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Using the Health Belief Model to Predict Tuberculosis Preventive Behaviors Among Tuberculosis Patients' Household Contacts During the COVID-19 Pandemic in the Border Areas of Northern Thailand

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Objectives: The coronavirus disease 2019 pandemic has exacerbated the rate of tuberculosis (TB) infection among close contacts of TB patients in remote regions. However, research on preventive behaviors, guided by the Health Belief Model (HBM), among household contacts of TB cases is scarce. This study aimed to employ the HBM as a framework to predict TB preventive behaviors among household contacts of TB patients in the border areas of Northern Thailand.

Methods: A cross-sectional study with multi-stage random sampling was conducted in Chiang Rai Province. The study included 422 TB patients' household contacts aged 18 years or older who had available chest X-ray (CXR) results. A self-administered questionnaire was used to conduct the survey.

Results: The participants' mean age was 42.93 years. Pearson correlation analysis showed that TB preventive behavior scores were significantly correlated with TB knowledge (r=0.397), perceived susceptibility (r=0.565), perceived severity (r=0.452), perceived benefits (r=0.581), self-efficacy (r=0.526), and cues to action (r=0.179). Binary logistic regression revealed that the modeled odds of having an abnormal CXR decreased by 30.0% for each 1-point score increase in preventive behavior (odds ratio, 0.70; 95% confidence interval, 0.61 to 0.79).

Conclusions: HBM constructs were able to explain preventive behaviors among TB patients' household contacts. The HBM could be used in health promotion programs to improve TB preventive behaviors and avoid negative outcomes.

Key words: Health Belief Model, Tuberculosis, Preventive behaviors, Household contacts, Thailand

INTRODUCTION

Tuberculosis (TB), which is caused by *Mycobacterium tuberculosis*, is one of the leading causes of death and morbidity worldwide, particularly in developing countries [1]. TB remains a formidable communicable disease, with over 4100 deaths and nearly 28 000 new cases reported daily [2]. The disease predominantly affects the lungs (80%) but can impact all body organs and is transmissible to others [2]. The 2020-2022 coronavirus disease 2019 (COVID-19) pandemic disrupted the pro-

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vision and access to health services, severely affecting health systems globally. This disruption was particularly acute for TB control, leading to an increase in new TB cases [3]. Furthermore, patients with positive sputum test results are more likely to transmit the disease to those in close contact [4]. A person's risk of contracting TB is influenced by the duration and proximity of exposure to TB patients and their own susceptibility to the disease [4,5]. After exposure to airborne aerosols containing *M. tuberculosis*, contacts may become infected and develop TB [6]. A systematic review indicates that, on average, 3.5-5.5% of household members or other close contacts of TB patients have undiagnosed TB [5,7]. A study conducted in the United States and Canada identified risk factors for increased TB exposure, with shared bedrooms and contact with more than one index patient being strongly associated with TB progression among close contacts [8]. Additionally, household exposure was linked to a higher risk of TB infection [9]. The World Health Organization recommends chest X-ray (CXR) screening for TB in patients with confirmed or suspected TB [10]. CXRs have demonstrated sensitivity and specificity in TB diagnosis, confirming their efficacy [11]. Similarly, a study on the effectiveness of tracing TB contacts among migrants highlighted various standardized methods for diagnosing and detecting TB [12], with most studies employing CXRs in conjunction with symptom screening [13]. Therefore, it is crucial to thoroughly screen these close contacts for TB to ensure they receive appropriate treatment and to aid in prevention and control efforts.

In Thailand, the incidence of TB has been declining over the past two decades. However, there has been a recent uptick in the number of new and recurrent TB cases identified and registered for treatment. A 2022 report documented 35 951 new and recurrent TB cases, which equates to 54.0 new and recurrent cases per 100 000 people [14]. Chiang Rai Province is among the top 10 provinces for new and recurrent TB cases [15]. The national report indicates that 20% of patients had been in close contact with individuals diagnosed with sputum-positive pulmonary TB [15]. Chiang Rai Province, located in Northern Thailand, shares borders with Burma to the north and Laos to the east [16]. The region is characterized by high mountains, plateaus, and basins formed by significant rivers. There is a high level of population movement in the border areas of Northern Thailand, with many foreign workers crossing into the country to access health services, which poses challenges for public health efforts [16]. Statistical data from 2020 to 2022 show a year-on-year increase in TB patients in Chiang Rai Province, with counts of 1828, 1958, and 2037 patients, respectively [17]. The majority of these cases were either new infections or recurrences, and 5% of patients had been living in the same household as someone with TB. Furthermore, during the COVID-19 pandemic, the multi-directional migration of migrant workers led to repeated TB outbreaks in the border regions [17]. A review of health literature suggests that the incidence of TB in Chiang Rai Province is influenced by cross-border population movements, close contact with TB patients, cohabitation with infected individuals, crowded living conditions, poor hygiene and sanitation, and suboptimal medication adherence [16,17]. These factors are implicated in the rising incidence of TB infection [18].

The Health Belief Model (HBM) is a theoretical framework that emphasizes individual perceptions in explaining health behaviors and adherence to patient treatment [19]. The HBM underscores the significance of personal attributes and cognitive factors, as people's beliefs about health risks and threats can motivate them to take action [19]. Additionally, the HBM considers the impact of social influence and the emotional aspects of behavior on an individual's self-care practices for disease prevention [20]. Predisposing factors for behavioral change include positive perceptions. Personal perceptions of variables such as susceptibility, severity, benefits, and barriers related to infection are critical predictors of preventive behavior [21]. However, there is a scarcity of research on preventive behaviors using the HBM among household contacts of TB cases. Therefore, this study employs the HBM constructs as a framework to predict TB preventive behaviors among household contacts of TB patients during the COVID-19 pandemic in the border areas of Chiang Rai Province. It is expected that the findings will inform the development of activities aimed at TB prevention and control, leading to improved health behaviors, personal hygiene, and sanitation among household contacts of TB patients, as well as enhanced health among residents of the border areas.

METHODS

Study Design

This cross-sectional study was conducted in the border areas of Northern Thailand from October 2022 to December 2022. A multi-stage random sampling approach was utilized. The study area was chosen through purposive sampling, with

Chiang Rai Province being selected due to its rising number of TB cases and its proximity to neighboring countries, including Burma and Laos. In the border areas, secondary hospitals have reported a consistent increase in new TB cases over the past three years, with migrant workers comprising more than 20% of the population. Local health administrators also provided support to the researcher in conducting the study. Chiang Rai Province is divided into 18 districts, out of which five were chosen using a simple random sampling method: Mae Sai, Mae Chan, Mae Fah Luang, Chiang Saen, and Chiang Khong. The registration numbers of TB patients who were receiving treatment in the TB clinics of these five hospitals were compiled. The researcher then employed simple random sampling to select patients by drawing names from this list until the required sample size was reached. The selected individuals' details were meticulously recorded, including their name, surname, patient registration number, and the number of household contacts. Each TB patient was asked to select a household member to participate in the study, based on the study's inclusion criteria.

Household members of TB patients were selected through purposive sampling. The inclusion criteria were as follows: (1) individuals who resided in the same household, shared a room, and/or had contact with a TB patient diagnosed by a medical doctor and registered at the hospital for at least two months; (2) females or males aged 18 years or older; (3) those who had received a CXR result within the past six months; (4) registered residents of Chiang Rai Province; (5) those with clear consciousness and the ability to communicate effectively; and (6) those who voluntarily agreed to participate in the study. Individuals with intellectual or mental disabilities, as well as those not officially registered as Thai citizens with the local municipality, were excluded from the study. The sample size was calculated using the formula for an unknown population, with criteria ranging from 30 units to 500 units and a standard deviation (SD) representation of $e_m = \sigma/10$ [22]. The confidence level was set at 95%, and the margin of experimental uncertainty error was 5%, using the formula $N = (Z_c\sigma/e_m)^2$. This calculation yielded a sample size of 384 individuals. To account for potential loss or incomplete data collection, the researcher increased the sample size by 10%, resulting in a final sample size of 422 people.

Before initiating the study, we recruited three research assistants from the hospital's vicinity, including nurses and public health scholars. Each assistant was proficient in the local language and had experience as a caregiver and health promotion coordinator within the health unit. Subsequently, a meeting was scheduled between the researcher and the assistants to discuss the study's objectives and the data collection process for the questionnaire. The purpose of this meeting was to ensure that the research assistants were aligned in their understanding of the procedures, such as arranging interviews and respecting the rights and privacy of the participants. The researcher translated the research questions from the official language into the local language to prevent miscommunication during data collection and to facilitate the assistants' comprehension and use in the interviews. Additionally, the researcher secured authorization from the Provincial Public Health Office and the district hospital where the study was to be conducted, thereby establishing a connection with public health officials and staff for research purposes. Following the acquisition of written consent from the participants, the researcher and assistants carried out the survey. Participants were asked to complete a self-administered survey, with the research assistants available to provide assistance with any questions as needed. In cases where responses were unclear, the research assistants conducted face-to-face interviews with the participants. Data collection took place at the hospital's TB clinic during working hours (9:00 a.m.-5:00 p.m.) or at other times convenient for the participants as arranged. Each interview lasted between 20 minutes and 30 minutes.

The researcher applied the conceptual framework of the HBM and created questionnaires based on prior research and a literature review in order to collect quantitative data [23,24]. The survey instrument was tailored to fit the specific context of rural areas in Northern Thailand. The questionnaire was divided into 9 sections. Section 1 collected general information, including sex, age, education, underlying diseases, financial status, relationship to index cases, Bacillus Calmette–Guérin (BCG) vaccination status, practices regarding sputum collection and disposal, air conditioning usage, COVID-19 infection history, COVID-19 vaccination status, and CXR results. Section 2 comprised a 12-item questionnaire assessing knowledge about TB, including its causes, symptoms, complications, prevention, and control measures among household contacts of TB patients. Participants answered these multiple-choice questions with either "correct" or "incorrect." The scoring system ranged from 0 points to 12 points, with scores categorized as high ($\geq$9 points), moderate (7-8 points), or low ($\leq$6 points). A pilot version of the questionnaire was tested on a sample of

30 individuals from a similar context to the study population. The reliability of the questionnaire was confirmed using the Kuder–Richardson formula 20, which yielded a KR20 value of 0.79.

Part 3 involved the perceived severity of TB prevention, featuring 12 items such as "If you are infected with TB, your lung function will decrease and you will feel tired easily" and "TB can cause respiratory complications, which may lead to death." Part 4 focuses on perceived susceptibility to TB prevention, with 10 items including "If you are infected with TB and do not receive treatment, you can transmit the disease to others" and "Living in the same household and sharing a bedroom or personal items with someone who has TB increases your risk of contracting the disease." Part 5 evaluated the perceived benefits of TB prevention, comprising 10 items. Examples include "Washing your hands after contact with the mucus and saliva of a TB patient will protect you from infection" and "Ventilating your bedroom will help prevent you and your family members from contracting TB." Part 6 assessed cues to action for TB prevention, with 8 items such as "People who have been in contact with a TB patient should be encouraged to undergo health screenings, sputum tests for TB, and CXRs every 6 months" and "Proper disposal of infected waste, like the phlegm and saliva of TB patients, will reduce the spread of germs within the family." Part 7 measured perceived self-efficacy in TB prevention, with 10 items including "You can ensure that a TB patient takes their medication consistently throughout the treatment period" and "You can arrange for a separate bedroom for a TB patient during the first 2 months of treatment." Parts 3-7 of the questionnaire related to the HBM structure and utilized a Likert scale that ranged from "1=disagree" to "3=agree." The scores are categorized into 3 levels: high (≥80% of the total scores), medium (60-79% of the total scores), and low (<60% of the total scores).

Part 8 of the questionnaire assessed TB preventive behaviors related to personal hygiene, including actions such as wearing a mask, washing hands, and maintaining sanitation and a clean environment. It comprised 22 items, for example, "You wash your hands with soap or antiseptic before and after coming into contact with the sputum or saliva of TB patients" and "You avoid sharing meals or using the same utensils as TB patients." Responses are evaluated on a 3-tiered rating scale: "never practiced," "sometimes practiced" (1-3 times/wk), and "regularly practiced" (≥4 times/wk). Scores are categorized into three levels: high (≥80% or 53 points), moderate (60-79% or 40-52 points), and low (<60% or ≤39 points). The questionnaire was validated and refined based on feedback from experts in the field. Prior to its final use, a pilot test was conducted on a group of 30 individuals with similar backgrounds and characteristics. The reliability of parts 3-9 of the questionnaire was confirmed, with Cronbach's alpha coefficients of 0.87, 0.80, 0.88, 0.84, 0.78, 0.76, and 0.80, respectively.

Statistical Analysis

We used SPSS version 28 (IBM Corp., Armonk, NY, USA) to conduct the statistical analysis. Descriptive statistics were used to analyze the frequency, mean, percentage (%), SD, minimum, and maximum values. To explore the relationship between participants' characteristics and levels of knowledge and prevention behaviors, we utilized the independent *t*-test and one-way analysis of variance (ANOVA). The Pearson correlation coefficient (*r*) and linear regression were applied to assess the correlation among the variables: knowledge, HBM constructs, and prevention behavior. Additionally, variables that were significant according to the independent *t*-test and one-way ANOVA were included in an adjusted model for further analysis. We also investigated the relationship between knowledge, HBM constructs, preventive behaviors, and the CXR results of the participants using simple logistic regression. A *p*-value of less than 0.05 was considered statistically significant.

Ethics Statement

Ethical review and approval were provided by the University of Phayao Human Ethics Committee, Thailand (UP-HEC 1.2/004/66 approved No. 22, 2022). All participants signed a consent form before taking part in the study.

RESULTS

The study included 422 participants. Table 1 shows the participants' characteristics. Most of the subjects (56.9%) were female; the mean age was 42.93 years (SD, 15.07; range, 18-83); 51.7% had no formal education; 74.9% had no underlying illness; and 68.2% had sufficient income. Most contacts did not reside in the same home (53.8%), more than half had been vaccinated against COVID-19 (70.1%), more than three-quarters had received the BCG vaccine (72.3%), most had covered sputum containers (54.0%), and 95.0% of CXRs were normal. The overwhelming majority of participants did not use home

Table 1. Scores of knowledge and preventive behaviors based on participant characteristics (n=422)

Characteristics	n (%)	Knowledge (score)	*p*-value	Preventive behaviors (score)	*p*-value
Sex			0.451[1]		0.237[1]
Male	182 (43.1)	7.97±1.86		49.34±6.97	
Female	240 (56.9)	7.82±2.04		50.15±6.87	
Age (y)			<0.001[2]		0.011[2]
18-30	110 (26.1)	8.37±19.4		50.00±7.02	
31-59	236 (55.9)	7.96±2.03		50.39±6.90	
≥60	76 (18.0)	6.93±1.45		47.68±6.52	
Mean±SD (range)	42.93±15.07 (18-83)	-		-	
Education			<0.001[1]		0.001[1]
No	218 (51.7)	7.00±1.80		48.72±7.12	
Yes	204 (48.3)	8.83±1.68		50.95±6.51	
Underlying disease			<0.001[1]		<0.001[1]
No	316 (74.9)	8.18±1.93		50.55±6.66	
Yes	106 (25.1)	7.00±1.81		47.55±7.22	
Financial status			0.472[1]		0.706[1]
Insufficient	134 (31.8)	7.84±2.01		49.61±6.81	
Sufficient	288 (68.2)	7.99±1.86		49.89±6.98	
Relationship			<0.001[1]		0.358[1]
Close up	195 (46.2)	8.35±1.87		49.51±6.99	
Far away	227 (53.8)	7.48±1.96		50.13±6.84	
BCG vaccination			0.585[1]		<0.001[1]
No	117 (27.7)	7.86±2.11		52.96±5.06	
Yes	305 (72.3)	7.96±1.52		48.59±7.16	
Sputum container			0.711[1]		0.422[1]
No	194 (46.0)	7.92±2.03		49.51±6.85	
Yes	228 (54.0)	7.85±1.89		50.05±6.98	
Air conditioner			0.197[1]		0.427[1]
No	350 (82.9)	7.61±1.94		49.68± 6.89	
Yes	72 (17.1)	7.94±1.97		50.39±7.07	
History of COVID-19 infection			0.512[1]		<0.001[1]
No	334 (79.1)	7.92±1.97		51.26±6.66	
Yes	88 (20.9)	7.76±1.95		44.26±4.78	
COVID-19 vaccination status			0.930[1]		<0.001[1]
No	126 (29.9)	7.90±2.08		52.05±6.72	
Yes	296 (70.1)	7.88±1.92		48.84±6.79	
Chest X-ray			<0.001[1]		<0.001[1]
Normal	401 (95.0)	7.99±1.95		50.35±6.58	
Abnormal	21 (5.0)	5.95±1.16		39.29±4.47	

Values are presented mean±standard deviation (SD).
BCG, Bacillus Calmette–Guérin; COVID-19, coronavirus disease 2019.
[1]Independent *t*-test.
[2]One-way analysis of variance.

air conditioning (82.9%).

Table 2 shows the knowledge of tuberculosis, the HBM constructs, and preventive behaviors among household contacts. TB knowledge (41.7%) had a low score. Cues to action (58.5%), perceived severity (54.5%), and preventive behaviors (48.6%) had moderate scores. Perceived susceptibility (65.9%), perceived benefits (76.3%), and self-efficacy (77.5%) had high mean scores.

Table 2. The levels of knowledge of tuberculosis, HBM constructs, and preventive behaviours among household contacts (n=422)

Variables (score)	n (%)
Knowledge of tuberculosis	
Low level (0-7)	176 (41.7)
Moderate level (8-9)	169 (40.0)
High level (10-12)	77 (18.2)
Mean±SD (range)	7.88±1.96 (2-12)
Perceived susceptibility	
Low level (0-17)	3 (0.7)
Moderate level (18-23)	141 (33.4)
High level (24-30)	278 (65.9)
Mean±SD (range)	25.29±3.81 (17-30)
Perceived severity	
Low level (0-21)	96 (22.7)
Moderate level (22-28)	230 (54.5)
High level (29-36)	96 (22.7)
Mean±SD (range)	25.22±4.45 (17-36)
Perceived benefits	
Low level (0-17)	5 (1.2)
Moderate level (18-23)	95 (22.5)
High level (24-30)	322 (76.3)
Mean±SD (range)	26.34±3.62 (17-30)
Self-efficacy	
Low level (0-17)	4 (0.9)
Moderate level (18-23)	91 (21.6)
High level (24-30)	327 (77.5)
Mean±SD (range)	26.38±3.43 (10-30)
Cues to action	
Low level (0-17)	15 (3.6)
Moderate level (18-23)	247 (58.5)
High level (24-30)	160 (37.9)
Mean±SD (range)	22.44±1.89 (16-24)
Prevention behaviors	
Low level (0-39)	43 (10.2)
Moderate level (40-52)	205 (48.6)
High level (53-66)	174 (14.2)
Mean±SD (range)	2.31±0.64 (31-63)

HBM, Health Belief Model; SD, standard deviation.

Statistical analysis using the independent *t*-test on the 11 variables showed that education, underlying disease, relationships with patients, and CXR results were significantly associated with TB knowledge ($p<0.05$). Age was also found to be significantly associated with TB knowledge when analyzed using one-way ANOVA. Furthermore, there were significant associations between preventive behaviors and the variables of education, underlying disease, BCG vaccination, COVID-19 infection, COVID-19 vaccination, and normal CXR findings ($p<0.05$). The association between age and preventive behaviors was also significant, as demonstrated by the one-way ANOVA statistics presented in Table 1.

Table 3 shows the Pearson correlation coefficients between TB knowledge, the HBM constructs, and preventive behavior scores among household contacts. Preventive behaviors were positively correlated with TB knowledge ($r=0.397$), perceived susceptibility ($r=0.565$), perceived severity ($r=0.452$), perceived benefits ($r=0.581$), self-efficacy ($r=0.526$), and cues to action ($r=0.179$). TB knowledge was also found to be significantly correlated with perceived susceptibility ($r=0.567$), perceived severity ($r=0.494$), perceived benefits ($r=0.485$), and self-efficacy ($r=0.431$).

After controlling for age, education, underlying disease, relationship, and BCG vaccination, the highest standardized regression coefficient for explaining preventive behavior scores was found for perceived benefits ($\beta=0.545$), followed by perceived susceptibility ($\beta=0.528$), and self-efficacy ($\beta=0.479$) (Table 4).

Table 5 presents an analysis of the relationship between knowledge, HBM constructs, and preventive behavior in relation to CXR results. Using simple logistic regression analysis, significant associations were found between abnormal CXR results and several factors: knowledge (odds ratio [OR], 0.60), perceived susceptibility (OR, 0.71), perceived severity (OR, 0.87), perceived benefits (OR, 0.84), self-efficacy (OR, 0.82), and cues to action (OR, 0.81). The analysis also indicated that the odds of having an abnormal CXR decreased by 30.0% for each 1-unit increase in the preventive behavior score (OR, 0.70; 95% confidence interval, 0.61 to 0.79).

DISCUSSION

In this study, the HBM was used to explain the relationship between its constructs and TB preventive behaviors and CXR findings. Our findings indicate that TB knowledge, perceived susceptibility, perceived severity, perceived benefits, self-efficacy, and cues to action are all statistically associated with TB preventive behaviors. These results align with previous research, which suggests that individuals' actions toward health are influenced by their knowledge, readiness to change, and mental preparedness to act. Additionally, the perceived risk and severity of a disease can motivate individuals to take preventive

Table 3. Correlations between the preventive behavior score, Health Belief Model constructs, and knowledge among household contacts using Pearson correlation coefficients (n=422)

Variables	1	2	3	4	5	6	7
1. Preventive behaviors	1.000	-	-	-	-	-	-
2. Perceived susceptibility	0.565**	1.000	-	-	-	-	-
3. Perceived severity	0.452**	0.618**	1.000	-	-	-	-
4. Perceived benefits	0.581**	0.764**	0.564**	1.000	-	-	-
5. Self-efficacy	0.526**	0.682**	0.480**	0.788**	1.000	-	-
6. Cues to action	0.179**	0.153**	0.053	0.236**	0.243**	1.000	-
7. Knowledge	0.397**	0.567**	0.494**	0.485**	0.431**	0.024	1.000

**$p<0.01$.

Table 4. Associations of knowledge and HBM constructs with preventive behavior scores among household contacts using linear regression (n=422)

Factors (score)	B	SE	Beta	*p*-value	95% CI		R^2
					LL	UL	
Knowledge	1.395	0.158	0.397	<0.001	1.08	1.70	0.157
Knowledge[1]	1.284	0.160	0.365	<0.001	0.97	1.60	0.245
Perceived susceptibility	1.025	0.073	0.565	<0.001	0.88	1.17	0.319
Perceived susceptibility[1]	0.957	0.076	0.528	<0.001	0.81	1.11	0.367
Perceived severity	0.702	0.068	0.452	<0.001	0.57	0.83	0.205
Perceived severity[1]	0.642	0.065	0.414	<0.001	0.51	0.77	0.293
Perceived benefits	1.113	0.076	0.581	<0.001	0.96	1.26	0.338
Perceived benefits[1]	1.044	0.079	0.545	<0.001	0.89	1.20	0.386
Self-efficacy	1.060	0.084	0.526	<0.001	0.89	1.22	0.277
Self-efficacy[1]	0.964	0.090	0.479	<0.001	0.79	1.14	0.319
Cues to action	0.655	0.175	0.179	<0.001	0.31	1.00	0.032
Cues to action[1]	0.489	0.169	0.134	0.004	0.16	0.82	0.146

HBM, Health Belief Model; SE, standard error; CI, confidence interval; LL, lower limit; UL, upper limit.
[1]Adjusted for age (years), education, underlying disease, relationship, and Bacillus Calmette–Guérin vaccination.

Table 5. Associations of knowledge, HBM constructs, and preventive behavior scores with CXR results among household contacts using simple logistic regression (n=422)[1]

Factors (score)	B	SE	*p*-value	OR (95% CI)	Nagelkerke R^2
Knowledge	-0.516	0.116	<0.001	0.60 (0.47, 0.75)	0.148
Perceived susceptibility	-0.347	0.080	<0.001	0.71 (0.60, 0.83)	0.188
Perceived severity	-0.139	0.061	0.022	0.87 (0.77, 0.98)	0.044
Perceived benefits	-0.168	0.058	0.004	0.84 (0.75, 0.95)	0.061
Self-efficacy	-0.199	0.057	0.001	0.82 (0.73, 0.92)	0.085
Cues to action	-0.210	0.094	0.026	0.81 (0.67, 0.98)	0.031
Preventive behaviors	-0.363	0.067	<0.001	0.70 (0.61, 0.79)	0.410

HBM, Health Belief Model; CXR, chest X-ray; SE, standard error; OR, odds ratio; CI, confidence interval.
[1]CXR (normal=0, abnormal=1); knowledge, perceived susceptibility, perceived severity, perceived benefits, perceived barriers, self-efficacy, cues to action, and preventive behaviors are analyzed as continuous data.

measures [25,26]. Cognitive variables, such as TB knowledge and family involvement, have been shown to significantly affect self-care behaviors and self-efficacy in patients [27]. A study conducted in India found that most patients do not practice TB preventive behaviors and continue to have close contact within their households [28]. This highlights the need to increase preventive behaviors to minimize exposure to TB patients and curb the transmission of the disease. Our research suggests that an intervention based on the HBM could be effective in increasing awareness and promoting preventive behaviors among individuals who come into contact with TB patients.

In addition, this finding is consistent with previous studies suggesting that the HBM is appropriate for predicting behaviors that prevent disease, reduce barriers to treatment, and augment awareness, perceived health benefits, and self-efficacy in managing TB [21,25]. Similarly, previous studies have indicated that the HBM is a suitable model for predicting therapeutic adherence in TB patients and emphasized the importance of self-efficacy in treatment compliance [29,30]. Additionally, the results revealed that the relationships between health beliefs and behavioral constructs (including susceptibility, severity, and the perceived net benefits of prevention behavior) were centered on action cues, which were linked to all the other HBM variables [31]. In line with this, a correlation analysis of the HBM constructs identified them as predictors of model-based health promotion, revealing that knowledge, perceived risk, and severity were significantly associated with TB preventive behavior [32]. Moreover, perceived benefits emerged as the strongest predictor of preventive behavior, while the perceived susceptibility construct was identified as the second most crucial target for implementing behavior improvement interventions [33]. Even though the HBM may partially account for preventive behaviors among household contacts of TB patients, who are at a heightened risk of TB infection, it is important to note that the transmission of TB from one person to another through the air is influenced by factors such as proximity, susceptibility to the disease, and the duration of exposure [7].

When classifying the level of knowledge, the results showed that most participants achieved only moderate to low scores. They performed poorly on knowledge items and received incorrect information, such as the misconception that "heat and sunlight can kill TB disease"; they were unaware that TB is caused by bacteria. This finding is consistent with a study in India, where the sample group had an average score of 61%. However, upon examining their educational backgrounds, it was found that the majority had only basic or low levels of education [34]. Regarding perceived susceptibility, participants scored poorly on items such as "You can contract TB if you do not wear a mask when having close contact with TB patients during the first 2 months" and "You are likely to contract TB if the patient spits saliva or sputum into an open container." Similarly, for perceived severity, items like "If your family member is infected with TB, you will be shunned by society" and "Infection and illness with TB do not impair lung function" received low scores.

When analyzing the mean scores, it was found that most participants engaged in preventive behaviors at a moderate level. The preventive behaviors that require improvement among TB contacts are handwashing with soap or antiseptic after being in contact with TB patients, due to the risk of contamination from phlegm, mucus, and saliva; wearing a mask during close contact; and undergoing health screenings for TB every 6 months. Moreover, our findings indicated that lower scores in preventive behaviors, knowledge, and other factors within the HBM constructs were significantly associated with a higher risk of abnormal CXRs. This underscores the importance of preventive behaviors among household contacts to protect themselves and reduce the risk of TB infection. However, the small number of abnormal CXRs may affect the power of the analysis, suggesting that further investigation is needed to confirm the ultimate outcome. As this study was conducted during the fourth wave of the COVID-19 pandemic in Thailand, it is crucial to investigate the exposure of TB patients' household contacts to TB. This research aligns with a previous study that suggested the COVID-19 pandemic could severely disrupt TB prevention and control, especially in low-income and middle-income countries. The burden of TB is significant, as it can impact the self-care behaviors of TB patients, the spread of the disease within households, and the treatment and diagnosis. It also affects healthcare services, treatment costs, and the overall prevention and control of the disease [35].

This study has several limitations. First, the data were collected at the hospital's TB clinic using a self-administered questionnaire. As a result, there is a potential for information bias if participants provided unclear or untruthful responses. Second, the study's findings may not be generalizable to other settings. Consequently, the applicability of this study is primarily limited to the rural areas of Chiang Rai Province, Thailand. Third, it is not possible to draw causal conclusions from this study, as it only establishes a correlation between knowledge, the HBM constructs, and the preventive behaviors observed in the samples from the selected study area. Therefore, experimental and/or longitudinal studies are necessary to determine the causal relationships of disease structures, prevention, and control in the region. Fourth, future research should consider cultural, political, and economic factors in addition to the HBM constructs to gain a more comprehensive understanding of the perceptions and beliefs associated with TB among indigenous populations, as well as the barriers to disease prevention.

In conclusion, this study provides empirical evidence highlighting the significance of social factors in explaining TB preventive behavior using HBM constructs. The results further indicate a correlation between TB knowledge, HBM constructs, and preventive behaviors that influence CXR outcomes among the household contacts of pulmonary TB patients. Additionally, the concerns highlighted by the HBM constructs suggest their utility in shaping preventive behaviors into effective health promotion strategies. Health education programs should focus on enhancing the perception of disease severity and strengthening self-efficacy, equipping individuals with the perceived benefits necessary to take action and make informed decisions regarding health and preventive behaviors. It is also crucial to prioritize rapid screening in health assessments to manage and curb the transmission of TB among the household contacts of TB patients.

NOTES

Conflict of Interest

The authors have no conflicts of interest associated with the material presented in this paper.

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