HEALTH STATUS, ENVIRONMENTAL LIVING CONDITIONS AND MICROBIAL INDOOR AIR QUALITY AMONG MIGRANT WORKER HOUSEHOLDS IN THAILAND

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Abstract. A large number of migrants have move to cities in Thailand seeking employment. These people may be at increased risk for environmental health problems. We studied the health status, environmental living conditions and microbial indoor air quality (IAQ) among selected groups of migrant workers and their households in Mueang District, Samut Sakhon, central Thailand. We conducted a cross sectional study of 240 migrant workers and their households randomly selected by multistage sampling. The person responsible for hygiene at each studied household was interviewed using a structured questionnaire. Two indoor air samples were taken from each household (480 indoor air samples) to determine bacterial and fungal counts using a Millipore air tester; 240 outdoor air samples were collected for comparison. Ninety-nine point six percent of study subjects were Myanmar, 74.2% were aged 21-40 years, 91.7% had a primary school level education or lower and 53.7% had stayed in Thailand less than 5 years. Eight point three percent had a history of an underlying disease, 20.8% had a recent history of pulmonary tuberculosis in a family member within the previous year. Forty-three point eight percent had a current illness related to IAQ during a previous month. Twenty-one point three were current cigarette smokers, 15.0% were current alcohol consumers, and 5.0% exercises ≥3 times per week. Forty-nine point two percent never opened the windows of their bedrooms or living rooms for ventilation, 45% never cleaned their window screens, and 38.3% never put their pillows or mattresses in the sunlight. The mean(±SD) air bacterial count was 230(±229) CFU/m^3 (outdoor air = 128±82 CFU/m^3), and the mean fungal count was 630(±842) CFU/m^3 (outdoor air = 138±94 CFU/m^3). When the bacterial and fungal counts were compared with the guidelines of the American Conference of Governmental Industrial Hygienists, the bacterial counts in 6.5% of houses surveyed and the fungal counts in 28.8% of house surveyed were higher than the recommended levels (<500 CFU/m^3). Bacterial and fungal counts in the sample households were not significantly correlated with household hygiene practice scores (p>0.05). There was a positive correlation between bacterial counts and fungal counts in household air samples, r=0.28, p<0.001.

Keywords: migrant workers, environmental living conditions, indoor air quality, tuberculosis

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INTRODUCTION

The Association of Southeast Asian Nations (ASEAN) has resulted in economic growth. Thailand is entering a capitalistic era of ASEAN (Plummer *et al*, 2005, 2006; Nguyen *et al*, 2012). A large number of workers have migrated to Thailand seeking work (Amarapibal *et al*, 2002). These migrants trend to move to cities. This has resulted in an increase in social problems, diseases, environmental and lifestyle changes (Amarapibal *et al*, 2002; Nguyen *et al*, 2012). Previous studies of migrant workers found they were at risk for diseases related to the environment, personal hygiene and chronic diseases (Jones and Pardthaisong, 1999; WHO, 2006; Yoosuf, 2007; Lee *et al*, 2011; Luksamijarulkul, 2011). The WHO has reported environmental factors, such as indoor and outdoor air quality play a role in as much as 80% of diseases and a quarter of all deaths are associated with environmental hazards (WHO, 2006; Luksamijarulkul, 2011). Chemical and biological problems with indoor and outdoor air quality can directly or indirectly cause a number of heart and lung diseases. Air quality can influence susceptibility to respiratory infections and aggravate existing respiratory diseases, such as asthma and chronic bronchitis (WHO, 1990; McNeel and Kreutzer,1996; Raaschou-Nielsen *et al*, 2001; Shelton *et al*, 2002; Douwes *et al*, 2003; Luksamijarulkul *et al*, 2004a). Although microbes in the air, which includes hundreds of species of bacteria and fungi, do not generally present a health hazard, high counts of bacteria indicate overcrowding and poor air hygiene (Seitz, 1989; Kodama and McGee, 1996). Dampness and mold in the household environment are associated with adverse respiratory effects (WHO, 1990; McNeel and Kreutzer, 1996; Shelton *et al*, 2002; Heseltine and Rosen, 2009). They may trigger allergic reactions, such as hypersensitivity pneumonitis, allergic rhinitis and cough, allergic skin problems, some types of asthma, and non-specific symptoms, such as, fatigue, headache, and dizziness, particularly among children, the elderly and immune-compromised hosts (WHO, 1990; Zweers, 1992; McNeel and Kreutzer, 1996; Shelton *et al*, 2002; Douwes *et al*, 2003; Luksamijarulkul *et al*, 2004a; Heseltine and Rosen, 2009).

A Thai province with rapid economic growth in central of Thailand is Samut Sakhon Province. The province attracts many migrant workers. This province is second after Bangkok in the number of migrant workers in Thailand (Wanichsuwan, 2008). Most migrants live in towns or Mueang District, especially having to do with the seafood industry. Our pilot study revealed migrant workers live near work and in their own crowded community. Households consist of 2 types: row houses and apartments. Most households are small in area, consisting of 1 or 2 small rooms with a large number of family members or more than one family per household. To maintain adequate public health, health workers need information about health behavior of these workers, their personal and family hygiene habits, environmental health factors and the indoor air quality of homes. In this study, we attempted to investigate health status, environmental living conditions, and microbial indoor air quality among selected groups of migrant workers and their households in Mueang District, Samut Sakhon Province, Thailand. The results of this study may inform intervention efforts to improve the quality of life among this group.

MATERIALS AND METHODS

Research design and study samples

This was a cross sectional study. The study population was comprisal of migrant workers who have lived in urban Mueang District, Samut Sakhon Province, and included 31 migrant communities. Stratified sampling was used for sample selection. Two types of households were studied: row houses and apartments. Five communities were sampled from each stratum, and 24 households were investigated from each community. The head of each family or an individual who had responsibility for the household was interviewed using a structured questionnaire. Inclusion criteria included migrant workers who were willing to participate, were aged >18 years, of either sex who had lived in Mueang District for at least six months. Migrant workers who declined to participate were excluded. The study sample size was calculated from the formula: $n = Z^2_{a/2}PQ/d^2$; where n = sample size, P = average proportion of migrant workers with illnesses related to environmental living conditions (such as tuberculosis) obtained in a previous study =19.3% = 0.19 (Naing *et al*, 2012), Q = 1-P = 0.81, d = acceptable error = 0.05, $Z_{a/2}$ = 1.96 at $\alpha = 0.05$; $n = 237$. The study sample size was calculated to be not less than 237 migrant workers; therefore, this study was comprised of 240 individuals.

Research tools

Structured questionnaire. The structured questionnaire used to collect data consisted of three parts: socio-demographic characteristics, personal health status history, including diseases related to indoor air quality (IAQ) during the previous month and environmental living conditions (household characteristics and household hygiene practices). Household hygiene practices were assessed using nine questions with the answer being either 1, indicating a regular practice or 0 indicating something seldom practiced or not practiced at all.

Microbial air quality assessment and interpretation. To assess microbial indoor air quality, duplicate indoor air samples were collected from 2 points in each household (480 indoor air samples were collected from the 240 studied households) to investigate bacterial and fungal counts. Additionally, 240 outdoor air samples were collected for comparison. Indoor and outdoor air samples were collected from 09:00 AM to 12:00 AM, Saturday, Sunday and holidays using Millipore air tester (M Air T™; Merck KGaA, Darmstadt, Germany). The air collection technique followed the active air sampling method (Fradkin, 1987). The M Air T™ is a portable, lightweight air tester that has a cassette that collects airborne microorganisms. The system collects microorganisms on an agar surface. The machine samples up to 1,000 liters of air in 7 minutes and follows reference methods for analyzing air for microbial contamination (Millipore Technical Publications, 1999). The volume of air samples in our study was set at 250 liters. The plate count method (Fradkin, 1987) was used to estimate bacterial or fungal counts. The bacterial micro-organisms were cultured on the plate count agar at 37°C for 48 hours, and fungi were cultured on Sabouraud 4% dextrose agar at room temperature for 5 days with daily observations. After incubation, the bacterial and fungal colonies were counted and expressed in colony forming units/m³ (CFU/m³) using the following formula:

$$\text{Total count in CFU/m}^3 = [\text{Total colonies X } 10^3]/250$$

If the microbial count was >500 CFU/m³, this was defined as overcrowding or poor ventilation following the guidelines of the American Conference of Governmental Industrial Hygienists (ACGIH) (Seitz, 1989).

The study was conducted during January to March 2014. Written informed consent was obtained from each subject prior to participation.

Data analysis

Data were analyzed using descriptive statistics, including frequencies distribution, percentages, means and standard deviations. The correlation between household hygiene practice scores and microbial indoor air quality was analyzed using the Pearson's coefficient with a statistical confidence level of $\alpha = 0.05$.

Ethical approval

This study is a part of research project entitled "Model development for preventing pulmonary tuberculosis among migrant workers, Samutsakhon province" which was approved by the Human Research Ethics Committee, Faculty of Public Health, Mahidol University. (Ref. No. MUPH 2014-146; 06/01/2014).

RESULTS

Socio-demographic characteristics and health status

Most studied participants (239/240) were from Myanmar; 74.2% were aged 21-40 years, 17.9% were aged 41-60 years and 7.9% were aged ≤20 years. Sixty point four percent were female, 91.7% had a primary school education or lower, 7.5% had a secondary school education and 0.8% had a diploma. Eighty point four percent of study subjects were married; the rest were single, divorced or widowed. Fifty-three point seven percent had lived in the study area for <5 years, 26.7% for 5-10 years and 19.6% for >10 years. Eight point three percent had a history of underlying disease, 20.8% had a recent history of pulmonary tuberculosis among family members (1-year history). Forty-three point eight percent had symptoms related to indoor air quality during the previous month, such as sneezing, stuffy nose, running nose, throat dryness, skin symptoms such as dry or itchy skin, or non-specific symptoms, such as headache or dizziness, fatigue, tension, or irritability. Twenty-one point three percent of study subjects were current cigarette smokers, 15.0% were current alcohol consumers, and 5.0% exercised ≥3 times per week (Table 1).

Household characteristics and household hygiene practices

Fifty-nine point six percent to 83.8% practiced items, such as, removal of trash from all rooms every day, moping the floor in their bedrooms and living rooms every day. Forty-nine point two percent did not open windows in their bedrooms or living rooms for air ventilation during the previous month; 45% had never cleaned their window screens and 38.3% had never put their pillows or mattresses in the sunlight. The mean (± standard deviation) household hygiene score was 4.9 (±2.3 scores) out of a total possible score of 9. 55.8% of subjects had a poor household hygiene scores, 25.8% had a fair score and 18.3% had a good score. Fifty point eight percent of households were row houses, and 49.2% were apartment houses. Ninety-four point two percent were 1 room households. Eighty-seven point five percent had at least 1 window; 60.0% opened their windows daily. Thirty-three percent of households had ≥3 residents (Table 2).

Air microbial counts

The total mean(±SD) bacterial indoor air was 230(±229) CFU/m^3. The highest mean count was in the KL community

Table 1
Socio-demographic characteristics and personal health history of study subjects (*N*=240).

Socio-demographic characteristics and personal health history	No. (%)
Socio-demographic characteristics	
Age (years)	
≤20	19 (7.9)
21-40	178 (74.2)
41-60	43 (17.9)
Gender	
Female	145 (60.4)
Male	95 (39.6)
Education	
≤Primary school	220 (91.7)
Secondary school and high school diploma	20 (8.3)
Marital status	
Married	193 (80.4)
Single/divorced/widowed	47 (19.6)
Length lived at current location (years)	
<5	149 (53.7)
6-10	64 (26.7)
>10	47 (19.6)
Personal health history	
History of underlying diseases[a]	
Yes	20 (8.3)
No	220 (91.7)
History of TB among family members in a previous year	
Yes	50 (20.8)
Symptoms for indoor air quality in a previous month[b]	
Yes	105 (43.8)
Current cigarette smoking	
Yes	51 (21.3)
Current alcohol consumption	
Yes	36 (15.0)
Exercise ≥ 3 times/week	
Yes	12 (5.0)

[a]Such as hypertension, diabetes mellitus, thyroid, muscle problems or HIV infection.
[b]Twenty point eight percent had respiratory symptoms (running nose, ect), 3.3% had skin problem (itching skin), and 37.8% had non-specific symptoms (headache, dizziness fatigue, ect).

(373±224 CFU/m^3) and the lowest mean count was found in the Eawartorn community (109±103 CFU/m^3) (Table 3). For fungal count in indoor air of studied households, mean±SD was 630±842 CFU/m^3. The highest mean level was found in households at KL community (1,289±939 CFU/m^3) and the lowest mean level was found in households at Mahachainiwet community (181±390 CFU/m^3) (Table 3).

Table 2
Household characteristics and hygiene practices of study subjects (N=240).

Household characteristics and household hygiene practices	No. (%)
Household characteristics	
Type of home	
Row house	122 (50.8)
Apartment	118 (49.2)
No. of rooms	
1	226 (94.2)
≥2	14 (5.8)
No. of windows	
None	30 (12.5)
≥1	210 (87.5)
No. of opening windows	
None	96 (40.0)
≥1	144 (60.0)
No. of residents per room	
≥3	79 (32.9)
<3	161 (67.1)

Household hygiene practices[a]	Frequently practiced No. (%)	Seldom or not practiced No. (%)
Bedroom		
Do you frequently clean the bed linens?	65 (27.1)	175 (72.9)
Do you frequently put the pillows and mattresses in the sun?	62 (25.8)	178 (74.2)
Do you mop the floor every day?	143 (59.6)	97 (40.4)
Do you open the windows for ventilation daily?	75 (31.3)	165 (68.7)
Living room		
Do you frequently clean the window screens?	58 (24.2)	182 (75.8)
Do you mop the floor every day?	148 (61.7)	92 (38.3)
Do you frequently dust the furniture?	80 (33.3)	16 (66.7)
Do you remove trash from the rooms daily?	49 (20.4)	191 (79.6)
Do you open the windows for ventilation daily?	201 (83.8)	198 (16.2)
Mean score ± SD (Total possible score = 9)	4.9±2.3	

[a]Hygiene practice scores defined into 3 levels; ≥80% for good level, 60-79% for fair level and ≤60% for poor level: Good level = >7.2 (18.3%), Fair level = 5.4-7.2 (25.8%), Poor level = <5.4 (55.8%).

When the bacterial and fungal counts were compared with the IAQ guidelines of the American Conference of Governmental Industrial Hygienists (ACGIH), it was found that 6.5% of bacterial counts and 28.8% of fungal counts were higher than the recommended level (>500 CFU/m^3). Households in the KL community had the highest percentages of bacterial and fungal counts (>500 CFU/m^3) of the studied communities (22.9% and 56.3%, respectively) (Table 4).

Table 3
Microbial air quality by studied communities.

Studied communities	Bacterial counts in CFU/m^3		Fungal counts in CFU/m^3	
	Indoor air (Min-Max) (*n*=480)	Outdoor air (Min-Max) (*n*=240)	Indoor air (Min-Max) (*n*=480)	Outdoor air (Min-Max) (*n*=240)
KL	373 ± 224 (48 - 1,056)	161 ± 111 (32 - 480)	1,289 ± 939 (48 - 2,000)	130 ± 94 (36 - 320)
Kumpla	149 ± 113 (40 - 400)	105 ± 47 (28 - 184)	718 ± 927 (28 - 2,000)	103 ± 74 (24 - 224)
Klohsamut	319 ± 216 (68 - 1,408)	123 ± 49 (32 - 192)	1,034 ± 987 (44 - 2,000)	170 ± 89 (28 - 420)
Klokklag	281 ± 257 (28 - 1,600)	103 ± 79 (32 - 400)	648 ± 889 (32 - 2,000)	109 ± 63 (24 - 200)
Taladkung	277 ± 431 (32 - 2,880)	89 ± 98 (24 - 480)	747 ± 910 (24 - 2,000)	115 ± 64 (28 - 216)
Thachalom	226 ± 182 (16 - 720)	95 ± 87 (24 - 360)	314 ± 402 (20 - 2,000)	155 ± 114 (24 - 480)
Thachai	179 ± 126 (20 - 576)	106 ± 35 (24 - 136)	543 ± 862 (28 - 2,000)	128 ± 80 (24 - 400)
Mahachainiwet	151 ± 179 (28 - 1,216)	132 ± 108 (24 - 544)	181 ± 390 (40 - 2,000)	116 ± 46 (28 - 224)
Moo4	235 ± 134 (32 - 576)	105 ± 65 (32 - 296)	726 ± 771 (28 - 2,000)	187 ± 145 (24 - 480)
Eawartorn	109 ± 103 (16 - 400)	119 ± 31 (28 - 120)	240 ± 544 (24 - 2,000)	94 ± 58 (28 - 180)
Total average	230 ± 229 (16 - 2,880)	128 ± 82 (24 - 544)	630 ± 842 (20 - 2,000)	138 ± 94 (24 - 480)

CFU/m^3 = colony forming units per cubic meter of air.

Relationship between microbial indoor air quality and household hygiene practice scores

Using the Pearson's correlation coefficient, household hygiene practice scores were not correlated with bacterial and fungal counts (p>0.05). However, bacterial and fungal counts were significantly correlated with each other (r = 0.28, p < 0.001) (Table 5).

DISCUSSION

We studied air quality in dwellings of migrant workers living in Mueang District of Samut Sakhon Province, Thailand. Most of the study subjects worked in the seafood industry. Most had a low education level that could have affected their household hygiene practices similar to a study by Govender *et al* (2010). Most of our study subjects lived in overcrowded, unsanitary conditions, which could have affected the prevalence of diseases influenced by poor sanitation. Previous studies have found overcrowded living conditions are associated with increased risk for infectious disease transmission by respiratory route, such as tuberculosis, streptococcal, and meningococcal infec-

Table 4
Studied communities with high microbial air counts.

Studied communities	Bacterial counts in CFU/m³		Fungal counts in CFU/m³	
	300 - 500 No. (%)	>500 No. (%)	300 - 500 No. (%)	>500 No. (%)
KL	15 (31.3)	11 (22.9)	0 (0.0)	27 (56.3)
Kumpla	8 (16.7)	0 (0.0)	0 (0.0)	15 (31.3)
Klohsamut	20 (41.7)	4 (8.3)	0 (0.0)	24 (50.0)
Klokklag	13 (27.1)	3 (6.3)	1 (2.1)	17 (35.4)
Taladkung	10 (20.8)	5 (10.4)	3 (6.3)	15 (31.3)
Thachalom	13 (27.1)	2 (4.2)	14 (29.2)	3 (6.3)
Thachai	7 (14.6)	1 (2.1)	1 (2.1)	11 (22.9)
Mahachainiwet	0 (0.0)	2 (4.2)	0 (0.0)	2 (4.2)
Moo4	9 (18.8)	3 (6.3)	7 (14.6)	20 (41.7)
Eawartorn	4 (8.3)	0 (0.0)	0 (0.0)	4 (8.3)
Total (*N*=480)	99 (20.6)	31 (6.5)	26 (5.4)	138 (28.8)

CFU/m³, colony forming units per cubic meter of air.

Table 5
Pearson's correlation coefficients for air bacterial count, fungal count and household hygiene practice scores.

Variables	Air bacterial counts	Air fungal counts	Household hygiene practice scores
Air bacterial counts	NC	$r = 0.28$, $p < 0.001$[a]	$r = 0.02$, $p = 0.737$
Air fungal counts	$r = 0.28$, $p < 0.001$[a]	NC	$r = 0.07$, $p = 0.119$
Household hygiene practice scores	$r = 0.02$, $p = 0.737$	$r = 0.07$, $p = 0.119$	NC

[a]Statistically significant correlation at $\alpha = 0.05$. NC, not calculated.

tions (Perry and Roberts, 1973; Baker *et al*, 2000). Naing *et al* (2012) investigated symptoms related to environmental living conditions among migrant workers in Hat Yai District, Songkhla Province, Thailand and found 19.3% of studied migrant workers had symptoms suggestive of pulmonary tuberculosis. In our study, 20.8% have a history of pulmonary tuberculosis in a family members during the previous year. Forty-three point eight percent had symptoms that could be related to indoor air quality during the previous month. Twenty point eight percent had respiratory symptoms, 3.3% had skin problems, and 37.8% had non-specific symptoms. These symptoms could have been due to poor household hygiene and poor ventilation (Ooi, 1998; Reijula and Sundman-DiGert, 2004; WHO, 2006; Yoosuf, 2007). In our study, over half the studied subjects had what we determined to be poor household hygiene practice scores. Forty-nine point two percent never opened the windows in their bedrooms or living rooms for ventilation during the previous month, 45% never cleaned their window screens, and 38.3% never put their pillows or mattresses in the sun. Many migrant workers work overtime and do not have time for home hygiene. Sixty percent of study subjects opened their windows for ventilation. This could increase their risk of respiratory problems, such as asthma, and pulmonary tuberculosis (Kodama and McGee,1996; Graham, 2004; Luksamijarulkul *et al*, 2004b).

If the microbial count ratio between indoor air and outdoor air was greater than 1.0, it was thus an indication that the source of microbial contamination was to be found in the indoor environments (Seitz, 1989; Zweers, 1992; Heseltine and Rosen, 2009). The present study found indoor air bacterial counts in several households were higher than outdoor air bacterial counts. The high bacterial and fungal counts in our study suggest overcrowding and poor ventilation (Seitz, 1989; WHO, 1990; Kodama and McGee, 1996). A previous study found an increase in ventilation can reduce bacterial and fungal counts in air air-conditioned buses (Luksamijarulkul *et al*, 2005). The study was conducted at KL community which we found to have high bacterial and fungal counts also has a high incidence of tuberculosis patients admitted to the hospital. Further studies are needed to determine if these are associated. The World Health Organization recommends microbial counts in the workplace and at home should be <300 CFU/m^3; for individuals with immunosuppression, microbial count should be <100 CFU/m^3 (WHO, 1990).

There were limitations in this study: some subjects may have been working illegally, so they may not have answered questions truthfully. This can influence conclusion. The present study was a cross-sectional survey. A longitudinal study needs to be done to determine etiology. For the health of the study population, good hygiene principles need to be taught. Further exploration is needed to determine who should provide this education and what methods are effective in reducing disease.

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