The Sources and Factors of Tuberculosis Transmission at Hospital for Sustainable Indoor Air

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Abstract-**The Sick Building Syndrome is often related to poor indoor air quality. Healthy indoor environment is needed for a healthy hospital building. Appropriate design elements need to be implemented to accommodate the mass usage of a hospital's various facilities. Tuberculosis (TB) is an infectious disease most commonly caused by *Mycobacterium tuberculosis* (MTB) which can spread via inhalation of infected aerosols. Therefore, Health Care Workers (HCWs) in a hospital are most vulnerable to TB infection. This paper explicates the sources and factors of TB transmission in the indoor environment of Hospital Sultanah Aminah Johor Bahru, Johor, Malaysia (HSAJB). The study considered the relationship between the physical layout of the TB ward and its indoor air environment quality. This study utilized the opinions from HCWs who are directly exposed to this kind of environment. The data were obtained from face-to-face questionnaire surveys. The questionnaire used the Likert Scale with five ordinal measures of agreement. From the study, it was found that the source of TB transmission is from positive MTB carriers or active TB patients. Ten factors that control the indoor air environment sustainability (IAES) of TB ward are relatively connected to space area design of TB ward.**

Keywords-Health Care Workers; Healthy Building Hospital; Qualitative Data; Sustainable Indoor Air Environment; Tuberculosis

I. INTRODUCTION

Healthy indoor environment is needed for a healthy building including the hospital. In relation to that, the room setting is important to provide better indoor environment. The room setting takes into account the room facilities, room layout, location of room, interior finishing, air circulation system and accessibility for maintenance purposes which are vital to the design concepts of a room [1]. Tuberculosis (TB) is primarily an airborne disease [2],[3] whereby the bacteria are transmitted from person to person via tiny microscopic droplets which are expelled and suspended in the air when an active TB patient coughs, sneezes, speaks, sings, or laughs. Individuals with close contact to the patient are at a high risk of acquiring TB infection [4]-[6]. Health Care Workers (HCWs) refer to the personnel working in a hospital. They are most vulnerable to TB infection because of the indoor air environment which contains these bacteria known as Mycobacterium tuberculosis (MTB) [7],[8].

About one in every three people carries the TB infection and is at risk of TB disease. In 2008, there was an estimated 9.4 million new cases of TB per year which is equivalent to 139 cases per population of 100 000 globally and two million deaths per year. Most cases of active TB occur in regions of Africa (55%) and Asia (30%), with small proportions of cases in the other regions [9],[10]. Sources from Health Fact 2010, Heath Information Centre, Planning and Development Division, Ministry of Health Malaysia indicate that the tuberculosis communicable disease incidence rate and mortality rate per population of 100 000 are 68.25 and 5.50 respectively [11],[12]. In 2010 there were 2,088 recorded TB patients in Johor [11].Therefore HCWs is highly susceptible to MTB [9]-[15].

The risk of MTB infection is related to several factors: organism load, ventilation of working environment, protective measures taken by the HCWs and duration of exposure to the human body. The quantity of risk varies according to the type of health care setting; the prevalence of TB in the community; the patient population served; the area of the healthcare facility in which the HCWs work; and the effectiveness of TB infection control interventions. Currently TB prevention and surveillance among HCWs under the Ministry of Health, Malaysia followed the second edition of Clinical Practice Guidelines for the Control and Management of Tuberculosis, published in 2002 [13]-[16].

All these indoor air environmental quality components will come together in an ideal situation to produce an indoor air environment that satisfies all occupants. The TB colony transmission is hypothetically associated with multiple regressions. This will elucidate the relationship between the sources of TB disease and the factors which influence the design of health care setting that can help to provide a more sustainable indoor air environment quality [13]-[16].

II. RESEARCH METHODOLOGY AND METHODS

This paper entailed the administration of a questionnaire survey as a means of gathering the opinion of HCWs. A face-to-face questionnaire survey was selected to have respondents who are involved as the HCWs for TB related treatment. Respondents were required to fill in only one questionnaire form. The questionnaire form was structured into four (4) sections:

Section 1.0: Background data of the respondents;

- Respondent's Demographic.

Section2.0: General information on the sources of tuberculosis in hospital;

- View on the main causes of tuberculosis.

Section 3.0: Transmission of tuberculosis in hospital;

- Dissemination and transfer of the tuberculosis disease.

Section 4.0: Factors of sustainable indoor air environment for protection and control of tuberculosis transmission;

- Control factors for sustainable indoor air environment.

- Preference of Heating, Ventilation and Air Conditioning (HVAC) systems.

- Type of protection and air disinfection system

The result of the data collected was summarized by using mean value index analysis. In the data analysis, Likert's scale with five ordinal measures of agreement ranging from strongly disagree (1) to strongly agree (5) has been used in the questionnaire. The mean value index (I) analysis for each variable was calculated by using the similar classification of the rating scale proposed by Abd. Majid (1997) and Likert scaling as follows [13],[15],[17]:

$$\text{Mean Value Index (I)} = \left[\frac{\sum_{i=1}^{5} \alpha_i x_i}{\sum_{i=1}^{5} X_i} \right] \quad (1)$$

Where,

a_i = constant expressing the weight given to i,

x_i = variable expressing the frequency of the response for i;

i = 1, 2, 3, 4, 5 and illustrated as follows:

X_1 = frequency of the 'strongly disagree' response and corresponding to $a_1 = 1$;

X_2 = frequency of the 'disagree' response and corresponding to $a_2 = 2$;

X_3 = frequency of the 'not sure' response and corresponding to $a_3 = 3$;

X_4 = frequency of the 'agree' response and corresponding to $a_4 = 4$; and

X_5 = frequency of the 'strongly agree' response and corresponding to $a_5 = 5$.

TABLE I DESCRIPTIONS OF THE RATING SCALE AND MEAN VALUE INDEX (I) OF AGREEMENT WHICH RESPONDENTS USED IN THE STUDY

Ordinal Numbers	Agreement	Mean Value Index (I)	Rating Scale
1	"Strongly Disagree"	$1.00 \leq (I) < 1.50$	Insignificant
2	"Disagree"	$1.50 \leq (I) < 2.50$	Less Significant
3	"Not Sure"	$2.50 \leq (I) < 3.50$	Moderately Significant
4	"Agree"	$3.50 \leq (I) < 4.50$	Significant
5	"Strongly Agree"	$4.50 \leq (I) \leq 5.00$	Very Significant

After the compilation of responses, all types of data received under different questions had been separated and gathered to answer different research objectives. The data were categorized under different variables to represent the result of the research objectives. Table 1shows that the analysis of data according to different objectives was done by using different statistical methods such as frequency analysis and mean value index analysis. The empirical data were collected and then analyzed by using the Statistical Packages for Social Sciences or SPSS 15.0 and Microsoft Office Excel 2003 software. The SPSS software established comprehensive and efficient statistical analysis of data in the form of a percentage, mean, standard deviation, variance and total number of questionnaire feedbacks.

III. RESULTS AND DISCUSSIONS

The answer selection for the questionnaire consists of predetermined answers. A total of 50 questionnaire forms were collected and then analyzed. The frequency of the answer was calculated in the form of percentage. The percentage is used to review the actual situation and the significance of the sources and factors of Tuberculosis transmission at a hospital for indoor environment sustainability. The proportions of 50 respondents who are HCWs in four (4) categories of service is working in the hospital. In this study it consists of 5.00% male and 15.00% female from the skilled worker group Support 1 such as registered staff nurses and assistant medical officers; 14.00% male and 8.00% female from the unskilled worker group Support 2 such as health care assistants; 12.00% male and 10.00% female from a private company with Ministry of Health Malaysia concession such as cleaning staff and maintenance workers; and, 2.00% male and 14.00% female of professionals such as doctors, medical specialist officers and medical officers.

The respondents' demographic is extracted from the questionnaire forms distributed at the TB Isolation Ward and Respiratory Clinic at Hospital Sultanah Aminah Johor Bahru, Johor, Malaysia (HSAJB). The gender distribution of respondents of which 31 (62.00%) were female and 19 (38.00%) were male, and also based on the categories of service of the HCWs which comprised of 8 (16.00%) professionals, 20 (40.00%) skilled workers and 22 (44.00%) who are unskilled workers group support 2 or from a concessionaire company.

The main source of TB disease is from MTB, followed by carriers who delay seeking treatment, both of which resulted in significant mean value index of 4.68 (93.60%) and 4.54 (90.80%) respectively. Illegal immigrants also contributed to the high incidence rate of TB as they are usually carriers who have not undergone TB infection screening. The level of agreement resulted in a mean value index of 4.38 (87.60%). Figure 1 shows the findings for the main sources of active TB disease in indoor environment.

The transmission medium of MTB is the droplet nuclei suspended in the air which are produced when a TB carrier coughs or sneezes. Air contaminated with MTB droplets will be inhaled by people in the surrounding and infect the lung. Figure 2 shows the significant level of agreement for the transmission medium with the highest mean value index of 4.78 (95.60%) recorded for TB spread via droplet nuclei in the air. This is followed by MTB spread by cough or sneeze droplet nuclei with a mean value index of 4.68 (93.60%). The

third most significant transmission medium is inhalation of MTB by surrounding people with a mean value index of 4.60 (92.00%) and lastly MTB infection in the lung at a mean value index of 4.34 (86.80%).
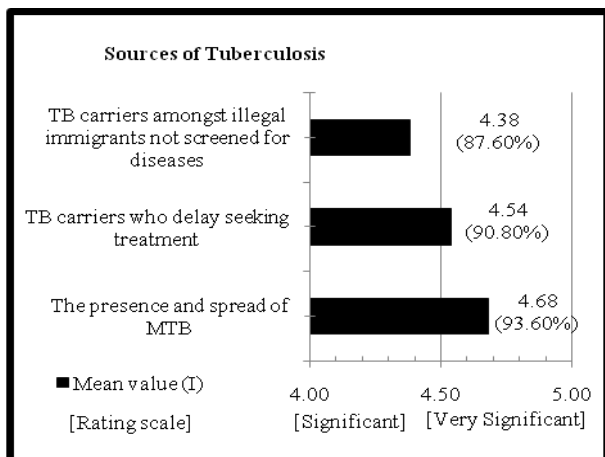

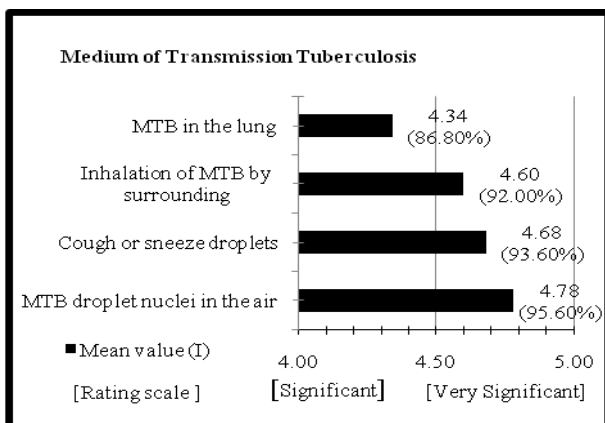Figure 1: Main Sources of active TB disease in indoor environment.

Figure 2: The mean value index and rating scale of significant level of agreement from respondent for transmission medium of TB disease infection.
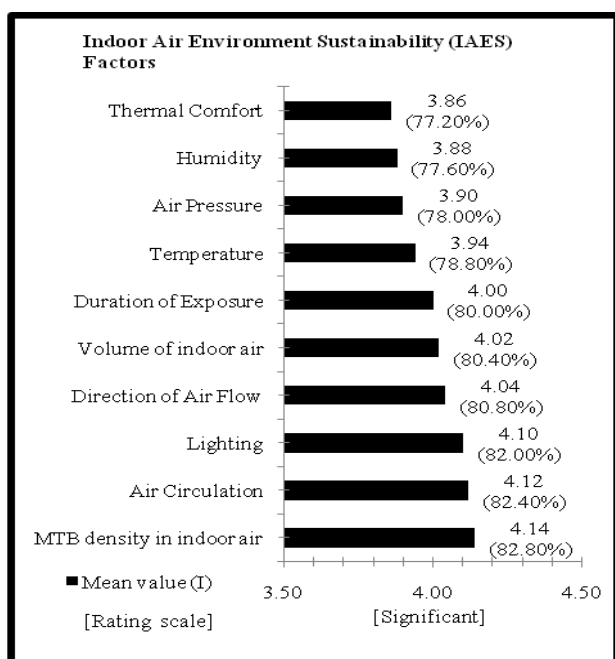

Figure 3: The mean value index and rating scale of significant level of agreement from respondents for Indoor Air Environment Sustainability (IAES) factors related to the transmission and spread of tuberculosis.

Figure 3 represents the finding for sustainability factor of TB disease transmission protection and control. The mean index value was used to determine the response for each factor related to the TB disease. The density of MTB in indoor air shows the highest mean value index that is 4.14 (82.80%) while the lowest is thermal comfort with a mean value index of 3.86 (77.20%). All ten factors are significant causes of TB transmission as all the results show a mean value index of more than 3.50.

IV. CONCLUSION

The findings of this study identifie the various sources and factors of MTB transmission in an indoor air environment. The Ministry of Health Malaysia, HWCs and other governing agencies (such as Department of Occupational Safety and Health (DOSH)) need to combine forces in order to prevent the spread of TB. This can be done by controlling the health care setting layout of hospitals especially for the TB isolation ward. Lack of consideration for sustainable indoor air environment will result in increased exposure of TB to HCWs and the public. It is found that TB transmission starts from TB carriers who produce MTB droplet nuclei which are suspended in the air when coughing and sneezing. Thus, when humans inhale the contaminated air, the MTB will sit in their lungs and become active if no proper medication is administered. This study also determined that there are various factors which influence the transmission of TB. Density of MTB in indoor air, air circulation and exchange, lighting, direction of air flow and duration of exposure are among the significant factors that need to be considered in designing the layout of TB wards. Elements of thermal comfort and its related factors such as humidity, air pressure and room temperature are also important aspects to be justified in designing the health care setting for TB isolation wards. The control of the physical design of TB isolation wards has to be given utmost attention by the Ministry of Health Malaysia. This study therefore recommends detailed measurement of optimum ventilation and thermal comfort related to room setting such as room size, presence of window and door, floor area and height of ceiling. This study will benefit future TB isolation ward development which will provide healthier and safer indoor air environment.

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