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Treatment supporters and level of health facility influence completion of sputum smear monitoring among tuberculosis patients in rural Uganda: A mixed-methods study

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ABSTRACT

Objectives: To investigate whether treatment supporters influence the completion of sputum smear monitoring (SSM) among adult persons with bacteriologically confirmed pulmonary tuberculosis (BC-PTB), and to explore the reasons for incomplete SSM according to healthcare workers, persons with BC-PTB, and their treatment supporters in rural eastern Uganda.

Methods: A mixed-methods design was used. Quantitative data were abstracted from tuberculosis unit registers, while qualitative data were obtained through key informant interviews with healthcare workers and in-depth interviews with persons with BC-PTB and their treatment supporters. Quantitative data were analyzed with Stata. Qualitative data were transcribed verbatim and analyzed using a thematic content approach.

Results: Records were abstracted for 817 patients. Of these, 226 (27.7%) completed SSM. Factors independently associated with SSM completion included having a treatment supporter (adjusted risk ratio (ARR) 2.40, 95% confidence interval (CI) 1.23–4.70), treatment at a district hospital (ARR 1.61, 95% CI 1.04–2.49), treatment at a regional referral hospital (ARR 2.00, 95% CI 1.46–2.73), and every additional year since 2015 (ARR 1.29, 95% CI 1.17–1.43). Reasons for incomplete SSM related to health system, patient, treatment supporter, and healthcare provider factors.

Conclusions: Completion of SSM was low. Persons with BC-PTB who have a treatment supporter were more likely to complete SSM compared to those without, and those receiving treatment at higher level facilities were more likely to complete SSM compared to those at lower level ones.

Introduction

Tuberculosis (TB) is the leading cause of death among people living with HIV (World Health Organization, 2017a). The 2018 World Health Organization (WHO) Global TB Report indicated that 10 million people developed TB disease in 2017 and two million of them died (World Health Organization, 2018). Sub-Saharan Africa (SSA) has the highest TB burden but the slowest decline in TB incidence rate (World Health Organization, 2016). Uganda is categorized as a high TB–HIV burden country because it contributes over 1000 new TB–HIV cases yearly (World Health Organization, 2015).

Standard 10 of the International Standards of Tuberculosis Care require all persons with bacteriologically confirmed pulmonary TB (BC-PTB) initiated on treatment to receive sputum smear monitoring (SSM) with microscopy test at 2, 5, and 6 months (Hopewell et al., 2006). This ensures treatment response, failure, and drug-resistant TB are detected promptly. Sputum smear microscopy is the gold standard for monitoring the treatment response since culture and GeneXpert tests are not validated for this purpose (Republic of South Africa, 2014), expensive, time-consuming, and require special expertise (Frieden, 2004).

Completion rates of SSM are crucial for local and national TB control programs. However, limited research has been conducted about SSM completion and the associated factors among persons with BC-PTB in SSA. Furthermore, the role of treatment supporters has been examined extensively for cure, treatment completion, and mortality (Burton et al., 2011; Hussain et al., 2018; McKay et al., 2019), but not for SSM. Also, data on the reasons for incomplete SSM are scarce.

The study purpose was to investigate whether treatment supporters among other factors, influence SSM completion among

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adult persons with BC-PTB in rural eastern Uganda, and to explore reasons for incomplete SSM according to healthcare providers, persons with BC-PTB, and treatment supporters. The results will contribute to the design of context-specific interventions across TB units in Uganda and similar regions in resource-limited settings.

Materials and methods

Study design

A mixed-methods research design was used, in which qualitative and quantitative data were collected in parallel, analyzed separately, but merged at interpretation and reporting stages, because a single data source was inadequate to address the research question (Fielding, 2012). Quantitative data were used to determine patient and health system-related factors associated with SSM completion. Qualitative data were used to contextualize quantitative results, hence ensuring a complete understanding of the research problem. Guidelines on Good Reporting and Analysis of Mixed-Methods Studies were followed to design, analyze, and report the results (Cameron et al., 2013). WHO standard TB definitions were adopted (Supplementary Material Table S1).

Study setting

This study was conducted at 10 health facilities with the highest volume of persons with TB (PWTB) in the four districts of Soroti, Kumi, Ngora, and Serere in eastern Uganda. The total population of the four districts, located between 250 km and 350 km from Kampala (the capital city), is 963 923 (Uganda Bureau of Statistics, 2017). In Soroti District, Soroti Regional Referral Hospital, Princess Diana Memorial Health Center IV, and Tiriri Health Center IV were the study sites. A health center IV is a county-level health facility in the structure of Uganda's health system. Study sites in Kumi District included Kumi Hospital, Atutur Hospital, and Kumi Health Center IV. Kumi Hospital is a private not-for-profit health facility. Study sites in Ngora District were Ngora Hospital and Ngora Health Center IV. There is no hospital in Serere District, therefore Serere and Apapai Health Center IVs were study sites.

Guidelines for the treatment of TB at the study sites

The study sites have a TB diagnostic and treatment unit that provides services per WHO TB treatment guidelines (World Health Organization, 2017b). Each TB unit has a TB focal person to provide TB services, who is either a nursing, clinical, or medical officer. The units operate 5 days a week, from 8.00 am to 5.00 pm, per Uganda labor laws.

Before 2017, new persons with BC-PTB were treated with either the 8-month anti-TB regimen consisting of rifampicin (R), isoniazid (H), pyrazinamide (Z), and ethambutol (E) for 2 months in the intensive phase and EH for 6 months in the continuation phase (2RHZE/6 EH), or with a 6-month regimen consisting of 2 months of RHZE in the intensive phase and 4 months of RH in the continuation phase (2RHZE/4RH). Re-treatment persons with BC-PTB were treated for 8 months: 2 months of RHZE and streptomycin and 1 month of RHZE in the intensive phase (2RHZES/1RHZE), and 5 months of RHZE in the continuation phase. From 2017 to date, new and retreatment persons with BC-PTB have been treated with the same regimen (2RHZE/4RH), provided drug-resistant TB has been ruled out with GeneXpert testing (Republic of Uganda, 2017). During TB treatment, new and retreatment persons with BC-PTB provide sputa for microscopy testing at 2 or 3, 5, and 6–8 months to monitor the response to treatment.

Study population and sampling

Participants were new and retreatment adult persons with BC-PTB, aged ≥15 years, recorded in the TB unit registers between January 2015 and June 2018. The following participants were excluded: (1) persons with clinically diagnosed and extra pulmonary TB; (2) dead, transferred out, and lost to follow-up persons with BC-PTB. Figure 1 shows the flowchart for abstracted and included records. For qualitative data, adult persons with BC-PTB and their treatment supporters were sampled by convenience, provided TB treatment had lasted for ≥5 months. TB and laboratory focal persons were purposively sampled as key informants. Seventeen interviews were held to identify reasons for non-SSM completion (five TB focal persons, two TB laboratory focal persons, five persons with BC-PTB, and five treatment supporters).

Data collection methods and quality control

Quantitative data were abstracted from TB unit registers using a standardized abstraction tool. The sequence of variables in the tool followed that in the TB unit register to ease data abstraction and reduce errors. Qualitative data were collected through key informant interviews (KIIs) and in-depth interviews (IDIs). KIIs were conducted in the English language, while IDIs were conducted in the local Ateso language by trained research assistants. Data collection tools were pre-tested in the neighboring Katakwi District to check appropriateness.

Quantitative study variables

Independent variables

Data on participant clinical characteristics, namely year of TB treatment, sex, age in years, anti-TB regimen, transfer-in status, pre-therapy bacillus load, HIV testing, HIV test result, antiretroviral therapy initiation among HIV-positive cases, having a child/or children under 5 years in the household, number of children in the

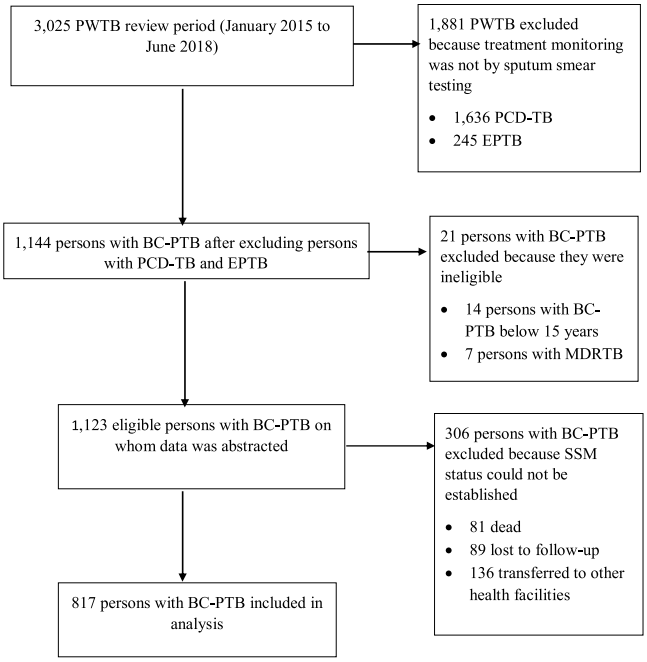

Figure 1. Study profile for the completion of sputum smear monitoring among adult persons with BC-PTB in rural eastern Uganda.
Note: (1) BC-PTB: bacteriologically confirmed pulmonary TB; (2) EPTB: extra-pulmonary TB; (3) MDRTB: multidrug-resistant TB; (4) PCD-PTB: pulmonary clinically diagnosed TB; (5) PWTB: persons with TB; (6) TB: tuberculosis.

household for those reporting they had a child/children and the number started on isoniazid preventive therapy, form of directly observed therapy short course (DOTs), and treatment supporter availability were abstracted. Health systems-related variables were health facility location, ownership type and level, and whether the participant lived in the same sub-county where the health facility is located. Based on their location, Atutur District Hospital and Soroti Regional Referral Hospital, as well as the health center IVs of Kumi, Princess Diana, and Serere were classified as peri-urban health facilities. Kumi and Ngora hospitals, and Tiriri, Ngora, and Apapai health center IVs were classified as rural health facilities.

Outcome variable

The outcome was SSM completion status as a binary variable: incomplete or complete. Complete SSM was defined as receiving three sputum smear microscopy tests scheduled at 2–3, 5, and 6–8 months of TB treatment, confirmed from the TB or laboratory unit registers. Incomplete SSM was defined as receiving fewer than three sputum smear microscopy tests.

Qualitative data

Healthcare workers were interviewed about the availability of laboratory supplies and reagents, motivation, sputum smear test requests and performance, SSM result documentation in the laboratory and TB unit registers, staffing in the TB and laboratory units, and access to the TB unit for PWTB, particularly operating hours/days. We further asked questions on patient waiting times, privacy, confidentiality of information, health messages, understanding of SSM, and decisions in the absence of SSM. Persons with BC-PTB were asked about their understanding, timing, importance, and frequency of SSM, and challenges in SSM. Treatment supporters were questioned on their roles in SSM. All interviews were audio-recorded and field notes were taken.

Data management and analysis

Quantitative data were double-entered into Epi-Data version 3.1 and exported to Stata version 15.1 for analysis. Frequencies and percentages were computed for categorical data, means with standard deviations (SD) for uniform numerical data, and medians with interquartile ranges (IQR) for skewed numerical data. SSM completion was summarized as a percentage. The Chi-square test or Fisher's exact test was used to assess associations between categorical variables like sex and SSM completion. The *t*-test was used to test whether means of numerical variables like age differed by SSM outcome. The prevalence of SSM completion was higher than 10%, so risk ratios (RR) were preferred to odds ratios as a measure of effect (Schmidt and Kohlmann, 2008). A generalized linear model (GLM) with log-link function and Poisson family with robust standard errors was used to calculate the RR with 95% confidence interval (CI). First, the unadjusted RR (URR) was calculated, and then multivariable analysis was conducted with all statistically significant and biologically plausible variables; the final results are the adjusted RR (ARR). The level of statistical significance was set at 5%.

Audio-recorded responses were transcribed verbatim within 48 h, while field notes were summarized within 24 h of interview to minimize transcription and interpretation errors. Transcripts were imported into ATLAS.ti version 7.5 for inductive thematic content analysis. Three steps were followed, namely data immersion, coding, and coding sort. Transcripts were read several times to gain familiarity and identify common and important texts, coded, and the codes sorted. Impressions were allowed to shape interpretations in different and unpredicted directions (Attride-Stirling, 2001). Two reviewers (JI and IKT) independently flagged relevant parts of the transcripts with appropriate codes, and harmonized and transformed them into themes. The third reviewer (FB) verified the final codes and themes. Participant quotes were used to contextualize the quantitative results.

Missing data imputation and multicollinearity checking

We checked for missing data and multicollinearity. One variable, whether the participant lived in the same sub-county as the health facility, had 166 observations missing completely at random. Chained equations were used to impute them and GLM regression analysis was applied to the completed dataset.

Ethical approval

A waiver of consent was received to access the medical records. Written informed consent was obtained from all interviewed study participants. Each participant was free to either withdraw or to remain in the study. Confidentiality of data was maintained by locking all completed data tools in a secure cupboard accessible only to the research team. Preceding the study, administrative support letters were acquired from the respective district health offices.

Ethical approval was received from Mbarara University of Science and Technology Research Ethics Committee (reference number 03/11-18) and Uganda National Council for Science and Technology (reference number HS 2531).

Results

Study profile

Between January 2015 and June 2018 (Figure 1), 3025 PWTB were registered and treated across the study sites. Of these, 1881 were excluded with reasons: 1636 were diagnosed clinically, while 245 had extrapulmonary TB. Of the remaining 1144 persons with BC-PTB, 21 were excluded: 14 were <15 years old and seven were multidrug-resistant TB cases. Of the remaining 1123 persons with BC-PTB, 306 whose full SSM status was not ascertained were excluded: 81 had died, 89 were lost to follow-up, and 136 had transferred out. Overall, 817 persons with BC-PTB were analyzed.

Socio-demographic and clinical characteristics of the study participants

The mean age of the participants was 38.1 (standard deviation ±15.2) years; there was no statistically significant difference in age between completers and non-completers of SSM. Most participants (47.5%) were in the age group 15–34 years and most were male (64.3%). SSM completion did not differ by sex, type of persons with BC-PTB, or anti-TB regimen, among others (Table 1).

Completion of sputum smear microscopy monitoring

Of 817 participants, 226 (27.7%; 95% CI 24.7–31.0%) completed SSM. Most participants who completed SSM had received treatment at government and peri-urban health facilities, and at regional referral hospitals (Table 1). Participants who completed SSM at follow-up visits dropped from 511 (62.5%) at 2–3 months, to 345 (42.2%) at 5 months, and 226 (27.7%) at 6–8 months.

Reasons for incomplete sputum smear monitoring

Of 17 participants interviewed to understand reasons for incomplete SSM (Supplementary Material Table S2), the majority were male, aged 40–46 years, and from a health center IV. The

Table 1
Participant socio-demographic and clinical characteristics.

Characteristics	Level	Sputum smear completion			*p*-Value
		No	Yes	Total	
		591 (72.3)	226 (27.7)	817 (100.0)	
Health facility type	Government	509 (70.4)	214 (29.6)	723 (100.0)	0.001
	Private not-for-profit	82 (87.2)	12 (12.8)	94 (100.0)	
Health facility level	Health center IV	290 (84.1)	55 (15.9)	345 (100.0)	<0.001
	District hospital	132 (78.6)	36 (21.4)	168 (100.0)	
	Referral hospital	169 (55.6)	135 (44.4)	304 (100.0)	
Health facility site	Rural	202 (87.4)	29 (12.6)	231 (100.0)	<0.001
	Peri-urban	389 (66.4)	197 (33.6)	586 (100.0)	
Year of treatment	2015	235 (76.8)	71 (23.2)	306 (100.0)	<0.001
	2016	155 (89.1)	19 (10.9)	174 (100.0)	
	2017	109 (60.9)	70 (39.1)	179 (100.0)	
	2018	92 (58.2)	66 (41.8)	158 (100.0)	
Age group (years)	15–34	270 (69.6)	118 (30.4)	388 (100.0)	0.223
	35–50	200 (74.1)	70 (25.9)	270 (100.0)	
	50 and over	121 (76.1)	38 (23.9)	159 (100.0)	
Age (years)	Mean (SD)	38.7 (15.3)	36.8 (15.0)	38.1 (15.2)	0.120
Sex	Male	373 (71.0)	152 (29.0)	525 (100.0)	0.269
	Female	218 (74.9)	74 (25.3)	292 (100.0)	
Type of PWTB	New	528 (73.1)	194 (26.9)	722 (100.0)	0.163
	Previously treated	63 (66.3)	32 (33.7)	95 (100.0)	
Anti-tuberculosis regimen[a]	2RHZE/4RH	355 (70.2)	151 (29.8)	506 (100.0)	0.206
	2RHZE/6HE	194 (75.8)	62 (24.2)	256 (100.0)	
	2RHZES/1RHZE/5RHE	42 (76.4)	13 (23.6)	55 (100.0)	
Transfer-in status	No	537 (71.9)	210 (28.1)	747 (100.0)	0.347
	Yes	54 (77.1)	16 (22.9)	70 (100.0)	
Tested for HIV	No	8 (100.0)	0 (0.0)	8 (100.0)	0.115
	Yes	583 (72.1)	226 (27.9)	809 (100.0)	
Result of HIV test	Negative	435 (72.6)	164 (27.4)	599 (100.0)	0.551
	Positive	148 (70.5)	62 (29.5)	210 (100.0)	
Has a child/children below 5 years in the household	No	346 (75.9)	110 (24.1)	456 (100.0)	0.011
	Yes	245 (67.9)	116 (32.1)	361 (100.0)	
Form of DOTS	Facility	30 (88.2)	4 (11.8)	34 (100.0)	0.032
	Community	561 (71.6)	222 (28.4)	783 (100.0)	
Treatment supporter	No	92 (92.0)	8 (8.0)	100 (100.0)	<0.001
	Yes	499 (69.6)	218 (30.4)	717 (100.0)	
Lives in same sub-county	No	241 (62.6)	144 (37.4)	385 (100.0)	<0.001
	Yes	256 (81.1)	60 (18.9)	316 (100.0)	
	Missing	94 (81.0)	22 (18.9)	116 (100.0)	

SD, standard deviation; PWTB, people with tuberculosis; DOTS, directly observed therapy short course.
[a] (1) 2RHZE/4RH:2 months of rifampicin (R), isoniazid (H), pyrazinamide (Z), and ethambutol (E)/4 months of RH. (2) 2RHZE/6HE: 2 months of RHZE/6 months of HE. (3) 2RHZES/1RHZE/5RHE: 2 months of RHZE and streptomycin (S)/1 month of RHZE/5 months of RHE.

mean age was 41.6 (standard deviation ±9.3) years. Qualitative results indicated patient, treatment supporter, healthcare provider, and health system-related factors influenced SSM completion. Notable reasons for SSM non-completion were the following: knowledge gap on importance of SSM among persons with BC-PTB and frequency of SSM among TB focal persons, resolution of cough following TB treatment initiation, physical and economic barriers facing persons with BC-PTB, lack of team work among healthcare workers, not adhering to TB treatment guidelines, gaps in TB data capture/reporting, and absence of a tracking system for identifying persons with BC-PTB who need SSM. Table 2 summarizes the codes and quotations related to these factors.

Factors associated with the completion of sputum smear monitoring among persons with BC-PTB

In the unadjusted analysis (Table 3), participants who had received TB treatment at a private not-for-profit health facility (URR 0.43, 95% CI 0.25–0.74), were aged between 35 and 50 years (URR 0.85, 95% CI 0.66–1.10) or more than 50 years (URR 0.79, 95% CI 0.57–1.08), and those who lived in the same sub-county as the health facility (URR 0.51, 95% CI 0.39–0.66) were less likely to complete SSM. Participants who had a treatment supporter (URR 3.90, 95% CI 1.94–7.46) and those who had received treatment at a regional referral hospital (URR 2.79, 95% CI 2.12–3.66) or peri-urban health facility (URR 3.53, 95% CI 2.30–5.40) were more likely to complete SSM. Other significant factors were having a child below 5 years of age and year of enrollment in TB treatment.

In the adjusted analysis (Table 3), having a treatment supporter (ARR 2.40, 95% CI 1.23–4.70), receiving TB treatment at a district hospital (ARR 1.61, 95% CI 1.04–2.46) or regional referral hospital (ARR 2.00, 95% CI 1.46–2.73), treatment at a peri-urban health facility (ARR 1.72, 95% CI 1.01–2.92), and year of TB treatment (ARR 1.29, 95% CI 1.17–1.43) were independently associated with SSM completion. However, SSM completion was not associated with several other factors namely treatment at a private not-for-profit health facility (ARR 0.77, 95% CI 0.35–1.71), age between 35 and 50 years (ARR 0.93, 95% CI 0.74–1.17) or over 50 years (ARR 0.96, 95% CI 0.71–1.30), female sex (ARR 0.87, 95% CI 0.70–1.09), community-based DOTS (CB-DOTS) (ARR 1.01, 95% CI 0.43–2.38), and residence in the same sub-county as the health facility (ARR 0.88, 95% CI 0.70–1.11).

Discussion

SSM completion was investigated among adult persons with BC-PTB in rural Uganda. The overall SSM completion was found to be low and decreased at subsequent testing times. The present SSM completion is lower than that reported in Rwanda at 48.9% (Kayigamba et al., 2012) and Uganda at 45% (Nakaggwa et al., 2016). The decrease in SSM completion as treatment progressed is consistent with a study in Malawi where SSM was 78% at 2 months, 75% at 5 months, and 74% at 6 or 8 months (Harries et al., 2004). In a

Table 2
Summary of themes from interviews with TB focal persons, persons with BC-PTB, and their treatment supporters

Quotations	Reasons	Theme
"For sputum monitoring, I am expected to give sputum at least 2 times or 4 times like that. The first time is after 1 month, then after 2 months and the last one is in the 4th month" (TB patient, Soroti District)	Persons with BC-PTB have insufficient knowledge on sputum smear monitoring	Patient factors
" . . . So my problem will only be transport possibly which can hinder me from coming for sputum checkups and from picking my medicines" (TB patient, Kumi district) "The health center is very far and you cannot get money for transporting yourself to the health center. That is the thing we face. Transport, coming to the health facility to pick drugs" (TB patient, Soroti District)	Physical and economic barriers	
"In the first place they can come coughing. Once they are started on treatment, the majority of them when you ask for sputum samples they say they are no longer coughing" (female TB focal person, Serere District)	Resolution of clinical syndromes following treatment	
" . . . My role is to ensure that he eats at home because I know the medicines can finish his energy. The other one, I ensure he takes his medicine in time, when he fails to take medicines in time, the disease will not clear. Then I have to protect the other family members by ensuring he sleeps in another place" (TB treatment supporter, Kumi District)	Treatment supporters do not focus TB messages on sputum smear monitoring	Treatment supporter factors
"In practice, I monitor TB patients two times" (TB focal person, Soroti District)	TB focal persons do not know the frequency of sputum smear monitoring	Health provider factors
"When I am not here (TB unit), it is really a very difficult time for TB patients. Because since I started working in this hospital, I am almost alone here (TB unit) with my cough monitor. When I am not here, I ask the cough monitor to handle TB patients (to give TB medications). But for another health worker to work with me or in my absence, I have never had one" (TB focal person, Kumi District)	Lack of team work among healthcare providers	Health systems factors
"Most of these patients (TB patients) will request from us health workers that since I come from a distant place, I am requesting for more medications. So you tend to give them treatment beyond that stipulated time of 2, 5, or 6 months. So now, by the time you are supposed to get sputum sample from the patient, he or she already has medications and is at home. He has not come and there is no way you can get the sputum samples for monitoring" (TB focal person, Kumi District)	Not adhering to TB treatment guidelines	
" . . . Some people are reluctant to record the follow-up tests and even the refill. They just write on the patients' cards and the patient goes to pick drugs and the follow-up is just left like that" (TB focal person, Serere District) "I am seeing there is a gap in the laboratory. All the 2019 results are not back. Some TB patients go to the laboratory and report that the laboratory man told them to come back next week. So when they go, I think at the end they do not return" (TB focal person, Ngora District)	Gaps in TB data capture and reporting	
"Generally, issues of identification such as who deserves a sputum follow-up is something which is a gap" (TB focal person, Soroti District) "Sometimes when they (TB patients) come, we realized the person who is seeing them (meaning the clinician) has not taken a keen look or interest to know if the person is ready for follow-up test. So you find the patient goes back home and the sputum followed up test is not done" (TB focal person, Kumi Hospital)	Absence of a tracking system for persons with BC-PTB who require sputum smear monitoring	

TB, tuberculosis; BC-PTB, bacteriologically confirmed pulmonary tuberculosis.

Ugandan study, the corresponding proportions were much lower at 51.2%, 42.4%, and 40.9%, respectively (Musaazi et al., 2017).

Persons with BC-PTB who had a treatment supporter were found to be more likely to complete SSM compared to those who had no treatment supporter. Supervision of PWTB by a community volunteer or family member promotes adherence to medical advice and good treatment outcomes (Soomro et al., 2012). Without a treatment observer, treatment non-adherence is common (Hassard et al., 2017). In Uganda, the National TB and Leprosy Control Program requires PWTB to have a treatment supporter, ideally someone trusted and respected like a family member or friend with whom PWTB declares a good mutual relationship. Treatment supporters remind and encourage PWTB to bring sputa to TB units for follow-up testing. They also support treatment adherence and completion, provide emotional and physical support, and remind PWTB about health facility visits and escort them (Danso et al., 2015; Olukolade et al., 2017). These roles promote SSM completion. The present study thus confirms the importance of treatment supporters in implementing CB-DOTS. District and national TB control programs should design strategies to optimize the importance of treatment supporters in CB-DOTS.

From interviews, participants indicated treatment supporters provided encouragement and key messages on adherence to healthcare provider instructions, which included adherence to monthly drug refill visits, thus offering the opportunity for SSM to be performed by TB focal persons. In the absence of SSM, TB focal persons relied on resolution of cough and chest pain symptoms,

Table 3
Factors associated with completion of sputum smear monitoring among persons with bacteriologically confirmed pulmonary tuberculosis in rural eastern Uganda.

Characteristics	Level	Unadjusted analysis URR (95% CI)		Adjusted analysis ARR (95% CI)	
Ownership type of health facility	Public	1		1	
	Private not-for-profit	0.43**	(0.25, 0.74)	0.77	(0.35, 1.71)
Health facility level	Health center IV	1		1	
	District hospital	1.34	(0.92, 1.96)	1.61*	(1.04, 2.49)
	Regional referral hospital	2.79***	(2.12, 3.66)	2.00***	(1.46, 2.73)
Health facility location	Rural	1		1	
	Peri-urban	3.53***	(2.30, 5.40)	1.72*	(1.01, 2.92)
Year of tuberculosis treatment	2015	1		1	
	1-year increase	1.30***	(1.18, 1.43)	1.29***	(1.17, 1.43)
Age group (years)	15–34	1		1	
	35–50	0.85	(0.66, 1.10)	0.93	(0.74, 1.17)
	Over 50	0.79	(0.57, 1.08)	0.96	(0.71, 1.30)
Sex	Male	1		1	
	Female	0.88	(0.69, 1.11)	0.87	(0.70, 1.09)
Type of persons with BC-PTB	New	1		1	
	Retreatment	1.25	(0.92, 1.70)	1.09	(0.82, 1.45)
Form of DOTS	Health facility	1		1	
	Community	2.41	(0.95, 6.09)	1.01	(0.43, 2.38)
Treatment supporter	No	1		1	
	Yes	3.80***	(1.94, 7.46)	2.40*	(1.23, 4.70)
Has a child/children below 5 years in the household	No	1		1	
	Yes	1.33*	(1.07, 1.66)	1.07	(0.87, 1.32)
Lives in same sub-county with health facility[a]	No	1		1	
	Yes	0.51***	(0.39, 0.66)	0.88	(0.70, 1.11)
Number of observations	Sample size	817		817	

URR, unadjusted risk ratio; CI, confidence interval; ARR, adjusted risk ratio; BC-PTB, bacteriologically confirmed pulmonary tuberculosis; DOTS, directly observed therapy short course.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
[a] Variable has imputed data since some observations were missing.

increasing body weight, and return of appetite as indicative of a good treatment response.

This study explored reasons for SSM non-completion and these included patient, healthcare provider, health systems, and treatment supporter factors, consistent with a previous study in Uganda (Nakaggwa et al., 2016). Ignorance of healthcare workers concerning SSM timing and frequency is consistent with an earlier study (Hoa et al., 2004). Some persons with BC-PTB missed appointments and never received SSM, confirming earlier findings (Dooley et al., 2011). Besides, persons with BC-PTB mentioned longer waiting times at the laboratory unit and insufficient health education by healthcare providers. New barriers to SSM completion were identified, namely the absence of systems to track and identify persons with BC-PTB requiring SSM, physical and economic barriers, non-adherence to TB treatment guidelines as medications were prescribed and dispensed longer than 28 days, and absence of team work as TB care was left to TB focal persons.

It was observed that persons with BC-PTB who had received treatment at a district or regional referral hospital were more likely to complete SSM compared to those treated at a lower level facility, namely health center IV (a county-level health facility). The reason might be due to better healthcare at hospitals, characterized by a wide range of health services, more skilled personnel, and sufficient medicines, diagnostics, and supplies (Government of Uganda, 2011). Elsewhere, PWTB who received care at hospitals had better treatment success rates compared to those attending lower level health facilities (Musaazi et al., 2017).

Since health center IVs do not perform SSM, they should be targeted by district and national TB control programs for TB mentorship and technical support supervision.

This study indicates that persons with BC-PTB enrolled in the TB control program in the latter years of the period 2015 and 2018 were more likely to complete SSM compared to those enrolled earlier in this time period. No published studies are consistent with these results from this region or similar areas in rural SSA. In qualitative interviews, TB focal persons reported TB clinic days had been introduced across health facilities in eastern Uganda, leading to patient-centered approaches to TB care. TB focal persons currently have sufficient time to tackle patient concerns and deliver improved TB services than in previous years. To support this hypothesis, seven of the study sites have a TB clinic day. Besides, new initiatives like TB data review days for harmonizing TB data collected at the TB and laboratory units and continuous quality improvement to address gaps in TB care have been introduced. TB focal persons indicated that these initiatives have strengthened the healthcare system and have enhanced TB performance in recent years.

It was found that persons with BC-PTB receiving treatment at peri-urban health facilities were more likely to complete SSM compared to those receiving treatment at rural health facilities. This is consistent with a past study (Musaazi et al., 2017) in which SSM was less common for PWTB at rural compared to urban health facilities. Frequently, rural health facilities are inadequately resourced with staffing, supplies, reagents, and equipment, among others, to ensure PWTB receive sufficient monitoring of the treatment response and achieve good outcomes. Furthermore, PWTB in rural settings lack sufficient information on basic TB facts and have difficulty accessing health facilities due to the longer travel distance, thus reducing their likelihood of receiving SSM.

Previous epidemiological studies from SSA (Musaazi et al., 2017; Seid et al., 2018) have reported rural residence as being associated with poor treatment outcomes among PWTB. This suggests the need to expand and improve the quality of TB services in rural settings to increase SSM completion.

In contrast to what was expected, there was no difference in SSM completion between new and previously treated persons with BC-PTB. It was anticipated that retreatment persons with BC-PTB

might be more experienced and familiar with sputum smear follow-up hence more likely to complete SSM, but this was not the case. The lack of a difference could be that both groups receive the same key TB messages at the health facilities. In addition, contrary to a previous study in Uganda where incomplete SSM was more common among females than males (Nakaggwa et al., 2016), the present study showed no association between sex and SSM completion. Further prospective studies should be done to explain these findings.

Study strengths and limitations

We abstracted data spanning 2.5 years, which is sufficient to demonstrate SSM practices at the study sites. The use of a mixed-methods design ensured comprehensive investigation of the reasons for SSM non-completion. Nonetheless, there are limitations. Part of the study used secondary data and we encountered significant missing entries in the laboratory log-books. This study was conducted in a rural setting, so the results may not apply to urban settings. We did not interview persons with BC-PTB who completed SSM and those who did not as separate groups, hence we may not have sufficiently explored more specific reasons for SSM non-completion. We suggest future studies should focus on these limitations.

Conclusions and recommendations

SSM completion among adult persons with BC-PTB was low in rural eastern Uganda. Persons with BC-PTB who had a treatment supporter and those who received treatment at higher level or peri-urban health facilities were more likely to complete SSM. To improve SSM, lower level health facilities should be targeted with potential interventions such as TB mentorship and technical support supervision, which may impact SSM. Furthermore, healthcare providers should ensure persons with BC-PTB have treatment supporters as recommended by the national TB control program.

Ethical approval

We received a waiver of consent to access medical records, obtained written informed consent from all study participants before interviews, and ensured each participant was free to either withdraw or to remain in the study. We received ethical approval from the Mbarara University of Science and Technology (MUST) Research Ethics Committee (reference number 03/11-18) and the Uganda National Council for Science and Technology (reference number HS 2531).

Conflict of interest

None declared/not applicable.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijid.2019.12.003.

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