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Development and testing of models of tuberculosis contact tracing in rural southern Africa

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Setting: A regional hospital in rural Swaziland.
Objectives: To evaluate a hospital-based contact screening programme and test approaches to improve its effectiveness.
Design: An evaluation and quality improvement study of tuberculosis (TB) contact tracing services.
Results: Hospital-based TB contact tracing led to screening of 157 (24%) of 658 contacts; of these, 4 (2.5%) were diagnosed with TB. Of 68 contacts eligible for human immunodeficiency virus (HIV) testing and counselling, 45 (66%) were tested and 7/45 (16%) were identified as HIV-positive. Twelve (50%) of 24 screened contacts aged <5 years were provided isoniazid prophylaxis. Three enhanced models of TB contact tracing were piloted to screen contacts in the community. Although some enhanced models screened large numbers of contacts, no contacts were diagnosed with TB.
Conclusion: Contact tracing of household members conducted in TB clinics within hospital settings is effective in high-burden, low-income settings, and can be provided using current resources. Enhanced household contact tracing models that followed up contacts in the community were not found to be effective. Additional resources would be required to provide household TB contact tracing in the community.

Household contacts are at high risk of developing tuberculosis (TB).[1] A systematic review found that 3% of household contacts in low- and middle-income settings have TB, with higher rates in children aged <5 years and human immunodeficiency virus (HIV) positive contacts.[2] Contact investigation can lead to early identification and treatment and reduce onward transmission.[3]

The Global Plan to Stop TB identifies the importance of diagnosing contacts of TB cases.[4] Although contact investigation is widely recommended, there is no guidance on care models.[5] Two South African studies in which contacts were screened in their homes found a high yield of TB of between 3% and 9%.[6,7] However, these programmes can be costly, and intensive interventions operating in parallel to existing services may not be sustainable.[8] The Stop TB Partnership advises that contact screening should be managed within existing programmes by establishing a 'contact clinic' at the health centre.[9]

Swaziland has the highest global incidence of TB, at 1317 per 100000 population,[10] fuelled by poverty, poor housing, malnutrition, poor health care infrastructure and high HIV prevalence.[11] The country has a 53% TB case detection rate (World Health Organization target 70%); there is currently no systematic programme for tracing contacts of TB cases for screening. The Swaziland Ministry of Health has identified inadequate investigation of household contacts as one reason why the national TB response is insufficient, and it has committed to conducting systematic investigation of contacts.

The aim of the present study is to evaluate hospital-based contact screening and test approaches to improve effectiveness, through community follow-up.

METHODS

Study setting

The present study was conducted in the TB department of Good Shepherd Hospital (GSH), a regional rural hospital serving a population of 200000. The hospital provides support to community clinics and outreach services such as trained field officers, known as motorcycle adherence officers.

Study design

This is an evaluation of hospital-based universal TB household contact screening, conducted from November 2011 to October 2012. It includes a quality improvement project evaluating three enhanced models to investigate the effectiveness of community follow-up.

Study population

All household contacts of index patients were included in the study. An index patient was defined as any patient aged >5 years with pulmonary TB or <5 years with any form of TB. A household contact was defined as someone living under the same roof as an index case at the time of, or within 3 months of, diagnosis.

Intervention

Newly diagnosed index patients providing consent for contact tracing were asked to list their household contacts. The standard (hospital-based) model for TB contact tracing was as follows: 1) all contacts attending the TB clinic with the index patient at any appointment were offered TB screening, and 2) a letter was given to the index patient to invite household contacts for screening at the hospital.

Adult contacts were screened by clinical assessment using the Swaziland TB screening tool (Table 1).[9] In high HIV prevalence settings, symptom-based screening tools are sensitive in adults (84%), although not very specific (60%).[12] Contacts aged <5 years were screened by the paediatrician, and investigated using chest X-ray

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KEY WORDS
tuberculosis; contact tracing; poverty; Swaziland; rural health

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TABLE 1 Swaziland five-question TB screening tool

Does the individual have
- Cough for any duration?
- Fever ⩾ 2 weeks?
- Night sweats ⩾ 2 weeks?
- Weight loss ⩾ 4 weeks?
- Chest pain for any duration?

If the patient answers yes to any of these symptoms, the screen is positive and the patient should be counted as a TB suspect requiring clinical evaluation and further investigation.

or gastric lavage. Those screening negative were offered isoniazid preventive therapy (IPT).[9] Patients with a positive screen were treated as TB suspects.[13] All contacts (or their parents/guardians) were asked about HIV status, and if unknown or negative were offered HIV testing and counselling (HTC).

Development of enhanced models

Three enhanced models were developed and piloted sequentially as part of a quality improvement project, with the aim of improving the accessibility of screening in the community. Enhanced models for screening were developed assuming that no additional resources were available, as no resources were identified nationally.

A working group (including researchers and health care workers) was developed to evaluate the models during the intervention period. The group met regularly, with quarterly data updates, and enhanced models were adapted to address any difficulties identified by the working group. The revised model was then implemented and the process repeated. An outline of the main concerns identified through the quality improvement project, the models developed and the timescales are shown in Table 2.

Outcome measures

The primary outcome measure is the number of contacts screened. Secondary outcomes are the number of household contacts identified as TB suspects (positive screen) and the number of contacts diagnosed with TB. In addition, secondary outcome measures for the standard model are the number of under-fives provided with IPT, the number of those with unknown HIV status offered HTC and the number of HTC testing positive. A qualitative description of enhanced models outlines challenges of implementation.

Data collection and analysis

A register was developed and piloted and national TB and HIV registers were used to ensure accuracy of recording. The distance travelled was calculated using TomTom Route Planner (TomTom, Amsterdam, The Netherlands) and consensus from two local motorcycle adherence officers. Costs were identified with the TB Programme Co-ordinator and the GSH Finance Director.

Sample size calculations were conducted for the standard model. Assuming that no contacts out of 500 contacts before the intervention was implemented had been screened, an α of 0.05 and a power of 0.9, 95 contacts would be required to detect a 10% difference, increasing screening from 0% to 10%.

Ethics

This study was approved by the Research Ethics Committees of the Swaziland Ministry of Health, Mbabane, Swaziland, and the University of Leeds, Leeds, UK.

TABLE 2 Outline of three enhanced models of TB contact tracing developed as part of quality improvement project and feedback after implementation

Description of enhanced model	Feedback from implementation	Adaptations to models made
Model 1: phone call reminders (November 2011–February 2012) Reminder by phone to attend at 1 month, and 7 days after if patient does not attend If patient does not attend, home visit from motorcycle adherence officer for TB screening	Whole families were happy to be screened when seen at home, therefore screening in the community was mostly considered to be acceptable, although some stigma was present, with some families not wishing to engage. Contacts would often be at work or school Feedback from contacts that travelling to hospital was too expensive Many contacts required home visits, which negatively impacted on other commitments of motorcycle adherence officers	As patients are unlikely to attend the clinic after a reminder, contacts should be screened by phone. This will reduce the number of follow-up visits to be undertaken by motorcycle adherence officers
Model 2: screening by phone (March–July 2012) Screening of contact by phone at 7 days If unable to contact, home visits from motorcycle adherence officers	Screening by phone yielded no positive screens. A number of households who reported no symptoms on the phone were visited and a number were found to be symptomatic Feedback from contacts was that they often did not know the symptoms of household contacts who may be at work or school and so denied symptoms on the phone	Screening by phone was removed from the model. A targeted model was introduced to ensure that only follow-up of high-risk contacts would be undertaken
Model 3: targeted screening (August–October 2012) Home visit from motorcycle adherence officer for TB screening of high-risk patients* after 7 days Second letter given to low-risk contacts at follow-up TB appointment	Considerable time taken by motorcycle adherence officer to visit communities. They can usually see two households per day, and contacts are often not in. This had impact on other, more urgent follow-up visits	

*Defined as an index case with multidrug-resistant TB, any member of the household aged <5 years and an index case with 3+ sputum smear.
TB = tuberculosis.

TABLE 3 Number of household contacts screened using standard hospital-based TB contact tracing, November 2011–October 2012

	n	% (95%CI)
Total number of contacts identified	658	
Number screened at initial visit	109	17 (14–20)
Number screened after letter	48	7 (5–9)
Total screened after standard intervention	157	24 (17–31)
Number with positive screen	57	36 (28–44)
Number diagnosed with TB	4	3 (0–6)

TB = tuberculosis; CI = confidence interval.

RESULTS

Baseline characteristics

A total of 658 household contacts were identified for 122 index cases, i.e., a mean of five household contacts per index case (range 1–24); the median age was 16 years and 55% of the contacts were female. Contacts had to travel a median distance of 18 km (range 1–94) to reach the hospital.

Standard model of TB contact tracing

Of 157 household contacts (24%) screened using the standard model of TB contact tracing, 109 (17%) were screened at the initial appointment and 48 (7%) were screened after the letter was sent with the index case. Of these, 57 household contacts (9% of all contacts, 36% of screened contacts) were identified as TB suspects using the standard model (Table 3). Four contacts (2.5% of those screened) were diagnosed with TB. Of 111 children, 26 (23%) aged <5 years were screened, and two were diagnosed with TB. Of the remaining 24 eligible children, 12 (50%) were initiated on IPT. Of those screened, 68 (43%) did not have a recent HIV test result and were not known to be HIV-positive. Of 68 contacts eligible for HTC, 45 (66%) were offered it. Seven (16% of those tested) were found to be HIV-positive.

Among contacts who attended the hospital, a significantly higher proportion were women (35% vs. 13% men). People who attended the hospital as part of the standard model tended to be older (28 vs. 19 years) and lived closer to the hospital (17 vs. 22 km; Table 4).

Enhanced models of TB contact tracing

In Model 1 (phone call reminders) 23/137 contacts (17%) were screened, in Model 2 (screen by phone) 150/226 (66%) were screened and in Model 3 (targeted screening) 31/107 (29%) were screened (Table 5).

Contacts identified as TB suspects and diagnosed with TB in the enhanced models are presented in Table 4. Although the number of contacts screened by phone and through motorcycle adherence officer visits was high, no cases of TB were diagnosed,

TABLE 4 Comparison of baseline characteristics of those who attended for screening at hospital as part of standard model of contact tracing

	Screened at hospital		Not screened in hospital	
	n/N	% (95%CI)	*n/N*	% (95%CI)
Female sex	115/332	34.6 (29.5–40.0)	217/332	65.3 (59.0–71.6)
Male sex	35/273	12.8 (8.8–16.8)	238/273	87.2 (83.0–91.4)
Age, years, mean [range]	28 [25–31]		19 [17–21]	
Distance to travel to reach hospital, km, mean [range]	17 [15–19]		22 [21–24]	

TABLE 5 Results of enhanced community-based models of TB contact tracing

	Contacts remaining to be screened *n*	Contacts screened *n* (%)	Contacts screened positive *n* (%)	Patients diagnosed with TB among those who screened positive *n* (%)
Enhanced Model 1: phone call reminders (November 2011–February 2012)				
Phone call reminder to patient/contact to attend at 1 month	137	1 (1)	1 (1)	0
Phone call reminder to patient/contact to attend 7 days after initial phone call	136	0	—	—
Home visit from motorcycle adherence officer for TB screening	136	22 (16)	11 (8)	0
Enhanced Model 2: screening by phone (March 2012–July 2012)				
Screen contact by phone at 7 days	226	118 (52)	0	—
Home visit from motorcycle adherence officer for TB screening	108	32 (14)	11 (5)	0
Enhanced Model 3: targeted screening (August 2012–October 2012)				
Home visit from motorcycle adherence officer for TB screening after 7 days (if high-risk*)	107	31 (29)	2 (2)	0
For low risk contacts, second letter given to index patient at follow-up TB appointment	31	0	—	—

*Defined as household contact of multidrug-resistant TB patient, household contact of patient with 3+ sputum smear, presence of children aged <5 years in household.
TB = tuberculosis.

TABLE 6 Costs of TB contact tracing models

Intervention	Components*	Cost/ screen US$	Cost/ TB diagnosis† US$
Standard hospital intervention			
Initial visit	5 min for TB nurse to complete register; print register; 30 min HTC	1.50	49.50
Screen after letter	5 min for TB nurse time to complete register; print letter; 30 min HTC	1.50	49.50
Enhanced Model 1			
Phone call reminder	30 s nurse time to inform motorcycle adherence officer; print register; phone call; 5 min to inform motorcycle adherence officer for phone call	0.60	—
Phone call reminder	30 s nurse time to inform motorcycle adherence officer; phone call; 5 minutes to inform motorcycle adherence officer for phone call	0.40	—
Home visit	Half day motorcycle adherence officer; half day motorbike cost	8.97	—
Enhanced Model 2			
Phone call to screening	30 s nurse time to inform motorcycle adherence officer; print register; phone call; 5 min motorcycle adherence officer for phone call	0.60	—
Home visit	Half day motorcycle adherence officer; half day motorbike cost	8.97	—
Enhanced Model 3			
Home visit	Half day motorcycle adherence officer; half day motorbike cost	8.97	—

*TB nurse salary US$16 330 per annum; HTC US$2667 per annum; motorcycle adherence officer US$3273 per annum; printing US$0.20 per double sided page; phone call US$0.20; motorbike cost per annum US$1293. US$1.00 = 9.9 SZL, as of July 2013.
†Assuming 3% of those screened using the standard hospital intervention are diagnosed with TB; 0% of patients with phone call reminder or visits by the motorcycle adherence officer are diagnosed with TB.
TB = tuberculosis; HTC = human immunodeficiency virus testing and counselling; SZL = Swaziland lilangeni.

suggesting that these models were not effective in identifying cases of TB.

Costs

The cost per screen for standard contact tracing was US$1.50, with a cost per diagnosis of TB of nearly US$50 (Table 6).

DISCUSSION

In the standard hospital-based contact-tracing model, 24% of contacts were screened, with 36% of these being identified as TB suspects; 2.5% of screened contacts were diagnosed with TB, showing a similar yield to other studies.[2] This modest screening yield was possible using current resources. Other benefits include opportunities for HIV testing and initiation on IPT.

A number of issues impacted the effective implementation of the standard model. To improve TB diagnosis, and to maximise other health impacts of this programme, further improvements to the process of screening and diagnosis in the TB department are required.

The enhanced models of contact tracing were less effective, with varying yields of screening. No new cases of TB were identified. Model 1 relied on contacts coming to hospital; however, travel costs were a barrier to their attendance. Phone calls were an alternative means of screening; however, as contacts were not always aware of the symptoms of their family members, these led to false-negative screens. Other problems included conflicting pressures on staff, difficulty in meeting all contacts during one visit, and contacts being away at school or work. There was also significant stigma attached to motorcycle adherence officers attending patients' homes. None of the enhanced models following up contacts in the community were found to be effective.

The importance of TB contact tracing is well documented. The standard hospital-based model was effective, and could be adopted for similar settings. Careful monitoring of the process should be undertaken to ensure that the intervention is both effective and cost-effective at national level. TB contact tracing in the community is vital. Other models from the literature have shown much higher yields, although with a significant increase in resources.[6,7] While the enhanced models presented here were not effective at detecting undiagnosed TB cases, there were a number of operational issues that may have impacted on their effectiveness. The lessons learnt and the practical challenges demonstrated are relevant for those working to implement services in similar settings. Further work is being undertaken to address limitations in implementation and to test different models to increase the screening yield, such as by using lay community health workers for screening.

CONCLUSION

Hospital-based TB contact tracing is an effective, low-cost method for screening household contacts. Models for community screening were not effective due to operational issues and limited human resources. Further efforts to increase screening yields in this high-burden country are ongoing.

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Contexte : Hôpital régional en zone rurale au Swaziland.
Objectifs : Evaluer un programme de dépistage des sujets-contact basé dans un hôpital et étudier différentes stratégies destinées à améliorer son efficacité.
Schéma : Evaluation et étude de l'amélioration de la qualité des services de dépistage des sujets-contact de patients tuberculeux.
Résultats : Le dépistage des sujets-contact à partir d'un hôpital a permis de rechercher des cas de tuberculose (TB) chez 157 contacts sur 658 (24%). La TB a été confirmée chez 4 contacts (2,5% des contacts dépistés). Parmi 68 contacts éligibles pour un test et des conseils concernant le virus de l'immunodéficience humaine, 45 (66%) ont subi un test et 7/45 (16%) se sont révélés positifs. Parmi les 24 contacts dépistés âgés de <5 ans, 12 (50%) ont reçu une prophylaxie par isoniazide. Trois modèles améliorés de dépistage des sujets-contact ont été testés dans la communauté. Bien que le dépistage ait été massif, aucun cas de TB n'a été confirmé.
Conclusion : Le dépistage de sujets-contact de patients tuberculeux réalisé dans des dispensaires anti tuberculeux au sein d'un hôpital est rentable dans un contexte de prévalence élevée et de pauvreté, et peut être organisé avec les ressources existantes. Les modèles améliorés de dépistage au sein de la communauté avec un suivi à domicile des contacts ne se sont pas avérés rentables ; ils requièrent des ressources supplémentaires.

Marco de referencia: El hospital regional en una zona rural en Swazilandia.
Objetivos: Evaluar un programa hospitalario de investigación de contactos y examinar las estrategias que permitan mejorar su eficacia.
Método: Se llevó a cabo una evaluación de los servicios de investigación de los contactos de los pacientes con diagnóstico de tuberculosis (TB) y un análisis de las medidas que puedan favorecer el mejoramiento de la calidad del servicio.
Resultados: La investigación hospitalaria de los contactos de pacientes con diagnóstico de TB tuvo como resultado el examen de 157 de los 658 contactos (24%). Se estableció el diagnóstico de TB en cuatro personas (3% de los contactos examinados). Se practicó la prueba del virus de la inmunodeficiencia humana (VIH) a 45 de los 68 contactos examinados (66%) y siete de ellos obtuvieron un resultado serológico positivo (16%). Se suministró profilaxis con isoniazida a 12 (50%) de los 24 contactos examinados de <5 años de edad. Se propusieron tres modelos de investigación reforzada de los contactos en la comunidad y se pusieron a prueba. Aunque con algunos de los modelos se investigó un gran número de contactos, en ninguno se estableció el diagnóstico de TB.
Conclusión: La investigación de los contactos domiciliarios de los pacientes con TB que se lleva a cabo en los consultorios de un entorno hospitalario es eficaz en los medios con alta carga de morbilidad por TB y bajos ingresos y es posible realizarla con los recursos existentes. No se demostró la eficacia de los modelos de investigación reforzada en los cuales se siguieron los contactos en la comunidad. Serían necesarias nuevas fuentes de recursos con el objeto de practicar el estudio de los contactos domiciliarios de pacientes tuberculosos en la comunidad.

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