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Efficacy of brief motivational interviewing on smoking cessation at tuberculosis clinics in Tshwane, South Africa: a randomized controlled trial

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ABSTRACT

Background and Aims Tuberculosis (TB) patients who smoke risk adverse TB outcomes and other long-term health effects of smoking. This study aimed to determine the efficacy of brief motivational interviewing by lay health-care workers (LHCWs) in assisting TB patients to quit smoking. **Design** Multi-centre two-group parallel individual randomized controlled trial. **Setting** Six primary care tuberculosis clinics in a South African township. **Participants** Newly diagnosed adult TB patients identified as current smokers were randomized to brief motivational interviewing by a LHCW (intervention group, $n = 205$) or brief smoking cessation advice from a TB nurse (control group, $n = 204$). **Measurements** The primary outcome was self-reported sustained 6-month smoking abstinence. Exhaled carbon monoxide (CO) testing was offered to about half the participants. Secondary outcomes were sustained abstinence at 3 months; 7-day point prevalence abstinence at 1, 3 and 6 months; and quit attempts. Allocation was concealed. Primary analysis relied on intention to treat. Multi-level analysis accounted for site heterogeneity of effect. **Findings** Self-reported 6-month sustained abstinence was 21.5% for the intervention group versus 9.3% for the control group [relative risk (RR) = 2.29, 95% confidence interval (CI) = 1.34, 3.92]. Biochemically verified 6-month sustained abstinence was also higher in the intervention group (RR 2.21, 95% CI = 1.08, 4.51) for the 166 participants who were offered carbon monoxide testing. Self-reported 3-month sustained abstinence was 25.4% for the intervention group and 12.8% for the control group (RR = 1.98, 95% CI = 1.24, 3.18). **Conclusions** Motivational interviewing by lay counsellors to promote smoking cessation in tuberculosis patients in South Africa approximately doubled sustained smoking abstinence for at least 6 months compared with brief advice alone.

Keywords HIV, lay health-care worker, randomized controlled trial, tobacco, tobacco cessation, tuberculosis.

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INTRODUCTION

South Africa has the third highest number of incident tuberculosis (TB) cases in the world [1]. Infection with the human immunodeficiency virus (HIV) is an important driver of the epidemic, with coinfection rates of approximately 60% [1]. Treatment success rates remain low; death and treatment interruption are the most frequent negative outcomes [1]. The importance of integrating HIV and TB services is now recognized, and progress in integrating these services has been made [1]. Another potentially important driver of the TB epidemic and contributor to poor TB treatment outcomes is active tobacco smoking, which is an established risk factor for TB infection, progression to active TB disease and mortality from TB [2–4]. Smokers also have more severe clinical manifestations and poorer outcomes, aside from dying from TB. In particular, smokers appear to be at increased risk of delayed sputum conversion [5], TB treatment failure [6], TB recurrence [7–9] and possibly drug resistance [10]. Tobacco smoke impairs lung defence mechanisms through structural changes and alterations in cellular and humoural immunity [11–14]. Behavioural characteristics associated with smokers—in particular

lower drug adherence [15,16]—may also partially explain poorer outcomes for TB patients who smoke tobacco. Tobacco smoking is even more harmful for HIV/TB coinfected patients who are at risk of additional short- and long-term mortality and morbidity due to tobacco smoking and HIV infection [17–21]. As patients with HIV survive longer in the era of highly active antiretroviral therapy (HAART), it becomes increasingly important to prevent these long-term adverse health outcomes related to tobacco smoking.

Smoking cessation is one intervention that can be introduced relatively easily. Both TB and smoking affect the lungs, so being diagnosed with TB provides an ideal learning opportunity [22]. Several studies report promising exploratory and piloting results about integrating tobacco cessation services with TB care [22–26]. In a large cluster-randomized controlled trial in Pakistan, two behavioural support sessions with or without bupropion were highly effective in assisting patients with suspected TB with quitting [27]. To our knowledge, no tobacco cessation trials have been undertaken in a population of TB patients with high HIV coinfection rates, where effectiveness may differ, because dually infected TB patients may be severely ill and/or may have negative outcome expectancies about life, which may function as either a positive or a negative motivator for quitting. The provision of ART care and smoking cessation services, along with TB services, adds another layer of complexity to the feasibility of integrating such services in an already understaffed health system. This study therefore aimed to determine the efficacy of brief motivational interviewing by lay health-care workers (LHCWs) in assisting TB patients with tobacco cessation in a setting with high HIV–TB coinfection rates.

METHODS

Study setting and participants

The study took place at the six largest TB clinics in Soshanguve, a large urban township in the City of Tshwane Metropolitan Municipality in South Africa, which were purposively selected for the study because of their large number of TB patients. These primary care facilities offer TB diagnosis and treatment, counselling and testing for HIV and referral to antiretroviral treatment services. LHCWs assist with a variety of administrative and counselling tasks at these clinics. For the purposes of this study, eight of these LHCWs were selected and trained as data collectors and tobacco cessation counsellors and were paid a stipend of about 160 US dollars/month. They all had a minimum of 11 years of schooling and had at least 1 year experience as LHCW. The majority had previously completed one or more formal counselling courses.

All adult patients initiating TB treatment at the six clinics were approached to participate in the study. Participants were excluded if they were under 18, too ill to participate, unable to understand one of the two languages in which the questionnaire was administered, not currently smoking and had already been on TB treatment for more than 1 month.

The initial planned sample size was 548, based on an assumed 10% sustained quit rate in controls and 20% in the intervention group, with 80% power (two-sided test) and including 20% attrition. These percentages were based on estimates from another study protocol on smoking cessation in TB patients [28] and on the assumption that TB patients may be particularly motivated to quit [22,23]. However, due to slower recruitment of smokers than anticipated for the period of project funding, permission was granted by the institutional ethics committee to review the actual number of smokers needed. A sample size of a minimum of 400 was estimated, based on a more conservative estimate of 5% cessation in the control group and 15% in the intervention group, taking into account 20% attrition.

Trial design and procedures

This was a multi-centre, two-group, parallel, individual randomized controlled trial (RCT). LHCWs identified current smokers among patients awaiting registration as TB patients at the six clinics, using a baseline screening questionnaire. No validation of self-reported current smoking status was performed at that stage. Current smokers were then allocated by the LHCWs to either the intervention or the control arm by means of sequentially numbered sealed opaque envelopes, thus ensuring allocation concealment. The randomization sequence was generated by an independent epidemiologist who was not otherwise involved in the research project, with a 1 : 1 allocation and random block sizes of 2, 4, 6, 8 and 10. Participants allocated to the intervention arm received a brief motivational interviewing (MI) session (15–20 minutes) from the LHCW, and were then referred to the TB nurse—who was working in another consultation room—for TB treatment. All participants, whether they belonged to the randomized intervention or control group, received the following short standardized smoking cessation message from the TB nurse: 'Tobacco use is extremely harmful for your health. If you stop smoking now, your TB will heal better and you will have a lower risk of getting TB again in the future. You will also reduce your risk of heart disease and cancer and protect your children against TB. As a professional nurse, I advise you to stop using tobacco in the interests of your health.' All patients also received a

smoking cessation booklet supplied by the National Council against Smoking of South Africa [29]. It was not possible to blind respondents and LHCWs to the intervention received, because there was only one LHCW per site at four of the six sites. However, TB nurses were blinded to the allocation arm.

Follow-up questionnaires were administered by the LHCWs at participants' routine 1-, 3- and 6-month TB treatment visits. Participants who missed the planned visit were reminded by telephone of the follow-up interview. Participants unable to come back to the clinic in person were interviewed by telephone.

The TB nurse in charge of each clinic underwent 1-day training on the project and in delivering a brief tobacco cessation message. LHCWs received in-depth training on administering questionnaires, enrolment and randomization procedures and a 3-day MI training. Weekly to 2-weekly supervisory site visits were undertaken by the research coordinators to each site for the duration of the project. The baseline leg of the study was piloted at each clinic in a staggered fashion over the course of 6 weeks, after which minor changes were made to the questionnaires.

Intervention

The intervention was based on 'brief MI' [30]. MI is defined as a 'directive, client-centred counselling style for eliciting behaviour change by helping clients to explore and resolve ambivalence' [31]. This method is moderately effective for various clinical conditions, including smoking cessation [32–34]. A short form, commonly referred to as 'brief MI' has been developed for busy clinical settings. For smoking cessation, the simple one-page approach consists of a quick assessment, the patient identifying problems and solutions and the setting of targets [30]. This was the approach used in our study. Messages about risks, when appropriate, were tailored to the relationship between smoking and TB. LHCWs helped patients who were already highly motivated to quit and were highly confident about their ability to quit with a quit plan [35]. LHCWs received 3 days' in-depth training in tobacco cessation and brief MI for tobacco cessation from an experienced brief MI counsellor and trainer. Training involved video-taped role-play with feedback sessions that ensured that counsellors understood the principles and spirit of MI, and were able to apply the primary skills of using open-ended questions, affirmations, reflective listening and summaries consistently during patient encounters. No pre–post training test was administered immediately after the training. However, as a start-up work-shop alone may be insufficient [36,37], on-site follow-up practical sessions were organized approximately every 4 months with non-videotaped role plays and informal reinforcement of knowledge and skills.

Outcome measures

Outcome measurements were according to the Russell Standard criteria [38] with some variation—such as not allowing for lapses and the fact that not all participants had a biochemically verified outcome measure. The primary outcome was self-reported 6-month sustained abstinence. Respondents were asked: 'Let's now look back at the period from our very first interview (about 6 months ago) and now. Ignoring the first 2 weeks after the interview, have you smoked any cigarette or smoked any other tobacco product—even a part—since the very first interview?' A similar question was asked at 3-month follow-up. These questions were followed by questions on permissible lapses as defined by Hughes *et al.* [39]. However, in the actual analysis, a more stringent criterion of 'no smoking at all after the initial window period' was used, as participants often appeared to misunderstand the complex questions relating to permissible lapses.

Participants with missing results at 1 or 3 months could still be regarded as a success at 6 months provided they had not smoked at all for the past 6 months [38]. However, if participants made conflicting statements—for example, self-reporting of smoking at 3 months while declaring sustained abstinence at 6 months—they were classified as continued smokers.

Secondary outcomes were: sustained 3-month abstinence, 7-day point-prevalence abstinence (PPA) at 1, 3 and 6 months after the intervention, and quit attempts (defined as not smoking for 24 hours or more with the intention to quit). At the 1-month follow-up, we also enquired about the receipt of brief cessation advice and the smoking cessation booklet from the TB nurse at the enrolment visit.

Self-reported smoking abstinence was biochemically verified with the piCO$^+$ Smokerlyzer carbon monoxide (CO) monitor (Bedfont Scientific Ltd, Maidstone, UK) using the standard recommended cut-off value, whereby a reading of 10 parts per million (p.p.m.) or more signifies smoking [38]. CO was selected as the preferred monitoring device because of its ease of use and because it excludes users of smokeless tobacco [38,40,41]. Due to financial constraints, the only three available exhaled CO monitors were rotated to half the clinics, and changed over to the other half every second month. Therefore, about half of all respondents were offered testing at follow-up visits. However, as patients did not know whether the monitor was allocated to their clinics at specific time-points, this approach introduced a bogus pipeline procedure, thus increasing the likelihood of truthful answers.

For each follow-up period, 4 weeks post-dating the actual follow-up date was allowed [38]. Moreover, the following pre-dating periods were permitted: 1 week for the 1-month follow-up, 3 weeks for the 3-month follow-up and 4 weeks for the 6-month follow-up.

Baseline measures

Questionnaires were translated into the most commonly used local language and back-translated to English to ensure accuracy of translation, and implemented in this translation and in English. TB- and HIV-related information was obtained from the participants' standardized individual TB records. The questions on tobacco use were adapted from the Global Adult Tobacco Survey questionnaire [42]. We used the Heaviness of Smoking Index (HSI) ('how soon after you wake up do you smoke your first cigarette' and 'how many cigarettes do you smoke per day?') as an indicator of tobacco dependence [43].

We collected information on demographic, socio-economic and psychosocial indicators which may influence smoking cessation rates: recent depressive symptoms [44], perceived stress [45], social support [46], illicit drug use and an alcohol problem [47]. We also enquired about smoking-related characteristics self-efficacy [48], confidence and motivation to quit and stage of change [49].

Ethical considerations

Informed consent was obtained from all participants, for the smoking baseline screening questionnaire and participation in the trial for participants identified as current smokers. This included information about the nature of the study, the procedures involved, potential benefits and harms, the right to withdraw at any time, alternative treatment, confidentiality and compensation (lunch parcel to the value of two US dollars).

The trial was registered in the South African (DOH-27-0811-3539) and the Pan African (PACTR 201311000695277) Clinical Trials Register and approved by the Ethics Committee of the University of Pretoria (Protocol 116/2011). Funders had no influence on the data collection, analysis or reporting.

Data management and analysis

All data were double-entered in Microsoft Excel and analysed with Stata, version 12 [50].

Relative risks (RR) for primary and secondary outcomes were estimated using multi-level Poisson regression analysis to account for site heterogeneity of effect. We repeated this analysis adjusted for the following baseline variables, as pre-specified in the study protocol: HSI, age, duration of smoking and alcohol problem. Absolute risk differences were also calculated. To determine biochemically verified smoking abstinence, two types of analysis were performed, one limited to the subgroup of study participants who were offered testing, the other including all study participants. Participants who refused testing were counted as continued smokers.

Primary analysis was by intention-to-treat (ITT): patients lost to follow-up or who came for follow-up outside the window period were assumed to have continued smoking. Results were also analysed as per protocol, whereby non-eligible patients and patients lost to follow-up were excluded from the analysis.

RESULTS

Participant follow-up and trial execution

Subjects were recruited from 14 September 2011 to 25 April 2013 and were followed-up until the end of October 2013. Of the 2411 patients screened for eligibility, 69 did not consent to the study, 1505 were not current smokers and the remainder were excluded for other reasons, as listed in Fig. 1. This resulted in 205 participants randomized to the intervention and 204 to the control. Follow-up rates were 82.4, 80.2 and 76.5% at 1-, 3- and 6-month follow-up, respectively, and did not differ significantly by arm. A total of 21 participants died during follow-up [10 in the control group (4.9%), 11 in the MI group (5.4%), $P = 0.83$].

Baseline characteristics

Thirty-six, 42, 44, 122, 102 and 63 smokers were enrolled at the six respective TB facilities. The baseline characteristics of the two arms of the trial were similar, with only minor differences between groups (Table 1).

Outcomes

As there was heterogeneity of effect across sites, all relative risk results were calculated with facility as random effect in a two-level analysis.

Primary outcome

Self-reported 6-month sustained abstinence was more than twice as high in the intervention group as in the control group [21.5 versus 9.3%, RR = 2.29, 95% confidence interval (CI) = 1.34, 3.92], with an absolute difference of 12%. Results were similar when adjusted for pre-specified potential predictors (RR = 2.31, 95% CI = 1.33, 4.01).

At 6 months, 165 participants underwent exhaled CO testing (one participant refused testing and was counted as a continued smoker; the others were not offered testing). Biochemically verified quit rates were signifi-

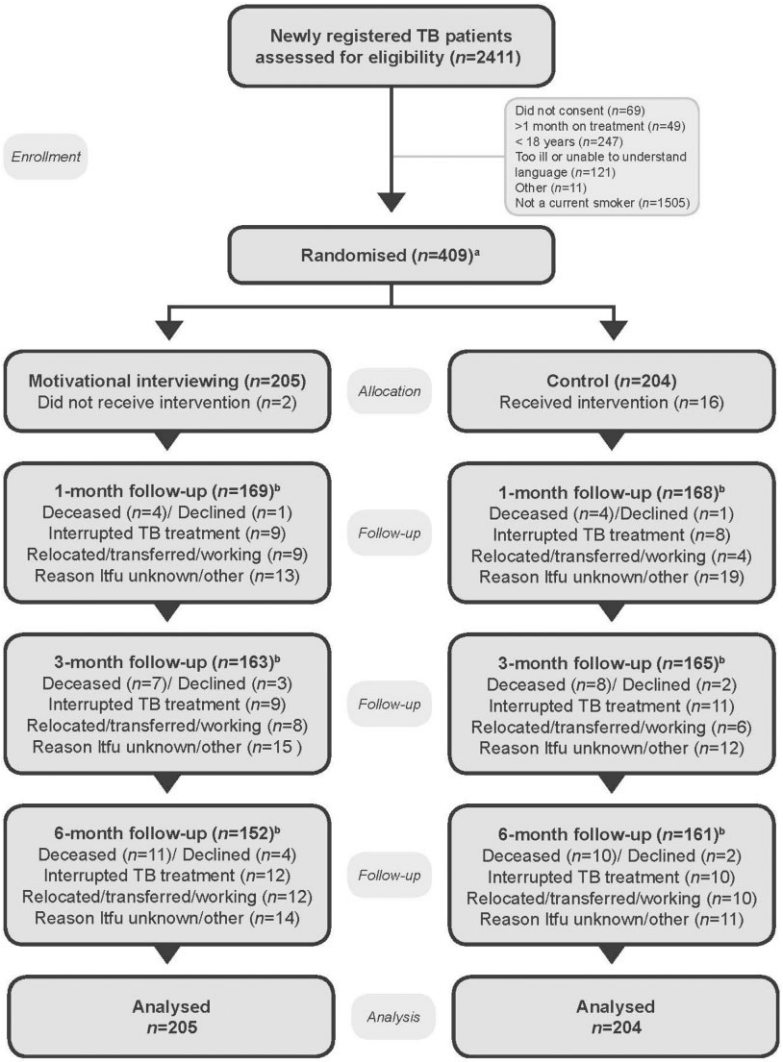

Figure 1 Consort flow diagram. [a]Includes one patient who was later diagnosed as not having tuberculosis (TB), three patients found to have been on treatment for more than 1 month, and one patient who was in fact a past smoker; [b]22, 24 and 34 of these came outside the window period and are counted as smokers for the intention-to-treat (ITT) analysis

cantly higher in the intervention arm than in the control arm (28.9 versus 13.3%, crude RR = 2.21, 95% CI = 1.08, 4.51; adjusted RR = 2.33, 95% CI = 1.11, 4.90) in this subgroup analysis. The association remained significant (RR = 2.15, 95% CI = 1.06, 4.40) when all study participants were included in the denominator (Table 2).

Secondary outcomes

Three-month sustained abstinence was twice as high in the intervention group as in the control group in both unadjusted (25.4 versus 12.8%, RR = 1.98, 95% CI = 1.24, 3.18) and adjusted analyses (RR = 2.04, 95% CI = 1.24, 3.35). The biochemically verified 3-month abstinence rates were significantly higher for the intervention group in the adjusted analysis, but not in the crude analysis. Self-reported 7-day PPA was higher in the intervention group at 1- and 3-month follow-up. However, quit attempts did not differ by intervention arm (Table 3).

Similar but slightly stronger associations were found in the per-protocol analyses for both the primary and secondary outcomes (results not presented). Most respondents (87%) confirmed that the TB nurse enquired about their smoking status at enrolment. In more than two-thirds of cases, the nurse advised the patient to stop smoking in general, without tailoring the advice to TB (68.1%), about one in 10 patients (10.3%) received a TB-tailored smoking cessation message, 11% were advised to reduce smoking, and the rest did not receive any message (10.6%). Most smokers received the smoking cessation booklet at baseline (82.4%), and about three-quarters of these (74.6%) reported reading it (Table 4).

DISCUSSION

The current study showed that brief MI counselling by LHCWs was effective in assisting TB patients to quit tobacco smoking. Both the relative and absolute effects

Table 1 Baseline characteristics of the participants.

	MI group (n = 205)	*Control group (n = 204)*
Men, *n*/*N* (%)	188/205 (91.7)	180/204 (88.2)
Age [mean (SD)] (*n* = 409)	40.3 (SD 10.3)	42.3 (SD 10.1)
Education, *n*/*N* (%)		
Primary schooling or less	66/200 (33.0)	85/204 (41.7)
Some high school	100/200 (50.0)	94/204 (46.1)
Completed high school or higher	34/200 (17.0)	25/204 (12.3)
Marital status, *n*/*N* (%)		
Now married	52/202 (25.7)	62/204 (30.4)
Divorced/separated/widowed	16/202 (7.9)	21/204 (10.3)
Never married	134/202 (66.3)	121/204 (59.3)
Asset score [median (IQR)] (*n* = 404)	4 (3–4)	4 (3–4)
Hungry for ≥ 1 day/month, *n*/*N* (%)	30/202 (14.9)	33/203 (16.3)
Employment category, *n*/*N* (%)		
Unemployed	55/199 (27.6)	60/201 (29.9)
Working full- or part-time	131/199 (65.8)	130/201 (64.7)
Not working[a]	13/199 (6.5)	11/201 (5.5)
Household earnings, *n*/*N* (%)		
ZAR[b] 1–500	74/201 (36.8)	64/202 (31.7)
ZAR 501–2500	100/201 (49.8)	101/202 (50.0)
ZAR > 2500	27/201 (13.4)	37/202 (18.3)
Depressive symptoms (past 2 weeks)	57/181 (31.5)	69/182 (37.9)
Perceived stress score (range 0–16) [median (IQR)] (*n* = 401)	8 (5–10)	8 (5–9)
MOS-social support[c] (range 1–100) [median (IQR)] (*n* = 392)	75 (59.2–88.2)	75 (56.6–89.5)
Alcohol problem,[d] *n*/*N* (%)	109/203 (53.7)	91/199 (45.7)
Illicit drug use, *n*/*N* (%)	26/199 (13.1)	33/197 (16.8)
First episode of tuberculosis, *n*/*N* (%)	170/198 (85.9)	177/200 (88.5)
Pulmonary tuberculosis, *n*/*N* (%)	183/200 (91.5)	189/203 (93.1)
HIV-positive, *n*/*N* (%)	164/187 (87.7)	156/188 (83.0)
Age started smoking [median (IQR)] (*n* = 316)	17 (15–20)	18 (15–20)
Years of regular smoking [median (IQR)] (*n* = 372)	20.0 (14.2–26.8)	20.7 (14.4–28.9)
Daily cigarette consumption[e] [median (IQR)]	8 (5–14)	8 (5–12)
Mean (SD) (*n* = 341)	10.0 (SD 7.1)	9.8 (SD 7.1)
Heaviness of smoking index ≥ 4, *n*/*N* (%)	37/182 (20.3)	40/188 (21.3)
Quit attempt in past 12 months, *n*/*N* (%)	104/198 (52.5)	103/200 (51.5)
Motivation score [median (IQR)] (range 1–10) (*n* = 400)	9 (7–10)	9 (7–10)
Confidence score [median (IQR)] (range 1–10) (n = 401)	9 (6–10)	9 (6–10)
Self-efficacy score [median (IQR)] (range 9–45) (*n* = 389)	26 (18–35)	25 (18–36)
Preparation stage of change, n/N (%)	106/187 (56.7)	116/190 (61.1)

[a]Retired/unable to work/homemaker/student/other. [b]ZAR 8.7 ≈ 1 US dollar at time of end of study. [c]Medical Outcomes Survey, weighted score from 0–100. [d]CAGE (Cut-Down, Annoyed, Guilt, Eye-Opener) score ≥2. [e]Daily smokers only. MI = motivational interviewing; SD = standard deviation; IQR = interquartile range.

were somewhat higher than results of systematic reviews regarding the effectiveness of MI in non-TB populations [33,34]. The relatively high cessation rates in our study could possibly be partially attributed to very low prior exposure to any type of smoking cessation counselling in our study population [51]. Furthermore, we believe the non-judgemental client-centred approach of MI was crucial to our success rates, in a care context where patients are more often exposed to paternalistic and condescending counselling styles [52]. Lastly, our participants were often very ill with TB and HIV and the link between smoking and TB is easily understood [22]. However, the effect of our intervention was much lower than in the cluster-RCT in patients with suspected TB in Pakistan. The higher quit rates in the Pakistan study could possibly be explained by their more intensive smoking cessation intervention (a behavioural change consultation of 30–40 minutes followed by a second shorter session, with or without buproprion).

Self-reported quit rates were quite high in the control group, and similar to the Pakistan TB study [27]. Some possible explanations are, first, that the brief advice and smoking cessation booklet provided by the TB nurse may have aided participants in quitting; secondly, answering

Table 2 Primary outcome: 6-month sustained abstinence.

	Intervention	*Control*	*Absolute difference*	*Crude RR*[a]	*Adjusted RR*[b]
	n (%)	*n (%)*	*(95% CI)*	*(95% CI)*	*(95% CI)*
Self-reported 6-month sustained abstinence[c]	44/205 (21.5)	19/204 (9.3)	0.12 (0.05;0.19)	2.29 (1.34;3.92)	2.31 (1.33;4.01)
Biochemically verified 6-month sustained abstinence[d] (participants offered CO testing, $n = 166$[e])	24/83 (28.9)	11/83 (13.3)	0.16 (0.03;0.28)	2.21 (1.08;4.51)	2.33 (1.11;4.90)
Biochemically verified 6-month sustained abstinence[c] (all participants[f])	24/205 (11.7)	11/204 (5.4)	0.06 (0.01;0.12)	2.15 (1.06;4.40)	2.14 (1.01;4.51)

[a]Univariate multi-level Poisson regression with facility as random effect. [b]Multi-level Poisson regression with facility as random effect, adjusted for Heaviness of Smoking Index (HSI), age, duration of smoking, alcohol problem, as pre-specified in study protocol ($n = 395$ for entire sample and 161 for the biochemically verified results). [c]Participants lost to follow-up and those who came outside the 6-month visit window period were considered to be still smoking. [d]Self-reported sustained abstinence at 6 months and carbon monoxide (CO) < 10 parts per million (p.p.m.). [e]166 participants were offered CO testing, of whom one refused; the CO-level of the participant who refused was assumed to be ≥10 p.p.m. [f]Assumes that all participants not followed-up and those coming outside window period and those not offered CO testing had a CO-level of ≥10 p.p.m. RR = relative risk; CI = confidence interval.

Table 3 Secondary outcomes.

	Intervention	*Control*	*Absolute difference*	*Crude RR*[a]	*Adjusted RR*[b]
	n (%)	*n (%)*	*(95% CI)*	*(95% CI)*[a]	*(95% CI)*
6-month follow-up					
Self-reported 7-day PPA[c]	92/205 (44.9)	82/204 (40.2)	0.05 (–0.05; 0.14)	1.12 (0.83; 1.50)	1.09 (0.80; 1.47)
3-month follow-up					
Self-reported sustained 3-month abstinence[c]	52/205 (25.4)	26/204 (12.8)	0.13 (0.05; 0.20)	1.98 (1.24; 3.18)	2.04 (1.24; 3.35)
Biochemically verified sustained 3-month abstinence (participants offered testing, $n = 156$[d])	21/83 (25.3)	10/73 (13.7)	0.12 (–0.01; 0.24)	2.03 (0.95; 4.33)	2.32 (1.02; 5.27)
Biochemically verified sustained 3-month abstinence (all participants, $n = 409$)[e]	21/205 (10.2)	10/204 (4.9)	0.05 (<0.01; 0.10)	2.08 (0.98; 4.42)	2.39 (1.05; 5.43)
Self-reported 7-day PPA[c]	81/205 (39.5)	56/204 (27.5)	0.12 (0.03; 0.21)	1.44 (1.02; 2.03)	1.44 (1.01; 2.05)
1-month follow-up					
Self-reported 7-day PPA[c]	72/205 (35.1)	45/204 (22.1)	0.13 (0.04; 0.22)	1.59 (1.10; 2.31)	1.58 (1.07; 2.34)
Biochemically verified 7-day PPA (participants offered testing, $n = 168$[f])	39/79 (48.4)	25/89 (28.1)	0.21 (0.07; 0.36)	1.76 (1.06; 2.90)	1.74 (1.01; 3.01)
Biochemically verified 7-day PPA (all participants, $n = 409$)[g]	39/205 (19.0)	25/204 (12.3)	0.07 (>–0.01; 0.14)	1.55 (0.94; 2.56)	1.63 (0.95; 2.79)
Successful quit attempt	139/205 (67.8)	125/204 (61.3)	0.07 (–0.03; 0.16)	1.11 (0.87; 1.41)	1.09 (0.85; 1.40)

[a]Univariate multi-level Poisson regression with facility as random effect. [b]Multi-level Poisson regression with facility as random effect, adjusted for Heaviness of Smoking Index (HSI), age, duration of smoking, alcohol problem, as pre-specified in study protocol ($n = 395$ for entire sample and 151 and 161 for the 3- and 1-month biochemically verified subgroup, respectively). [c]Participants lost to follow-up and those who came outside the window period were considered to be still smoking. [d]156 participants were offered testing, of whom three refused testing; the carbon monoxide (CO)-level of the three participants who refused was assumed to be ≥10 parts per million (p.p.m.). [e]Self-reported sustained abstinence at 3 months and CO < 10 p.p.m. (assumes that all participants not followed-up and those coming outside the window period and those not offered CO testing had a CO level of ≥10). [f]168 participants were offered CO testing, of whom six refused testing. [g]Self-reported 7-day point prevalence abstinence (PPA) and CO < 10 p.p.m. (assumes that all participants not followed-up and those coming outside the window period and those not offered CO testing had a CO level of ≥10). RR = relative risk; CI = confidence interval.

Table 4 Delivery of brief cessation message by tuberculosis (TB) nurse; receipt and use of smoking cessation booklet[a].

	All respondents	*Intervention*	*Control*	
	n/N (%)	*n/N (%)*	*n/N (%)*	*P-value*
TB nurse inquired about smoking at baseline	282/324 (87.0)	146/162 (90.1)	136/162 (84.0)	0.098[b]
Message given by TB nurse				
No message	30/282 (10.6)	12/146 (8.2)	18/136 (13.2)	0.278[b]
Advised to stop smoking	192/282 (68.1)	104/146 (71.2)	88/136 (64.7)	
Advised to reduce smoking	31/282 (11.0)	13/146 (8.9)	18/136 (13.2)	
TB-related cessation message	29/282 (10.3)	17/146 (11.6)	12/136 (8.8)	
Usefulness score of TB nurse message [median (IQR)] ($n = 247$)	5 (4–5)	5 (4–5)	5 (4–5)	0.060[c]
Smoking cessation booklet received	230/283 (82.4)	121/145 (83.5)	109/134 (81.3)	0.644[b]
Read any part of smoking cessation booklet	160/224 (74.6)	69/105 (69.1)	91/119 (79.1)	0.089[b]

[a]All questions posed at the 1-month follow-up visit; analysis limited to participants followed-up at 1 month. [b]χ^2 test. [c]Wilcoxon's rank-sum test. IQR = interquartile range.

questions on tobacco use, health beliefs and motivation to quit may have led to reflection about the harmful effects of smoking and may have altered subsequent smoking behaviour; lastly, being ill with TB may, in itself, be sufficient to induce people to stop smoking [22,24,26]. Considerable effects in the control group have also been found for another behavioural intervention in South African TB patients [53].

There were 21 reported deaths during the trial. It is extremely difficult to obtain the exact causes of death in this community setting, but it is unlikely that these deaths occurred due to the smoking cessation trial. Because all participants were ill with TB and most were also HIV-positive, the most likely cause of death was related to HIV and/or TB [54] or other causes unrelated to tobacco cessation. Death rates did not differ significantly between arms, and the majority of deaths occurred within 3 months after TB registration.

Our study has some limitations. A relatively high percentage of patients could not be traced for one or more of the follow-up visits; however, the loss to follow-up rate was similar in the intervention and control groups. Furthermore, all patients lost to follow-up were considered smokers in the ITT analysis. MI was offered in only a single brief session by LHCWs. We were unable to monitor intervention fidelity by video-taping actual MI sessions with real patients, as it is considered invasive to patients within the context of standard clinical care. It is therefore possible that LHCWs, although intensively trained, did not deliver MI adequately [55]. However, the outcomes were similar or even better than would have been expected with MI. Follow-up measurement was not blinded, which may have introduced respondent- or interviewer-bias. Over-reporting of self-reported quit rates is thus possible, which may partially explain the high self-reported 7-day PPA obtained at 6-month follow-up. We attempted to minimize over-reporting by offering potential testing with exhaled CO monitoring. However, a drawback of CO monitoring is the short half-life of CO in smokers—morning readings may thus give misleadingly low results [56]. Furthermore, only half the participants were offered testing.

We did not offer pharmacotherapy to smokers, as smoking cessation medication is expensive and currently not available in public primary care clinics in South Africa. There is also insufficient evidence of its effectiveness in light smokers [57,58]. The longest follow-up was 6 months. It may have been advisable to follow-up the patients again at 12 months, even more so because there is evidence that TB patients may relapse to smoking when they feel better as the TB is treated [22,24,26]. However, 6 months was chosen because this time-period coincides with the minimum duration of TB treatment. Lastly, the results of the trial may not be generalizable to primary care clinics in different settings, but can probably be extrapolated to similar public health clinics in South Africa.

In conclusion, brief MI delivered by LHCWs was effective in assisting TB patients with smoking cessation under trial conditions in a South African setting. Of particular relevance is that this study demonstrates effectiveness in a population of mainly light smokers. It follows from these results that smoking cessation is possible in TB patients with high HIV coinfection rates in a low- to medium-income country such as South Africa. The second important finding is that smoking cessation services can be delivered by LHCWs—as demonstrated in only a few other studies [59–61]—thus freeing valuable nurse time for more clinical tasks. This is important in the South African context, because TB patients often receive treatment for both TB and HIV. Although these conditions are usually managed in parallel fashion by different providers [62], TB nurses spend a great deal of time referring patients to and from HIV services. Adding intensive smoking cessation

counselling to their tasks may lead to poor implementation and be unsustainable. Furthermore, the use of LHCWs fits neatly with the enhanced role of LHCWs as outlined in South Africa's National Health Insurance plans [63]. Based on the above findings, we recommend the careful implementation of brief MI by LHCWs at TB clinics in Tshwane. If successful, the same programme could be rolled out to other parts of South Africa. Adding smoking cessation to TB programmes will not only reduce long-term smoking-related complications, but crucially TB and HIV-related treatment outcomes.

Clinical trial registration

Pan African Clinical Trials PACTR201311000695277 and South African Clinical Trials DOH-27-0811-3539.

Declaration of interests

K.O. received Pfizer funding for an FDA-approved research project (unrelated to this project) involving the use of nicotine patch, bupropion and varenicline. O.A.A.-Y. is a sub-awardee of an unrestricted Pfizer Education grant to Mayo Clinic for the Global Bridges Health Alliance project and received an honorarium as a speaker at the 2012 congress of the South African Dental Association for a session on treatment funded by Pfizer.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1 Motivational interviewing framework.
Table S2 Brief motivational interviewing intervention (source: Rollnick, Butler & Stott 1997).
Table S3 Training programme overview.