**Title:** Tuberculosis among Nurses: Prevalence and Factors that Associated with Infection

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**ABSTRACT**

**Background**: The spread of tuberculosis (TB) is a major health problem that needs to be monitored. Health care workers (HCWs) who perform the services patients in hospital are high risk, especially among nurses who spend a majority of time with patients.

**Objective**: To determine prevalence of TB and factors that associated with TB among nurses.

**Methods**: This study utilized data from Thai Nurse Cohort Study database. It was a mailed survey conducted in 2009 involving a total of 18,756 respondents. The primary outcome was TB infection in service nurses during operation that reported by nurse. Effects of TB were quantified by prevalence, odds ratio (ORs) and its 95% confidence intervals (CIs) using multiple logistic regression.

**Results**: Among 8,378 service nurses included in the studied, 96.4% were female, mean of age 40.3 years (SD = 9.8). Prevalence of TB was 3.5% (95%CI = 3.1 to 3.9). The highest prevalence was in group whose relatives have been TB 6.9% (95%CI: 4.9 to 8.8). Factors that associated with TB showed that age from 30 to 44 years (OR = 2.5; 95%CI: 1.4 to 4.5; p-value = 0.002), and relative have been TB (OR = 2; 95%CI: 1.4 to 2.9; p-value < 0.001).

**Conclusions**: To solve problem, researcher should focus to service nurses whose high age and relatives have been TB. However, this study shows that prevalence of TB remains a health problem that needs to be burned, especially among nurses who closes to patients.

**Key words**: tuberculosis, prevalence, risk factors, associated, nursing

**INTRODUCTION**

Tuberculosis (TB) is caused by *Mycobacterium tuberculosis* infection remains a major global health problem that needs to be monitored.[1](#_ENREF_1)[2](#_ENREF_2) The World Health Organization (WHO) reported about 9 million people in 2011 fell ill with TB and more than 1 million died. TB is highest in Asia and Africa. Almost 40% of the world’s TB cases were in India and China. Thailand is one of the 22 countries in the world with the highest TB infection and prevalence nearly 130,000 cases with populations 64 million.[3](#_ENREF_3)[4](#_ENREF_4) There are many factors that associated with TB infection and occupation is a factor in it, especially among health care workers (HCWs) who spend a majority of time with TB patients.[5](#_ENREF_5)

HCWs especially nurses who perform the services patients in hospital are high risk of TB particular in many low and middle-income countries.[6](#_ENREF_6)[7](#_ENREF_7) [8](#_ENREF_8) The study of TB in National Health Service hospital staff in the West Midlands region of England indicate that most cases of TB were in nurses and doctors.[9](#_ENREF_9) There were several studies reported on TB infection among nurses, for example, tuberculin skin test positive was 69.5% of 128 nursing professionals from Central Brazil,[10](#_ENREF_10) and 42.9% from the 91 nursing home in Puerto Rico.[11](#_ENREF_11) The prevalence of TB infection was 4% of 310 qualify nurses in hospital nurses in Blantyre, Malawi,[12](#_ENREF_12) and among female nurses in British Columbia was 0.25% in who was born in Asia and the highest rate was who had age from 25 years and above.[13](#_ENREF_13) Incidence rate of TB was 188 per 100,000 person-years from 3,959 HCWs at King Chulalongkorn Memorial Hospital in Thailand, and the highest risk was nurse, RR = 2.4 (95%CI: 0.9 to 9.1).[14](#_ENREF_14) The study was aware of the spread of TB among nurse’s issue and health problems that affect their daily lives, which cause by several factors, and factors that may be related to TB included personal factors.

Factors that associated with TB have several aspects, including environmental, behavioral, and personal factors. Previous studies reported that various factors that associated with TB. The study of TB among HCWs in Samara Oblast, Russia found that whose working in TB services were highest risk, with an incidence rate ratio of 17.7 (95%CI 11.6 to 27.0).[15](#_ENREF_15) Study of prevalence and risk factors for latent TB among HCWs in China found that technician staff, working duration for 11 to 20 years and 20 years above, and history of household TB contact were associated with increased risk of TB infection.[16](#_ENREF_16) The study of TB among HCWs at King Chulalongkorn Memorial Hospital found the highest risk TB was emergency room.[14](#_ENREF_14) The study risk of *Mycobacterium tuberculosis* infection among HCW, Chiang Rai, Thailand foundfactors that associated with positive tuberculin skin test were age more or equal 30 years (OR = 2.38; p-value = 0.005), and duration of employment more than 1 years (OR = 2.02; p-value = 0.030).[17](#_ENREF_17) Study of TB among HCWs in a short working period at a teaching hospital in southeast Turkey found that the mean age of nurses was 20.6 years, and the mean working experience was 2.8 years.[18](#_ENREF_18) These problems affect the reliability of health personnel. Especially among nurses that is to find the first checkpoint on the use of health services. Even with measures to prevent this from happening, but it is not possible to eliminate the problem permanently. However, there are few studies on the factors associated with TB infection among nurses.

The above situation can be seen that the spread of TB is a major health problem. TB Infection among nurses just one person can cause problems, which affects the living that needs to monitor and managed to prevent. This study aims to determine the prevalence of TB infection in service nurses and factors that associated with TB infection in Thailand.The study used data from Thai Nurse Cohort Study (TNCS). With the large sample size and spread across the country like this can make the population aware of the broad range of contexts, and much more that are not in the earlier study.

**MATERIALS AND METHODS**

***Study design***

This study is part of the Thai Nurse Cohort Study (TNCs). The TNCs was planned as a 20 years longitudinal cohort study. In 2009 the baseline survey was performed. A random sample of registered nurses (RNs) who held nursing licenses granted by Thailand Nursing and Midwifery Council (TNMC) as of 2008 were surveyed by mailed questionnaires and the respondents were enrolled as cohort members. The first wave of the study was carried out as a cross-sectional survey. The sampling method was stratified random sampling with probability proportional to size of nurses in each 10-year age intervals. This paper involved a total of 18,756 members of the cohort then excluded those nurses who worked outside of service nurses.

***Study population***

A total of 142,699 RNs who held nursing licenses and were listed in TNMC database in 2008 were the population of this study. From the 18,756 RNs who randomly selected, responded to the survey, and agreed to participated as members of the TNCS, 8,708 RNs were excluded for this paper due to worked outside of services nurses and 1,670 missing data, hence 8,378 nurses were included in the analysis (Figure 1).

Excluded due to worked outside of services nurses (n = 8,708)

Cohort members

(n = 18,756)

Studied participants

(n = 10,048)

Services nurses

(n = 8,378)

Missing data (n = 1,670)

**Figure 1** Consort diagram of samples

***Study outcome***

Primary outcome was Tuberculosis infection during the operation that reported by nurses.

***Statistical analysis***

Demographic characteristic of service nurses were described using frequency and percentage for categorical data such as gender, age group, marital status, highest education attainment, received a scholarship, working experienced, and relatives have been TB infected. To describe continuous data such as age of service nurse and working experienced using mean, standard deviation, median, minimum, and maximum.

Prevalence of TB infection was calculated using the number of nurses who reported TB infection during operation as the numerator and total number of nurse who responded to the questionnaire and work in service nurse as the denominator. The 95% confidence interval (CI) of the prevalence was computed based on normal approximation to binomial distribution.

To investigate factors that associated with TB infection, adjusted odds ratios (ORs) and their 95% confidence intervals (CIs) were estimated using multiple logistic regression. This analysis was adjusted for age, marital status, received a scholarship, highest education, working experienced, and relatives have been TB infected that were considered biologically and sociologically relevant or which showing a univariate relationship with TB infection.

All analyses were performed by using STATA version 10.0 (StataCorp, College Station, TX). All test statistics were two-sided and a p-value of less than 0.05 was considered statistical significant. This project was approved by the Human Research and Ethics Committees of the Ministry of Public Health of Thailand.

**RESULTS**

***Demographic Characteristics***

From the 8,378 service nurses, almost of them 96.4% were female with mean of age 40.3 years (SD = 9.8) range from 20.5 to 64.8 years old (Table 1). They were mainly married (64.6%) and mean of working experience 15.5 years (SD = 10.2) range from 0.5 to 53 years.

**Table 1** Demographic characteristic of the service nurses presented as number and percentage

| **Characteristics** | **Number** | **Percent** |
| --- | --- | --- |
| **Gender (n =** **8,338)** |  |  |
|  Male  | 301 | 3.6 |
|  Female  | 8,037 | 96.4 |
| **Age (n =** **8,378)** |  |  |
|  Less than 30 years | 1,642 | 19.6 |
|  From 30 to 44 years | 3,827 | 45.7 |
|  More or equal 45 years | 2,909 | 34.7 |
|  Mean (standard deviation) | 40.3 (9.8) |  |
|  Median (Min : Max)  | 40.5 (20.5 : 64.8) |  |
| **Marital status (n =** **8,347)** |  |  |
|  Single | 2,955 | 35.4 |
|  Married | 5,392 | 64.6 |
| **Highest education attainment (n =** **8,134)** |  |  |
|  Bachelor’s degree | 7,413 | 91.1 |
|  Master’s degree or higher | 721 | 8.9 |
| **Receive a scholarship (n =** **8,115)** |  |  |
|  No | 1,901 | 23.4 |
|  Yes | 6,214 | 76.6 |
| **Working experienced (n =** **8,348)** |  |  |
|  Lower or equal 2 years | 1,008 | 12.1 |
|  More than 2 to 5 years | 682 | 8.2 |
|  More than 5 years | 6,658 | 79.7 |
|  Mean (standard deviation) | 15.5 (10.2) |  |
|  Median (Min : Max)  | 15 (0.5 : 53) |  |
| **Relatives have been infected (n = 8,378)** |  |  |
|  No  | 7,738 | 92.4 |
|  Yes | 640 | 7.6 |

***Prevalence of Tuberculosis infection***

From 8,378 service nurses, prevalence of TB was 3.5% (95%CI: 3.1 to 3.9) (Table 2). Found that prevalence in group whose relatives have been infected with TB were highest 6.9% (95%CI: 4.9 to 8.8). Followed by whose finish master’s degree or higher and age from 30 to 44 years old 4.7% (95%CI: 3.2 to 6.3) and 4.3% (95%CI: 3.6 to 4.9), respectively.

**Table 2** Prevalence of Tuberculosis infection among service nurses and their 95% confidence intervals (CIs)

| **Variables** | **Number** | **Tuberculosis (TB) infection** |
| --- | --- | --- |
| **% TB** | **95% CI** | **p-value\*** |
| **Tuberculosis infection** | 8,378 | 3.5 | 3.1 to 3.9 | NA\*\* |
| **Gender** |  |  |  | 0.155 |
|  Male | 301 | 2 | 0.4 to 3.6 |  |
|  Female  | 8,037 | 3.5 | 3.1 to 3.9 |  |
| **Age (years)** |  |  |  | < 0.001 |
|  Less than 30 years | 1,642 | 1.2 | 0.7 to 1.7 |  |
|  From 30 to 44 years | 3,827 | 4.3 | 3.6 to 4.9 |  |
|  More or equal 45 years | 2,909 | 3.7 | 3.0 to 4.4 |  |
|  Mean (standard deviation) | 41.7 (7.9) |  |  |
|  Median (Min : Max) | 42.7 (22.9 : 60.7) |  |  |
| **Marital status** |  |  |  | 0.113 |
|  Single | 2,955 | 3.1 | 2.4 to 3.7 |  |
|  Married | 5,392 | 3.7 | 3.2 to 4.2 |  |
| **Highest education attainment** |  |  |  | 0.067 |
|  Bachelor’s degree | 7,413 | 3.4 | 3.0 to 3.8 |  |
|  Master’s degree or higher | 721 | 4.7 | 3.2 to 6.3 |  |
| **Receive a scholarship** |  |  |  | 0.031 |
|  No | 1,901 | 2.7 | 1.9 to 3.4 |  |
|  Yes | 6,214 | 3.7 | 3.2 to 4.2 |  |
| **Working experienced (years)** |  |  |  | < 0.001 |
|  Lower or equal 2 years | 1,008 | 1 | 0.4 to 1.6 |  |
|  More than 2 to 5 years | 682 | 2.2 | 1.1 to 3.3 |  |
|  More than 5 years | 6,658 | 4 | 3.5 to 4.5 |  |
|  Mean (standard deviation) | 17.5 (8.9) |  |  |  |
|  Median (Min : Max)  | 17 (0.5 : 42) |  |  |  |
| **Relatives have been infected** |  |  |  | < 0.001 |
|  No  | 7,738 | 3.2 | 2.8 to 3.6 |  |
|  Yes | 640 | 6.9 | 4.9 to 8.8 |  |

\* The p-value of comparison difference prevalence of TB between groups in each variable.

\*\* Not applicable.

|  |  |  |
| --- | --- | --- |
| **Nurses (n)** | **Prevalence (%)** | **95% CI** |
| TB infected (8,378) |  | 3.5 | 3.1 to 3.9 |
| Female (8,037) |  | 3.5 | 3.1 to 3.9 |
| Age 30 to 44 years (3,827) |  | 4.3 | 3.6 to 4.9 |
| Married (5,392) |  | 3.7 | 3.2 to 4.2 |
| MS’s degree or higher (721) |  | 4.7 | 3.2 to 6.3 |
| Receive a scholarship (6,214) |   | 3.7 | 3.2 to 4.2 |
| Working experienced > 5 years (6,658) |  |  4 | 3.5 to 4.5 |
| Relatives have been infected (640) |  | 6.9 | 4.9 to 8.8 |
|   |  |  | 100 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  0 1 2 3 4 5 6 7 |

**Figure 2** Prevalence of TB infection among service nurses

***Factors that associated with TB infection***

Among a total of 8,378 service nurses, factors that associated with TB, presented as adjusted ORs and 95%CIs (Table 3) showed that age from 30 to 44 years (OR = 2.5; 95%CI: 1.4 to 4.5; p-value = 0.002), and relative have been TB infected (OR = 2; 95%CI: 1.4 to 2.9; p-value < 0.001).

**Table 3** Odds ratio (ORs) of factors that associated with TB and their 95% confidence intervals (CIs) for each factor adjusted for all other factors using logistic regression

| **Factors** | **Number** | **% TB** | **Crude OR** | **Adjusted OR** | **95%CI** | **p-value** |
| --- | --- | --- | --- | --- | --- | --- |
| **Age (years)** |  |  |  |  |  | 0.002 |
|  Less than 30 years | 1,642 | 1.2 | 1  | 1  |  |  |
|  From 30 to 44 years | 3,827 | 4.3 | 3.6 | 2.5 | 1.4 to 4.5 |  |
|  More or equal 45 years | 2,909 | 3.7 | 3.1 | 2.1 | 1.2 to 3.8 |  |
| **Marital status** |  |  |  |  |  | 0.573 |
|  Single | 2,955 | 3.1 | 1 | 1 |  |  |
|  Married | 5,392 | 3.7 | 1.2  | 0.9  | 0.7 to 1.2 |  |
| **Highest education** |  |  |  |  |  | 0.456 |
|  Bachelor’s degree | 7,413 | 3.4 | 1 | 1 |  |  |
|  MS degree or higher | 721 | 4.7 | 1.4 | 1.2 | 0.8 to 1.7 |  |
| **Receive a scholarship** |  |  |  |  |  | 0.229 |
|  No | 1,901 | 2.7 | 1 | 1 |  |  |
|  Yes | 6,214 | 3.7 | 1.4  | 1.2  | 0.9 to 1.7 |  |
| **Working experienced (years)** |  |  |  |  |  | 0.046 |
|  Lower or equal 2 years | 1,008 | 1 | 1 | 1 |  |  |
|  More than 2 to 5 years | 682 | 2.2 | 2.2 | 1.6 | 0.7 to 3.7 |  |
|  More than 5 years | 6,658 | 4 | 4.2 | 2.1 | 1.0 to 4.4 |  |
| **Relatives have been infected** |  |  |  |  |  | < 0.001 |
|  No  | 7,738 | 3.2 | 1 | 1 |  |  |
|  Yes | 640 | 6.9 | 2.2 | 2.0 | 1.4 to 2.9 |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Factors** |  | **Adj.OR** | **95% CI** | **p-value** |
| Age from 30 to 44 years old |  | 2.5 | 1.4 to 4.5 | 0.002 |
| Married |  | 0.9 | 0.7 to 1.2 | 0.573 |
|  MS degree or higher |  | 1.2 | 0.8 to 1.7 | 0.456 |
| Receive a scholarship |  | 1.2 | 0.9 to 1.7 | 0.229 |
| Working experienced more than 5 years |  | 2.1 | 1.0 to 4.4 | 0.046 |
| Relatives have been infected with TB |  | 2.0 | 1.4 to 2.9 | < 0.001 |
|  0 |  |  |  |  |  |  |  |  |  |  |  ∞ |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 0.25 | 0.33 | 0.50 | 1 | 2 | 3 | 4 | 5 |

**Figure 3** Factors that associate with TB, presented as odds ratio adjusted for age, marital status, education, scholarship, working experienced and relative have been TB infected

**DISCUSSIONS**

Prevalence of TB infection among nurses was 3.5% (291/8,378). This is consistent with the prevalence in hospital nurses in Blantyre, Malawi, 4% of 310 qualify nurses,[12](#_ENREF_12) but not consistent with the study of TB risk among nurses from Central Brazil, which found that tuberculin skin test (TST) positive was 69.5% of 128 nurses and the study of prevalence rate of TB infection in the 91 nursing home in Puerto Rico was 42.9%, etc.[10](#_ENREF_10)[11](#_ENREF_11) This is because the difference in the size of the sample and other studies conducted in only some areas of the country which do not cover as this study. And possibly due to nurses who had a positive TST result but not as disease, also known as false positive result, which can be lead to estimation errors. However when considering the population of the other side found that the prevalence of TB infection increase with more working experienced, and also increases in the age group from 30 to 44 years, while the prevalence decrease in the age group from 45 years and above. For the average age of those infected with TB are 42 years and work experience is about 18 years, which is different from the study of TB among HCWs in a short working period at a teaching hospital in southeast Turkey found that the mean age of nurses was 20.6 years, and the mean working experience was 2.8 years.[18](#_ENREF_18)

For the factors that associated with TB among nurses, the study found two first factors that most associated include age from 30 to 44 years, and relatives have been TB (OR = 2.5; 95%CI: 1.4 to 4.5; p-value = 0.002), and OR = 2; 95%CI: 1.4 to 2.9; p-value < 0.001, respectively. This were consistent with study risk of *Mycobacterium tuberculosis* infection and disease among HCWs, Chiang Rai, Thailand foundfactors that associated with positive tuberculin skin test were age more or equal 30 years old.[17](#_ENREF_17) While the result of analysis were not controlled by other factors showed that service nurses who received a scholarship, and working experienced were associated with TB, but when adjusted for all other factors, the result found that these factors were not associated with TB.

However, the prevalence of TB infection among service nurse in this study made it possible to image health problems that cannot be ignored. Tuberculosis infection in nursing career although only one person, it could affect the image and credibility among people who use the service in many ways. The service nurse is a profession that is highly dependent on patient needs. Most of the time was spent in the nursing care of patients including consulting health and how to prevent diseases. Therefore, surveillance and prevent such incidents as important measures to be implemented to achieve a substantial reduction in the prevalence of infection among nurses until the end to be eradicated.

***Strength of the study***

This study was conducted in a large population across the country with a variety of cultural, well-being and environmental which can be a good representation of the population will be able to study and reference.

***Limitation of the study***

This study has several limitations. Firstly, study result from a large number of samples may be varying in terms of statistics. Second, the study sample, only one group is a group of professional nurses, which are not covered in other professional groups. Third, the data from the study were derived from self-administered questionnaire, which if interpreted the wrong question to answer certain questions that will lead to results that are inaccurate. Fourth, TB infection was reported by nurses who respondents without medical diagnosis confirmed, which could cause under estimate ​​due to the fact some people do not dare to report or not to disclose such results. Finally, because the study was cross-sectional, which cannot identify the causal factors and cannot order that either before or after the data can only be described by the relationship.

***Conclusions***

Prevalence of TB infection is high in service nurses whose relatives have been TB infected, highest education, and age from 30 to 44 years old found that high age and relatives have been TB infected groups were associated with TB infection among nurses. However, this study shows that prevalence of TB infection remain high and remains a health problem that needs to be burned. Especially, in medical personals who closes to patients.

***Recommendations***

This study was conducted in only one nursing group, which may not be referred to other populations across the country with a wide diversity of professional education, income, etc. For the forward education should focus on specific disease in a population with diverse demographic characteristics to be compared with this study. However, the results from this study can reflect a problem and solutions in a large sample survey of nursing across the country, and it can be used as a guideline in conducting the upcoming events in the future.

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**REFERENCES**

1. Maciel EL, Viana MC, Zeitoune RC, Ferreira I, Fregona G, Dietze R. Prevalence and incidence of Mycobacterium tuberculosis infection in nursing students in Vitoria, Espirito Santo. *Revista da Sociedade Brasileira de Medicina Tropical* 2005;38(6):469-72.

2. WHO. Global tuberculosis report 2012.: World Health Organization, 2012.

3. WHO. Global Tuberculosis Control: World Health Organization, 2011. *Geneva:World Health Organization* 2011.

4. Bureau of Tuberculosis. *Department of Disease Control, Ministry of Health* 2553.

5. Sepkowitz KA. Tuberculosis and the health care worker: a historical perspective. *Ann Intern Med* 1994;120(1):71-9.

6. Joshi R, Reingold AL, Menzies D, Pai M. Tuberculosis among health-care workers in low- and middle-income countries: A systematic review. *Plos Med* 2006;3(12):2376-91.

7. Menzies D, Joshi R, Pai M. Risk of tuberculosis infection and disease associated with work in health care settings. *Int J Tuberc Lung D* 2007;11(6):593-605.

8. Christopher DJ, Daley P, Armstrong L, James P, Gupta R, Premkumar B, et al. Tuberculosis infection among young nursing trainees in South India. *PLoS One* 2010;5(4):e10408.

9. Hill A, Burge A, Skinner C. Tuberculosis in National Health Service hospital staff in the west Midlands region of England, 1992-5. *Thorax* 1997;52(11):994-7.

10. Lopes LKO, Teles SA, Souza ACS, Rabahi MF, Tipple AFV. Tuberculosis risk among nursing professionals from Central Brazil. *Am J Infect Control* 2008;36(2):148-51.

11. Vega RA, Conde JG, Diaz M. Prevalence of tuberculin reactivity and prevalence of risk factors for the development of active tuberculosis in a nursing home in Puerto Rico. *Puerto Rico health sciences journal* 1996;15(1):27-31.

12. Harries AD, Kamenya A, Namarika D, Msolomba IW, Salaniponi FM, Nyangulu DS, et al. Delays in diagnosis and treatment of smear-positive tuberculosis and the incidence of tuberculosis in hospital nurses in Blantyre, Malawi. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 1997;91(1):15-7.

13. Burrill D, Enarson DA, Allen EA, Grzybowski S. Tuberculosis in female nurses in British Columbia: implications for control programs. *Can Med Assoc J* 1985;132(2):137-40.

14. Jiamjarasrangsi W, Hirunsuthikul N, Kamolratanakul R. Tuberculosis among health care workers at King Chulalongkorn Memorial Hospital, 1988-2002. *Int J Tuberc Lung D* 2005;9(11):1253-58.

15. Dimitrova B, Hutchings A, Atun R, Drobniewski F, Marchenko G, Zakharova S, et al. Increased risk of tuberculosis among health care workers in Samara Oblast, Russia: analysis of notification data. *Int J Tuberc Lung D* 2005;9(1):43-48.

16. Zhang X, Jia HY, Liu F, Pan LP, Xing AY, Gu SX, et al. Prevalence and Risk Factors for Latent Tuberculosis Infection among Health Care Workers in China: A Cross-Sectional Study. *PLoS One* 2013;8(6).

17. Yanai H, Limpakarnjanarat K, Uthaivoravit W, Mastro TD, Mori T, Tappero JW. Risk of Mycobacterium tuberculosis infection and disease among health care workers, Chiang Rai, Thailand. *Int J Tuberc Lung D* 2003;7(1):36-45.

18. Hosoglu S, Tanrikulu AC, Dagli C, Akalin S. Tuberculosis among health care workers in a short working period. *Am J Infect Control* 2005;33(1):23-26.