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A national infection control evaluation of drug-resistant tuberculosis hospitals in South Africa

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Abstract

Background—The importance of infection control (IC) in health care settings with tuberculosis (TB) patients has been highlighted by recent health care-associated outbreaks in South Africa.

Objective—To conduct operational evaluations of IC in drug-resistant TB settings at a national level.

Methods—A cross-sectional descriptive study was conducted from June to September 2009 in all multidrug-resistant (MDR-TB) and extensively drug-resistant TB (XDR-TB) facilities in South Africa. Structured interviews with key informants were completed, along with observation of IC practices. Health care workers (HCWs) were asked to complete an anonymous knowledge, attitudes and practices (KAP) questionnaire. Multilevel modeling was used to take into consideration the relationship between center and HCW level variables.

Results—Twenty-four M(X)DR-TB facilities (100%) were enrolled. Facility infrastructure and staff adherence to IC recommendations were highly varied between facilities. Key informant interviews were incongruent with direct observation of practices in all settings. A total of 499 HCWs were enrolled in the KAP evaluation. Higher level of clinical training was associated with greater IC knowledge ($P < 0.001$), more appropriate attitudes ($P < 0.001$) and less time spent with coughing patients ($P < 0.001$). IC practices were poor across all disciplines.

Conclusion—These findings demonstrate a clear need to improve and standardize IC infrastructure in drug-resistant TB settings in South Africa.

Keywords

MDR-TB; XDR-TB; infection control; South Africa

The global burden of tuberculosis (TB) affects millions of persons each year, and the rising threat of multidrug-resistant (MDR-TB) and extensively drug-resistant TB (XDR-TB) adds new urgency to this problem. South Africa has the world's highest incidence of TB co-infection with the human immunodeficiency virus (HIV), and ranks among the top three countries for prevalence of drug-resistant TB.[1] As in many countries, South African patients

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with drug-resistant TB are admitted to in-patient facilities for initiation of MDR- and XDR-TB treatment, where they remain during the intensive phase of treatment. This system facilitates a standardized treatment approach, but also concentrates drug-resistant patients into a single setting. Transmission of drug-resistant TB to both patients and health care workers (HCWs) within this system is well described.[2-5]

Although data from high-income countries demonstrate that a well-designed and managed infection control (IC) program reduces the risk of TB transmission,[6-12] applying IC practices from high-income environments to low- and middle-income countries is difficult. Many HCWs in these settings practice with limited IC training[3,13-15] as well as inadequate administrative, environmental or personal protective equipment (PPE) measures.[16,17] Apart from mathematical modeling exercises based on interventions in well-resourced health care environments,[18] evaluations of the impact of IC measures in resource-limited settings are rare.

In South Africa, national and provincial IC guidelines have been adapted to implement IC measures;[19] however, a systematic, national evaluation of IC implementation and operational challenges in M(X)DR-TB facilities has not been conducted. It remains u nclear whether there are significant differences in infrastructure between facilities and, if so, to what level IC infrastructure, including the availability of an IC officer, impacts knowledge, attitudes and practices (KAP). To address this gap, we evaluated the IC administrative, environmental and PPE infrastructure, along with KAP, in all nine provinces of South Africa.

PARTICIPANTS AND METHODS

Study design

A cross-sectional descriptive study was conducted from June to September 2009. All 24 M(X)DR-TB facilities were eligible for inclusion. Facilities were identified through discussions with each provincial Department of Health. After telephone or e-mail contact describing the study, a letter was sent to each site to schedule a site visit. Structured interviews were conducted with key informants (i.e., persons with administration, medical, nursing, occupational health or IC duties), who led the team through the site's TB program. After completion of the interviews, the research team inspected the facilities to evaluate IC infrastructure. The facility was asked to describe and demonstrate their admitting process, treatment methods, sputum collection, discharge planning and how IC was integrated into each step. During this process, the team observed the IC behaviors of the HCWs in each unit.

IC infrastructure was first investigated during key informant interviews. Discrepancies between informants were further investigated through collection of written evidence or evaluation of policy/procedures that supported the claim. Finally, in order for the infrastructure to be documented by the team as present, each item described in the informant interview was required to be present and in practice for administrative measures, present and operational for environmental measures, and present and in use for PPE measures during the facility ward rounds.

Study setting and sample

All 24 M(X)DR-TB facilities in the country at the time of this study were invited to participate, and all agreed. Each province and the M(X)DR-TB facilities provided written permission to visit the facility. At the individual level, HCWs were approached during the facility-based tour. The KAP survey was reviewed with each unit, and individual HCWs were requested to complete the anonymous survey. An HCW was defined as a person with

medical, nursing or allied health training who was present during our visit. The HCW had to be able to read and understand Zulu, Xhosa, Afrikaans or English.

Data collection instruments

There are no standardized data collection instruments for evaluation of KAP for IC in M(X)DR-TB treatment centers. After a review of the TB IC guidelines and recommendations from the US Centers for Disease Control and Prevention (CDC),[20] the World Health Organization (WHO),[21-23] the South African Department of Health,[24] as well as the cited TB IC literature, an 83-item IC facility-based audit was developed. This tool explored administrative, environmental, and PPE infrastructure. A 73-item self-assessment instrument was also developed to evaluate HCW IC knowledge (10 items), attitudes (25 items) and practices (4 items). The remaining 34 questions investigated HCW demographics, training, and perceptions of IC infrastructure, including two open-ended questions. The knowledge questions were divided into multiple-choice (9 questions) and true/false (1 question). Multiplechoice questions were available as 'select the correct answer' or 'select all that apply'. We used the following rules for grading the 'select all that apply' questions: if a participant's selections were all correct, but he/she did not select all of the correct answers the question was marked as correct. If, however, a participant selected an incorrect answer from the list of choices the question was marked as incorrect. Attitudes were dichotomized as appropriate or inappropriate, and the number of appropriate attitudes was calculated for each HCW.

Both the audit tool and the KAP survey were reviewed by the Tuberculosis Epidemiology and Intervention Research Unit of the South African Medical Research Council (MRC) and a panel of experts in TB IC for content and face validity. A pilot test of an English version of the instruments was conducted with six HCWs in a South African MDR-TB hospital. The interview tool was revised as appropriate based on this information. Translation of the instrument was completed by an external translation service. Back translation and review of each translation was completed in collaboration with native speakers.

Statistical analysis

Descriptive statistics were used to describe the facilities and HCWs. As HCWs are nested within facilities, multilevel regression models (HLM 6.0, Scientific Software International, Lincolnwood, IL, USA, 2004) were used to test the relationship between HCW knowledge, attitudes, and IC practices (sputum collection in ward, time spent with coughing patients, time wearing a respirator, teaching of respiratory etiquette/cough hygiene in wards) with HCW training (clinical training and prior IC training) and facility-level variables (has an IC plan, ≥50% of nurse's time dedicated to IC duties, annual TB screening, takes precautions during sputum collection). Knowledge, attitudes and IC practices were the dependent variables in the model. Multilevel models use robust standard errors, which accounts for the fact that responses from HCWs within a facility may be correlated. Each of the predictor variables were tested in separate models, as the number of facilities was too few to support conducting multivariable models. In addition, we were interested in the relationship of each factor with the dependent variables, and not the unique (controlling for the other variables) association for each factor.

Ethical review and approval

The study was reviewed and approved by the MRC's Ethics Committee, the provincial research committee of all nine South African provinces, and the Johns Hopkins University Institutional Review Board.

RESULTS

Facility-level IC infrastructure assessment

All 24 facilities (100%) were enrolled in the study. The types of facilities evaluated include 7 (29%) TB specialty hospitals with MDR-TB wards, 8 (33%) district hospitals with specialized MDR-TB wards, 8 (33%) MDR-TB facilities with XDR-TB wards, and 1 (4%) non-TB specialty hospital that housed an MDR-TB ward. A facility's infrastructure was evaluated to determine the key IC parameters available across the entire facility and, specifically, in drug-resistant TB wards (Table 1). At the facility level, 9 (38%) had a full-time IC officer, 10 (41%) facilities identified a person with IC oversight, but with other primary responsibilities, and 5 (21%) had no IC officer at the time of the visit. Interviews with IC officers identified that the majority (17/19, 89%) felt that they had no authority to influence the changes necessary to protect HCWs from TB. Annual IC training for all levels of staff was available in nine (38%) facilities and a written IC plan to reduce TB transmission among patients and HCWs was available in 13 (54%). An infection prevention and control committee was also present at 19 (79.2%) facilities. Of all HCWs surveyed, 78% (n = 350) stated that their facility had an occupational health nurse, while 63% (n = 275) stated they received annual TB symptom screening. Twelve facilities (50%) conducted annual HCW TB symptom screening.

Administrative measures were generally poorly implemented in the majority of facilities. Although all facilities had available signage to educate patients and HCWs about cough hygiene, only six (25%) provided surgical face masks, tissue and waste bins for patients. Physical separation of smear-positive patients and those patients not on treatment (i.e., cohorting) was implemented in seven (29%) facilities. Sputum was induced and/or collected in almost every ward. Two wards (8%), one with a mobile sputum collection booth, the other with an outdoor sputum collection area, had infrastructure facilitating appropriate collection. Ward visits by family members were common practice, with only two (8%) facilities implementing an outdoor-only visit policy.

The majority of facilities (67%) were maximizing the potential for natural ventilation through open windows and doors, but with no directional air flow control mechanisms, and only five (31%) of these had or were utilizing circulating fans to improve air mixing. Eight (33%) facilities had an operational mechanical ventilation or extraction system. The use of ultraviolet (UV) germicidal irradiation was noted in 14 (58%) facilities. A cleaning, monitoring and maintenance plan for these environmental interventions (both UV and mechanical ventilation) was noted in two (8%) facilities.

Personal protective equipment was uniformly available in all facilities. One facility was using a respirator of questionable quality, and upon further investigation, it was determined that this respirator was a fake N-95 respirator.[25] HCWs at all training levels were witnessed in 21 (88%) facilities entering drug-resistant TB wards without N-95 respirators. No facility offered fit-testing for use of these respirators. Furthermore, when visits did occur inside the wards, no facility offered N-95 respirators to visitors.

Directly observed IC practices were incongruent with practices reported by key informants at all 24 (100%) facilities. One principal example of this was the collection of sputum specimens in the ward. All key informants reported that sputum specimens were collected out of doors, yet at least one HCW in every facility reported that sputum specimens were collected in the ward, despite policies against this practice.

Demographics of HCW participants in the KAP survey

In all, 499 HCWs were enrolled in the KAP evaluation. The mean number of participants per facility was 20.8. The majority (83.0%) of the sample were female, with a mean age of 41.9 years. The most common health care training reported was registered nurse (39.7%), and participants had a mean number of years of experience in TB of 8.5 years (Table 2). Despite numerous years of experience, 289 (69.0%) HCWs reported no ongoing continuing education in the care of TB patients in the previous 12 months, and a minority (33.0%) reported receiving some level of facility-specific IC training since starting their current TB position.

Knowledge

In knowledge assessment, the average number of correct responses was 3.1 (range 0–9; Table 3). Higher level of clinical training was associated with greater IC knowledge scores ($P < 0.001$). Attending a facility-specific IC training in the previous 12 months was associated with significantly higher knowledge scores ($P = 0.003$). However, the facility having an IC plan, >50% time IC nurse, annual TB training, and taking precautions when assisting in sputum collection were not associated with greater knowledge among participating HCWs (Table 4).

Attitudes

Attitudes were highly varied among participants (Table 3). Surprisingly, 26.8% ($n = 113$) of participants agreed that it is acceptable to collect sputum samples in the wards; 32.2% ($n = 148$) reported not wearing an N-95 respirator, yet 94.1% agreed that wearing a respirator should be required; 20.9% ($n = 93$) of staff agreed that they close the windows at night; 37.5% ($n = 174$) believed visitors should be allowed inside the ward; and 41.5% ($n = 188$) agreed a financial incentive would improve their personal IC practices. Higher level of clinical training (i.e., physician and professional nurse) was associated with more appropriate IC attitudes ($P < 0.001$). HCWs attending facility-specific IC training in the previous 12 months, facility having an IC plan, >50% time IC nurse, annual TB training, and taking precautions when assisting in sputum collection, were not associated with more appropriate attitudes among participating HCWs (Table 4).

Infection control practices

Inquiries about IC practices associated with the care of TB patients were limited to four principle areas (Table 5): 59% ($n = 245$) of participants reported collecting sputum specimens in the ward; 63% ($n = 278$) reported spending at least half of their clinical day directly with coughing patients; and 72.0% ($n = 322$) reported wearing a respirator at least 50% of their day. The majority (68.1%) of HCWs reported exceptional teaching of respiratory etiquette/cough hygiene in the wards as a method to limit transmission. None of the variables tested were related to the collection of sputum in the wards. Higher level of clinical training (i.e., physician and professional nurse) was associated with less time spent with coughing patients ($P < 0.001$) and less teaching of patients about respiratory etiquette ($P = 0.001$). HCWs' attendance at facility-specific IC training was associated with less time spent with coughing patients ($P = 0.047$), while facilities requiring HCWs to take precautions when assisting in collecting sputum was associated with less teaching of respiratory etiquette to patients ($P = 0.005$; Table 4).

DISCUSSION

This study is the first to systematically evaluate the national IC infrastructure in M(X)DR-TB treatment centers in South Africa and, to our knowledge, globally. These findings

demonstrate a clear need to improve IC infrastructure in drug-resistant TB facilities across the country. The IC infrastructure was highly varied across the facilities surveyed, with some facilities having almost no IC while others had a fully functioning prevention program. In general, the lack of attention to IC practices is particularly worrying, as research in this setting has demonstrated ongoing transmission between patients.[2,4] A recent retrospective analysis of M(X)DR-TB hospital admissions identified transmission of drug-resistant strains to HCWs providing care in all health care settings.[2,5] These data suggest the need for comprehensive health system improvements in IC, as our findings identify an environment that supports TB transmission.

The South African health system has made a significant attempt to provide IC education and training to HCWs in these facilities, with 66% of participants reporting receiving IC training, yet the majority had not received any continuing education on care of the patient with TB. While the present study did not address M(X)DR-TB regimen selection as a means of reducing infectivity, there is emerging evidence that a key principal of TB IC is the selection of appropriate anti-tuberculosis treatment as well as models of care that reduce hospital admission time.[19,26] To achieve improvements in IC, we must inform HCWs of approaches that limit transmission, including alternative models to in-patient care and effective treatment regimens that lead to shortened durations of infectivity.

As would be expected, and consistent with the findings of other investigators,[15] a higher level of clinical training was associated with greater IC knowledge and more appropriate attitudes. A higher level of clinic training was associated with a reduced amount of time spent with coughing patients and, thereby, theoretically less risk or perceived risk, which may account for less teaching of respiratory etiquette to patients. In addition, our data indicate that having a facility-specific IC plan was not associated with greater IC knowledge, more appropriate attitudes or practices among the participants. This may be due to lower-level clinical staff, who spend more time in the wards, are less likely to receive IC training and are less informed about facility-specific IC plans. These findings suggest that the focus of IC education should be on those individuals with less clinical training who, according to these findings, spend the greatest amount of their day at risk. While we believe that education and training is a key component of a strong IC program, we did find a lack of association between the presence of a nurse whose job functions include IC and overall IC knowledge in treatment facilities. While this is a finding that is counter to data from well-resourced health care environments that demonstrate greater knowledge associated with in-service training by IC nurses,[27] it is not surprising in this situation. We believe that this is likely related to relatively poor academic and theoretical preparation among IC nurses. Furthermore, IC nurses reported insufficient institutional power to organize mandatory training or to influence institutional change. Empowering nurses to influence practice change has been associated with major advancements in IC practices across health care settings,[28] and is an important strategy to improve patient and health care worker safety for South Africa.

This analysis identified that directly observed IC practices were incongruent with practices reported by key informants. Studies of HCW practices in the care of TB patients in the United States have also identified that adherence to TB IC policy may not be seen in practice.[29,30] As hospitals prepare audits of IC programs, IC evaluations must include direct observation of bedside practices to avoid health care-associated transmission and to ensure congruence between policy and practice. Given the risks imposed by not following such guidelines, a non-adherent HCW is placing both him/herself and the health care system at risk. Strategies are required to disseminate and train HCWs on facility IC plans and routinely assess adherence to ensure that guidelines and policy documents are followed.

The study has several limitations related to the challenges of operational research in a dynamic health care setting. First, although we did enroll all 24 (100%) hospitals with M(X)DR-TB wards, many patients are housed in other health care settings while awaiting admission to these sites. We were unable to evaluate these sites as they were unknown to the research team. It is likely, however, that these sites had no additional IC infrastructure or resources, and we feel confident that our assessment accurately reflects IC practices for these patients across the country. Although we had a large sample of HCWs, the lack of significance for facility-level variables may be a function of low statistical power due to the relatively small number of facilities. Another possible limitation of this study was the cross-sectional design. We are only able to report on what was seen during the IC evaluation on the day of the site visit. There may have been seasonal differences or differences between day and night shifts or weekend shifts. However, as there were similarities of generally poor IC infrastructure and practices across sites, this would probably not have changed the findings.

Importantly, the settings included here are well-resourced in IC infrastructure compared to other settings where drug-resistant TB is initially diagnosed. Standardization of IC infrastructure across facilities is a significant ongoing challenge for the health care system, but appropriate training and enforcement of IC policy and procedures is essential to provide e very HCW and patient the same opportunities for infection prevention. Even in well-resourced settings, adherence to IC practices is often limited and enforcement is monitored by both IC professionals within the health system and external regulatory agencies. In South Africa, IC monitoring committees that use a standardized method of assessing infrastructure and HCW adherence to IC policy and procedures are recommended.

CONCLUSION

In the first systematic, national evaluation of IC implementation and operational challenges in M(X)DR-TB facilities, we identified the need to standardize available resources across facilities. We found that HCWs with the highest level of clinical training have the greatest IC knowledge as well as better attitudes toward IC practices, but personal IC practices did not differ. Further research is needed to determine the impact of improvements in IC on averting cases of active disease as well as facilitating improvements in overall M(X)DR-TB treatment outcomes.

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Table 1

Basic facility-level IC infrastructure in South African hospitals with dedicated drug-resistant TB wards, June–September 2009

	Facility level						Drug-resistant TB ward infection control infrastructure										
	Infection control infrastructure*						Environmental†					Administrative‡				PPE§	
Facility	Type of facility/ hospital¶	Full-time IC officer	HCW TBIC training	Written TBIC plan	Annual HCW symptom screen	HCW offered VCT	MV	Fans	NV	UVGI	MP	Cough hygiene in wards	Smear-positive patient cohort#	Sputum collection in ward	Ward visit for family	N-95	Use**
A	TB	−	−	−	−	+	+	−	−	+	−	−	−	−	−	+	−
B	TB	−	−	−	−	+	−	−	+	+	−	−	−	−	−	+	+
C	Other	−	−	+	−	−	+	+	+	+	−	−	+	−	−	+	−
D	DR-TB	−	−	−	−	−	−	−	+	−	−	−	+	−	−	+	−
E	District	+	−	+	+	−	−	−	+	+	+	+	+	+	−	+	−
F	TB	−	−	−	−	+	+	+	+	+	−	−	−	−	−	+	−
G	DR-TB	−	−	−	+	+	+	−	−	+	−	−	−	−	−	+	−
H	DR-TB	+	+	+	+	−	−	−	−	−	−	+	−	−	−	+	−
I	District	+	−	−	+	−	−	−	−	+	+	−	−	−	+	+	+
J	Other	−	−	−	−	−	−	−	+	+	−	−	−	−	−	+	−
K	District	−	−	+	−	−	−	−	−	+	−	−	−	−	−	+	−
L	DR-TB	+	+	+	+	+	−	+	+	−	−	−	+	−	−	+	−
M	DR-TB	−	+	+	−	+	−	−	+	−	−	−	−	+	−	+	−
N	District	−	−	+	−	+	−	−	+	−	−	−	−	−	−	+	−
O	District	+	+	+	−	+	−	+	−	−	−	+	+	−	−	+	−
P	Other	+	+	+	+	+	−	+	+	−	−	+	−	−	−	+	−
Q	DR-TB	−	+	+	−	−	+	−	+	−	−	−	−	−	−	+	−
R	District	−	+	−	+	+	+	+	+	−	+	+	−	−	−	+	−
S	DR-TB	−	−	+	+	+	+	−	+	−	−	−	−	−	−	+	+
T	District	+	+	+	+	+	−	−	+	−	−	−	−	−	−	+	−
U	TB	+	−	+	+	+	−	+	+	+	−	−	−	−	−	+	−
V	District	+	+	−	+	+	−	−	−	+	−	−	−	−	−	+	−
W	TB	−	−	−	−	+	+	−	+	+	−	+	+	−	−	+	−
X	DR-TB	−	−	−	+	+	−	−	−	+	−	−	+	−	+	−	−

IC = infection control; TB = tuberculosis; PPE = personal protective equipment; HCW = health care worker; TBIC = TB infection control; VCT = voluntary counseling and testing; MV = mechanical ventilation/extraction system; fans = paddle or circulating fans; NV = natural ventilation; UVGI = ultraviolet germicidal irradiation (upper room); MP = maintenance plan for environmental infrastructure; DR-TB = drug-resistant TB.

[*] + = The infrastructure was present and reported by key informants during structured interviews.

[†] + = The environmental condition was present and operational the day of visit.

[‡] + = A written policy or procedure on the administrative issue AND concurrent practice noted on observational review.

[§] PPE present.

[¶] TB = TB specialty hospital with DR-TB wards; District = district hospital with TB/DR-TB wards; Other = specialty hospital with DR-TB ward; DR-TB = drugr esistant specialty TB facility.

[#] Cohort = physical separation.

[**] Use = all staff wearing N-95 in ward.

Table 2

Demographics of health care workers in M(X)DR-TB facilities in South Africa, June–September 2009 (*n* = 499)

Demographic variables	Frequency	%
Age (*n* = 414)		
Age, years, mean ± SD [range]	41.9 ± 10.9	[21–66]
Sex		
Female	395/475	83.2
Level of health care training		
Physician/Medical Officer	42/443	9.5
Registered nurse	176/443	39.7
Enrolled nurse	125/443	28.2
Nursing assistant	85/443	19.2
Other*	15/443	3.4
Years in current position (*n* = 431)		
Years, mean ± SD [range]	8.5 ± 9.3 [0–42]	
TB continuing education training Within last 12 months	130/419	31.0
Facility-specific infection control training Ever received	145/440	33.0

MDR-TB = multidrug-resistant TB; XDR-TB = extensively drug-resistant TB; TB = tuberculosis; SD = standard deviation.

* Several cadres of health care workers, including radiographers, social workers, audiologists and physical therapists.

Table 3

Health care worker TB infection control knowledge and attitudes survey results (n = 499) in South Africa, June–September 2009

Knowledge questions (multiple choice and true/false)	**Frequency (% correct)**
1 Which of the following are adverse effects of UV light exposure? (select all that apply)	13/309 (4.2)
2 What is the main reason a health care worker develops TB disease? (select one)	113/466 (24.3)
3 Which of the following are symptoms of TB? (select all that apply)	63/486 (13.0)
4 How long should a patient with TB be considered infectious?	120/433 (27.7)
5 How can a health care worker reduce the chances of getting TB in a hospital or out-patient clinic?	88/479 (18.4)
6 What are the parts of an infection control program designed to prevent TB transmission in health care facilities?	302/457 (66.1)
7 Select the examples of environmental control measures to reduce TB transmission in health care settings.	58/420 (13.8)
8 Select the examples of administrative control measures to reduce TB transmission in health care settings.	160/430 (37.2)
9 What is the difference between TB infection and TB disease?	331/451 (73.4)
10 True/false: XDR-TB is a preventable disease among health care workers.	277/457 (60.6)
Attitude questions (agree or disagree)	Frequency (% agreement)
1 Health care workers should be required to wear respirators when caring for patients with drug-resistant TB	434/461 (94.1)
2 Respirators do not protect against MDR- and XDR-TB, even if worn all of the time	163/455 (41.4)
3 I do not wear a respirator because my patients do not like me to wear it	17/453 (3.9)
4 It is OK to collect a sputum specimen in the ward if it is cold and rainy outside	113/459 (26.8)
5 Most nurses and doctors have already been infected with TB, so prevention measures are not necessary	36/462 (8.2)
6 My infection control practices have greatly improved since learning about XDR-TB	349/462 (75.5)
7 I am very worried about being infected with drug-resistant TB	360/453 (79.5)
8 I sometimes do not wear a respirator even when I know I should	148/459 (32.2)
9 Our hospital has a strong infection control policy	298/452 (65.9)
10 I close the windows at night because cold air will make the patients more sick	93/446 (20.9)
11 Patients with MDR- and XDR-TB should not be allowed to see visitors in the ward	174/464 (37.5)
12 If a health care worker develops symptoms of TB, he/she must have HIV	27/468 (5.8)
13 A health care worker owes it to the patient to minimize fear by not wearing a respirator	50/458 (10.9)
14 Properly using respiratory protective equipment interferes with my work	48/432 (11.1)

Knowledge questions (multiple choice and true/false)	Frequency (% correct)
15 My hospital is concerned about my health and safety	237/462 (51.3)
16 I believe I have a good understanding of my ward's infection control policy	357/456 (78.3)
17 HIV-positive health care workers should not work in drugresistant TB wards	285/456 (62.5)
18 If I develop symptoms of TB, I would not tell anyone at work because I might be fired	11/463 (2.4)
19 It is OK to place a patient with HIV in the same room with a patient with drug-resistant TB	88/452 (19.5)
20 My hospital provides equipment and resources to limit my exposure to TB	317/458 (69.2)
21 My ward often does not have the supplies I need to protect myself	149/450 (33.1)
22 I may turn off fans if they become too noisy or cause cold air to blow around	52/450 (11.6)
23 I have been adequately trained in infection control measures by my facility	228/450 (50.7)
24 I would likely follow infection control precautions more closely if I got a financial incentive for doing so	188/453 (41.5)
25 Respirators will not protect you against MDR- and XDR-TB	111/450 (24.7)

TB = tuberculosis; UV = ultraviolet; XDR-TB = extensively drug-resistant TB; MDR-TB = multidrug-resistant TB; HIV = human immunodeficiency virus.

* In calculating denominators for each question, persons providing 'no opinion' have been removed; therefore, the total denominator for each question will differ.

Table 4

Regression coefficients for factors associated with health care worker knowledge, attitudes, and infection control practices (n = 499) in M(X)DR-TB wards in South Africa, June–September 2009

	Knowledge	Attitudes	Collection of sputum in ward	Time spent with coughing patients	Time wearing a respirator	Teaching of respiratory etiquette/ cough hygiene in the wards
HCW level of clinical training	0.605 $P < 0.001$	0.578 $P < 0.001$	0.284 P = 0.567	−0.396 $P < 0.001$	−0.001 $P = 0.996$	−0.326 $P = 0.001$
HCW attending facility-specific IC training	0.760 $P = 0.003$	0.429 $P = 0.085$	4.087 $P = 0.311$	−0.448 $P = 0.047$	20.067 $P = 0.261$	−0.122 $P = 0.500$
Facility has an IC plan	−0.237 $P = 0.216$	−0.120 $P = 0.691$	0.512 $P = 0.428$	0.098 $P = 0.695$	0.479 $P = 0.285$	0.010 $P = 0.956$
Facility has an IC nurse at ≥50% time	−0.162 $P = 0.376$	0.038 $P = 0.898$	0.637 $P = 0.367$	0.442 $P = 0.083$	0.315 $P = 0.505$	0.244 $P = 0.137$
Facility has annual TB testing	−0.057 $P = 0.759$	−0.041 $P = 0.891$	−0.626 $P = 0.395$	0.102 $P = 0.704$	−0.495 $P = 0.350$	0.238 $P = 0.146$
Facility has HCW take precautions when assisting in sputum collection	−0.081 $P = 0.683$	−0.248 $P = 0.470$	0.694 $P = 0.333$	−0.007 $P = 0.983$	−0.093 $P = 0.811$	−0.381 $P = 0.005$

MDR-TB = multidrug-resistant TB; XDR-TB = extensively drug-resistant TB; HCW = health care worker; IC = infection control; TB = tuberculosis.

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Table 5

TB infection control practices reported by health care workers in M(X)DR-TB wards in South Africa, June–September 2009

	Never n (%)	10% *n* (%)	25% *n* (%)	50% *n* (%)	75% *n* (%)	Almost always *n* (%)	Not applicable *n* (%)
1 What proportion of your sputum collections is completed in the ward? (*n* = 413)	124 (30.0)	68 (16.5)	22 (5.3)	33 (8.0)	37 (9.0)	85 (20.6)	44 (10.7)
2 What proportion of your shift/day is spent in a room/ward with coughing patients? (*n* = 441)	21 (4.8)	79 (17.9)	51 (11.6)	51 (11.6)	76 (17.2)	151 (34.2)	12 (2.7)
3 During what proportion of your shift/day caring for TB patients do you wear a respirator? (*n* = 448)	48 (10.7)	49 (10.9)	28 (6.3)	53 (11.8)	91 (20.3)	178 (39.7)	1 (0.2)
4 To what percentage of your patients do you teach respiratory etiquette/cough hygiene? (*n* = 454)	28 (6.2)	25 (5.5)	10 (2.2)	26 (5.7)	56 (12.3)	309 (68.1)	0

TB = tuberculosis; MDR-TB = multidrug-resistant TB; XDR-TB = extensively drug-resistant TB.