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RESEARCH ARTICLE

A health systems intervention to strengthen the integration of tuberculosis and COVID-19 detection: Outcomes of a quasi-experimental study in a high burden tuberculosis district in KwaZulu Natal, South Africa

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Abstract

Objectives: The adverse effects of the COVID-19 pandemic on tuberculosis (TB) detection have been well documented. Despite shared symptoms, guidance for integrated screening for TBand COVID-19 are limited, and opportunities for health systems strengthening curtailed by lockdowns. We partnered with a high TB burden district in KwaZulu-Natal, South Africa, to co-develop an integrated approach to assessing COVID-19 and TB, delivered using online learning and quality improvement, and evaluated its performance on TB testing and detection.

Methods: We conducted a mixed methods study incorporating a quasi-experimental design and process evaluation in 10 intervention and 18 control clinics. Nurses in all 28 clinics were all provided access to a four-session online course to integrate TB and COVID-19 screening and testing, which was augmented with some webinar and in-person support at the 10 intervention clinics. We estimated the effects of exposure to this additional support using interrupted time series Poisson regression mixed models. Process evaluation data comprised interviews before and after the intervention. Thematic coding was employed to provide explanations for effects of the intervention.

Results: Clinic-level support at intervention clinics was associated with a markedly higher uptake (177 nurses from 10 intervention clinics vs. 19 from 18 control clinics). Lack of familiarity with online learning, and a preference for group learning hindered the transition from face-to-face to online learning. Even so, any exposure to training was initially associated with higher rates of GeneXpert testing (adjusted incidence ratio [IRR] 1.11, 95% confidence interval 1.07–1.15) and higher positive TB diagnosis (IRR 1.38, 1.11–1.71).

Conclusions: These results add to the knowledge base regarding the effectiveness of interventions to strengthen TB case detection during the COVID-19 pandemic. The findings support the feasibility of a shift to online learning approaches in low-resource settings with appropriate support and suggest that even low-intensity interventions are capable of activating nurses to integrate existing disease control priorities during pandemic conditions.

KEYWORDS
COVID-19, health systems intervention, integrated care, online learning, tuberculosis

Sustainable Development Goal: Good Health and Wellbeing, Reduced Inequalities

INTRODUCTION

The public health and economic crisis caused by the COVID-19 pandemic and phased nationwide lockdowns has resulted in severe disruption in TB case detection [1,2]. WHO's 2021 Global TB Report [3] describes a global decline of 18% in case detection. According to the South African District Health Information System (DHIS), the number of people screened for TB declined by 19% from 87.6 million in 2019 to 70.8 million in 2020. By the end of 2020, South Africa saw an overall decrease in testing of 22%, and incidence rates of confirmed active TB fell by 15% in the public sector; with a 18% reduction in attendance in primary health care (PHC) facilities [4,5]. The National Health Laboratory Service (NHLS) reported that the number of GeneXpert tests conducted, declined by 26% with a 41% decline in TB case notifications [6].

As TB and COVID-19 share both respiratory and systemic symptoms, the ability of health workers to differentiate between these two possible diagnoses is challenging. This is especially concerning among patients in high TB burden settings [6,7]. An added complication is the relatively recent identification of asymptomatic TB with a large national survey showing that 58% of people with culture proven active TB had no TB- related symptoms [8] and COVID-19 prevalence studies identifying the majority of COVID-19 cases as asymptomatic [9–11]. COVID-19 related presentations may therefore be an opportunity to detect TB or COVID-19 and a reason one should test for both diseases [4]. However, initial guidance for screening and testing for COVID-19 neglected to address other causes of respiratory symptoms, where these were present.

In South Africa, public-sector primary health care facilities are led by nurses, most of whom are of an older generation and who are accustomed to have received in-service training in person and in groups, with minimal exposure to the online guidance and training that characterised the COVID-19 pandemic [12]. Furthermore, many of these nurses are from disadvantaged socioeconomic backgrounds with limited exposure to technology [13]. Perceived ease of use of digital technology is critical, having a significant impact on attitude towards online learning [14]. With insufficient network connectivity and restrictions on gatherings, equipping nurses with knowledge and skills during the pandemic proved challenging. Studies in low-resource settings regarding the effects of online learning are scarce and of poor methodological quality [15].

This paper reports on a study that forms part of a broader 5-year research programme (ASSET) with pre-implementation, intervention development, and pilot and evaluation phases, closely aligned with the Sustainable Development Goal of Universal Health Coverage, conducted across four countries—Ethiopia, Sierra Leone, South Africa, and Zimbabwe [16]. ASSET has an overall aim of developing and evaluating effective and sustainable health system strengthening interventions that support the translation of evidence-based practices that promote equitable person-centred care into routine health services. Our original plan was to strengthen person-centred approaches to TB screening and management in a high-burden TB district in KwaZulu Natal, South Africa. This strategy was based on findings of the diagnostic phase, that identified delayed diagnosis as being caused by interactions between fragmented healthcare provision, limited resources, verticalised care, poor TB screening, sputum collection and record-keeping. We also noted that frequently a solitary nurse was responsible for TB care, with little integration of TB with other conditions, and a policy focused on treatment adherence contributed to staff stress and limited consideration of patients' psychosocial needs. Patients were lost to follow up due to discontinuity of information, poverty, employment restrictions and limited support for treatment side-effects [17]. We subsequently co-developed a Health Systems Strengthening intervention to support person-centred case detection and initiation of treatment which was rendered less relevant when the pandemic hit and clinics were overwhelmed by people presenting with respiratory symptoms. In response, we adapted the intervention, co-developing an integrated approach to TB and COVID-19 screening and testing during the first COVID-19 wave in mid-2020 [18]. The aim was to investigate whether a health systems intervention could mitigate anticipated losses in TB detection during the pandemic and to explore methods to bring about a shift to online learning in a system which was previously dependent on face-to-face training. We report findings from the quasi-experimental study and parallel process evaluation of the co-developed health systems intervention in a high-burden TB district during the second and third COVID-19 waves (from late 2020 to late 2021).

METHODS

Research setting

The setting for this study was in 28 public PHC facilities (10 intervention; 18 control) serving urban and rural communities in the Amajuba District of KwaZulu-Natal province, South Africa. Amajuba district municipality is a geographically small (7102 km^2) district in North-Eastern KwaZulu-Natal, comprised of three local municipalities (Newcastle, eMadlangeni and Dannhauser), eight towns, with a mix of urban, peri-urban and rural areas. The population is mainly isiZulu-speaking. The district has a total population of 556,580 (0.9% of South Africa) and 127,000 households, 12.3% of whom live in informal dwellings. 416,000 people lived in poverty in 2019, an increase of 11.3% from 2009. The largest economic sectors are community services, manufacturing, and financing [19]. We worked closely with the district stakeholders, hospital and PHC level to identify intervention facilities, focusing on those serving communities most impacted by TB and known as 'high-transmission areas' and had described processes and gaps in TB diagnosis before COVID-19 [17]. In most clinics in this

Type of Facilities	Intervention	Control
Number of facilities	10	18
Hybrid Training	Access to data-free online course	
Summary of training sessions	Session 1: Introductory activity to intervention and clinical decision pathway Session 2: Health worker exposure to COVID-19 and practisingsafely, occupational stress Session 3: COVID19 and TB screening and diagnosis Session 4: Integrated TB and COVID-19 management (specimen collection)	
Intervention materials		
Remote support	One orientation Webinar (Managers & Facility trainers) and one online learning experience feedback session for each facility	None
Quality Improvement Mentor	2-3 In-person visits to facilities; support at initial facility-based session	None
Technical Support	One visit to assist with course registration; in person and remote support with log-in issues and trouble-shooting	None

FIGURE 1 Health system intervention for strengthening TB and COVID-19 integration.

district, from the outset of the pandemic, COVID-19 screening was conducted in the clinic but most of the COVID-19 swabbing was the responsibility of hospitals or outreach teams who visited people in their homes following referral by clinic staff.

Health systems strengthening intervention

Interventions across control and intervention clinics are summarised in Figure 1. The following were provided at the level of the district and thus available to staff at both intervention and control clinics:

- Regular online meetings between the researchers and 4–5 district level managers.
- An integrated clinical decision support pathway assessing people with respiratory symptoms (Appendix S1).
- Printed materials and a data-free online training course of four sessions including integrated screening, testing and management of COVID-19 and TB and prevention of occupational infection, made available to all staff in the district.

In addition the 10 intervention clinics received clinic-based support in the form of:

- A webinar orientation.

- Two to three visits by a project *Quality Improvement Mentor*, who provided session support and facilitated communication as part of the intervention team.
- A visit by a technical *support person* who would trouble-shoot errors with log-ins and password issues; and
- One feedback session (Appendix S2).

The intervention was first piloted in two clinics and then rolled out in the other eight intervention facilities.

Data collection

We conducted a mixed-methods study incorporating a quasi-experimental design and process evaluation in 10 intervention clinics and 18 control clinics. All 18 primary care in the district that did not implement the intervention were included as controls so as to maximise statistical power for effect estimation, considering that routinely collected outcome data were available for all clinics. A key focus of this mixed-methods approach was to use findings from the qualitative data to offer explanations for observed trends in the testing data.

Quantitative methods

The quantitative evaluation had a quasi-experimental time series design. All 28 PHC facilities in the district were initially in the control condition, that is, unexposed to the intervention. Ten intervention facilities were then incrementally exposed to the intervention over a 12-month period, with nine facilities starting in October or November 2020 and one facility starting in September 2021. Intervention facilities continued to complete online training for a median of six (interquartile range 3–9, range 1–12) months after starting. Each intervention facility was coded as exposed from the first date on which a member of the facility staff started online training, until the end of follow-up in December 2021, and coded as unexposed before the first training date. Date of first training was used to define exposure because we expected that individual clinicians' participation in online training was the component of the intervention most likely to influence their decision to test eligible patients for TB. Duration of each facility's exposure was defined from the same date. The 18 control facilities were coded as unexposed to the intervention throughout follow-up. The period of follow-up was from the start of the first national COVID-19 lockdown in March 2020, until December 2021. The reason for starting follow-up at that date, and not earlier, was because the first lockdown resulted in the greatest disruption of PHC attendance and performance that had been recorded over several years and was followed by further disruptions over the four waves of the COVID-19 pandemic in the province. Thus, the usual seasonal variations in activity observed before COVID-19, which could have been used to model temporal variations in TB testing, were not directly applicable to variations during the study period. However, we did account for facilities' pre-COVID-19 TB testing activity when comparing exposed and unexposed facilities, and did include pre-COVID TB test data in sensitivity analyses, as described below.

Quantitative data were coded and analysed at the facility-month level. The two primary outcomes, for each month in each facility, were incidence rates of GeneXpert TB testing, and of positive GeneXpert test results. We estimated the effect of any exposure to the intervention, and of duration of exposure to the intervention, by comparing the two outcomes between facility-months in which facilities had been and had not been exposed to the intervention.

Qualitative methods

We recruited health workers in the intervention facilities before and after intervention implementation to evaluate how staff engaged with the online training, barriers and facilitators to completion, and their perceived impact on screening and testing processes for TB and COVID-19. We purposively sampled managers and nurses to obtain maximum variation in levels of access to and engagement with the intervention, and differing roles within the facility to support safe management of TB and COVID-19 patients. In the pre-intervention stage of data collection in April 2021, we conducted seven manager interviews (two of these were telephonic), six clinician in-person interviews, and six in-person non-clinician interviews at nine intervention facilities. In November 2021 we conducted in-person post intervention interviews with seven managers (three of whom were follow-up interviews), six clinicians including registered nurses and an enrolled nurse (two of whom were follow-up interviews) and two non-clinicians (data capturer, counsellor).

Interviews were semi-structured and carried out in the language most appropriate for each participant, audio-recorded, translated and transcribed. Once informed consent was obtained, the researcher checked whether the participant was willing to have the interview audio-recorded, explaining the reason for doing so. In one interview, the manager preferred not to be audio-recorded. Participants were reassured that neither the transcript of the interview nor the handwritten notes would contain any personal identifying information and that nobody would listen to the audio recording or read the notes, except the research team involved in transcribing and/or analysing the data. Interviews were conducted by RC (clinician and social scientist), AvR (social scientist) and a fieldworker (social scientist). Interviews in isiZulu were conducted by the fieldworker. Following the national guidance on participant reimbursement [20], staff were not provided with incentives to participate and as interviews were conducted at facilities, no additional travel or time off work was required. The pre-intervention interviews (Appendix S3) with managers, clinicians and non-clinicians explored perspectives of screening and testing procedures within their facility, processes for managing different streams of patients (patients with respiratory symptoms vs. non-respiratory symptoms), collective and individual psychosocial needs, level of perceived risk and the community of practice within the facility. Post-intervention interviews (Appendix S4) additionally explored perspectives of the intervention components and how they were translated into everyday practice. In control facilities and low-uptake intervention facilities we sought to understand failed uptake of the intervention including the extent to which staff accessed the online training resources, what other information resources were used for managing TB and COVID-19 and how this impacted on screening, diagnosis and treatment of patients with respiratory symptoms.

Data analysis

Effects of the intervention in monthly rates of testing and of positive test results were estimated by time series analysis, with exposure and outcome data coded at facility-month level from March 2020 to December 2021. We used Poisson mixed regression models, with facility as a random effect to account for intra-facility correlation of outcomes over time. Exposure to the intervention was coded as a time-varying covariate, because the intervention was phased in across intervention facilities over a 12-month period. The Poisson regression models' outcomes were either numbers of patients tested, or numbers of positive tests, recorded by each facility each month, with monthly patient headcount as denominator.

We first graphically explored temporal variation in outcomes among exposed, unexposed and all facilities using locally weighted scatterplot smoothing (lowess) [21]. In the Poisson regression models, temporal variation in outcomes due to the four COVID-19 waves among all facilities was statistically modelled using cubic splines, with knots coded as the first and last month of each wave. Seasonal variation in outcomes was modelled with dummy variables representing each calendar month. The overall effect of exposure to the intervention on each outcome was estimated with a binary exposure variable. We also estimated the changing effect of the intervention after first exposure by adding variables representing duration of exposure, and square of duration of exposure. We did not model interactions between exposure and calendar time, because of the variation in the dates at which intervention facilities began training, and because the numerous cubic spline variables representing temporal variation made such interactions difficult to interpret. To adjust for baseline (pre-COVID-19) characteristics of each facility, we calculated the mean monthly proportion of all patients tested for TB, and the mean monthly proportion of all patients who had a positive test, between January 2018 and February 2020. The former variable was included as a covariate in Poisson models with testing rate as outcome, and the latter in models with test positivity rate as outcome. We carried out several sensitivity analyses: (1) replacing cubic splines with linear splines or binary variables representing each COVID-19 wave, (2) extending the follow-up period retrospectively to January 2018 and (3) replacing Poisson regression models with equivalent negative binomial models, with robust adjustment for clustering of outcomes, to avoid potential overdispersion in the Poisson models.

For the qualitative analysis, all transcribed interviews were initially analysed to understand the relationship between the wider context of primary health care, TB and the COVID-19 pandemic systems for screening and testing for TB and COVID-19 within intervention and control facilities and in the intervention arm, the process of translating the content of the health systems intervention into routine practice. We drew on Braun and Clarke's thematic analysis as a 'contextualist' method, examining how macro-contextual features shaped meso and micro (or vice versa), thereby tracing a thread between specific perspectives to the broader context in which they were manifested [22]. Rather than necessarily developing higher-order themes within the discrete datasets, this approach required treating each participant report as a potential contextual feature which we then explored within and across contextual levels and across data types to develop and test against observed trends. This iterative approach enabled us to transition from the particularities of the Amajuba District as a single case to theoretical explanations of how contextual determinants applicable in other South African settings may shape the patterns we observed, facilitating generalisable inferences and predictions on what implementation strategies are needed to facilitate uptake of a health systems strengthening intervention for TB.

RESULTS

Uptake of online learning

Uptake of the health systems package to strengthen TB case detection, although available across control and intervention clinics was markedly higher in intervention clinics where support was provided. A total of 177 clinicians (78% of the total staff; 44 years average, 10 over the age of 60; 89% women) from the 10 intervention facilities registered for the training course whereas only 19 staff from 18 control facilities did. Of those who registered for the training, 85% ($n = 166/196$) reported no prior exposure to online training. At the intervention facilities, 43% of those who registered completed all sessions. Session completion rates at intervention facilities fell most noticeably after Sessions 1 and 2: Session 1 (91%); Session 2(60%); Session 3 (47%) and Session 4 (43%).

An adaptation from the traditional in-service method of a face-to-face mode of training to online learning surfaced multiple challenges. Some of the reasons for low uptake included limited access to smart phones or experience of the digital world, including the need to log in using passwords.

> 'I find that it was very, very challenging, especially for the elderly; the nurses who are older. People are very scared of new things: number one they're very scared of trying new things. Secondly they don't have the right equipment; they still using the non-smartphones. I don't want to say they really didn't have time, it was just a matter of, "I don't want to do this. it's not going to do anything for me."' (Nurse, Intervention Clinic 1)

> 'Most of us were not used to it. It's something new and there are so many passwords maybe battling if this needs a password, what needs a password, opening your cell phone needs a password. So, we forget some of the things, and I mean forgetting the password on how to go about the training'. (Nurse, Intervention Clinic 5)

Part of the reluctance could be attributed to the view that management did not value online learning at the same level as face-to-face learning, and therefore positioned online learning as an added responsibility requiring unfamiliar self-directed engagement, typically in nurses' spare time:

> 'So only problem with online learning is unlike the other courses, where you'll say, there'll be a course at district office, we have to go there, and then you'll know that from work, you'll take the time off and then you'll do this. For now it is mixed with work, with all these challenges that we are having at work and then it's just mixed on the side. There is no time for it, and then they say you can do it at your own time'. (Nurse, Intervention Clinic 7)

> 'Even with these online courses, whenever people are doing it as a group, it's doable, and then they can do it, but once you assign them to do it individually, in their spare time, that's why they are not finishing it'. (Nurse, Intervention Clinic 7)

In response to these challenges we worked closely with facilities throughout, tailoring implementation strategies to optimise delivery and receipt of the online training on an ongoing basis. This included providing one additional technical support visit per intervention clinic, reinforcing messages about online training in groups, successfully requesting a policy for protected time for online training, one tablet device per clinic, evolution of the facility trainer as an online learning champion, and introduction of facility-level reports to track individuals' progress and target champions' support.

Effect on TB testing

Before the first COVID-19 wave and the start of follow-up, intervention facilities had larger monthly patient headcounts than control facilities (mean 4774 [standard deviation 2559] versus 2552 [1965] respectively), lower rates of TB testing per 100 headcount (1.2 [0.6] vs. 1.7 [1.1]) but higher rates of positive tests per 10,000 headcount (9.3 [2.8] vs. 6.3 [2.1]).

During follow-up, after the start of the first COVID-19 lockdown, mean testing rates increased overall (Figure 2a). Among intervention facilities that had begun to be exposed to the intervention, testing rates were initially higher than among unexposed facilities, but then decreased unevenly (Figure 2a). Overall test positivity rates initially decreased during the first COVID-19 wave, then increased and decreased slightly, before increasing steeply after 15 months (Figure 2b). Among facilities that had started exposure to the intervention, test positivity rates were initially much higher than among unexposed facilities, then changed in a steep-sided U-shaped curve but remaining higher than unexposed facilities at all times (Figure 2b). These observed trends are potentially misleading, however, both because the composition of exposed and unexposed facilities changed as intervention facilities switched from unexposed to exposed, and also because of systematic baseline differences in testing and positivity rates between intervention and control facilities.

The results of the time series statistical models avoided these limitations (Table 1). According to these models, testing rates overall were 9% higher after exposure to the intervention (incidence rate ratio [IRR] 1.09, 95% confidence interval [CI] 1.03–1.15), and test positivity rates were 27% higher (IRR 1.27, 95% CI 1.03–1.56). When duration of exposure was added to the models, testing rates were estimated to be 56% higher (IRR 1.56, 95% CI 1.45–1.69) immediately after exposure began, and decreased thereafter. Test positivity rates were estimated to be 69% higher (IRR 1.69, 95% CI 1.23–2.32) immediately after exposure began, then decreased and increased again. Graphs illustrating the latter changes in effects, derived from the coefficients shown in Table 1, are shown in Figure 2c,d. Figure 2c suggests that positive effects of the intervention on testing rates disappeared after 7 months, while Figure 2d suggests that effects on positivity rates also disappeared by around 7 months, but then increased again. Three sets of sensitivity analyses (representing COVID waves as linear splines or binary variables, including pre-COVID data, and using negative binomial regression instead of Poisson regression models) produced similar results to those reported above, supporting the robustness of the primary analyses.

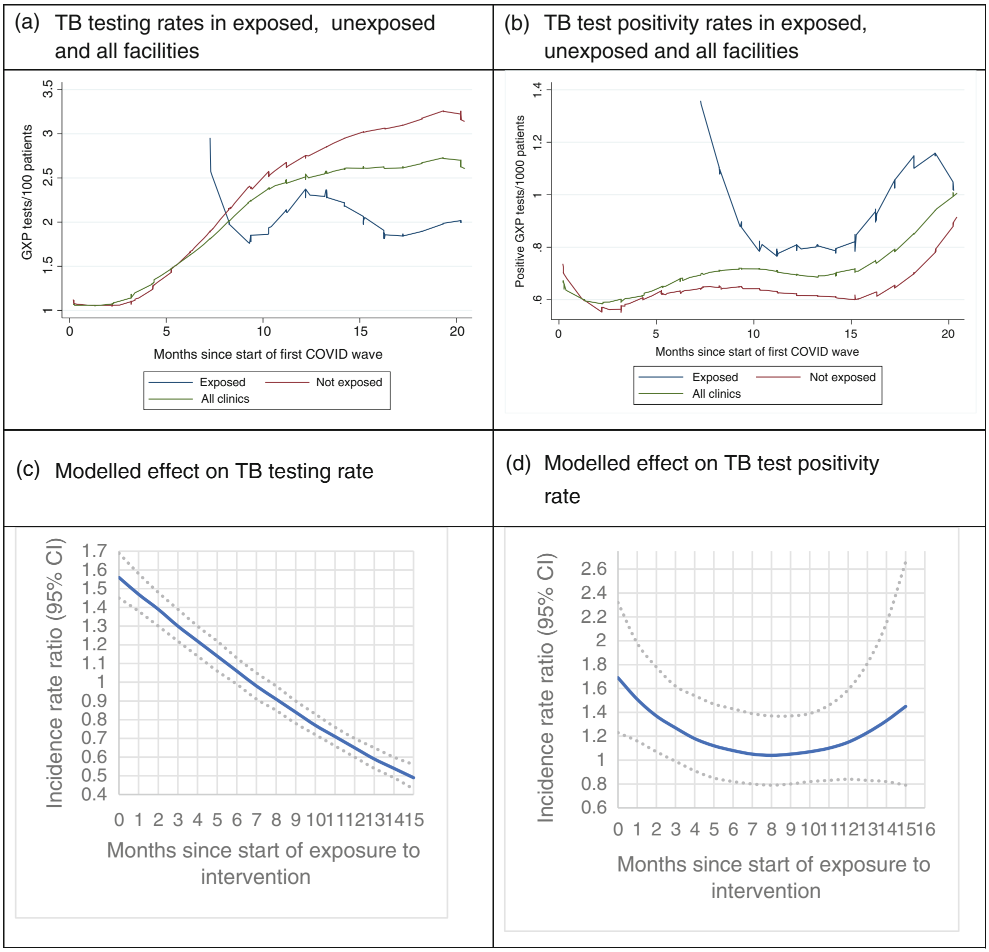

FIGURE 2 Observed changes in outcomes and modelled effects of intervention over time.

TABLE 1 Estimated effects of exposure to the intervention: time series Poisson regression 410 mixed models.[a]

	Outcome variable					
	No. TB tests/headcount			No. positive TB tests/headcount		
Explanatory variable	**IRR**	**95% CI**	***p***	**IRR**	**95% CI**	***p***
Model 1. Overall effect (without modelling change with duration of exposure)						
Exposure	1.09	1.03–1.15	0.004	1.27	1.03–1.56	0.026
Model 2. Initial effect and change in effect with increasing duration of exposure						
Exposure	1.56	1.45–1.69	<0.001	1.69	1.23–2.32	0.001
Months of exposure	0.945	0.922–0.967	<0.001	0.889	0.797–0.991	0.034
Months of exposure^2	0.999	0.997–1.000	0.145	1.007	0.999–1.016	0.094

Abbreviations: CI, confidence interval; IRR, incidence rate ratio.
[a]All models adjusted for COVID-19 wave periods, calendar month, and mean pre-pandemic monthly rates of testing or test positivity in each facility, with facility as random effect.

Integration of TB and COVID-19 screening and testing

Interviews with managers and clinicians in the intervention facilities supported the observed trends in increased TB testing and positivity through integration of TB with COVID screening and testing. Descriptions provide evidence that at the beginning of the pandemic alternative causes of respiratory symptoms were neglected.

"When COVID started I think we started neglecting TB. Anyone who has a cough, you don't care how long, what sputum, whatever. It was just a matter of, okay this one is coughing, outside, isolate COVID. So we stopped, when the pandemic started, we stop looking at what you should look at every day. You stop concentrating on your pneumonia, stopped about TB. It was now okay cough, COVID."

The training provided guidance for facilities on how to complete TB and COVID-19 screening and testing simultaneously, leading to identification of TB cases among patients being tested for COVID-19.

> 'We used to screen people before we only focusing on when the COVID started we only focused on COVID on leaving TB alone and then we only take doing COVID test, but after learning here we are able to do COVID test and TB test to the patient, and then we wait for the results. So in that case, we were able to do it the proper way, because before we used to send patients… people come with COVID symptoms, we'll send patient for COVID testing and then you go. The results will come back negative and then you start to check the TB and then you'll find that the TB is positive but it's better you if you do it screen symptoms, and then you combine it. That's how we will now identify or the results TB and COVID'. (Nurse, Intervention Clinic 7)

> **'Researcher:** Was there anything new that was learnt in terms of even just managing patients with TB and COVID?
> **Operational manager:** Yes because in the past they were not able because we were not doing it to screen for both. Now, when they screen patients COVID so we also included TB, so when they screen for COVID they also screened for TB simultaneously and even with those who qualify who has symptoms of COVID, we will also test them for TB. So some of the patients, the results for COVID will come back negative and TB positive. So it actually helped that we were able to do it simultaneously'. (Operational Manager, Intervention Clinic 6).

As a result of the integration of screening and testing for TB and COVID-19, participants perceived higher numbers of patients being tested for TB and more of them testing positive.

> '**Interviewer**: So was there any changes in the number of patients that you know you were finding and being able to follow up?
> **Participant:** Yes we had a very high number of the patients we were testing and even their results came back positive,* yeah'. (Operational Manager, Intervention Clinic 5)

Such reports provide limited evidence that linked the online intervention to changes in screening and testing practices. However, following marked declines in TB testing during the first wave a district wide mandate was introduced to test everyone with a cough for both TB and COVID. This created a favourable policy environment in which to implement the intervention.

> **'Interviewer**: Has it been easy to tell when a patient has COVID or TB or to screen for them?
> **Participant**: The guidelines (clinical decision support tool) make it very easy. The symptoms as well also do make it easy to screen for both, but currently in Amajuba District, if anyone presents with a cough, whether it's COVID, it's a COVID cough, or it's a TB cough, everyone have to produce a sputum anyway'. (Nurse, Intervention Clinic 1)

Strengthened quality of TB testing and tracing

Use of adult primary care (APC) guidelines was linked to improvements in TB screening and contact tracing, picking up cases which would have previously been missed:

> 'In terms of urgent attention there were those cases where I didn't give the patient the urgent attention according to the guidelines. I would just treat them normally, but now when I check the APC guidelines I am able to see now this one it's supposed to be given an urgent attention. When you read those symptoms in red,† you'll find that before sometimes you had patients with symptoms there but you just treated them and sent them home'.

The content of the integrated online learning provided clinicians with simple reminders of how to conduct testing and what information the patient may require. Clinicians linked these reminders to improved education for patients on sputum sample collection, and consequentially a reduction in sputum sample rejection rates from laboratories.

> 'The how-to take a sputum is very helpful, because many a times, I think with the sputum, before we used to have sputum like not enough, or insufficient, you know, whatever that the lab wants, but now we actually do send tests, and they come back with the results.… even the way they educate the clients when they sent them for sputum taking, it has really improved'. (Nurse, Intervention Clinic 1)

> 'For me it was TB. Just the basic information like how to collect sputum, because usually we just give the sputum bottle. We don't give the

*Positive for TB

†Symptoms in the red box require urgent attention.

> patient the whole information about when they're supposed to come and all those things'. (Nurse, Intervention Clinic 1)

Another aspect of the systems strengthening included the extension of a patient registry for presumptive cases which was used to support community tracing, and had not been in place before.

> 'And it also helped us to… because after that we decided we've seen the importance of screening, not only the screening tools but to have the register of all the patients and their addresses that is come to the facility. So that if we receive any positive results for COVID it made easy for us to refer all those patients and to check those patients that they came on that particular day'. (Manager, Intervention Clinic 3)

DISCUSSION

The effect of this hybrid health system strengthening package was that uptake of online training was higher among intervention clinic nurses, onset of which was associated with short-term increases in both TB testing and TB test positivity results compared to clinics where hybrid support was not provided. This upward trend was not observed in all settings. The quantitative findings were supported by qualitative interviews which suggested that integrated screening for TB and COVID-19 was being implemented for people presenting with respiratory symptoms.

The quasi-experimental design of the quantitative investigation, with stepped introduction of the intervention, may however have led to biases in effect estimation, compared to a parallel arm randomised controlled trial design. A key concern is that intervention clinics were systematically different from control clinics before the intervention started, and that intervention clinics started training at different times. The statistical analyses aimed to account for these systematic differences between clinics, and for changes in clinic attendance and testing over time, but limitations in these data restricted our ability to fully adjust for them statistically.

We noted challenges with the transition to digital technology in a professional population used to face-to-face group learning. This is consistent with other studies reporting that nurses are often not technologically ready to fulfil e-Learning requirements and that learners need to have the basic technical skills and readiness to concentrate on the content of the offering [23]. Despite the obvious need to shift training from face-to-face to virtual methods, and evidence of the utility to integrate TB and COVID-19 screening capacities among health workers in LMICs such as Colombia, adapting to a new learning approach and understanding course content at the same time is challenging and demanding [24–26]. Our findings support others' recommendations that a prerequisite to facilitate uptake of online training offerings should be technical support through assistance with setting up emails and navigating online course by a designated person [27–29].

Investment in digital platforms for training health workers is fundamental for addressing endemic TB alongside future health systems shocks [4]. Our study highlighted the predominance of older nurses who were used to face-to-face group forms of learning, insufficient access to smartphones and inexperience of nurses in digital methods of learning, and hesitant attitudes towards new ways of learning. In 2021, the South African Nursing Council reported that 73% of registered nurses are over 40 years, and 44% over 50 years of age [30]. Older staff are less likely to be digitally equipped and more like to be working in primary care where online approaches are increasingly used.

Despite many challenges, uptake of online training was associated with an immediate and positive effect on TB testing and case finding in pandemic circumstances. This occurred despite modest completion rates of all sessions with the qualitative data suggesting that being reminded of pre-existing priorities revitalised improved clinical practices using a low intensity intervention. The fact that it diminished over time suggests there may be a role for shifting towards more frequent but less intensive in-service training. Despite a sense of being overwhelmed in times of crisis, health system managers should be encouraged to support early adoption of integrated approaches to respiratory symptoms in future waves or respiratory pandemics in TB endemic areas.

CONCLUSION

These results add to a small knowledge base regarding the effectiveness of a health systems intervention to strengthen TB case detection during the COVID-19 pandemic. The findings support the feasibility of hybrid training approaches and suggest that even refresher interventions are capable of activating nurses to integrate existing disease control priorities during pandemic conditions.

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DATA AVAILABILITY STATEMENT

The datasets generated and/or analysed during the current study are not publicly available due to data transcripts including personal participant information not suitable for sharing, but are available from the corresponding author on reasonable request.

ETHICS STATEMENT

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Human Research Ethics Committee of University of Cape Town (529/2020 on date of approval) and Research Ethics Committee of Kings College London (LRS-20/21-21011 on 26 Novermber 2020). The study was registered with the South African National Health Research Database (KZ_201811_031).

INFORMED CONSENT TO PARTICIPATE

Written consent for interviews was obtained from all participants. All participants were provided with written information about the research, informed that their participation was voluntary and that they could withdraw from participation at any time.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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