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Determining Relationship Between Physical Health Care Settings and Mycobacterium Tuberculosis

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Abstract. Healthy indoor air environment quality is needed for healthy building hospital. *Mycobacterium tuberculosis* (MTB) is a microbial infectious agent which causes tuberculosis (TB) disease in human. Hence, health care workers (HCWs) are belonged to a highly potential risk group to be infected by MTB. This research aims to investigate the source and factor(s) of TB transmission in sustainable indoor air environment at the Hospital Sultanah Aminah Johor Bahru (HSAJB), Malaysia. The view taken in this paper is that the transmission dynamic of MTB from an active pulmonary TB (PTB) patient to another person via indoor air environment in the health care setting is generated as a result of an interaction between architect, building planner and owner, design and facility engineer, construction engineer, occupational health and safety professionals, hospital and HCWs, epidemiologist and public health officer. The findings were obtained by combining questionnaire and interview approaches using five ordinal measures of agreement using Likert Scale measurement. Analysis of qualitative data found that the source of MTB transmission was coming from active PTB patients especially those with sputum smear positive (SS+). The studied ambient parameters and factors affecting indoor air environment sustainability were thermal comfort, humidity, air pressure, temperature, duration exposure, area and volume, direction of air flow, lighting, air circulation exchange and MTB density in the air.

Introduction

Healthy indoor environment is a prerequisite for healthy building hospital. Therefore, good room setting is crucial in order to have good indoor air environment. Room setting is the concept design for the provision of room facilities, room layout, location of room, interior finishing, air supply, and exhaust locations with maintenance accessibility. Health care workers (HCWs) refer to persons who are working in the hospital with potential risk of exposure to Mycobacterium tuberculosis (MTB), through air space shared with infectious Tuberculosis (TB) disease patients, [1] thus contracting the tuberculosis (TB) disease.

TB is primarily an airborne disease. The MTB spreads from person to person through microscopic droplets released from an active TB sufferer when he/she coughs, sneezes, speaks, sings, or laughs. Anyone goes into MTB contaminated air environment would breathe the MTB into their lungs. Nevertheless, persons exposed to MTB may not immediately show TB symptoms due to the ability of the MTB to stay dormant. An infection of MTB in a person without overt clinical TB symptoms is known as latent TB infection (LTBI) [2]. Majority of TB disease affects lungs causing pulmonary TB (PTB) which is infectious. Moreover, TB also affect organs other than lungs (extra-PTB) such TB spine, lymph nodes, kidneys, brain *et cetera* as due to lysis (break down) of

macrophage containing MTB in blood and lymphatic drainage at the affected organ. TB infectivity rate is profoundly reduced after two weeks of TB treatment [3]. Furthermore, TB can be cured by adhering to the strict anti-TB regime (including isoniazid and rifampicin) for at least six months [4].

The World Health Organisation (WHO) estimated that one in every three persons alive carries the TB infection worldwide. In 2008, about 9.4 million new cases of TB (with two million deaths) were detected which were equivalent to 139 cases per 100,000 of the world population. Most cases of active TB occur in regions of Africa (55%) and Asia (30%), with small proportions of cases in the other region. Hence, TB is a threat to public health causing a significant morbidity and mortality [5]. In Malaysia, TB notification and mortality rates for the year 2009 were 63.95 and 5.59 per 100,000 populations respectively [6].

Problem Statement

The primary objective of designing a work place, a health care setting in this case, is to provide conducive environment that sustains the activities, by the HCWs, to be carried out within. Indoor air environmental quality components which have been quantified by the Department of Building Services Engineering of Hong Kong Polytechnic University (1998) are :

(i) Indoor air quality which refers to the levels of freshness, health and comfort, and related sensory immunity to any chemical or toxicological effects of compounds within the air;
(ii) Ventilation which facilitates the naturally occurring ventilation and exhausts stale air; and
(iii) Thermal comfort which refers to the temperature, to the air velocity, to the humidity, and to the insulation [7].

Above components must be considered in order to achieve healthy indoor air environment. Also, area setting such as windows or doors opening, placement of windows or doors into allowing through-flow of air, ceiling height, floor area and wind speed can be used as control measures for MTB transmission [8,9]. These parameters lead to key research questions as following:

(i) Where is the source of MTB disease in indoor air environment?
(ii) Who are at high risk of getting TB infection?
(iii) What are the sustainable factors to protect and control TB transmission?

Aim and Objectives

This research aims to study the source of TB transmission and the indoor air environment sustainability factors that control TB transmission. Specific objectives to be achieved are:

(i) To identify the source of active TB disease in indoor air environment;
(ii) To identify the transfer medium of MTB in indoor air environment; and
(iii) To determine indoor air environment sustainability factors for TB transmission, for better protection and control.

Methodology

This research was carried out in four stages : First, searching a comprehensive literature reviews from academic and non-academic publications, journals, newspapers and commercial online data bases. Second, conducting face-to-face interview using structured questionnaires, divided into four sections, on 50 respondents who were HCWs working at the respiratory clinic and TB isolation ward at the Hospital Sultanah Aminah Johor Bahru (HSAJB). The interview explored HCWs' perception on TB transmission using Likert's scale of five ordinal measures of agreement ranging from strongly disagree which was labeled as "1", and to strongly agree which was labeled as "5" [10]. Third, analysing data collection using SPSS 15.0 from SPSS Inc. and spreadsheet. Fourth, interpreting the findings by focusing on source and sustainable factors that contribute to TB transmission within the health care setting.

Results

A total of 50 questionnaires, from respective 50 respondents, was collected and analysed. Majority of the respondents were females (62%). Out of all respondents, 40% were skilled HCWs such as nurses and assistant medical officers; followed by a mixed group of unskilled and concessionaires workers (22%) such cleaners and auxillary workers; and professionals (16%) such as doctors, as shown in Figure 1.

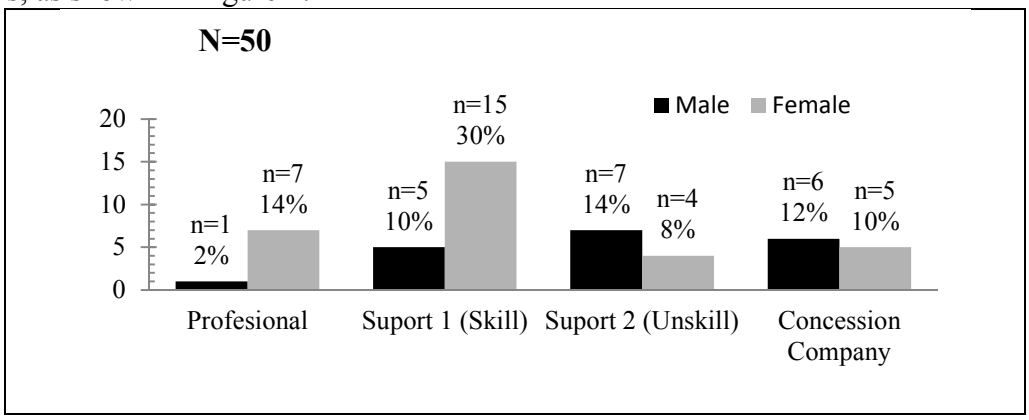

Figure 1: Respondents (HCWs) by Gender and Job Category

Findings for Objective 1

Referring to Figure 2, MTB was identified to be the main source of TB disease based on the mean = 4.54 (90,8%). TB transmission from the source was found to be contributed to delay in TB treatment (mean = 4.68, 93.6%) and TB incidence among illegal immigrants who did undergo TB screening (mean = 4.38, 87.6%).

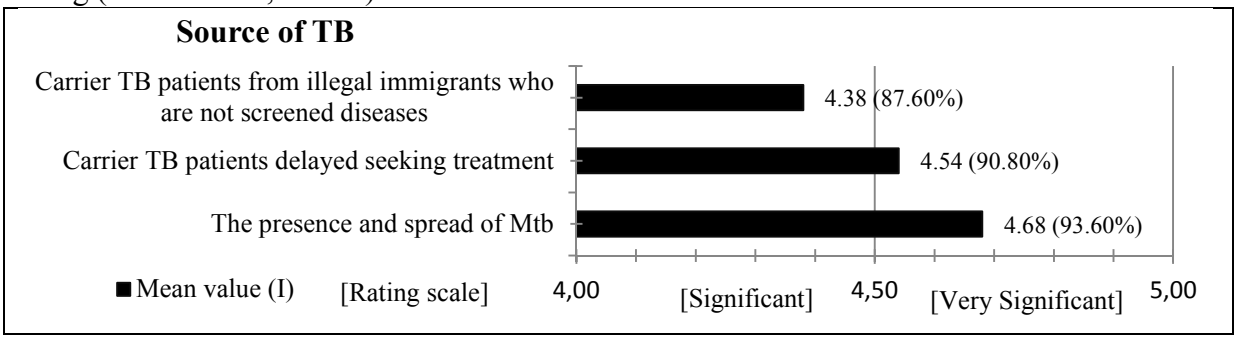

Figure 2 : The Mean Value and Significant Level of Respondents' Agreement on Source of TB

Findings for Objective 2

Figure 3 highlights the findings for Objective 2 whereby the respondents agreed that the medium of MTB transmission was droplet nuclei through air (mean = 4.78, 95.6%); followed by release of MTB into indoor air environment when an active TB patient coughs or sneezes (mean = 4.68, 93.5%); inhalation of MTB by exposed persons (mean = 4.60, 92.0%); and TB infection that started from the lungs (mean = 4.34, 86.0%).

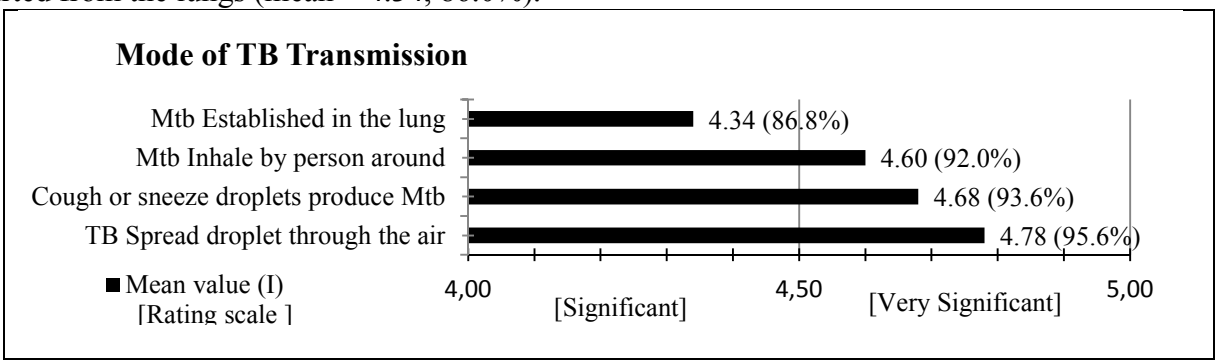

Figure 3: The Mean Value and Significant Level of Respondents' Agreement on TB Transmission

Findings for Objective 3

Figure 4, 5 and 6 representing the findings for Objective 3 that determining the indoor air environment sustainability factors for TB transmission and proposed TB protection and control. Figure 4 and Table 1 shows list the findings on Indoor air Environment Sustainability (IES) factors which were air pollutant density from MTB, indoor air circulation and exchange, lighting, direction of air flow, area and volume, duration of exposure, temperature, air pressure, and thermal comfort. All the ten IES factors obtained had mean values in the range between 4.14 (82.80%) and 3.86 (77.20%).

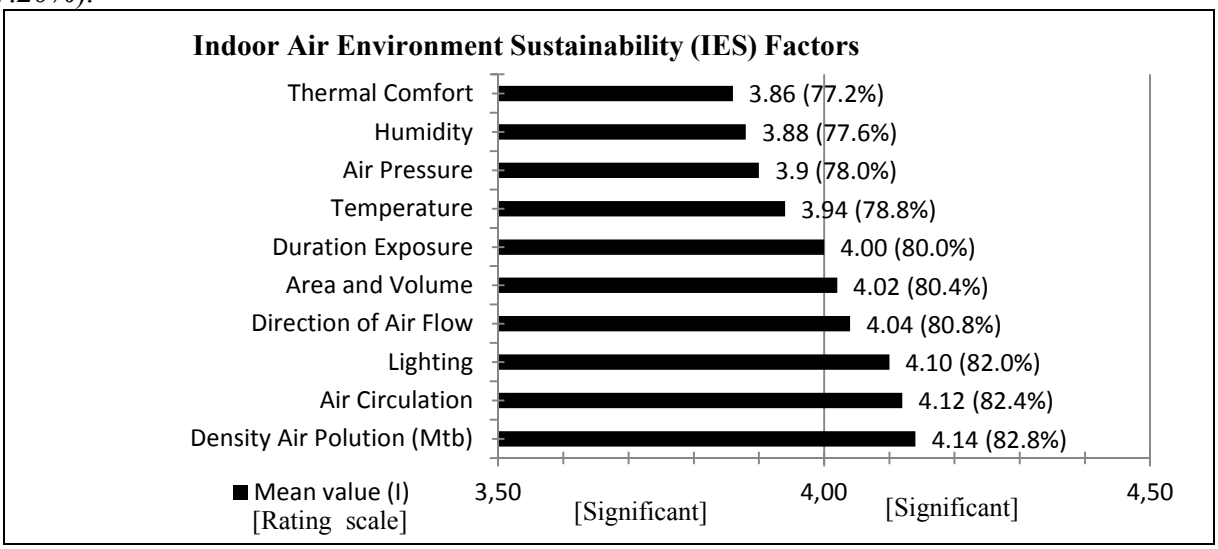

Figure 4 : The Mean Value and Significant Level of Respondents' Agreement on Indoor air Environment Sustainability (IES) factors Contributing TB Transmission

Table 1: Factors of Indoor air Environment Sustainability (IES) for TB Transmission and Proposed TB Protection and Control

Ranking	IES Factor for TB Transmission	Proposed IES Factor for TB Transmission	
		Control	Protection Indoor Air Environment
1	**D**ensity air pollution (MTB)	Source MTB	Does not exist Mycobacterium tuberculosis
2	**A**ir circulation and exchange	Ventilation, Air dilution	Indoor; 20 air change in hour (ACH) and with outdoor ; 4 ACH or natural air ventilation
3	**L**ighting	Sun light or Artificial light	Natural light with solar UV-C irradiation or Ultraviolet germicidal irradiation (UVGI)
4	**D**irection of air flow	To or from patients	Air supply to exhaust or return air
5	**A**rea and volume	Size room	Area (LxW) m^2 and volume (LxWxH) m^3 per occupants
6	**D**uration exposure	Hours or days	Less or not close to patient or used respiratory personal protection equipment (PPE)
7	**T**emperature	Cool and hot	In room; 20^0C to 24^0C and normal body; $36.0^0C \leq T_{body} < 37.5^0C$
8	**A**ir pressure	atmospheric pressure	Natural or Positive or Negative below atmospheric pressure
9	**H**umidity	Relative humidity	Relative Humidity in room 20% to 60%
10	**T**hermal comfort	Cold to hot	Comfort zone; -0.5 < Predicted Mean Vote (PMV) < +0.5 and Predicted Percent Dissatisfied (PPD)

The following Figure 5 shows that the respondents' preference in Heating Ventilating and Air Conditioning system (HVAC) in rendering TB transmission. Natural air ventilation and use of fan were found to be the main preferred choices with level of agreement at 4.02 (80.40%) and 4.22 (84.40%) respectively. Both were the common methods applied at the TB ward and consultation rooms at the Respiratory Clinic, HSAJB. Choices on the other two systems of hybrid and split air-conditioned systems resulted in moderately significant results with mean index at 3.08 (61.60%) and 2.70 (54.00%) respectively. The least preference was the centralised air-conditioned system with mean at 2.48 (49.60%).

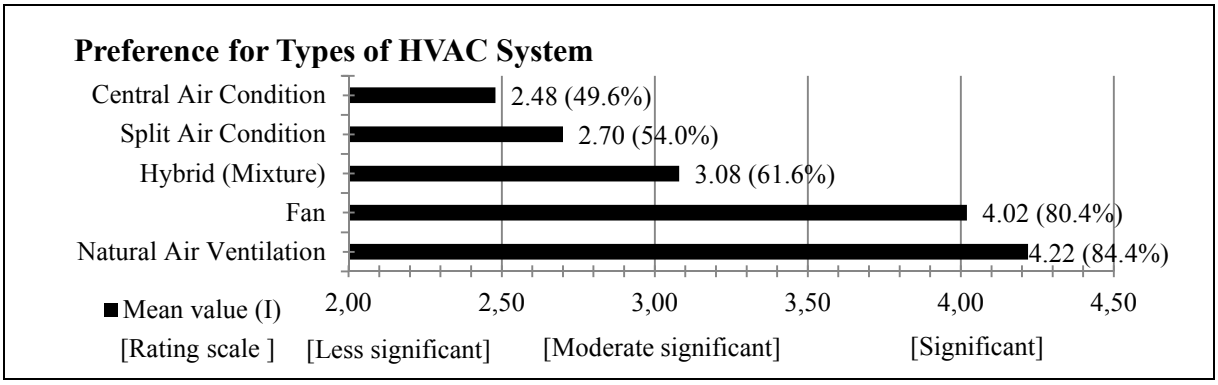

Figure 5 : The Mean Value and Significant Level of Respondents' Agreement in the Preference of Heating Ventilating and Air Conditioning (HVAC) System

Figure 6 lists out preferred types of air disinfection system with their mean values (and significant level of agreement) ranged between 4.10 (82.00%), which was sunlight consisting ultraviolet rays, and 3.76 (75.20%) with the use of ultraviolet germicidal irradiation (UVGI) devices.

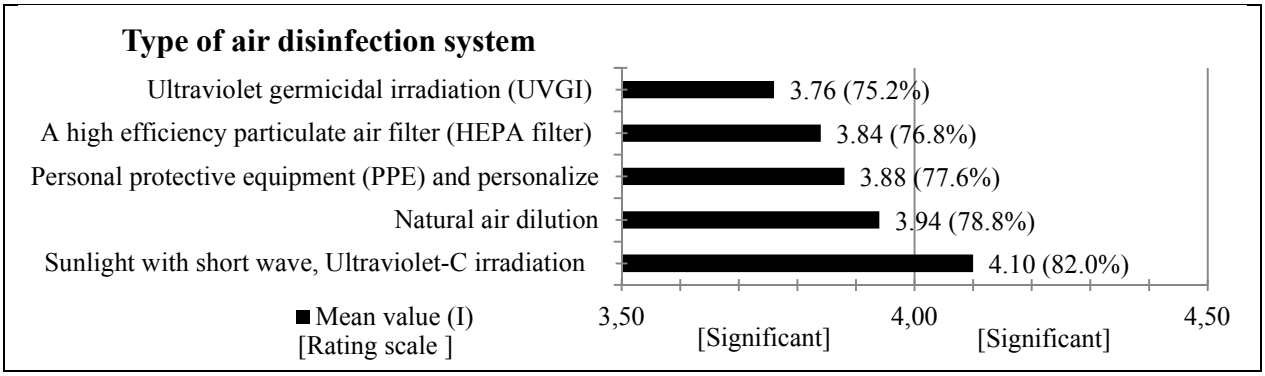

Figure 6 : The Mean Value and Significant Level of Respondents' Agreement on Types of Air Disinfection System

Conclusion

Findings from this study agree with the multiple IES factors that contribute to TB transmission in an indoor air environment. Hence, lack of compliance on the requirements of IES factors may significantly increase exposure risk to TB infection among HCWs as well as the public within the health care settings. Also, these findings will help in enhancing further research in TB related areas concerning appropriate design in building up hospital and health care setting.

Recommendations

The researcher has identified IES factors for TB infection control in hospital or health care setting. However, this study had gathered information mainly from the second level input which from the view of engineering and environmental control. Nevertheless, actual control measurements of the identified factors need to be further explored which is best to be conducted by Ministry of Health (MoH) Malaysia. In addition, TB exposure can be minimised by also applying the first level and the second level of the TB infection control by complying to administrative procedures; and appropriate protective personal equipment (PPE) usage.

Suggestions on future research by expanding the areas of interest from this study are :

i. Identification of the optimal IES factors in controlling TB transmission
ii. Effective use of IES control factors in sustaining an indoor air environment
iii. Use and benefits of applying Green Building Index (GBI) for TB infection control in Malaysia

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