research Results

This chapter summarises the findings of papers of the research that were conducted in sub-Saharan Africa.

4.1 Results

All of the databases yielded a total of 5101 articles. After removing duplicates, 2956 articles were left for title and abstract review. Following that, a list of 77 articles was generated based on inclusion criteria, and 9 articles were chosen for the final stage based on full text evaluation(Figure 2).

Figure 2 The PRISMA flow in indicates the process of selection.



4.2 Description of studies

The final data of nine studies for extraction and synthesis are reported (Table 2). The publication dates of the included studies ranged from 2016 to 2020. The studies included were geographically located in sub-Sahara Africa. The majority of studies included in this review were from Uganda. Six studies were conducted in Uganda, two studies in South Africa, and one in Botswana.

TABLE 4. Data abstraction of included studies

Author	Year	country	Study design	Type of mHealth device	Nature of mHealth intervention	Target	Purpose of mHealth intervention
Maraba (38)	2018	South Africa	Qualitative study	Mobile device	SMS PIN-Protected USSD	TB Patients	For contact tracing
Yoonhee (8)	2016	Botswana	Qualitative study	Mobile device	Mobile app	TB Patients	For contact tracing
Ggita (56)	2020	Uganda	Cross-sectional	Mobile device	SMS	Homes of index TB patients	house contacts experience in receiving the test results via SMS.
Meyer (57)	2018	Uganda	Cross-sectional	Mobile device	SMS	Homes of index TB patients	For contact tracing

Ggita (58)	2019	Uganda	Cross-sectional studies	Mobile device	SMS and voice calls	Household contacts and TB patients	For contact tracing
Davis (59)	2019	Uganda	Randomised controlled trial	Mobile device	SMS	Household contacts and TB patients	For contact tracing
White (60)	2018	Uganda	Mixed-Methods Analysis	Mobile device	Digital fingerprints	Household contacts and TB patients	To understand the feasibility, acceptability, and adoption of digital fingerprinting
DiAndreth (61)	2020	South Africa	Non-Randomised controlled trial	Mobile device	SMS PIN-Protected USSD and Mobile app	HIV and TB patients	To assess an mHealth intervention to deliver results.
Meyer (62)	2020	Uganda	Case study	Mobile device	Mobile app	TB patients	Implementation of mHealth

4.2 Quality assessment

Table 5: Final assessment table (JBI-QARI critical appraisal instrument) for qualitative

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Meyer et al. 2020	Y	Y	Y	Y	Y	Y	U	Y	Y	Y
Maraba et al. 2018	Y	Y	Y	Y	Y	U	U	Y	Y	Y
Yoonhee et al, 2018	Y	Y	Y	Y	Y	N	U	Y	Y	Y
Ggita et al. 2018	Y	Y	Y	Y	Y	Y	U	Y	Y	Y
White et al. 2018	Y	Y	Y	Y	Y	N	U	Y	Y	Y
Ggita et al. 2020	Y	Y	Y	Y	Y	N	U	Y	U	Y
Meyer et al.2018	Y	Y	Y	Y	Y	N	U	Y	U	Y
%	100	100	100	100	100	30	0	100	71	100

N- no, U-unclear, Y-yes, Q1. Is there congruity between the stated philosophical perspective and the research methodology? Q2. Is there congruity between the research methodology and the research question or objectives? Q3. Is there congruity between the research methodology and the methods used to collect data? Q4. Is there congruity between the research methodology and the representation and analysis of data? Q5. Is there congruity between the research methodology and the interpretation of results? Q6. Is there a statement locating the researcher culturally or theoretically? Q7. Is the influence of the researcher on the research, and vice-versa, addressed? Q8. Are participants, and their voices, adequately represented? Q9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body? Q10. Do the conclusions draw in the research report flow from the analysis, or interpretation, of the data?

Table 6: Final assessment table (JBI-QARI critical appraisal instrument) for RCT

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
DiAndreth et al. 2020	N	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y
Davis et al. 2019	Y	Y	Y	U	N	U	Y	Y	Y	Y	Y	Y	Y
%	50	50	100	0	0	0	100	100	100	100	100	100	100

N-no, U-unclear, Y-yes, Q1. Was true randomization used for assignment of participants to treatment groups? Q2. Was allocation to treatment groups concealed? Q3. Were treatment groups similar at the baseline? Q4. Were participants blind to treatment assignment? Q5. Were those delivering treatment blind to treatment assignment? Q6. Were outcomes assessors blind to treatment assignment? Q7. Were treatments groups treated identically other than the intervention of interest? Q8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed? Q9. Were participants analysed in the groups to which they were randomized? Q10. Were outcomes measured in the same way for treatment groups Q11. Were outcomes measured in a reliable way? Q12. Was appropriate statistical analysis used? Q13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?

Tables 5 and 6 provide the results of the quality assessment of these studies. The JBI-QARI Critical Appraisal Checklist for Interpretive and Critical Research was used to critically appraise all of the listed research. All of the papers received a score of between 60% to 80%. The scoring patterns were similar for the qualitative studies (Table 4). Out of seven qualitative studies that were assessed, only two studies located the researcher (Q6) All seven studies were unclear if the researcher had an influence (Q7) on the research. Two studies were unclear if they were approved by an appropriate body (Q9) Two studies included in this review were RCTs. An appropriate tool was used to assess the quality as per JBI-QARI Critical Appraisal Checklist. Both studies scored between 60% to 75%. The study that was conducted by DiAndreth et al. was a non-randomized study where no concealment and blinding took place (Q1, Q2, Q4, Q5 and Q6). The study conducted by Davis et al. was not clear if the participants were blinded to intervention **JBI check list A to I**.

4.3 Findings of the review

This systematic review is based on data taken from nine studies, which resulted in two synthesized findings. There are a total of eight categories. Five categories from eighteen findings backed up the first synthesized finding. Three categories from fourteen findings backed up the second synthesized finding. Illustrations from the listed research were used to inform all of the conclusions (Table 7).

None of the findings in the systematic review were graded as unsupported (Table 7). The total number of findings from the systematic review was 32, with 27 being unequivocal and 5 credible (Table 7). Specifically, synthesized finding one had four credible findings and fourteen unequivocal findings. Synthesized finding two had one credible findings and thirteen unequivocal findings.

The extracted findings were consistently supported by research participants quotes that adequately informed and supported the finding. Following the assignment of a level of credibility, the findings were aggregated into statements that described them based on similarity of meaning. The findings were grouped into statements that described them based on their similarity. Based on the commonality of meaning, the findings from the collected research were divided into eight groups. The categories were then synthesized to provide synthesized findings that could be used as a foundation for practice as well as suggestions.

Table 7: Review of findings

List of Study Findings with Illustrations

Finding	Illustration
Study: Meyer et al. 2020 (62) **Title: Implementing mHealth interventions in a resource-constrained setting**	
Hardware and software requirements could severely limit the adaptability of mHealth technology in a resource-limited setting (U)	Specialized software and hardware requirements for fingerprinting made the overall app less adaptable to the local setting.
End users and implementers may have an overall positive view of mobile health however if they experience more failures and frustrations they are likely to avoid the technology (U)	Failures introduced embarrassing delays for participants, further undermining motivation of CHWs to use the technology .
Complexity of data management system delayed feedback. (C)	Data coming from the app slowed the development and implementation of data management and prevented engaging stakeholders from achieving timelier, data driven improvements to services.
Data structure, missing data was identified as a barrier. (C)	The survey software did not differentiate between a failure to complete a service and a failure to simply record it.
Study: Maraba et al. 2018 (38) **Title: Using mHealth to improve tuberculosis case identification and treatment initiation**	
MHealth technology reduce the time for patients ,workload for healthcare worker (U)	The patients did not need to return to clinic until notified that results were available also has lessen the financial and time burden on those who test negative results. Improved time to receipt of results and TB treatment initiation as that mHealth app eliminated the administrative work required to locate patients therefore workers could rapidly locate patients results on the tablet. Majority of the patients valued the convenience of the mHealth application allowing them to access results without going to clinic.
Improvements when comparing the mHealth application to the paper-based approach. (U)	MHealth application obtained TB lab results through a direct data download from the national laboratory system server therefore eliminated potential human transcription error. mHealth application improved the proportion of TB results documented at the clinic within 48hours when comparing the period prior to mHealth. Pre-implementation 68.6% of TB results documented: during the implementation of mHealth 96.8% results documented within 48hours.

Lack of proficiency in receiving the text messages, in understanding the content of the messages and in replying to the text messages with secret pin (U)	Patient challenges were related to lack of proficiency and familiarity in using mobile phone..
Reduce the time to TB treatment initiation(C)	When patients were notified that their results were ready, they returned to the clinic. This reduced the time it took the laboratory to hand-deliver printed results to the clinic, as well as the time it took the TB nurse to comb through the paper results and contact patients who had positive results.
Study: Yoonhee et al. 2016 (8) **Title: Evaluation of Mobile Health Approach to Tuberculosis Contact Tracing**	
mHealth approach eliminated the need of paper forms, writing manual entry of data into database and manual generation of summary reports. (U)	It reduced time taken to complete TB contact tracing. As it was substantially longer for the paper form-based approach than for the mHealth strategy 5.0 minutes per contact versus 2.8 minutes per contact, respectively. The data quality improved preventing the user from leaving fields blank or entering of illogical values.
Improved the quality of location data collected (U)	The user could activate the mobile devices GPS functionality and capture geographic coordinates of each case's home
The mHealth app was well received (U).	TB contact tracing team members had favourable overall rating, system usefulness, information quality and interface quality scores on the CSUQ
Study: Ggita et al. 2019(58) **Title: Patterns of usage and preferences of users for tuberculosis-related text messages and voice calls**	
Access and ability to use basic functions of mobile phone is high, with significant interest in receiving TB-related personal-health information and clinic-visit reminders via SMS or voice calls. (C)	They discovered that phone-sharing is common and that proficiency, comfort and message preferences may vary by age, gender and geography.
Identified variability within populations (U)	A significant number of patients from rural clinics did not reply to messages from a health centre or unknown sender. Additionally one-third of contacts had previously changed phone numbers, further complicating delivery of mHealth interventions.
Almost all participants were willing to receive TB-related personal-health information and reminders via voice calls or SMS. (U)	However one-third of general outpatients surveyed were uncomfortable receiving personal-health information via SMS on a shared phone.
Study: White et al. 2018(60) **Title: Feasibility, Acceptability, and Adoption of Digital Fingerprinting During Contact Investigation for Tuberculosis**	
Digital fingerprinting was feasible but not reliable (U)	Failed to capture fingerprints in about one quarter of cases during household contact investigation.
Fingerprinting was acceptable in principle despite the technology failures that decreased their confidence in this setting.(U)	The low rate of fingerprinting at follow-up suggest that CHWs saw little value in the digital fingerprinting systems usefulness as a verification tool.

The patterns of fingerprinting failures pointed towards the implementation of both software and hardware. (U)	Fingerprinting technology either worked or did not work on a given visits to a household.
Study: Ggita et al. 2020 (56) **Title: Experiences and intentions of Ugandan household tuberculosis contacts receiving test results via text message**	
SMS is a useful tool for delivering of TB test results however it cannot replace the post-test counselling interactions. (U)	These personal interactions help to relieve anxiety about testing and motivate them to respond as requested.
SMS was highly acceptable and more convenient than face-to-face communication of results. (U)	Household contacts who received results via SMS intended to follow the SMS-delivered suggestions.
Beliefs about the seriousness and curability of TB (U)	Among individuals who are household contacts of TB patients and undergoing evaluation for TB, beliefs about the seriousness and curability of TB also shape their intention to follow up at the clinic if their symptoms persist.
Non-adherence (U)	Some household contacts lacked intention and many did not follow-up.
Clinic hours that conflict with working schedules as potential barrier(U).	Participants anticipated that misalignment of clinic hours with their work schedules would prevent them from visiting the clinic if this kind of visit became necessary.
Study: Meyer et al. 2018 (57) **Title: Text Messages Sent to Household Tuberculosis contacts**	
Multiple , frequently unobserved barriers exist which prevent implementing an SMS text messaging intervention.(U)	Significant proportion of participants never received the SMS text messages as intended and a large proportion of those who received the SMS never read them. Even those who read them a notable proportion were unable to accurately report the details.
Few individual confirmed the message receipt through SMS text message. (C)	Participants literacy and the ability of participants to independently access SMS text messages on their phones at enrolment were associated with receiving SMS. Proportion of messages received was unexpectedly low.
Study: DiAndreth et al. 2020 (61) **Title: Secure Delivery of HIV-Related and Tuberculosis Laboratory Results to Patient Cell Phones**	
Acceptability and accessebility (U)	Nearly 90% viewed their PIN-protected messages and found the program highly acceptable. It accessible to non-smart phones by utilizing USSD protocols. Because USSD systems are pre-installed on all mobile phones and are open for usage without an internet connection or mobile data
Pin-protected USSD systems were feasible and safe delivering of sensitive health information to patients with cell phone in South Africa. (U)	More than 80% patients accessed their messages using a PIN.

No participants had unintentional disclosure of results. (U)	No participants reported any unintentional disclosures of TB status in this study.
MatlalaMobile has been highly acceptable in South Africa (U)	Nearly all participants (96.9%)preferred to receive results via mobile phone than at clinic, reducing face to face healthcare encounters among patients with non-actionable test results.
mobile phone illiteracy (U)	Patient education or SMS reminders about the call-me-back feature was not used and several participants unintentionally requested nurse call-me-back. the study yielded a low patient return rates.
Study: Davis et al.2019 (59) **Title: Home-based tuberculosis contact investigation**	
Low success rates of sputum collection have been observed (U).	Contacts and CHWs reported several challenges with home sputum collection, including difficulties for asymptomatic contacts in expectorating, limited private space to expectorate indoors, and reluctance to expectorate outside due to stigma
SMSs were successfully delivered for only half of the intervention arm(U)	More than 20% of SMSs achieved their full effects, defined being sent, delivered, read by the intended recipient and having the message content understood and retained. Participants who confirmed receiving of SMS stated that while they found SMS helpful, it could not replace in-person disclosure of results..
Barriers were reported to engaging with SMS (U).	Participants reported several barriers including sharing a phone with friends and family, broken phones, an inability to read text messages and lack of familiarity with SMS.

Synthesis finding 1: Challenges were encountered during the implementation of mHealth in sub-Saharan Africa among the patients and healthcare workers. These challenges included difficulties with the collection of information, identification and tracking of patients between their homes and multiple clinics. Synthesized finding 1 was the result of the identification of five categories that are 1) Adaptability and complexity 2) System integration 3) Reliability 4) Completion of task and 5) Usability from eighteen findings. The findings were supported by illustrations taken directly from the papers that reflected the end-users (Patients and Healthcare workers) (Table 7).

Adaptability and complexity category is developed from the following findings with two equivocal and one credible

- End users and implementers may have an overall positive view of mobile health however if they experience more failures and frustrations they are likely to avoid the technology (U).
- Hardware and software requirements could severely limit the adaptability of mHealth technology in a resource-limited setting(U).
- Complexity of data management system delayed feedback(C)

System integration category is developed from three findings with two equivocal and one credible

- Data structure, missing data was identified as a barrier (C).
- The patterns of fingerprinting failures pointed towards the implementation of both software and hardware(U)
- Multiple, frequently unobserved barriers exist to implementing as SMS text messaging intervention(U)

Reliability category is developed from the following findings with two equivocal and one credible

- Digital fingerprinting was feasible but not reliable (U).
- Fingerprinting was acceptable in principle despite the technology failures that decreased their confidence in this sitting (U).
- Few individuals confirmed the message receipt through SMS text message (C).

Completion of task category is developed from four findings with all unequivocal.

- Mobile phone literacy (U).
- Low success rates of sputum collection have been observed (U).
- Non-adherence(U).
- Clinic hours that conflict with working schedule as a potential barrier (U)

Usability category is developed from five findings with four equivocal and one credible.

- Lack of proficiency in receiving the text messages, in understanding the content of the messages and in replying to the test messages with secret pin (U).
- Access and ability to use basic functions of mobile phone is high, with significant interest in receiving TB-related personal-health information and clinic- visit reminders via SMS or voice calls (C).
- Identified variability within populations (U).
- SMS is a useful tool for delivering of TB test results however it cannot replace the post-test counselling interactions (U).
- SMSs were successfully delivered for only half of the intervention arm (U).

Synthesized finding one indicated that there was evidence of challenges encountered when implementing the mHealth technology. Although household contacts and healthcare workers expressed positively regarding mobile apps and text messaging, low rate of delivering and acceptance of text-messaged instruction were observed. Despite the extensive testing and the implementation of changes requested by CHWs, there was evidence of low fidelity for both SMS messages and fingerprinting app. The study by Meyer et al. (62), reported that healthcare workers identified limited adaptability of the fingerprinting mHealth app and related hardware as a major barrier. Although the app could easily add or remove questions, the whole app was less adaptive to the local setting due to unique specialized software and hardware requirements for fingerprinting.

The requirement for custom coding reduced app flexibility and adaptability. Additional barriers occurred because the digital fingerprinting necessitated a tablet with specific hardware and software components that were not accessible in Africa and had to be purchased from outside the continent. Other factors that hindered the adaptability of the app was the intervention`s complexity and logistics of its execution. According Davis et al. (59) reported that a low proportion of contacts were providing sputum sample and receiving SMS's. Clinic attendance due to financial barriers may have been the reason for not completing this step as part of the TB evaluation.

Patients' proficiency was also a barrier in the implementation of mHealth as there was a low rate in engaging with the SMS. To improve adherence, patient education is required. Ggita et al (58) and Davis et al (59) observed that phone sharing was unexpectedly high. Participants were unable to read the text messages and was unfamiliar with SMS technology.

Ggita et al (56) reported the behavioural intention as a hindrance whereby some patients had no desire to follow-up due to a lack of motivation. Similarly DiAndreth et al (61) suggested that the perceived barrier may become less if motivational messages are sufficiently sent to patients.

Synthesised finding 2: Effectiveness of mHealth technology in improving TB contact tracing in sub-Saharan Africa. Synthesized finding 2 was the result of the identified of three categories from fourteen findings that is 1) feasibility, 2) acceptability and 3) confidentiality.

Feasibility category is developed from five findings and all are unequivocal.

- mHealth technology reduce the time for patients and/or workload for healthcare workers (U).
- Improvements when comparing the mHealth application to traditional paper-based approach (U).
- mHealth approach eliminated the need of paper forms, writing manual data entry into databases and manual generation of summary reports (U).
- Improve the quality of location data collected (U).
- Clinic hours that conflict with working schedules as potential barrier (U).
- Reduce the time to TB treatment initiation(C)

Acceptability category is developed from five findings and all are unequivocal

- The mHealth app was well received (U).
- Almost all participants were willing to receive TB-related personal-health information and reminders via voice calls or SMS (U).
- SMS was highly acceptable and more convenient than face-to-face communication of results (U).
- Perceptions about the seriousness and curability of TB (U).

- MatlalaMobile has been highly acceptable in South Africa(U).
- Acceptability and accessibility (U)

Confidentiality category is developed from two findings and all are unequivocal

- Pin-protected USSD systems were feasible and safe delivering of sensitive information to patients with cell phone in South Africa (U).
- No participants had unintentional disclosure of results (U)

There is evidence that mHealth is effective in improving TB contact tracing. The evidence shows that mHealth technology can address both clinic workers' and patients' needs by reducing delays in capturing patient information, sending of patient results and time to initiation of TB treatment.

Yoonhee et al. [8] and Maraba et al. [38] reported that mHealth reduced the time required to complete TB contact tracing and enhanced data quality by preventing the user from leaving fields blank or entering illogical values. In addition, mHealth has improved the quality of location data collection and made it easy to locate the patients or potential cases. The time needed to complete TB contact tracing reduced for the paper form-based approach it was 5.0 minutes per contact versus 2.8. Another improvements indicators when comparing mHealth and the standard of care regarding the proportion of TB positive patients on treatment initiation after testing, represents valid and significant change. On the mHealth intervention, treatment initiation within 28 days of testing positive for TB was greater than the standard of care by 84.8% and 68.2%, respectively[38]. The mHealth intervention's loss to follow-up was lower (15.2%) than the standard of care's (31.8%) [8,38].

The experience of patients and CHWs has shown that the mHealth was well received. Health workers were cited saying “It has reduced the administrative work required in locating the patients results, due to rapidly acquiring patient’s information on the tablet”[38]. Majority of the patients valued the apps ease in allowing them to view their results without having to visit the clinic. As in most instances clinics hours were conflicted with their working hours. DiAndreth et al. (61) and Moraba et al. [38] reported that having PIN-protection made the programme highly acceptable in terms of avoiding unintentional disclosure of status. Patients’ understanding of the seriousness and curability was an added value, as they were willing to do follow-up if symptoms persisted regardless of the results outcome.

4.3.1 Conflict evidence on mHealth effectiveness

According to Maraba et al[38]., the rate of treatment initiation after 28 days improved to 84.8 % from 68.2 % for standard of care, and the loss to follow-up was lower in the intervention arm at 15.2 % as opposed to 31% for standard of care. In terms of TB diagnosis, the evidence from Davis et al [59]. does not distinguish between the intervention arm and the standard of care. The yield in the intervention arm was 1.5 %, whereas the yield in the standard of care arm was 1.1 %, with an OR of 1.34 and a 95% confidence interval (CI) of 0.42 to 2.24, respectively, with a p value of 0.62.

According to DiAndreth et al(61)., more participants from the intervention arm (73.0 %) than the control arm (8.6 %) examined their test results within 7 days of their enrollment (p0.0001). They also stated that the proportion of participants in both arms who returned to the clinic within 7 days after enrollment did not differ significantly (8.6 % vs 9.5 %; p=0.82).

In terms of completion the TB evaluation within 14 days, Davis et al reported that there was no significant difference between the two arms, with the intervention arm at 14 % (95 % CI: 8-20) and the standard of care arm at 15 % (CI 9-21). Participants in the Maraba et al[38]). and DiAndreth et al (61) study preferred to obtain their results through mobile phone, and they described how mHealth technology eliminates needless line waiting. While several participants in the Ggita et al (56) study commended the convenience of mHealth technology, they also expressed continued anxiety. They indicated a preference for face-to-face results delivery due to a perception that new technologies may be error-prone.

CHAPTER 5. Discussion

The goal of this review was to investigate and summarize the existing evidence on the use of mHealth for TB contact tracing. Nine studies were chosen after a thorough review of the literature using the apriori search and selection criteria. Only a limited amount of research on the use of mHealth for TB contact tracing in sub-Saharan Africa was found to be relevant to the inclusion criteria. The review presented the evidence covering the challenges and effectiveness of mHealth intervention, early TB identification and initiation of TB treatment. Therefore, the results offer mixed evidence for the efficacy of mHealth interventions intended to improve contact tracing. We cannot disregard how mHealth interventions could improve TB contact tracing in sub-Saharan Africa.

The JBI approach is used in this qualitative synthesis review to extract data from selected research, group them into categories, and lastly synthesize findings based on similarity in meaning. This systematic review yielded two synthesized findings from eight categories derived from thirty-two findings retrieved from nine investigations and illustrated with images obtained directly from the studies (Table 7).

The synthesised findings indicated that mHealth has the potential to reduce the spread of TB. However, the success of mHealth lies on the provision of healthcare workers, computer servers and software, mobile telephone networks, mobile handsets and community members for such a complex intervention. A detailed process evaluation is required to understand if all elements work together as intended. However, there were challenges with the implementation strategy. These included patient level challenges.

Patients or participant’s literacy was a limiting factor as illustrated by the low response rate and underutilizing features like “call-me back”. The South African study by DiAndreth et al yielded a low patient return rate (61).Meyer et al found that a considerable proportion of participants never received the SMS text messages as planned, and that a big proportion of those who did get the messages two weeks later were unable to accurately recount the message's details(57).

In the end, less than a third of participants claim to have received and retained the tuberculosis-related material delivered via SMS text messages. Due to a lack of expertise with using a cell phone, another problem was the lack of competency in receiving text messages, interpreting the substance of the messages, and answering to the text messages using a secret pin.Some household contacts had no intention to follow-up. Patients were not educated about the call-me-back feature, and several participants unintentionally requested a nurse call-me-back.

These patient-level problems, on the other hand, may be overcome with better patient teaching, such as instructional videos. Furthermore, as society progressively adopts mobile technology, expertise in the usage of mobile phone apps will improve. This, together with the majority of participants' high levels of satisfaction with the app, suggests that the app's added value surpasses the limitations posed by patient-level challenges.

The challenges associated with the implementation of interventions involved lack of empowerment among healthcare workers, barriers to engaging SMS, phone sharing, broken phones, inability to read text messages, lack of SMS knowledge, and limited acceptance of two way SMS invitations (59). This review showed that there were

multiple, frequently unobserved barriers that exist to effectively implementing the SMS text messaging intervention. The opinion was that future iterations should include messages that sufficiently motivate patients to return to clinic(61).

Digital interventions may necessitate the use of specialized hardware and software elements to function effectively (62). Like fingerprinting technology was feasible but not reliable due to the patterns of fingerprinting failures pointed towards the implementation of both software and hardware. The technology had limited adaptability as it requires a specialised software and hardware. Data management complexity was also highlighted as a constraint. A specific feedback plan in place to communicate goals to every level of stakeholder before the implementation commencement was one recommendation to consider when selecting a software system for ease of data management and accessibility. Throughout the selection process, effective communication between implementers and end users on progress and acceptance should be possible.

The Global Strategy to End TB, which aims to eliminate TB as a public health issue by 2050, includes active case-finding of undiagnosed individuals with TB in settings outside of health facilities [(23)]. Contacts and healthcare personnel reported a variety of issues with collecting sputum at home, including inability for asymptomatic contacts to expectorate, a lack of private space to expectorate indoors, and a fear of expectorating outside owing to stigma. Leaving the sputum containers for eligible contacts to be collected later was unsuccessful, according to healthcare workers. Despite being instructed on safe sputum collection and transport, healthcare personnel raised concerns about catching tuberculosis by collecting and carrying sputum in their bags. Another potential stumbling block was clinic hours that clashed with working hours. Participants predicted that if this type of visit became essential,

the mismatch of clinic hours with their work schedules would prohibit them from visiting the clinic [56]. However, mHealth mitigated this by decreasing the amount of time spent in a clinic by informing patients when results were available and reduced time it would take a health worker to access their file[8,38].

Synthesized finding two “Effectiveness of mHealth technology in improving TB contact tracing in sub-Saharan Africa” was supported by illustrations taken directly from the studies. The second of the two findings indicated that mHealth has a potential to improve access to evaluation and treatment for TB in sub-Saharan Africa by increasing communication between patients and healthcare workers. Mobile health strategy can deliver relevant health information, reduce unnecessary patient burden and relieve clinic patient volumes.

The included studies were comparing the effectiveness of TB contact tracing using mHealth with traditional contact tracing strategy in terms of feasibility, usability, acceptability and confidentiality. Maraba et al and Yoonhee et al evaluated the paper-based strategy to mHealth approach [8,38]. Both studies reported reduced time for patients and workload for healthcare workers using mHealth. mHealth approaches eliminated the need of paper forms, and reduced writing manual entry of data into database and manual generation of summary reports [8,38].

The patients were not required to return to the clinic until they received a result notification via mHealth. Those who received negative results have had their financial and time burdens reduced as a result of this. Majority of the patients valued the convenience of the mHealth app allowing them to access the results without going to clinic [38] .

In addition, the technology also improved the quality of location by activating the mobile devices GPS functionality and capture geographic coordinates [8]. Clinic workers were able to rapidly locate patients' results on the mobile phone eliminating the administrative work required to locate patients.

The mHealth app SMS intervention TB laboratory results were obtained by downloading data directly from the Laboratory system server therefore eliminated potential human transcription error [38]. When compared to the period before the mHealth app, the proportion of TB results documented at the clinic within 48 hours was higher. Pre-implementation only 68% of TB results were documented, during the implementation of mHealth this improved to 96.8% of results documented within 48hours [38].

Participants were willing to receive TB-related personal information and reminders via voice calls and SMS. SMS text message was a useful tool in delivering of TB test results. However in a study done in Ghana by Ggita et al, participants stated their views by saying that SMS cannot replace the post-test counselling interactions(56). These personal interactions help to relieve anxiety about testing and motivate to respond as requested. In contrast to this, studies conducted in South Africa and Uganda reported that SMS was highly acceptable and more convenient than face-to-face communication of results. Nearly 90% viewed their PIN-protected messages and found the program highly acceptable (61). However, patients should be given the option of face-to-face or mobile based interactions.

PIN-protected USSD systems were feasible and safe in delivering of sensitive information to patients with cell phone. Access and ability to using basic functions of mobile phones was high(58,61). Participants expressed their perceptions regarding

the seriousness and curability of TB that has shaped their intention to follow up at the clinic if their symptoms persist.

In this review mHealth proved that it is accessible since it can be used on non-smart phones by utilizing USSD protocols. Because USSD systems are pre-installed on all mobile phones and are open for usage without an internet connection or mobile data[60]. For instance, MatlaMobile employed the USSD protocol, and participants were only disqualified from the trial if they had no phone when they signed up[60]. However, in the South African trial that used the app-based SmartLink program 90% of those who were interested were turned away because they lacked a smartphone(61,63). In comparison to apps, USSD-based mHealth programs can reach a larger audience(61). Therefore it is crucial to take non-smartphone users into account when designing mHealth apps.

The major strengths of this review include the high methodological quality of studies selected as all selected studies scored between 60% to 80% on quality assessment. This is the first review to focus on sub-Saharan Africa only, compared to previous reviews. Limitations of the review include drawing only on English language papers and those that were peer reviewed. In addition, none of the studies had used two-way communication effectively. For example, a pilot comparative study conducted in South Africa using MatlaMobile had a call-me-back service however the patients did not use the service(61).Despite these limitations this review provides an overview of the current reported outcome measures for mHealth interventions to improve TB contact tracing in sub-Saharan Africa.

CHAPTER 6. Conclusion

Overall, mHealth technologies have the potential to improve public health programs irrespective of disease or setting. However, the challenges raised by these technologies should be investigated prior to implementation. The study shows that there is limited research on the availability and the use of mHealth intervention for TB contact tracing in sub-Saharan Africa. This review simultaneously identifies two synthesised findings. It highlighted the challenges faced by the end users which should be addressed to maximize the use of the mHealth app in resource constrained settings. Technical issues highlighted by this study need to be considered because they strongly contributed to the usability of other apps for e.g. the fingerprinting app. End users should be involved in assessing the technical barriers of hardware and software. These challenges should be addressed to increase acceptance.

The findings of this review indicate that patient literacy were associated to lack of ability in receiving text messages, in understanding the content of the messages and responding to text messages. In this regard there is an urgent need to empower patients. The study also showed that SMS text message and mHealth for capturing the details of the patients were effective, reliable and feasible as compared to paper-based approach. This review shows that mHealth interventions were well accepted by healthcare workers and patients to support TB contact tracing. Therefore, we commend that more primary investigations should be conducted in sub-Saharan Africa on the use of mHealth by healthcare workers and patients for TB contact tracing to improve early diagnostic and TB treatment initiation.

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Appendix

Appendix 1: Plagiarism declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I Peggy N. Nhleko (Student number: 716638) am a student registered for the degree of Msc in Epidemiology in the academic year 02.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: [redacted] Date: 29/08/2002

1

Appendix 2 Clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Innovation)

26/08/2021

Ref: W-CBP-210826-01

TO WHOM IT MAY CONCERN

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical)

Investigator: Ms PN Nhleko
Student No. (if appropriate): 716638
Staff No. (if appropriate):

Supervisor: Professor S Charalambous

School: Public Health
Department: Epidemiology and Biostatistics
Medical School
University

Project title: *Mobile health technology to improve tuberculosis contact tracing in sub-Saharan Africa: a systematic review, 2010-21*

Reason: Review of information in the public domain
No human participants will be involved in the study

Dr CB Penny
Chairperson: Human Research Ethics Committee (Medical)

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Appendix 3: Plagiarism Report

RESEARCH REPORT PEGGY N NHLEKO 716638T-1.pdf

ORIGINALITY REPORT

13%	12%	12%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.ncbi.nlm.nih.gov Internet Source	2%
2	journals.lww.com Internet Source	2%
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7	Ping Sun, Manli Wang, Tingting Song, Yan Wu, Jinglu Luo, Lili Chen, Lei Yan. "The Psychological Impact of COVID-19 Pandemic on Health Care Workers: A Systematic Review and Meta-Analysis", Frontiers in Psychology, 2021 Publication	1%

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11	Colleen F. Hanrahan, Bareng A. S. Nonyane, Lesego Mmolawa, Nora S. West et al. "Contact tracing versus facility-based screening for active TB case finding in rural South Africa: A pragmatic cluster-randomized trial (Kharitode TB)", PLOS Medicine, 2019 Publication	1 %

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		

PPENDIX 4: PRISMA Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	COVER PAGE
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	22
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	17
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	15-16
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	15-16
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	15-17
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	17
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	17
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	-
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	18
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	20
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	26
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	18

Section and Topic	Item #	Checklist item	Location where item is reported
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	18
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	18
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	20
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	20
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	18-20
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	18-20
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	22-23
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	22
Study characteristics	17	Cite each included study and present its characteristics.	29-32
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	26-27
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	29-32
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	36-39
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	36-39
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	39
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	26-27
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	29-32
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	40
	23b	Discuss any limitations of the evidence included in the review.	45
	23c	Discuss any limitations of the review processes used.	45

Section and Topic	Item #	Checklist item	Location where item is reported
	23d	Discuss implications of the results for practice, policy, and future research.	45
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	N/A
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	N/A
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	N/A
Competing interests	26	Declare any competing interests of review authors.	N/A
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

JBI CRITICAL APPRAISAL CHECKLIST

A- Meyer et el, 2020 Checklist

Reviewer : P N Nhleko Date:15 November2021

Author: Meyer et el Year: 2020 Record Number 01

		Yes	No	Unclear	Not applicable
1.	Is there congruity between the stated philosophical perspective and the research methodology?	√	□	□	□
2.	Is there congruity between the research methodology and the research question or objectives?	√	□	□	□
3.	Is there congruity between the research methodology and the methods used to collect data?	√	□	□	□
4.	Is there congruity between the research methodology and the representation and analysis of data?	√	□	□	□
5.	Is there congruity between the research methodology and the interpretation of results?	√	□	□	□
6.	Is there a statement locating the researcher culturally or theoretically?	□	□	√	□
7.	Is the influence of the researcher on the research, and vice- versa, addressed?	√	□	□	□
8.	Are participants, and their voices, adequately represented?	√	□	□	□
9.	Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	√	□	□	□
10.	Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

B- Maraba et al, 2018 Checklist

Reviewer_ _ _ _ : P N Nhleko_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _Date_15 November 2021_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Author:_Maraba et al_ _ _ _ _Year: 2018_ _ _ _ _ _ _ _ Record Number_02__

	Yes	No	Unclear	Not applicable
1. Is there congruity between the stated philosophical perspective and the research methodology?	√	□	□	□
2. Is there congruity between the research methodology and the research question or objectives?	√	□	□	□
3. Is there congruity between the research methodology and the methods used to collect data?	√	□	□	□
4. Is there congruity between the research methodology and the representation and analysis of data?	√	□	□	□
5. Is there congruity between the research methodology and the interpretation of results?	√	□	□	□
6. Is there a statement locating the researcher culturally or theoretically?	□	□	√	□
7. Is the influence of the researcher on the research, and vice- versa, addressed?	□	□	√	□
8. Are participants, and their voices, adequately represented?	√	□	□	□
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	√	□	□	□
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

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C- Yoonhee et al, 2018 Checklist

Reviewer_____: P N Nhleko_____Date_15 November 2021_____

Author:__Yoonhee et al_____Year: 2018_____ Record Number_03__

	Yes	No	Unclear	Not applicable
1. Is there congruity between the stated philosophical perspective and the research methodology?	√	□	□	□
2. Is there congruity between the research methodology and the research question or objectives?	√	□	□	□
3. Is there congruity between the research methodology and the methods used to collect data?	√	□	□	□
4. Is there congruity between the research methodology and the representation and analysis of data?	√	□	□	□
5. Is there congruity between the research methodology and the interpretation of results?	√	□	□	□
6. Is there a statement locating the researcher culturally or theoretically?	□	□	□	√
7. Is the influence of the researcher on the research, and vice- versa, addressed?	□	□	√	□
8. Are participants, and their voices, adequately represented?	√	□	□	□
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	√	□	□	□
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

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D-: _Ggita et al, 2018__Checklist__

Reviewer_____: P N Nhleko_____Date_15 November 2021_____

Author:_Ggita et al_____Year: 2018_____ Record Number_04__

	Yes	No	Unclear	Not applicable
1. Is there congruity between the stated philosophical perspective and the research methodology?	√	□	□	□
2. Is there congruity between the research methodology and the research question or objectives?	√	□	□	□
3. Is there congruity between the research methodology and the methods used to collect data?	√	□	□	□
4. Is there congruity between the research methodology and the representation and analysis of data?	√	□	□	□
5. Is there congruity between the research methodology and the interpretation of results?	√	□	□	□
6. Is there a statement locating the researcher culturally or theoretically?	√	□	□	□
7. Is the influence of the researcher on the research, and vice- versa, addressed?	□	□	√	□
8. Are participants, and their voices, adequately represented?	√	□	□	□
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	√	□	□	□
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

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E- White et al, 2018 Checklist

Reviewer: P N Nhleko_____Date_16 November 2021_____

Author:_White et al_____.Year: 2018_____ Record Number_05__

	Yes	No	Unclear	Not applicable
1. Is there congruity between the stated philosophical perspective and the research methodology?	√	□	□	□
2. Is there congruity between the research methodology and the research question or objectives?	√	□	□	□
3. Is there congruity between the research methodology and the methods used to collect data?	√	□	□	□
4. Is there congruity between the research methodology and the representation and analysis of data?	√	□	□	□
5. Is there congruity between the research methodology and the interpretation of results?	√	□	□	□
6. Is there a statement locating the researcher culturally or theoretically?	□	□	□	√
7. Is the influence of the researcher on the research, and vice- versa, addressed?	□	□	√	□
8. Are participants, and their voices, adequately represented?	√	□	□	□
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	√	□	□	□
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

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F- Ggita et al, 2020 Checklist

Reviewer_____: P N Nhleko_____Date_16 November 2021_____

Author: Ggita et al_____ Year: 2020_____ Record Number_06__

	Yes	No	Unclear	Not applicable
1. Is there congruity between the stated philosophical perspective and the research methodology?	√	□	□	□
2. Is there congruity between the research methodology and the research question or objectives?	√	□	□	□
3. Is there congruity between the research methodology and the methods used to collect data?	√	□	□	□
4. Is there congruity between the research methodology and the representation and analysis of data?	√	□	□	□
5. Is there congruity between the research methodology and the interpretation of results?	√	□	□	□
6. Is there a statement locating the researcher culturally or theoretically?	□	□	□	√
7. Is the influence of the researcher on the research, and vice- versa, addressed?	□	□	√	□
8. Are participants, and their voices, adequately represented?	√	□	□	□
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	□	□	√	□
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

G- Meyer et al, 2018 Checklist

Reviewer_____: P N Nhleko_____Date_16 November 2021_____

Author: Meyer et al_____Year: 2018_____ Record Number_07__

	Yes	No	Unclear	Not applicable
1. Is there congruity between the stated philosophical perspective and the research methodology?	√	□	□	□
2. Is there congruity between the research methodology and the research question or objectives?	√	□	□	□
3. Is there congruity between the research methodology and the methods used to collect data?	√	□	□	□
4. Is there congruity between the research methodology and the representation and analysis of data?	√	□	□	□
5. Is there congruity between the research methodology and the interpretation of results?	√	□	□	□
6. Is there a statement locating the researcher culturally or theoretically?	□	□	□	√
7. Is the influence of the researcher on the research, and vice- versa, addressed?	□	□	√	□
8. Are participants, and their voices, adequately represented?	√	□	□	□
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	□	□	√	□
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

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H- DiAndreth et al, 2020 Checklist

Reviewer: P N Nhleko Date: 16 November 2021

Author: DiAndreth et al Year: 2020 Record Number :08

		Yes	No	Unclear	NA
1.	Was true randomization used for assignment of participants to treatment groups?	□	√	□	□
2.	Was allocation to treatment groups concealed?	□	√	□	□
3.	Were treatment groups similar at the baseline?	√	□	□	□
4.	Were participants blind to treatment assignment?	□	√	□	□
5.	Were those delivering treatment blind to treatment assignment?	□	√	□	□
6.	Were outcomes assessors blind to treatment assignment?	□	√	□	□
7.	Were treatment groups treated identically other than the intervention of interest?	√	□	□	□
8.	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	√	□	□	□
9.	Were participants analysed in the groups to which they were randomized?	√	□	□	□
10.	Were outcomes measured in the same way for treatment groups?	√	□	□	□
11.	Were outcomes measured in a reliable way?	√	□	□	□
12.	Was appropriate statistical analysis used?	√	□	□	□
13.	Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

I- Davis et al, 2019 Checklist

Reviewer_____: P N Nhleko_____Date: 16 November 2021_____

Author:__Davis et al_____ Year: _2019_____ Record Number :09_____

	Yes	No	Unclear	NA
1. Was true randomization used for assignment of participants to treatment groups?	√	□	□	□
2. Was allocation to treatment groups concealed?	√	□	□	□
3. Were treatment groups similar at the baseline?	√	□	□	□
4. Were participants blind to treatment assignment?	□	□	√	□
5. Were those delivering treatment blind to treatment assignment?	□	√	□	□
6. Were outcomes assessors blind to treatment assignment?	□	□	√	□
7. Were treatment groups treated identically other than the intervention of interest?	√	□	□	□
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	√	□	□	□
9. Were participants analysed in the groups to which they were randomized?	√	□	□	□
10. Were outcomes measured in the same way for treatment groups?	√	□	□	□
11. Were outcomes measured in a reliable way?	√	□	□	□
12. Was appropriate statistical analysis used?	√	□	□	□
13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?	√	□	□	□

Overall appraisal: Include √ Exclude □ Seek further info □

Comments (Including reason for exclusion)

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