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Tuberculosis infection control in a high drug-resistance setting in rural South Africa: Information, motivation, and behavioral skills

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Summary
Background: Tuberculosis (TB) is transmitted in resource-limited facilities where TB infection control (IC) is poorly implemented. Theory-based behavioral models can potentially improve IC practices.
Methods: The present study used an anonymous questionnaire to assess health-care worker (HCW) TB IC information, motivation, and behavioral skills (IMB) and implementation in two resource-limited rural South African hospitals with prevalent drug-resistant TB.
Results: Between June and August 2010, 198 surveys were completed. Although the respondents demonstrated information proficiency and positive motivation, 22.8% did not consider TB IC to be worthwhile. Most tasks were rated as easy by survey participants, but responding HCWs highlighted challenges in discrete behavioral skills. The majority of responding HCWs reported that they always wore respirators (54.3%), instructed patients on cough hygiene (63.0%), and ensured natural ventilation (67.4%) in high-risk areas. Most respondents (74.0%) knew their HIV status. Social support items correlated with the implementation of the first three aforementioned practices but not with the respondents' knowledge of their HIV status. In most cases, motivation and behavioral skills, but not information, were associated with implementation.

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Conclusion: HCWs in rural South African hospitals with high drug-resistance demonstrated moderate IMB and implementation of TB IC. Improvement efforts should emphasize the development of HCW motivation and behavioral skills as well as social support from colleagues and supervisors. Such interventions should be informed by baseline IMB assessments. In the present study, a trimmed/modified IMB model helped characterize TB IC implementation.

Introduction

Tuberculosis (TB) is often transmitted in healthcare facilities [1,2]. Nosocomial TB transmission in resource-limited settings causes high morbidity and mortality, especially in the current era of HIV and multi- and extensively drug-resistant TB (M/XDR-TB) [3]. Nosocomial transmission also undermines TB control [4] and endangers healthcare workers (HCWs) [5].

TB infection control (IC) can prevent nosocomial transmission in resource-limited settings [6,7], but TB IC is poorly implemented in the developing world [8,9].

TB IC implementation and research could benefit from the inclusion of behavioral approaches [3]. These strategies have been shown to increase the implementation of health policies [10]. Behavioral models describe actions by characterizing their causes and correlates, thereby identifying potential avenues for behavioral changes and guiding the development, monitoring, and evaluation of interventions [11].

The information—motivation—behavioral skills (IMB) model (Fig. 1) states that well-informed, motivated individuals develop necessary behavioral skills, which lead to effective practices [12]. This model has been useful in characterizing and enhancing HIV risk reduction behaviors [13—15], antiretroviral therapy adherence [16—18], and diet and exercise [19]. We hypothesized that the IMB model could characterize HCW TB IC adherence and inform IC enhancement.

Methods

Setting

The present study was conducted at two resource-limited rural district hospitals in Umzinyathi district, KwaZulu-Natal, South Africa. Church of Scotland Hospital (COSH) is a 350-bed facility in Tugela Ferry with documented nosocomial TB and M/XDR-TB [20,21]. Charles Johnson Memorial Hospital (CJMH) is a similarly sized facility in Nqutu. At the time of this study, COSH had an appointed IC officer, had implemented a TB IC policy, and had already conducted some minor TB IC staff training two years earlier, which consisted of a half-hour long information-based lecture to a few dozen staff members. CJMH had two IC officers but no TB IC policy or formal staff training. TB and MDR-TB incidence rates in Tugela Ferry are 1100/100,000 and 140/100,000, respectively. Although precise numbers are not available, we presumed that Nqutu bears a similar TB and MDR-TB burden as Tugela Ferry. In 2009, the antenatal HIV prevalence in Umzinyathi district was 28.2% [22]. COSH was chosen for the present study because of its high burden of HIV, TB and M/XDR-TB. CJMH was chosen because of its comparability with COSH (in terms of size, resources, level of care, patient population, and disease burden), the receptivity of its administration to this study, and its relative geographic proximity to COSH (CJMH is the only district hospital in the neighboring Nqutu sub-district).

Questionnaire

The questionnaire was based on a proposed TB IC IMB model and adapted from an instrument that was previously used at COSH [23]. The questionnaire was piloted for clarity by Zulu staff from an affiliated organization. The survey was anonymous, English, paper-and-pencil, and 45 min long. All clinical staff members who worked day shifts during the study period in high-risk departments of the hospitals (medical and TB wards and outpatient, antiretroviral, and TB clinics) were asked to participate. Questionnaire participation was voluntary, and written informed consent was acquired. The study was deemed complete when all available staff members had been surveyed.

The survey assessed demographics, TB IC IMB, facility-wide implementation of several TB IC tasks, self-reported personal TB IC practices, and attitude questions about the effects of staff TB deaths and perceived managerial efforts to protect HCWs. Survey questions were presented in the following formats: yes/no, true/false/do not know, and a 5-point Likert scale.

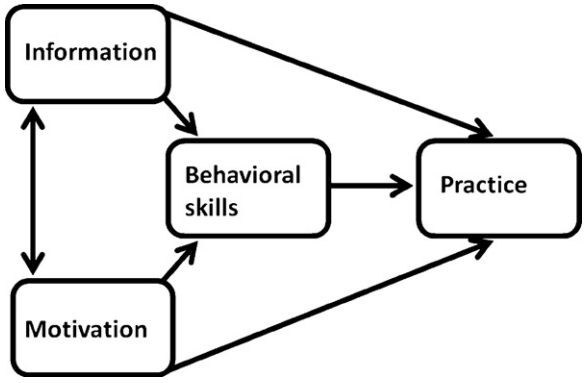

Figure 1 The information—motivation—behavioral skills (IMB) model. The double-headed arrows represent correlations, and the directional arrows represent directional path relationships.
Source: Adapted from Fisher et al. [12].

Analysis

The results of the information section of the surveys were scored as correct or incorrect, and missing, invalid, and ''do not know'' answers were scored as incorrect (except for the Likert perceived knowledge item). Missing, invalid, and ''do not know'' responses to all other survey items were excluded. Where appropriate, Likert item responses for motivation and behavioral skills were reverse-scored in the direction of increasing motivation and perceived ease, respectively. Point statistics, which were used to characterize the study sample across all items, were compared between the two participating hospitals with χ^2 and *t*-tests. Correlations between IMB variables and self-reported personal TB IC practices were assessed using Spearman correlations and Wilcoxon scores. Each self-reported practice was regressed in a path analytic model against a pre-planned set of IMB items that was hypothesized to be conceptually related. These structural equation models were examined for magnitude and direction of paths. All of the analyses were conducted using SAS 9.2 (Cary, NC) and M-Plus 5.0 (Muthén & Muthén, CA) software.

Ethical approval

Ethical approval was obtained from the review boards at the Yale University School of Medicine and the University of KwaZulu-Natal School of Medicine.

Results

The surveys were completed by 123 HCWs at COSH and 75 HCWs at CJMH between June and August 2010 (Table 1). The respondents were predominantly female (84.2%), nurses (78.1%), and working in outpatient (16.1%), medical (35.2%), or TB (22.8%) wards. No respondents refused to be surveyed, but 7 were unavailable to participate (all physicians at CJMH).

Most of the information items (Table 2) were answered correctly by >70% of respondents with some exceptions. Respondents recognized the classic symptoms of pulmonary TB and were generally well informed about TB transmission. The respondents' knowledge regarding surgical masks and respirators was moderate. Indeed, 34.3% believed that surgical masks are equivalent to respirators in terms of protection to the wearer, and 49.0% did not know that respirators require a seal check. Although respondents were knowledgeable about cough hygiene and natural ventilation, 54.0% thought mechanical ventilation is always better than natural ventilation. The majority (69.4%) did not know that HIV-positive HCWs can still acquire TB even if they practice TB IC. Knowledge relating to TB screening and triage was moderate, as 64.1—68.7% knew of the need to undertake crucial steps, including chronic cough screening or the separation/expedited care of TB suspects. Most respondents (74.5%) felt that they were well informed about TB IC strategies.

The present study revealed several statistically significant inter-hospital information differences. For example, 86.1% of the COSH respondents knew that watery eyes are not a common symptom of pulmonary TB, but only 71.0% of CJMH respondents were aware of this ($p = 0.013$). In addition, 93.3% of CJMH respondents (compared with 82.1% of the COSH respondents) knew that TB could not be spread by sharing bed linens ($p = 0.026$). Interestingly, 66.7% of COSH respondents knew that respirators did not need to be thrown away every day compared to 6.7% of CJMH respondents ($p = 0.000$). Moreover, 77.2% of COSH respondents (compared with 64.0% at CJMH) knew that wearing a surgical mask decreases the amount of TB particles that a patient coughs into the air ($p = 0.044$). Furthermore, 93.3% of CJMH respondents (compared with 83.7% at COSH) knew that respirators are necessary even if patients with confirmed or suspected TB infection are using cough hygiene ($p = 0.049$).

The motivation results (Table 3) indicated that many (29.4%) would not be bothered ''very much'' by catching TB. In addition, 19.3% felt less susceptible to TB upon exposure than their co-workers, and 22.8% did not think that TB IC was worthwhile. Almost half (44.6%) found respirators uncomfortable, and 30.4% felt that wearing a

Table 1 Respondent demographic data.

Demographic variable	Response option	Hospital				Combined	
		COSH		CJMH			
		Number	Percent	Number	Percent	Number	Percent
Department	Outpatient department	14	11.4	17	22.7	31	15.7
	Male/female tuberculosis ward	26	21.1	18	24.0	44	22.2
	Antiretroviral therapy clinic	32	26.0	6	8.0	38	19.2
	Male/female medical ward	37	30.1	31	41.3	68	34.3
	Other	9	7.3	3	4.0	12	6.1
	Unknown	5	4.1	0	0.0	5	2.5
	Total	**123**		**75**		**198**	
Job title	Medical officer	8	6.5	0	0	8	4.0
	Professional nurse	19	15.4	31	41.3	50	25.3
	Enrolled/pupil nurse	50	40.7	25	33.3	75	37.9
	Enrolled nursing assistant	20	16.3	8	10.7	28	14.1
	Other	25	20.3	10	13.3	32	17.7
	Unknown	1	0.8	1	1.3	2	1.0
	Total	**123**		**75**		**198**	
Career length	Less than 1 year	31	25.2	22	29.3	53	26.8
	1—10 years	68	55.3	41	54.7	109	55.1
	Greater than 10 years	19	15.4	11	14.7	30	15.2
	Unknown	5	4.1	1	1.3	6	3.0
	Total	**123**		**75**		**198**	
Gender	Male	20	16.3	11	14.7	31	15.7
	Female	102	82.9	63	84.0	165	83.3
	Unknown	1	0.8	1	1.3	2	1.0
	Total	**123**		**75**		**198**	

respirator ruined their appearance. Over 90% were comfortable with opening hospital windows, but 27.9% were afraid to do so at night. If they were to undergo personal HIV testing at their facility, 31.6% felt that colleagues would find out that they were tested, and 25.0% believed that their colleagues would learn the results of the test. Some respondents (27.0%) felt that HIV-positive HCWs at their facility would be severely stigmatized. If HCWs were to undergo personal TB testing at their facility, 44.6% felt that colleagues would find out that they were tested, and 41.3% believed that their colleagues would learn the results of the test. One-third of respondents (32.8%) felt that HCWs with TB and M/XDR-TB would be severely stigmatized. Most agreed that the following tasks are important: cough screening (83.3%), minimizing time TB suspects spend around other patients (83.8%), and knowing one's HIV status (98.5%).

The only statistically significant difference in motivation items between the two hospitals was in response to the prompt ''If I got TB disease, it would not bother me very much.'' CJMH staff members were more bothered by the thought of acquiring TB than COSH HCWs (mean scores were 3.87/5.00 versus 3.48/5.00, $p = 0.049$).

Most behavioral skills (Table 4) were rated as easy, including locating cough hygiene materials, acquiring a respirator, finding a place to test for HIV, and opening ward windows. Respondents highlighted discrete tasks as being relatively difficult, including tasks related to TB screening and triage (moving TB suspects to separate waiting areas if available), personal HIV diagnosis and/or relocation if HIV-positive (informing supervisors of positive results, trusting supervisors to maintain confidentiality, and dealing with HIV-related stigma) and personal TB diagnosis (dealing with TB-related stigma).

The only statistically significant behavioral skill difference between the two hospitals was the ability to find tissues/handkerchiefs/masks to give to coughing patients. COSH respondents rated this as easier than those at CJMH (mean values were 4.17/5.00 versus 3.60/5.00, $p = 0.02$).

Table 2 The frequency of correct responses for the information section of the model. Correct responses are listed in the first column. Subsequent columns list the number and percentage of respondents who answered correctly.

	Number correct (out of 198)	Percent correct
Pulmonary TB symptoms		
Blurry vision IS NOT a symptom	121	69.9
Coughing greater than 2 weeks IS a symptom	193	99.5
Coughing up blood IS a symptom	180	98.4
Ear pain IS NOT a symptom	148	82.2
Fever IS a symptom	146	79.8
Memory loss IS NOT a symptom	122	69.3
Night sweats IS a symptom	187	97.9
Pain on urination IS NOT a symptom	151	83.4
Watery eyes IS NOT a symptom	148	80.4
Weight loss IS a symptom	193	99.5
Infection and spread		
FALSE TB can be spread to others through semen or vaginal fluid	180	90.9
TRUE TB can be spread to others through the air	184	92.9
FALSE TB can be spread to others through blood	162	81.8
TRUE Patients with TB disease commonly infect people by coughing	191	96.5
FALSE Patients with TB disease commonly infect people by sharing food	166	83.8
TRUE Patients with TB disease commonly infect people by talking or singing	115	58.1
FALSE Patients with TB disease commonly infect people by sharing washed bed linens	171	86.4
TRUE Patients with TB disease commonly infect people by sneezing	177	89.4
TRUE Patients with TB disease are more likely to infect others if they cough up a lot of sputum	143	72.2
TRUE Treating a TB patient with the right drugs makes him less infectious	182	91.9
Respirators and surgical masks		
TRUE N95s [respirators] decrease the amount of TB particles being breathed in	174	87.9
FALSE N95s [respirators] must be thrown away after each day's use	87	43.9
FALSE N95s [respirators] work just as well when wet or visibly dirty	150	75.8
TRUE A surgical mask on a coughing TB patient decreases the amount of TB he coughs into the air	143	72.2
FALSE Surgical masks are just as good as N95s [respirators] at preventing the wearer from breathing in TB particles	130	65.7
FALSE An N95 [respirator] provides an airtight seal on the face that the user does not need to check	101	51.0
Cough hygiene		
FALSE A coughing/sneezing patient should be instructed to cough/sneeze freely into the air	165	83.3
FALSE If coughing/sneezing TB patients or suspects are using handkerchiefs or surgical masks, there is no need for staff to wear N95s [respirators]	173	87.4
FALSE Before a TB suspect has a confirmed diagnosis, having him wear a surgical mask or use cough hygiene (handkerchiefs/surgical masks) is unnecessary	153	77.3
Ventilation		
TRUE Opening windows can help prevent the spread of TB	193	97.5
FALSE If a fan is used in a room, opening windows will NOT provide additional infection control	143	72.2
FALSE Mechanical ventilation (like extractor fans) is always more effective than natural ventilation (open windows) for preventing TB	91	46.0
Increased susceptibility of HIV-positive people to TB		
TRUE An HIV positive person is more likely than an HIV-negative person to become sick with TB if exposed to TB	162	81.8

Table 2 (*Continued*)

	Number correct (out of 198)	Percent correct
FALSE An HIV positive staff member cannot get sick with TB if they practice TB prevention strategies	60	30.3
TRUE HIV positive staff who are healthy and on ARVs should still try to avoid working in high risk areas	146	73.7
Screening/separation of TB suspects		
TRUE When entering the outpatient department or ARV clinic, every patient should be asked if they are coughing	136	68.7
FALSE It is okay for a patient to give a sputum sample in the waiting room around other patients	179	90.4
TRUE Patients who are identified as TB suspects should be separated from other patients in the waiting area	127	64.1
FALSE TB suspects in the waiting area should wait just as long as everyone else, and should not be rushed through the queue	136	68.7

Respondents reported moderate levels of TB IC implementation within their facilities. Most reported that the following practices were always implemented: respirators were worn in high-risk areas (52.6%), coughing patients were made to use cough hygiene (60.1%), windows were opened in patient areas (80.0%), and TB suspects in the outpatient department or antiretroviral (ARV) clinic were immediately taken for diagnosis (50.0%). In contrast, only 26.3% stated that patients were always screened for cough upon entering the outpatient department or ARV clinic, and only 37.8% of the respondents reported that TB suspects were always separated from other patients. There were no statistically significant inter-facility differences among questions related to TB IC implementation.

When respondents were asked about their own practices when they were in high-risk TB areas of the hospital in the last month, more than half claimed to always wear a respirator (54.3%), instruct patients on cough hygiene (63.0%), and ensure natural ventilation (67.4%). There were no statistically significant inter-facility differences among these questions. Most (74.0%) reported that they knew their HIV status (81.0% at COSH versus 63.8% at CJMH, $p = 0.012$).

Because of staff TB and M/XDR-TB-attributed deaths, many felt less willing to work in high-risk areas of the hospital (65.5%) or to continue as an HCW (25.7%). Most (61.5%) agreed that their facility management ''cares about [them] and is trying hard'' to prevent staff infections. There were no statistically significant inter-facility differences among these questions.

Self-reported personal TB IC practices co-varied with numerous IMB variables (Table 5). Social support items (e.g., whether co-workers implement/support TB IC and whether supervisors praise implementation) were correlated with several practices, but not with knowledge of personal HIV status. We also observed associations between implementation and relevant behavioral skills.

Structural equation IMB models were created for each of the four self-reported practices (respirator use, cough hygiene instruction, natural ventilation instruction, knowledge of personal HIV status). Model inputs are available (Supplement), and the outputs are presented in Fig. 2 and described below.

Respirator use IMB model

Information co-varied with motivation ($p = 0.001$). Statistically significant paths included motivation to behavioral skills ($p = 0.001$), motivation to practice ($p = 0.003$), and behavioral skills to practice ($p = 0.010$). Information was not related to behavioral skills or practice.

Cough hygiene instruction IMB model

Information co-varied with motivation ($p < 0.001$). Statistically significant paths included motivation to behavioral skills ($p = 0.045$) and motivation to practice ($p = 0.004$). Information was not related to behavioral skills or practice, and behavioral skills were not related to practice.

Natural ventilation implementation IMB model

Information co-varied with motivation ($p < 0.001$). Statistically significant paths included motivation to practice ($p = 0.005$) and behavioral skills to practice ($p = 0.016$). Neither motivation nor

Table 3 The distribution of motivation responses. For the sake of presentation, 5-point Likert items (strongly agree—strongly disagree) have been collapsed to 3-point Likert items (agree—disagree).

Motivation item prompt	Response option	Count	Percent
If I got TB disease, it would not bother me very much.	Agree	58	29.4
	Neither agree/disagree	12	6.1
	Disagree	127	64.5
If my co-workers and I were exposed to TB, they might get infected but I would not.	Agree	38	19.3
	Neither agree/disagree	21	10.7
	Disagree	138	70.1
Patients know when they come to the hospital that there will be germs and diseases here, so prevention is really their responsibility, not mine.	Agree	30	15.3
	Neither agree/disagree	10	5.1
	Disagree	156	79.6
With everything I have to do each day, I don't have time to worry about preventing the spread of TB.	Agree	15	7.7
	Neither agree/disagree	2	1.0
	Disagree	179	91.3
It is important to ask each patient when they present to the outpatient department or ARV clinic if they are coughing, even if their complaint is unrelated to cough.	Agree	164	83.2
	Neither agree/disagree	13	6.6
	Disagree	20	10.1
It is important to minimize the time TB suspects spend around others in the outpatient department or ARV clinic waiting areas.	Agree	165	83.8
	Neither agree/disagree	9	4.6
	Disagree	23	11.7
Knowing my HIV status is important to me.	Agree	194	98.5
	Neither agree/disagree	1	0.5
	Disagree	2	1.0
TB infection control strategies are not worth all the effort that goes into them.	Agree	44	22.8
	Neither agree/disagree	22	11.4
	Disagree	127	65.8
Wearing an N95 [respirator] is uncomfortable.	Agree	88	44.7
	Neither agree/disagree	20	10.2
	Disagree	89	45.2
The N95 [respirator] ruins my appearance.	Agree	59	30.4
	Neither agree/disagree	15	7.7
	Disagree	120	61.9
Instructing coughing patients on cough hygiene when I am busy with other tasks is frustrating.	Agree	44	22.3
	Neither agree/disagree	15	7.6
	Disagree	138	70.1
I don't like opening windows in the hospital.	Agree	9	4.6
	Neither agree/disagree	8	4.1
	Disagree	180	91.4
I would be afraid to leave the windows of the hospital wards open at night.	Agree	55	27.9
	Neither agree/disagree	22	11.2
	Disagree	120	60.9
If I get myself tested for HIV at this hospital, my co-workers would probably find out that I got tested.	Agree	62	31.6
	Neither agree/disagree	17	8.7
	Disagree	117	59.7
If I get myself HIV tested at this hospital, my co-workers would probably find out my HIV test results.	Agree	49	25.0
	Neither agree/disagree	20	10.2
	Disagree	127	64.8
If co-workers found out that a healthcare worker at this facility was HIV-positive, he or she would probably be severely stigmatized.	Agree	53	27.0
	Neither agree/disagree	31	15.8
	Disagree	112	57.1
If I get myself tested for TB/MDR-TB/XDR-TB at this hospital, my co-workers would probably find out that I got tested.	Agree	87	44.6
	Neither agree/disagree	21	10.8
	Disagree	87	44.6
If I get myself tested for TB/MDR-TB/XDR-TB at this hospital, my co-workers would probably find out my TB/MDR-TB/XDR-TB test results.	Agree	81	41.3
	Neither agree/disagree	27	13.8
	Disagree	88	44.9

Table 3 (*Continued*)

Motivation item prompt	Response option	Count	Percent
If co-workers found out that a healthcare worker at this facility had TB/MDR-TB/XDR-TB, he or she would probably be severely stigmatized.	Agree	64	32.8
	Neither agree/disagree	29	14.9
	Disagree	102	52.3
People who are important to me want me to protect myself from catching TB.	Agree	182	93.3
	Neither agree/disagree	4	2.1
	Disagree	9	4.6
My co-workers practice TB infection control strategies.	Agree	157	80.9
	Neither agree/disagree	26	13.4
	Disagree	11	5.7
My supervisor would praise people for practicing TB infection control.	Agree	167	86.1
	Neither agree/disagree	11	5.7
	Disagree	16	8.2
My co-workers support TB infection control strategies.	Agree	169	86.7
	Neither agree/disagree	18	9.2
	Disagree	8	4.1
It frustrates me when patients complain after I ask them to follow cough hygiene (using handkerchiefs/surgical masks).	Agree	107	54.9
	Neither agree/disagree	19	9.7
	Disagree	69	35.4

information was significantly related to behavioral skills, and information was not related to practice.

Knowledge of personal HIV status IMB model

Statistically significant paths included motivation to behavioral skills ($p < 0.001$) and motivation to practice ($p = 0.008$). Information was not related to behavioral skills or practice, and behavioral skills did not relate to practice.

Discussion

We surveyed TB IC IMB and implementation among HCWs at two resource-limited rural South African hospitals with prevalent TB and M/XDR-TB. We found that HCWs were generally well-informed. With a few exceptions, HCWs had appropriate motivation, rated most TB IC tasks as easy to perform, and reported that they and their colleagues generally implemented many TB IC steps appropriately. Social support items correlated with self-reported implementation of several TB IC practices. Behavioral models demonstrated that motivation and behavioral skills were associated with TB IC practice in most cases, while information inputs were less helpful in characterizing implementation.

Implications for TB IC training and interventions

The present findings suggest that training and interventions to promote TB IC practices among experienced HCWs may be most influential when targeting motivation and behavioral skills development. This differs substantially from current training approaches, which heavily emphasize information or knowledge of TB IC guidelines [6,24]. For example, in addition to informing staff about natural ventilation, the implementation of this strategy could be greatly augmented by training HCWs to better explain the importance of open windows to their patients. Similarly, exploring and addressing concerns HCWs have regarding the likelihood that their natural ventilation efforts will be reversed by patients and colleagues may also be beneficial. In terms of motivation, improving perceived social support for TB IC could be particularly important for several activities (please see 'Social support' section below). Although future research is needed to identify the adult learning strategies that would most likely enhance motivation and skills, adding these considerations to TB IC training agendas may offer valuable contributions.

The present results also demonstrated that a brief baseline TB IC IMB measurement can highlight both strengths and weaknesses of HCWs. Simple tools, such as questionnaires [23] or staff interviews [25], provide crucial data that can guide and streamline TB IC training and interventions.

Social support

Some of the most consistent co-variates of self-reported practice were prompts related to social support. The perspectives and actions of co-workers can influence HCW behavior. For example,

Table 4 Behavioral skills. The mean refers to the perceived ease of each task, and the scores ranged from 1 (very difficult) to 5 (very easy).

Behavioral skill	Mean	Standard deviation
TB screening and triage		
When in the outpatient department or ARV clinic, ask each patient when they enter if they are coughing, and if so, for how long	3.64	1.12
When in the outpatient department or ARV clinic, move TB suspects to wait at a nearby but separate waiting area if one were available	2.89	1.15
When in the outpatient department or ARV clinic, rapidly move a TB suspect to the front of the queue so he or she is seen quickly to minimize the amount of time he spends in the waiting area around other patients	3.08	1.31
Cough hygiene		
Find tissues/handkerchiefs/masks to give to patients	3.95	1.15
Request a coughing patient to use cough hygiene (tissues/handkerchiefs/cough into arms)	3.99	1.05
Respond to patient complaints about having to use cough hygiene (like wearing a mask)	3.72	1.05
Get older patients to use cough hygiene (tissues/handkerchiefs/cough into arms)	3.20	1.27
Get male patients to use cough hygiene (tissues/handkerchiefs/cough into arms)	3.11	1.31
Respirator use		
Get your own N95 [respirator]	4.04	1.23
Breathe comfortably while wearing an N95 [respirator]	4.12	0.90
Interact with your patients while wearing an N95 [respirator]	3.55	1.14
Maintain your appearance while and after wearing an N95 [respirator]	3.54	1.24
Personal HIV testing and/or relocation		
Find a place to be privately and confidentially HIV tested (either at the facility or elsewhere)	3.94	1.20
Inform a supervisor of test results if they showed that you were HIV positive	2.62	1.29
Trust the supervisor to keep your HIV status confidential	2.52	1.30
Deal with HIV stigma at work if you had HIV	2.57	1.28
Personal TB diagnosis		
Recognize TB symptoms in yourself if they arose	4.03	1.03
Find a way to be privately and confidentially tested for TB	3.68	1.13
Trust that the occupational health officer or medical officer will keep the [TB] results confidential	3.11	1.34
Deal with TB/MDR-TB/XDR-TB stigma at work if I had TB/MDR-TB/XDR-TB	2.62	1.33
Natural ventilation		
Open windows in the wards	4.32	0.92
Ensure that patients don't close the windows in the wards	3.47	1.26
Ensure that other staff don't close the windows in the wards	3.86	1.10
Explain to patients why it is important to keep the windows open	4.34	0.79
Find ways to keep patients warm (e.g., blankets, heaters) if they complain about the cold because of the open windows	3.45	1.42

Table 5 Correlations between IMB items and self-reported behaviors of interest. For the sake of presentation, only those associations with $p \leq 0.05$ are shown.

	Frequency of self-reported use of respirators in high-risk situations/areas in the last month	Frequency of self-reported instruction to patients regarding cough hygiene in high-risk situations/areas in the last month	Frequency of self-reported natural ventilation implementation in high-risk situations/areas in the last month	Self-reported knowledge of personal HIV status
Information				
	None	None	None	Correct response to questions about cough hygiene ($p = 0.008$) Correct response to questions about importance of screening and separation of TB suspects ($p = 0.019$) Self-report of being well-informed about TB infection control strategies ($p = 0.038$)
Motivation				
	Disagree: If I get myself tested for TB/MDR-TB/XDR-TB at this hospital, my co-workers would probably find out that I got tested ($p = 0.044$)	Disagree: TB infection control strategies are not worth all the effort that goes into them ($p = 0.036$)	Disagree: TB infection control strategies are not worth all the effort that goes into them ($p = 0.016$)	Disagree: With everything I have to do each day, I don't have time to worry about preventing the spread of TB ($p = 0.037$)
	Agree: My co-workers practice TB infection control strategies ($p = 0.012$)	Disagree: Wearing an N95 [respirator] is uncomfortable ($p = 0.001$)	Disagree: Wearing an N95 [respirator] is uncomfortable ($p = 0.048$)	Agree: Knowing my HIV status is important to me ($p = 0.041$)
	Agree: My supervisor would praise people for practicing TB infection control ($p = 0.010$)	Disagree: Instructing coughing patients on cough hygiene when I am busy with other tasks is frustrating ($p = 0.079$)	Agree: My co-workers practice TB infection control strategies ($p = 0.000$)	Disagree: TB infection control strategies are not worth all the effort that goes into them ($p = 0.006$)
	Agree: My co-workers support TB infection control strategies ($p = 0.017$)	Agree: My co-workers practice TB infection control strategies ($p = 0.017$) Agree: My co-workers support TB infection control strategies ($p = 0.012$)	Agree: My co-workers support TB infection control strategies ($p = 0.005$)	Disagree: Wearing an N95 [respirator] is uncomfortable ($p = 0.046$)

Behavioral skills			
Find tissues/handkerchiefs/masks to give to patients ($p = 0.000$)	When in the outpatient department or ARV clinic, ask each patient when they enter if they are coughing, and if so, for how long ($p = 0.035$)	When in the outpatient department or ARV clinic, rapidly move a TB suspect to the front of the queue so he or she is seen quickly to minimize the amount of time he spends in the waiting area around other patients ($p = 0.036$)	None
Request a coughing patient to use cough hygiene ($p = 0.000$)	When in the outpatient department or ARV clinic, rapidly move a TB suspect to the front of the queue so he or she is seen quickly to minimize the amount of time he spends in the waiting area around other patients ($p = 0.008$)	Find tissues/handkerchiefs/masks to give to patients ($p = 0.001$)	
Respond to patient complaints about having to use cough hygiene (like wearing a mask) ($p = 0.036$)	Find tissues/handkerchiefs/masks to give to patients ($p = 0.030$)	Request a coughing patient to use cough hygiene (tissues/handkerchiefs/cough into arms) (p = 0.002)	
Get your own N95 [respirator] ($p = 0.000$)	Deal with TB/MDR-TB/XDR-TB stigma at work if I had TB/MDR-TB/XDR-TB ($p = 0.033$)	Get your own N95 [respirator] ($p = 0.001$)	
Interact with your patients while wearing an N95 [respirator] ($p = 0.015$)	Ensure that other staff don't close the windows in the wards ($p = 0.014$)	Interact with your patients while wearing an N95 [respirator] ($p = 0.035$)	
Maintain your appearance while and after wearing an N95 [respirator] ($p = 0.011$)	Explain to patients why it is important to keep the windows open ($p = 0.002$)	Find a way to be privately and confidentially tested for TB ($p = 0.002$)	
Ensure that patients don't close the windows in the wards ($p = 0.029$)		Ensure that patients don't close the windows in the wards ($p = 0.003$)	
Ensure that other staff don't close the windows in the wards ($p = 0.000$)		Ensure that other staff don't close the windows in the wards ($p = 0.000$)	
Explain to patients why it is important to keep the windows open ($p = 0.003$)		Explain to patients why it is important to keep the windows open ($p = 0.000$)	

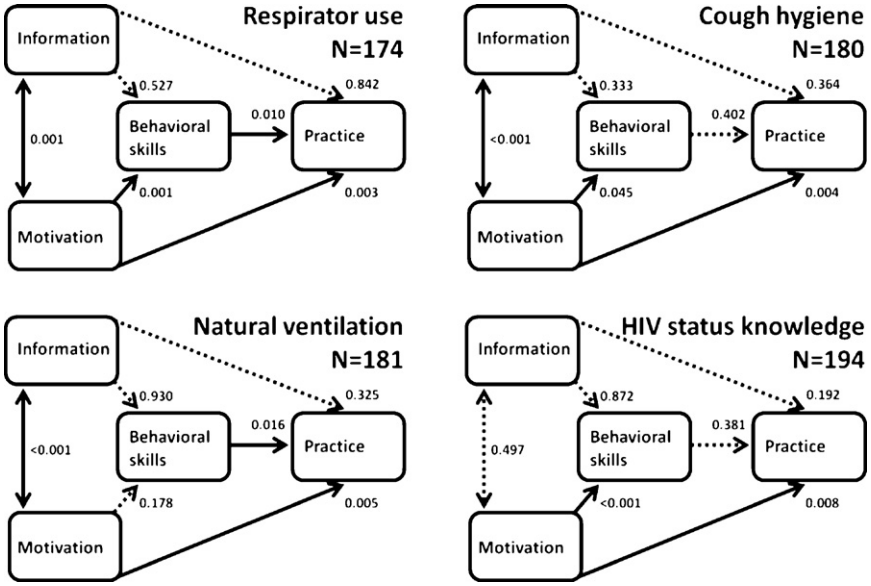

Figure 2 Information—motivation—behavioral skills (IMB) models for self-reported respirator use, cough hygiene instruction, natural ventilation implementation, and knowledge of personal HIV status. The numbers and *p* values are provided in the figure. The solid arrows indicate statistically significant correlations/directional path relationships ($p \leq 0.05$), whereas dotted arrows are not statistically significant. All correlations/directional path relationships are positive.

HCWs who wish to implement TB IC where it is not generally practiced may hesitate because of a fear of ostracization. Conversely, staff who see their co-workers enthusiastically and appropriately implementing TB IC may feel compelled and/or empowered. Our research indicated that HCWs support the prevention of nosocomial TB transmission. If HCWs knew that their colleagues shared this sentiment, they might be more likely to take further steps to achieve TB IC.

Supervisors are critical to creating an environment that is conducive to TB IC implementation. Hand hygiene studies from the United States have shown that supervisors who model effective behaviors have a powerful influence on the actions of their subordinates [26,27]. Beyond being role models, supervisors can also encourage staff members by noticing and rewarding HCWs' efforts to reduce nosocomial TB transmission. This can provide effective performance feedback [28] and positive reinforcement.

Comparisons to implementation in other resource-limited facilities

TB IC implementation at the two study hospitals compares favorably to other assessments in the developing world. Screening and triage appeared better at COSH and CJMH than at a Peruvian emergency department [29] or a cohort of Malawian facilities [30]. In addition, a greater proportion of COSH and CJMH HCWs knew their HIV status compared with staff at a Kenyan tertiary center [31]. Self-reported respirator use at the two hospitals included in the present study was greater than in 40 Chinese TB facilities [32] or a Peruvian emergency department [29].

The present COSH TB IC assessment also compares well to a previous one at the hospital in 2007 [23]. For instance, while 26.4% of respondents in 2007 cited the lack of available tissues and surgical masks for preventing cough hygiene implementation, in the current study 80.0% of COSH respondents rated locating such materials as easy or very easy. A similar improvement was apparent in terms of using respirators. Despite the persistence of troubling concerns related to stigma and confidentiality, HCWs are now much less likely to report not knowing their HIV status (19.0% in 2010 versus 41.5% in 2007). Though rare HCW TB deaths have continued since 2007, COSH staff members are now less likely to be hesitant to work in high-risk hospital areas (62.0% in 2010 versus 82.1% in 2007) or consider leaving the profession (29.5% in 2010 versus 42.9% in 2007) in light of their co-workers' mortality.

Taken together, the present results demonstrated that a greater level of TB IC implementation is possible in resource-limited settings than what

has been reported to date in the literature. The progress at COSH, which has benefited from a TB IC program that included the naming of an IC officer and the ratification of a facility policy, suggests that HCW TB IC uptake can be improved. We believe that the application of the IMB model and our recommendations can further enhance TB IC implementation at COSH, CJMH, and other hospitals and regions.

TB IC IMB modeling

The present study used the IMB behavioral model to characterize TB IC implementation. Our models generally performed as expected, particularly with regard to the associations between motivation and behavioral skills and self-reported implementation; however, the models also showed two key inconsistencies. First, information scales were not associated with behavioral skills or practice in any of the models. Trimming or modifying our TB IC IMB models by removing the information inputs resulted in a more accurate characterization of implementation. This finding is in line with some IMB studies that found that information was not strongly predictive of regular safer sexual practices among various populations [13—15,33]. A possible reason for the inconsistent associations of information in our study is that the generally high information levels of our sample may have caused a ceiling effect (i.e., knowledge was high enough to no longer have a measurable effect on implementation frequency). In addition, our information questions may have lacked the behavioral specificity needed to accurately capture the kinds of knowledge that would facilitate behavioral skills or practices. Alternatively, information may have less influence on TB IC practices than the IMB model predicted. Gaining a better understanding of how to best assess information and its role in TB IC is an important goal for future research.

Another inconsistency was that the IMB model for knowledge of personal HIV status performed poorly. Numerous factors influence an HCW's decision to get tested for HIV, and the items used in the present study were mostly limited to TB-related reasons for diagnosis. Not surprisingly, this relatively unsophisticated model was inadequate in characterizing a very complex and highly context-driven behavior [34—36]. A refined model is needed in future studies.

Although the models in the present study were not fully consistent with the predicted IMB model in all cases, this research yielded important insights, including measurement issues and strengths and opportunities for improvement in TB IC IMB among HCWs. We hope that this investigation will be a helpful starting point for the design and use of further behavioral approaches to improve TB IC implementation.

Limitations

The present study had several limitations. First, self-report is subject to systematic biases that overstate adherence [37]. Consequently, using self-reported practices as the outcome variable for a descriptive model can be limiting. Secondly, the survey was conducted in English, a second language for most participants. While all respondents who attempted the survey were able to complete it without issue, a Zulu instrument might have yielded more accurate results. Thirdly, the present study was observational, which means that we cannot attribute causation to any items that co-varied with self-reported TB IC practices. Finally, our demographic results demonstrated a slight discrepancy between occupations represented at each of the two hospitals, which limited inter-facility comparisons.

Conclusion

Ensuring better TB IC implementation is crucial to prevent nosocomial transmission in resource-limited settings. The present assessment demonstrated substantial strengths and highlighted opportunities for improvement in TB IC IMB and implementation in two rural South African district hospitals with prevalent TB and M/XDR-TB. Improving motivation, particularly providing social support, and developing behavioral skills are priorities for interventions to increase HCW TB IC implementation. Such efforts should be informed by baseline IMB assessments. A trimmed/modified IMB model was moderately successful in characterizing TB IC practice and has the potential to guide future behavioral research and interventions.

Contributions

ZK, AM, and GF provided substantial contributions to the conception and design. ZK, KM, and AM provided substantial contributions to the acquisition of the data. ZK, KA, FL and GF provided substantial contributions to the analysis and interpretation of the data. All of the authors were involved in drafting the article and/or critically revising the article

for intellectual content. All of the authors gave their final approval of the version to be submitted.

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Competing interest

The authors have no conflicts of interest to report.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jiph.2011.10.008.

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