Improving sputum collection processes to increase tuberculosis case finding among HIV-positive persons in Botswana

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Setting: Twenty-two human immunodeficiency virus (HIV) clinics in Botswana.

Objective: To compare sputum collection rates, sputum quality and volume, and tuberculosis (TB) diagnosis rates before and after field efforts to improve sputum collection among individuals newly diagnosed with HIV with TB symptoms.

Design: Newly diagnosed individuals living with HIV attending 22 HIV clinics in Botswana were screened for TB from August 2012 to March 2014. Starting in May 2013, a field intervention composed of the introduction of a tracking log for presumed TB patients, and patient instructions and sputum induction to improve sputum collection rates was implemented.

Results: Prior to the intervention, sputum collection rates were 44.1% (384/870). Subsequently, sputum collection increased to 58.3% (579/993) ($P < 0.001$). Sputum quality and volume also improved. Although rates of TB diagnosis increased from 9.7% (84/870) to 12.5% (120/993), this difference was not significant ($P = 0.143$).

Conclusion: Sputum collection rates among presumptive TB cases, as well as sputum quality and volume improved after implementation of the field intervention. To improve sputum collection rates, efforts at the program level should be ongoing.

TUBERCULOSIS (TB) remains the leading cause of death among people living with HIV (PLHIV) in low- and middle-income countries, including Botswana.¹ HIV co-infection among TB patients is high in Botswana, where the prevalence of HIV among registered TB patients was 60% in 2014.² Even when patients report to health facilities at the onset of TB symptoms, there are multiple challenges in early diagnosis and treatment of TB among HIV-positive persons: failure to screen patients for TB symptoms; failure to collect adequate sputum from symptomatic patients; insensitive TB diagnostic tests; failure to return results to patients; and loss to follow-up of patients before they benefit from TB treatment following a TB diagnosis.^{3–6} Delay in TB diagnosis has a significant impact on patient outcomes by increasing morbidity, mortality, and transmission rates in the community.⁷

The Xpert® MTB/RIF assay (Cepheid, Sunnyvale, CA, USA) represents a simple and robust molecular test suitable for use in resource-limited settings.^{8,9} However, underutilization and inadequate sputum collection (i.e., low volume and poor quality) among presump-

tive TB cases remains a barrier.⁴ Some studies have identified effective strategies healthcare workers can use to assist patients with sputum collection, including patient education, job aids,^{10,11} and sputum induction.¹² However, less is known about the impact of these interventions in clinical settings serving PLHIV.¹³

We thus evaluated a healthcare worker (HCW) and patient-focused field intervention to increase the numbers of individuals able to produce a sputum sample and determine if sputum volume, quality and rates of TB case-finding could be increased within the context of the Xpert rollout strategy in Botswana. We evaluated the following research questions: 1) Did the percentage of patients with symptoms who provided at least one sputum sample for TB diagnostic tests at the time of initial presentation for care and treatment increase following the introduction of the enhanced sputum collection intervention? 2) Did the macroscopic characteristics (quality, appearance, and volume) of sputum collected improve after enhanced sputum collection?; and 3) Did yield of *M. tuberculosis* among sputum specimens collected from PLHIV with symptoms attending antiretroviral treatment (ART) clinics during the study improve after enhanced sputum collection?

STUDY POPULATION, DESIGN AND METHODS

Setting

As a component of Botswana's national Xpert roll-out strategy, the Ministry of Health and Wellness (MOHW) initiated a cluster randomized trial to evaluate the impact of Botswana's Xpert diagnostic algorithm on TB diagnostic sensitivity and to strengthen compliance with TB screening, sputum collection, and diagnostic algorithms.¹⁴ Twenty-two HIV clinics with early access to Xpert were evaluated prospectively as part of the Xpert implementation evaluation study. These sites were selected for their high ART patient enrollment rate (>8 ART patients per month). Patients who were registering for HIV care for the first time and who screened positive for TB symptoms using the WHO-recommended four symptom screen (cough, fever, night sweats, and weight loss) for PLHIV¹⁵ were asked to provide sputum for testing for *Mycobacterium tuberculosis* (MTB). Four sputum specimens were collected, two on the day of initiation (spot samples collected at the time of patient visit) and two on the following day, including one morning sample collected at home and one spot sample collected at the clinic.

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KEY WORDS

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FIGURE Timeline of interventions to improve sputum collection, August 2012–March 2014, Botswana. TB = tuberculosis.

The specimens were evaluated using acid-fast bacilli (AFB) smear microscopy, Xpert, and liquid culture. Any mycobacterial growth was confirmed using Ziehl-Neelsen staining, blood agar plate, and immunochromatographic assays. Line-probe assay testing for isoniazid and rifampicin resistance on MTB-positive cultures, and phenotypic culture-based drug susceptibility testing was also conducted.¹⁴ Macroscopic characteristics of sputum quality (e.g., based on gross appearance: saliva, mucoid, or non-purulent specimen) were assessed by trained laboratory technicians using a standard sputum color chart. Sputum volume was assessed in millimeters by comparing to a reference container.¹⁶ Study staff also collected key demographic and patient information.

Despite initial HCW training, the proportion of symptomatic patients that had sputum collected per national guidelines during implementation and monitoring was suboptimal. Study staff reported patients were not able to produce sputum and even when produced, had low volume (<0.2 mL) and quality, in particular among those who were not coughing.

Field intervention

From May 2013 to March 2014, a field intervention to further support sputum collection was conducted and evaluated to determine if rates of sputum collection and TB case finding could be increased. The intervention comprised four components: 1) on-site mentorship to encourage HCWs to support sputum collection from all patients who had any one or more symptoms for TB before leaving the clinic (May 2013); 2) introduction of a tracking log sheet for presumed TB patients to ensure that the collected sputum reached the laboratory and results were returned to the patient (May 2013); 3) introduction of a sputum collection job aid and a patient assistance strategy in which patients were helped to do breath and coughing exercises to expectorate sputum (July 2013); and 4) introduction of sputum induction procedures for patients who failed to produce sputum (January 2014–March 2014) (Figure). Auxiliary non-clinical study staff, as well as nursing staff, received skills-based training in sputum induction procedures, including screening patients for contraindications, performing nebulization with hypertonic saline to induce cough, proper infection control precautions, and thorough equipment cleaning between patients. Regular site-level monitoring was conducted by nurse supervisors to assess sputum collection procedures, track sputum collection rates, and evaluate the overall quality of TB screening and documentation.

Data analysis

Data from patient clinical records and laboratory results were collected, and double data were entered into a central database, reconciled and cleaned. We estimated descriptive statistics and 95%

confidence intervals (95% CIs) for patient demographic and clinical characteristics among patients enrolled before and after enhanced sputum collection. To test for differences in characteristics before and after the intervention, adjusting for within-facility correlation, we fit linear (for continuous outcomes) and generalized linear mixed models (for binary outcomes) with a random effect for facility using SAS (SAS Institute, Cary, NC, USA). We used similar models to test for differences in sputum collection rates, sputum quality, and *M. tuberculosis* yield before and after enhanced sputum collection (generalized linear mixed models with a random effect for facility). We also fit models with interaction terms to test for a difference in the pre-post effect by presence of cough, smoking status, and WHO stage. To determine whether the intervention effect changed over the course of the 11-month enhanced sputum period, we also fit models comparing the first 6 months after enhanced sputum collection began and the next 5 months to the pre-intervention period. All tests were two-tailed; $P < 0.05$ was considered statistically significant.

Ethical considerations

The study protocol was approved by the Botswana Health Research and Development Committee (Gaborone, Botswana), and the Centers for Disease Control and Prevention (Atlanta, GA, USA) and University of Pennsylvania (Philadelphia, PA, USA) institutional review boards (IRBs). Patients at clinical sites were enrolled in the study following the IRB-approved, written informed consent process. The trial is registered at clinicaltrials.gov (NCT02538952).

RESULTS

Overall, 6041 prospective participants were enrolled in the study (2851 during the pre-intervention sputum collection period and 3190 during the enhanced sputum collection period). Patient characteristics were similar across time periods and all were HIV-positive (Table 1).

The introduction of the enhanced sputum collection intervention significantly increased the proportion of presumptive TB patients who provided at least one sputum sample for TB diagnostic tests, from 44.1% ($n = 384$) in the pre-intervention period to 58.3% ($n = 579$) in the post-intervention period (OR 1.87; 95% CI 1.54–2.27) and the proportion able to produce >1 sputum sample (Table 2). Although rates of TB diagnosis increased from 9.7% (84/870) to 12.5% (120/993), the difference was not significant ($P = 0.143$).

We found a significant difference in the impact of the enhanced sputum collection intervention based on whether the participant reported a cough ($P < 0.0001$). Among participants who

TABLE 1 Comparison of characteristics of patients enrolled during pre-intervention period (August 2012–April 2013) and those enrolled during enhanced sputum collection period (May 2013–March 2014), Botswana

Variable	Patients enrolled pre-intervention (August 2012–April 2013)			Patients enrolled during enhanced sputum collection period (May 2013–March 2014)			P value
	<i>n</i>	<i>n</i> (%) [*]	95% CI	<i>n</i>	<i>n</i> (%) [*]	95% CI	
Mean age, years	2851	35.4	34.7–36.0	3189	35.5	34.8–36.2	0.618
Male	2851	916 (32.0)	30.0–34.2	3190	1095 (34.3)	32.3–36.4	0.062
Mean baseline CD4 count, cells per mm ³	2809	241.6	230.4–252.8	3112	243.5	232.4–254.5	0.638
Mean body mass index, kg/m ²	2837	22.4	22.0–22.8	3171	22.7	22.3–23.1	0.345
Previous TB treatment	2848	310 (11.0)	9.4–12.9	3185	336 (10.8)	9.2–12.6	0.760
Any smoking [†]	2840	531 (18.5)	15.8–21.4	3185	631 (19.6)	16.9–22.6	0.269
Any alcohol [‡]	2841	613 (21.4)	18.7–24.3	3185	708 (21.7)	19.1–24.6	0.724
Miner [§]	2841	131 (4.5)	3.6–5.7	3185	172 (5.4)	4.3–6.6	0.149
Mean hemoglobin level, mg/dl	2628	11.8	11.7–12.2	2877	12.0	11.9–12.2	<0.001
TB symptoms							
Any one of cough, fever, night sweats, weight loss	2851	870 (31.9)	26.3–38.0	3190	993 (32.4)	26.8–38.6	0.692
Cough	2851	498 (18.3)	15.5–21.5	3190	674 (17.5)	19.2–26.1	<0.001
Fever	2851	265 (9.1)	7.1–11.7	3190	298 (11.7)	7.1–11.8	0.923
Night sweats	2851	271 (9.6)	7.5–12.3	3190	313 (10.0)	7.8–12.8	0.615
Weight loss	2851	607 (21.1)	16.6–26.5	3190	687 (21.1)	16.6–26.4	0.966

*Estimated using a random-effects model, so may not exactly equal raw percentages and means.

[†]Defined as current or ex-smoker.

[‡]Defined as current use of alcohol.

[§]Defined as current or ex-miner.

CI = confidence interval; TB = tuberculosis.

reported a cough, there was a small non-significant difference in the rate of sputum production between the standard and enhanced sputum collection periods. For those who did not report a cough, the effect was much larger and strongly significant. A similar effect was found for the proportion who submitted more than one sputum specimen, but with no interaction effect for TB diagnosis. No interaction effects for outcomes were found for smoking status or WHO stage.

Comparing the first 6 months and the next 5 months of enhanced sputum collection yielded no significant differences in rates of specimen production (57.8% vs. 59.1%, $P = 0.5127$), production of more than one specimen (53.6% vs. 56.2%, $P = 0.3269$), or TB diagnosis (10.8% vs. 14.2%, $P = 0.1287$). Patients who failed to produce sputum after exposure to the job aid and patient assistance strategy were referred for sputum induction. We induced 69 sputum samples during the intervention period at the 13 sites that had induction equipment. Of the 204 individuals diagnosed with TB, only 8 (3.9%) required an induced sputum. The percentages of participants able to produce at least one sputum in the post-intervention periods were similar if we removed patients with induced sputum (58.3% post-intervention including induced sputum vs. 56.7% post-intervention excluding induced sputum), suggesting sputum induction does not account for the improvement in sputum collection.

Enhanced sputum collection significantly improved the quality of sputum collected. The salivary sputum decreased significantly from 34.4% ($n = 379$) to 26.1% ($n = 455$) ($P < 0.001$). The proportion of mucoid and muco-purulent sputum samples increased from 9.6% ($n = 106$) to 15.9% ($n = 277$) (OR 1.65, 1.29–2.11); and 49.1% ($n = 541$) to 55.0% ($n = 960$), (OR 1.33, 1.14–1.56), respectively. Sputum samples with adequate volume increased significantly from 68.0% ($n = 1026$) to 74.1% ($n = 1270$) ($P < 0.008$; OR 1.28, 1.06–1.53) (Table 3).

DISCUSSION

This evaluation found that the rate of sputum collection as well as sputum production, quality and volume increased following a field intervention composed of staff training, introduction of a presumptive TB patient log, provision of job aids, and enhanced staff support procedures for patients with symptoms, as well as the introduction of sputum induction. The proportion of TB diagnoses increased during the intervention, but this was not statistically different from the pre-intervention period.

Although our study found an increase in sputum quality and volume, we did not find a significant increase in the rate of TB diagnosed following the intervention. By contrast, Alisjahbana et al. found an increase in sputum quality and volume in addition to an increase in TB diagnoses in 50.6% of patients who received additional counselling compared with 35.5% of patients in the control group (95% CI 2.9–27.4; $P < 0.050$).¹¹ Manabe et al. reported an increase in TB diagnosis and improved TB treatment outcomes following HCW training and the introduction of fluorescent smear-microscopy and Xpert testing.¹⁰ The effect of our intervention was likely less by comparison, as enhanced diagnostics, including Xpert, were available at baseline.

Although the contribution of introducing presumptive TB registers was not assessed in our study, a study in Zimbabwe found that the presence of TB registers increased the numbers of patients with a sputum sample received at the laboratory, but did not lead to significant increases in the number of TB cases.¹³ Similar to our study, the use of the job aid by HCWs did not lead to additional TB cases.¹⁷ In other studies, patient instruction contributed to improved case detection with minimal additional costs, and was thus recommended.¹⁸

In our study, salivary sputum decreased significantly post-intervention ($P < 0.001$), while mucoid and muco-puru-

TABLE 2 Comparison of sputum collection and TB case identification during pre-intervention period (August 2012–April 2013) and after enhanced sputum collection period (May 2013–March 2014), Botswana*

Patient characteristics	Pre-intervention (August 2012–April 2013)		Post-intervention (May 2013–March 2014)		OR (95% CI)	P value
	N	n (%)	N	n (%)		
Of presumptive TB patients, those with sputum collected						
Total	870	384 (44.1)	993	579 (58.3)	1.87 (1.54–2.27)	<0.001
Patient reported cough?						<0.0001
Yes	498	341 (68.5)	674	488 (72.4)	1.18 (0.91–1.54)	
No	372	43 (11.6)	319	91 (28.5)	3.78 (2.49–5.73)	
Patient reported smoking?						0.8967
Yes	231	118 (51.2)	279	175 (62.7)	1.80 (1.24–2.62)	
No	634	265 (41.8)	710	401 (56.5)	1.85 (1.48–2.33)	
WHO Stage						0.4318
Stage I	551	254 (46.1)	714	412 (57.7)	1.71 (1.35–2.16)	
Stage II	109	48 (44.0)	71	40 (56.3)	1.69 (0.88–3.22)	
Stage III	156	62 (39.7)	154	95 (61.7)	2.55 (1.59–4.11)	
Stage IV	54	20 (37.0)	54	32 (59.3)	2.41 (1.08–5.37)	
Of presumptive TB patients, the proportion with >1 sputum samples submitted						
Total	870	335 (38.5)	993	542 (54.6)	2.02 (1.66–2.46)	<0.001
Patient reported cough?						<0.0001
Yes	498	307 (61.7)	674	462 (68.6)	1.31 (1.01–1.68)	
No	372	28 (7.5)	319	80 (25.1)	5.07 (3.15–8.16)	
Patient reported smoking?						0.8913
Yes	231	104 (45.0)	279	165 (59.1)	2.04 (1.40–2.97)	
No	634	230 (36.3)	710	374 (52.7)	1.98 (1.57–2.49)	
WHO Stage						0.3845
Stage I	551	222 (40.3)	714	383 (53.6)	1.81 (1.42–2.30)	
Stage II	109	42 (38.5)	71	39 (54.9)	2.07 (1.08–4.00)	
Stage III	156	53 (34.0)	154	90 (58.4)	2.86 (1.77–4.62)	
Stage IV	54	18 (33.3)	54	30 (55.6)	2.45 (1.09–5.50)	
Of presumptive TB patients, the proportion diagnosed with TB						
Total	870	84 (9.7)	993	120 (12.1)	1.25 (0.93–1.70)	0.143
Patient reported cough?						0.6174
Yes	498	68 (13.7)	674	108 (16.0)	1.15 (0.82–1.60)	
No	372	16 (4.3)	319	12 (3.8)	0.93 (0.43–2.01)	
Patient reported smoking?						0.8553
Yes	231	25 (10.8)	279	36 (12.9)	1.31 (0.75–2.28)	
No	634	59 (9.3)	710	84 (11.8)	1.23 (0.86–1.76)	
WHO Stage						0.3014
Stage I	551	39 (7.1)	714	52 (7.3)	1.00 (0.65–1.55)	
Stage II	109	9 (8.3)	71	10 (14.1)	2.00 (0.75–5.32)	
Stage III	156	29 (18.6)	154	47 (30.5)	1.80 (1.04–3.10)	
Stage IV	54	7 (13.0)	54	11 (20.4)	1.70 (0.59–4.89)	

*Presumptive TB cases, 30.5% (870/2851) and 31.1% (993/3190) (OR 1.02, 95%CI 0.91–1.15, $P = 0.688$), pre-and post-intervention, respectively.

TB = tuberculosis; OR = odds ratio; CI = confidence interval; WHO = World Health Organization.

TABLE 3 Comparison of sputum microscopic characteristics during baseline sputum collection period (August 2012–April 2013) and after enhanced sputum collection period (May 2013–March 2014), Botswana

Microscopic characteristics	Baseline sputum collection (August 2012–April 2013)		Enhanced sputum collection (May 2013–March 2014)		OR (95% CI)	P value
	N	n (%)	N	n (%)		
Salivary	1101	379 (34.4)	1745	455 (26.1)	0.65 (0.54–0.77)	<–0.001
Mucoid	1101	106 (9.6)	1745	277 (15.9)	1.65 (1.29–2.11)	<–0.001
Muco-purulent	1101	541 (49.1)	1745	960 (55.0)	1.33 (1.14–1.56)	<–0.001
Volume ≥2 ml	1023	696 (68.0)	1715	1270 (74.1)	1.28 (1.06–1.53)	0.008

lent sputum increased significantly ($P < 0.001$, $P = 0.004$, respectively). Similarly, Amelia et al. found that samples were of higher quality, with more satisfactory volume, after an educational intervention.¹⁹ An additional study showed that both gross appearance and volume of sputum were associated with smear positivity.²⁰ A systematic review by Ho et al. found mixed evidence regarding the relationship between sputum quality and diagnostic yield.¹⁸ Importantly, Meyer et al. found that salivary sputum did not reduce the sensitivity of Xpert, thus indicating sputum quality may be less important when using that methodology.²¹

Even with HCW intervention, the number of PLHIV with symptoms able to produce a sputum sample remained suboptimal. This highlights the limitations of relying on sputum to diagnose TB in PLHIV, who are more likely to have extrapulmonary TB, and are less likely to produce sputum even when they have pulmonary TB.²² Therefore, although it is important to encourage production of sputum, this may not necessarily lead to a significant increase in diagnostic yield, which highlights the need for a non-sputum based test.

Our finding that sputum induction had limited impact on TB case finding contrasts with other studies in regions with high TB and HIV rates; several studies have found sputum induction to be an effective strategy for obtaining a microbiologically confirmed diagnosis of TB.^{12,23} Only slightly over half of the 22 study sites had sputum induction equipment and sputum induction also occurred at a late stage of the study, which could explain why it did not play a significant role in increasing sputum production rates in the intervention stage.

The strength of this study was that it included a nationally representative set of clinics in Botswana, a country with a high burden of TB and HIV. A total of 6,041 PLHIV were newly enrolled into HIV care and treatment clinics, and the study addressed a gap in knowledge regarding strategies to increase sputum collection. Although we did not assess the cost-effectiveness of the intervention strategies, we believe this to be a low-cost intervention. There were three limitations of this evaluation. First, it was conducted within the context of a structured field evaluation. Second, since patients were not randomly assigned to the standard and enhanced sputum collection groups, we were not able to conclusively ascertain that differences between the two groups of patients were due to the study intervention. Third, as the determination of sputum quality is somewhat subjective, laboratorians may have overestimated quality and volume post-intervention. Sputum collection is critical for TB diagnosis and a randomized clinical trial could address some of the limitations of this study.

This evaluation found increased rates of sputum collection, as well as increased sputum volume and quality following supportive interventions by HCWs. More intense training on sputum collection and effective use of job aids and education to guide the patient on how to produce sputum are recommended to improve diagnostic performance and yield. This should be further emphasized in national policy and facility standard operating procedures. To fully realize the impact of Xpert and improve the timeliness of TB diagnosis and initiation of appropriate TB treatment, it is essential that PLHIV be supported sufficiently in providing a sputum specimen.

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Contexte: Vingt-deux dispensaires pour l'infection par le virus de l'immunodéficience humaine (VIH) au Botswana.

Objectif: Examiner les niveaux de qualité des crachats, leur volume, et le diagnostic de TB avant et après les efforts sur le terrain d'amélioration du recueil des crachats parmi les individus ayant récemment eu un diagnostic de VIH avec des symptômes de TB.

Schéma: Les personnes nouvellement diagnostiquées, vivant avec le VIH (PLHIV) fréquentant 22 dispensaires VIH au Botswana ont eu un dépistage de TB entre août 2012 et mars 2014. Les patients ayant des symptômes de TB ont été invités à fournir des échantillons de crachats. À partir de mai 2013, a été mise en œuvre une intervention de terrain composée de l'introduction d'un registre de suivi des patients présumés atteints de TB, de l'instruction du patient et de l'induction de crachats afin

d'améliorer les taux de recueil de crachats. Les taux de recueil de crachats, leur qualité, leur volume et le rendement ont été comparés avant et après l'intervention.

Résultats: Avant l'intervention, les taux de recueil des crachats ont été de 44,1% (384/870). Le recueil de crachats a ensuite augmenté à 58,3% (579/993) ($P < 0,001$). La qualité des crachats et leur volume se sont également améliorés. Bien que les taux de diagnostic de TB aient augmenté de 9,7% (84/870) à 12,5% (120/993), la différence n'a pas été significative ($P = 0,143$).

Conclusion: Les taux de recueil de crachats parmi les cas de TB présumés ainsi que la qualité et le volume des crachats se sont améliorés après la mise en œuvre de l'intervention sur le terrain. Des efforts continus sont cependant requis au niveau du programme afin d'améliorer les taux de recueil des crachats.

Marco de referencia: Veintidós consultorios de atención de la infección por el virus de la inmunodeficiencia humana (VIH) en Botswana.

Objetivo: Examinar la calidad y el volumen de las muestras de esputo y el diagnóstico de tuberculosis (TB) antes y después de ejecutar iniciativas sobre el terreno encaminadas a mejorar la recolección de esputo, en personas con diagnóstico reciente de infección por el VIH que presentan síntomas indicativos de TB.

Método: Se realizó el tamizaje de la TB en las personas con diagnóstico reciente de infección por el VIH que acudieron a 22 consultorios de atención de la infección por el VIH en Botswana, de agosto del 2012 a marzo del 2014. Se solicitaron muestras de esputo a los pacientes con síntomas de TB. A partir de mayo del 2013, se llevó a cabo una intervención sobre el terreno que comportaba la introducción de un registro de rastreo de los pacientes con

presunción de tuberculosis, instrucciones a los pacientes y la inducción del esputo con el fin de mejorar las tasas de recolección de muestras de esputo. Se compararon las tasas de obtención de muestras, su calidad y su volumen antes y después de la intervención.

Resultados: La tasa de recolección de esputo fue 44,1% (384/870) antes de la intervención y 58,3% (579/993) después de la misma ($P < 0,001$). Asimismo, mejoró la calidad y el volumen de las muestras. Aunque el índice de diagnóstico de TB aumentó de 9,7% (84/870) a 12,5% (120/993), esta diferencia no alcanzó significación estadística ($P = 0,143$).

Conclusión: Tras la introducción de una intervención sobre el terreno se mejoró la tasa de obtención de muestras de esputo, su calidad y su volumen en los casos con presunción de TB. Se precisan no obstante esfuerzos permanentes a escala programática que mejoren las tasas de recolección.