Environmental sanitation and hygiene of elderly workers in Nakhon Si Thammarat Province, Thailand

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Introduction

By 2050, the world’s population aged 60 years and older was expected to be about 2 billion, and 80% of them will live in developing countries [1]. As a high proportion of older persons, governments should implement policies to address their needs and interests, including housing, employment, health care, and social protection [2]. Thailand will become a completely aged society in 2021 and a super-aged society in 2031 [3]. By 2040, there was estimated to be 17 million Thais 65 years and older, accounting for more than a quarter of the population. Together with China, Thailand already has the highest share of the older people of any developing country in East Asia and the Pacific [4]. The national survey found that 50.5% of Thai elders aged 60-69 years old are still working. The main reasons for them had physically able to work (47.7%) and had insufficient income to maintain their living and family (43.4%) [3].

Falls was a significant public health problem in older adults worldwide. Approximately 28-32% of more than 65 years of people fall each year, and up to 32-42% of those aged more than 70 years [5]. The study in Saudis found 49.9% of elders had experienced one or more falls for 12 months [6]. In the United States, 28.7% of older adults reported falling at least once in the preceding 12 months [7]. In China, 19.28% of older adults experienced fall incidents [8]. Injuries caused by falls in older persons are frequent events and lead to post-fall syndromes, which result in death or long-term care needs [5]. Fall-induced traumatic brain injuries of elderly adults Finns increased 377% in women and 424% in men from 1970 to 2017 [9]. The study of fall-related injuries of Swedish registry data in year 1999-2013 found that the home was the most common location for fall injuries, as about 40% of all fall injuries [10]. 87.2% of the incidence of hip fractures caused by falling in the elderly in Nan province, Thailand, during 2015-2017 happened inside the house [11]. Many injurious falls occur around indoor stairs, and therefore the proper design of stairs and appropriate handrails (shape, diameter, and height) should be investigated [12].

Sanitation, hygiene, drinking water, and indoor air quality are essential issues for public health concern, especially in developing countries. In 2017, 45% of the global population (3.4 billion people) accessed a safely managed sanitation service; however, 2.0 billion people still do not have the necessary sanitation facilities. 71% of the population used safely drinking water services, but 0.78 billion people even do not have the essential functions [13, 14]. A study in Tigray, Ethiopia indicated that availability and proper utilization of latrine, hand washing, and water facilities were low [15]. Poor sanitation reduced human well-being and was estimated to cause 432,000 diarrheal deaths annually [13]. Older adults are vulnerable groups to microbial contaminants...
and can be more at risk from waterborne and foodborne disease when living under unsanitary conditions [16]. Indoor environmental quality is a critical health determinant for elders because they spend more than 90% of their time in the indoor environment [17, 18]. Inadequate ventilation contributed to exposure to indoor air pollutants related to respiratory symptoms in older people [17-19].

In Thailand, one-third of the elderly (34.3%) had incomes below the poverty line (under 2,667 baht per month). Eighty percent of the elderly receiving allowances from the government (600-1,000 baht per month), but it was not enough for living [20, 21]. The cost of health care in Thailand was rapidly increased, especially in aging society situation. There was estimated that in case of without any control measures of the behavior lifestyle of the elderly, the cost will be increased from about 0.48-0.63 trillion baht to 2.2 trillion baht in 2032 [20]. Therefore, health promotion and prevention in the elderly are challenges for Thailand.

This research focuses on the elderly workers with age between 45-70 years old, who are still working and earning income, including formal workers (work in the government and private workplaces) and informal workers (self-employed workers). The research assessed housing sanitation, food and water sanitation, and indoor air quality in the house of the elderly worker in Nakhon Si Thammarat province, which has the highest number of older people in Southern Thailand [3].

**Methods**

The research project was approved by the Human Research Ethics Committee of Walailak University with the approval number WUEC-19-057-01 on 26 April 2019. This cross-sectional analytical study was set in Nakhon Si Thammarat province in 2 districts, Mueang and Tha Sala district. Mueang district was selected because of the highest of elderly worker proportion, and Tha Sala district was chosen because it has been set as the Long-term care sub-district of elders by the Health Promotion Center Region 11 Nakhon Sri Thammarat since 2014. The population in this was the elderly workers with age between 45-70 years. They have worked in the study area for at least two years. The sample was calculated using the equation of Wayne WD (1995) [22] with a finite population.

\[
n = \frac{Nz^2p(1-p)}{[e^2(N-1)+Z^2_{0.05}p(1-p)]}
\]

Where \(n\) was the calculated sample size, \(N\) was the population of the elderly workers in total 112,117 people (82,877 people in Muang District and 29,240 people in Tha Sala District), \(p\) was the proportion of the sampling population, which was the proportion of the elderly workers to the total population in Nakhon Si Thammarat Province (0.28). \(Z\) was the reliability coefficient of 95% (level 0.05) with \(Z\) (0.975) = 1.96. \(e\) was the standard error, which was set at 0.05. The calculated sample size in this study with reserving 5% for surveying and participating was 324 people. Simple random sampling was applied in the study. The samples were selected from the list of elderly workers in the database of Tambon Health Promoting Hospital.

Housing sanitation was assessed using the questionnaire, which was developed in the previous study by Nattaporn Sang (2019) [23], and it was already checked the content validity by the experts with the Item-Objective Congruence (IOC) index of 0.67-1.00. The first section was general information of the elderly workers, and the second section was the checklist form of housing sanitation. General information included sex, age, religions, education level, income, and career. Housing sanitation assessment included general features of external and internal area, living room, kitchen room, bedroom, bathroom, household facilities, and environmental sanitation, a total of 38 items. The questionnaires were completed by face to face at the house of the elderly workers. The informed consent to participate in the study was informed to them before starting the inquiry process.

For food sanitation, coliform bacteria were detected in the samples of food (cook rice and the side dish), food contact equipment (plate and spoon), and food handler (elderly hand). The field test kit (SI-2 or DOH13) of the Research and Laboratory Development Center, Department of Health, Thailand, was used for the detection [24]. The principle of the SI-2 test kit is the ability of coliform bacteria to ferment lactose with acid and gas formation within 17 hours. The pH of the culture medium then will be decreased, which caused the color of the indicator to change from purple to yellow. This color-changing indicated coliform bacteria in the sample exceed the quality criteria of bacteria [25]. The testing was performed with an aseptic technique according to the manual of instruction. All the equipment, such as the cap and the neck of the culture medium bottle, cutter, and work-in plate and inspector’s hand, were cleaned with 70% alcohol before carrying out the test. The test kit was stored in a dry and cool place. It can be stored at room temperature for about one month and stored in the refrigerator for about six months. For water sanitation, coliform bacteria contamination in the drinking water sample was tested by the field test kit for coliform in drinking water (DOH11), which was developed by the Research and Laboratory Development Center [24]. The culture medium was used to detect coliform bacteria after keeping in room temperature (25-40°C) for 24 hours. The medium color (clear red) will be changed to orange-red, brown-red, and yellow. Also, turbidity and the bubble gas will be appeared after shaking. These results indicated contamination of coliform bacteria in which the water is not safe for human consumption. The DOH11 is consistent with more than 85% with the multiple-tube fermentation technique [25]. Food and water samples being eating were collected for the test. For indoor air quality, total bacteria and total fungi were measured in the bedroom and the kitchen room. Gravity
Settling Plate (GSP) sampling was used to collect the bioaerosol. Blood Agar and Sabouraud Dextrose Agar were used as culture media for bacteria and fungi, respectively. Total bacteria and total fungi in indoor air were calculated by settling velocity of aerosol [26]. For quality control, the contamination of culture media every batch was tested before use for sampling, and seventy-one field blanks (approximately 10% of the samples) were performed. No contamination of bacteria or fungi was found in all sets of the prepared culture media and field blanks. For data analysis, the results of the questionnaire and environmental sanitation were explained using descriptive statistics (i.e., frequency, percentage, minimum, maximum, mean, and standard deviation). Factors affected the environmental sanitation were tested using a chi-square correlation. In case of limitation of the sample size, which reflected on more than 20% of the expected values in cells are less than 5, fisher’s exact test was instead conducted.

Results

Characteristics of the Elderly Workers

A total of 319 elderly workers were included in this study (98.5% response rate). Most of them were female (72.1%), Buddhists (81.2%), and their education level was primary education (67.1%). Most of them were farmers/fishery (26.3%), and their monthly income was 10,001-15,000 THB (315-472 USD) (35.7%). Detailed characteristics of the elderly workers were shown in Table I.

| Characteristics                  | Frequency (n = 319) | Percent |
|----------------------------------|---------------------|---------|
| Gender                           |                     |         |
| Male                             | 89                  | 27.9    |
| Female                           | 230                 | 72.1    |
| Education level                  |                     |         |
| Below primary education          | 4                   | 1.2     |
| Primary education                | 214                 | 67.1    |
| Secondary education/lower vocational | 53                  | 16.6    |
| Tertiary vocational              | 19                  | 6.0     |
| Undergraduate                    | 24                  | 7.5     |
| Graduate studies                 | 5                   | 1.6     |
| Monthly income                   |                     |         |
| <= 5,000 THB                     | 100                 | 31.4    |
| 5,001-10,000 THB                 | 114                 | 35.7    |
| 10,001-15,000 THB                | 48                  | 15.0    |
| 15,001-20,000 THB                | 19                  | 6.0     |
| > 20,000 THB                     | 38                  | 11.9    |
| Career                           |                     |         |
| Farmer/fishery                   | 84                  | 26.3    |
| Merchant                         | 66                  | 20.7    |
| Government/company employee      | 60                  | 18.9    |
| Self-employed                    | 77                  | 24.1    |
| Homemaker                        | 32                  | 10.0    |
| Religions                        |                     |         |
| Buddhism                         | 259                 | 81.2    |
| Islam                            | 58                  | 18.2    |
| Christianity                     | 2                   | 0.6     |

Housing Sanitation

The results of the housing sanitation assessment were shown in Table II. Most of the houses were in the criteria for all items in the general features, living room, and kitchen room. The house had a stable structure; the surrounding area of the house cleaned, and there was no cobweb inside the house. The living room was suitably arranged. The kitchens were cleaned and proper arrangement, sufficient ventilation and light and appropriate food keeping.

Most of the checked items in the bedroom were in the criteria. The bedroom had cleaned and proper arrangement, suitable insect prevention, and sufficient ventilation and light. The bed was an appropriate height to prevent falls. The mattress and pillows were suitable hardness to avoid the pain of the back and neck. However, 48.9% of the bedroom had a telephone or accessible emergency signal in case of an emergency. Most of the checked items in the bathroom were in the criteria. Every house had a toilet for excreta treatment. Toilet, water closet, water container, and the floor were cleaned and in good condition. There was proper ventilation, sufficient light, and the water was cleaned and enough for use. However, only 10.6% of the bathroom separated between wet and dry zone, and only 2.8% had anti-slip sheets in the bathroom.

All items of the door, chair, and the closets were in the criteria for household facilities. The door was in good condition and easily use. The chair had a suitable height, and the cabinets easily used. Most of the houses had the power plug with appropriate height for use, but 66.1% of them had electrical equipment in good condition and ready for use. Also, only 3.8% of the houses set the handrails and keep them in good shape for use. Only
42.3% of the house installed the ramp with a suitable width, length, and slope, and only 46.7% of the house had distinct floor colors. A few houses were in the criteria for environmental sanitation. Only 23.8% and 25.7% of them had suitable waste containers and treated wastewater before discharge, respectively. Also, 67.4% of them had a proper separation and collection of solid waste, and the breeding site of mosquitoes was found at 33.9% of the houses.

**Food and water sanitation**

Detection of coliform bacteria in the sample of food, food contact surface, and elderly hand was shown in Table III. There was a high detection rate of coliform bacteria in all types of samples. The detection rate was 93.3, 83.9, 82.5, 88.1, 78.0% in the cooked rice, side dish, dish, spoon, and elderly hand, respectively. The type of drinking water and their detection rate of coliform bacteria were shown in Table IV. Most of the
households used bottled water for drinking water by which 55% was big bottled water (20 L), and 15.8% was the small bottled water (0.5-1.0 L). Rainwater, deep and shallow well water, and tap water were also used for drinking water for some households in the study area. The detection rate of coliform bacteria was 97.5% of all samples. Coliform in vending machine water, rainwater, deep and shallow well water, and tap water was 100% detected.

### Indoor Air Quality

The measurement of total bacteria and fungi in indoor air was shown in Table V. The average amount of total bacteria in the kitchen (149 CFU/m³) was higher than that in the bedroom (111 CFU/m³). For total fungi, the average level was 83 CFU/m³ and 93 CFU/m³ in the bedroom and the kitchen, respectively. Most of the measurements were in the standard of Singapore [27], and Thailand (a draft of indoor air quality standard) [28], which specifies the concentration is not excess 500 CFU/m³ for both the total bacteria and total fungi in the indoor air. Only 4.4 and 6.8% of the measurements of total bacteria in the bedroom and the kitchen exceeded the standard. Also, 1.4 and 2.1% of the total fungi measures in the bedroom and the kitchen exceeded the standard.

#### Tab. III. Detection of coliform bacteria in food, food contact surface, and hand.

| Type of samples                  | Number of test | Positive result* | Detection rate |
|----------------------------------|----------------|------------------|---------------|
| Food-cooked rice                 | 180            | 168              | 93.3          |
| Food-side dish                   | 56             | 47               | 83.9          |
| Food contact surface-dish        | 297            | 245              | 82.5          |
| Food contact surface-spoon       | 294            | 259              | 88.1          |
| Hand                             | 309            | 241              | 78.0          |
| Total                            | 1,136          | 960              | 84.5          |
* Positive result indicated contamination of coliform bacteria exceed the quality criteria.

#### Tab. IV. Type of drinking water and detection rate of coliform bacteria.

| Type of drinking water           | No. of household | %    | Detection rate* (%) |
|----------------------------------|------------------|------|----------------------|
| 20 L bottled water               | 171              | 55.0 | 99.4                 |
| 0.5-1.0 L bottled water          | 49               | 15.8 | 85.7                 |
| Water vending machine            | 24               | 7.7  | 100.0                |
| Rainwater                        | 23               | 7.4  | 100.0                |
| Deep well water                  | 19               | 6.1  | 100.0                |
| Tap water                        | 15               | 4.8  | 100.0                |
| Shallow well water               | 10               | 3.2  | 100.0                |
| Total                            | 311              | 100.0| 97.5                 |
* Coliform bacteria detection indicated that water is not safe for human consumption.

### Factors Affected Environmental Sanitation

Chi-square correlation between the environmental sanitation and affected factors (i.e., characteristics of the elderly workers and housing sanitation) was shown in Tab. SI to Tab. SIII in the Supplementary information. The housing sanitation related to the cleanliness of the houses was selected for the correlation test. Factors affected the contamination of coliform bacteria in hand (p-value < 0.05) were gender, cobweb inside the house, the cleanliness of the kitchen room, bathroom ventilation, and wastewater treatment. No correlation was found between airborne bacteria and fungi in other samples (i.e., cooked rice, side dish, dish, spoon, and drinking water) and the factors of elderly characteristics and housing sanitation.

The career of the elderly workers affected airborne bacteria and fungi in both the bedroom and kitchen room. Bacteria and fungi in the bedroom were also affected by education and religion. Some housing sanitation factors, importantly, bathroom ventilation, solid waste collection and separation, and keeping of cooked food, affected airborne bacteria and fungi in the bedroom and kitchen room. Other correlated factors of housing sanitation affected some indoor air quality. These factors included debris scattered inside/outside the house, cobweb

#### Tab. V. Indoor air quality results.

| Parameters                             | No. of household | Min-max |Avg ± STD |
|----------------------------------------|------------------|---------|----------|
| Total bacteria in bedroom (CFU/m³)     | 293              | 0-2.063 | 111 ± 221|
| Total bacteria in kitchen (CFU/m³)     | 290              | 0-1.844 | 149 ± 262|
| Total fungi in bedroom (CFU/m³)        | 290              | 0-835   | 85 ± 109 |
| Total fungi in kitchen (CFU/m³)        | 287              | 0-806   | 95 ± 128 |

The standard of indoor air quality is 500 CFU/m³ for total bacteria and total fungi.
inside the house, cleanliness of bedroom, cleanliness of bathroom’s floor, cleanliness and sufficiency of waste container, wastewater treatment, and cleanliness of toilet and water in the bathroom.

Discussion

The main problems of housing sanitation in this study area were risk factors related to falls of the elderly workers, especially in the bathroom. Most of the houses had no separation of wet and dry zones (89.4%) and no anti-slip sheet in the toilet (97.2%), and the handrails were not correctly installed (96.2%). This study’s result corresponded to other study areas in Nakhon Si Thammarat Province, Thailand, which showed similar problems found in the houses [23], i.e., no separation between wet and dry zone (78.2%) and incorrectly installed of the handrails (92.5%).

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Thailand national survey of 83,880 households in 2018 found 6.8% of elderly falls within six months before the questionnaire day, and major causes of falls were slips (39%), stumble (36.6), and dizzy (9.3%) [3]. Another previous survey of elder’s health problem in the Mueang district in Nakhon Si Thammarat indicated eye disorders (20.3%) and bone and joint disease (16.8%) [29]. These health problems stated the risk of fall accidents of older people that was a critical problem in the area. The study of the consequence of fallings in the elderly in Nan, Thailand, found increasing in hip fractures. The median of refracture time was 143 weeks, and 32.7% of patients take more than five years. 3.7% of patients died in the hospital, and the one-year mortality rate was 17.2% [9]. More research associated with falls, i.e., characteristics, risk factors, burden, and consequence, is required, and preventing measures is challenges for the study area.

Preventing falls in the elderly in the study area should have proceeded with the homeowner and local officers. Food sanitation was another issue in the study area. Although, the assessment results of housing sanitation showed most of the kitchen room was proportional arranged and cleaned (88.1%). Also, cooked food was kept correctly (92.8%), and there was a suitable height of cabinet or table for preparing food and maintaining the kitchen’s equipment and cooking (97.8%). However, coliform bacteria contamination in the samples of food, food contact surface, and hand were high, with a rate of 78.0-93.3%. These results indicated a high risk of pathogen contamination, which might cause foodborne and waterborne diseases. High contamination of coliform bacteria might cause by unproperly maintenance and cleanliness, and the filters of water vending machines have not been changed in time. Detection of coliform bacteria in tap water samples was 100% at Chaing Rai province [37] and 76.9% at Khon Khean province [38]. Causes of the contamination in these studies were leakage of the pipeline and sediment remaining in the pipeline, and no chlorine residue. Boiling water before drinking was suggested for tab water.

Detection of coliform bacteria in groundwater samples was 91.5% at Khon Kaen province [39], which caused by unsealed storage containers or bottles, the drinking cups were used without cleaning, and those cups were using the same cup for all members without washing hands. Coliform bacteria were detected for 75.6% of ground water samples at Ubon Ratchatani province, and the results showed that septic tanks, wastewater, and waste disposal site located within a 30-meter distance near the groundwater wells [40]. Coliform bacteria were found in all rainwater samples (100%) at Nova Thammarat province [41]. The contamination caused by use first flush diverters, lack of cleaning, and no cover of the rainwater storage tank. Previous studies in Thailand reported that 90.7-100% of bottled water samples were in the standard for coliform bacteria in drinking water in a sealed container set by the Ministry of Public Health of Thailand [42-44]. However, high detection of coliform bacteria in bottled water was found in this study. During the survey, we observed that drinking water cups were not cleaned, and there was some dirt on the containers of drinking water, and most of the elderly workers were not wash their hands before drinking water. There were some studies of coliform contamination in drinking water in other countries and found high detection. A survey of fecal contamination of drinking water in Rwanda found 75.1% of samples...
with detectable thermotolerant coliforms [45]. A study of microbial quality of community drinking water supplies in west Amhara, Ethiopia for 2004-2014 found that 44.7% of water samples had total coliform [46]. A case study in Kermanshah, Iran, detected fecal coliform in urban, rural, and private drinking water sources in ten years (2006-2016) with 48.4, 82.3, and 63.0%, respectively [47].

In this study, some housing sanitation issues (i.e., cobweb inside the house, the cleanliness of the kitchen room, and the ventilation of the bathroom) were found to be affected factors of the coliform contamination of the elderly hand. Moreover, some factors such as washing hands before drinking and eating, cleaning and storage of utensils for food and drinking water, food waste disposal, and vector control were observed to be related to the contamination. Therefore, these inadequate sanitation and hygiene-related issues should be communicated and suggested to the elderly for the reduction of the contamination.

Indoor air quality in terms of total bacteria and fungi mostly complied with the standard, and most of the kitchen rooms and bedrooms were regularly cleaned. Some factors of house cleanliness affected airborne bacteria and fungi such as ventilation and cleanliness of the bathroom, cleanliness of bedroom, cobweb inside the house, solid waste management, and wastewater treatment. Regularly arrangement and clean the room with disinfection was an essential factor in reducing the amount of the bacteria and fungi in the indoor air [48]. The higher amount of fungi and bacteria found in the kitchen, compared to the bedroom, might be caused by the moisture from cooking and washing activities [49].

Conclusions

Assessment of housing sanitation for the elderly worker indicated health risk due to the falling accident, especially in the bathroom, because there were no anti-slip sheets and no separation of the dry and wet zone. Besides, we found some issues in the house that can cause a falling accident to the elders. Those issues included the handrails were not correctly installed, the ramp was an inappropriate shape, and the floor had not distinct colors. Solid waste and wastewater problems were other sanitation issues in the study area. Indoor air quality in the house was the problem for some homes. However, we found coliform contamination in most of the samples, including food, food contact surface, elderly hand, and drinking water. Therefore, foodborne and waterborne disease was the health risk to the elderly workers.

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Conflicts of interest statement

The authors declare no conflict of interest.

Authors’ contributions

The design and supervision of the research project were involved by all authors. JK has analyzed the data and interpreted the results and wrote the manuscript. All authors revised and approved the final manuscript.

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### Supplementary Information

#### Tab. S1. Correlation between environmental sanitation (coliform contamination in food surface contact and hand) and factors of characteristics of the elderly workers and housing sanitation.

| Characteristics | Coliform in dish | p-value | Coliform in spoon | p-value | Coliform in hand | p-value |
|-----------------|------------------|---------|-------------------|---------|------------------|---------|
| Gender          |                  |         |                   |         |                  |         |
| Male            | 15 (1.5%)        | 0.686   | 16 (1.5%)         | 0.600   | 16 (1.5%)        | 0.686   |
| Female          | 57 (12.8%)       | 37 (12.5%) | 8 (2.7%)          | 70 (25.8%) | 149 (63.3%)      | 0.011   |
| Education       |                  |         |                   |         |                  |         |
| Primary school  | 35 (11.8%)       | 0.724   | 37 (12.5%)        | 0.711   | 37 (12.5%)       | 0.724   |
| Secondary school | 55 (17.3%)       | 12 (4.0%) | 21 (7.1%)         | 9 (3.1%)  | 10 (3.2%)        | 0.056   |
| Higher school   | 17 (5.7%)        | 27 (9.2%) | 9 (3.1%)          | 49 (18.3%) | 189 (63.3%)      | 0.004   |
| **Housing**     |                  |         |                   |         |                  |         |
| No.22           | 12 (4.0%)        | 0.569   | 14 (4.8%)         | 0.569   | 14 (4.8%)        | 0.569   |
| No.20           | 62 (20.9%)       | 15 (4.8%) | 65 (24.1%)        | 18 (6.2%) | 79 (20.9%)        | 0.659   |
| No.19           | 55 (18.5%)       | 4 (1.4%)  | 60 (21.6%)        | 10 (3.2%) | 79 (24.6%)        | 0.041   |
| No.13           | 8 (2.5%)         | 1.000   | 12 (4.0%)         | 1.000   | 12 (4.0%)        | 1.000   |
| No.11           | 62 (20.9%)       | 0.148   | 65 (24.1%)        | 0.148   | 65 (24.1%)        | 0.148   |
| **Causes**      |                  |         |                   |         |                  |         |
| Farmer/Fisher   | 7 (2.4%)         | 0.607   | 7 (2.4%)          | 0.607   | 7 (2.4%)         | 0.607   |
| Merchant        | 10 (3.2%)        | 0.104   | 25 (8.8%)         | 0.104   | 25 (8.8%)        | 0.104   |
| Employee        | 6 (2.0%)         | 0.018   | 7 (2.4%)          | 0.018   | 7 (2.4%)         | 0.018   |
| Self-employed   | 9 (3.0%)         | 0.907   | 9 (3.0%)          | 0.907   | 9 (3.0%)         | 0.907   |
| Homemaker       | 10 (3.3%)        | 0.111   | 17 (5.7%)         | 0.111   | 17 (5.7%)        | 0.111   |
| **Occupation**  |                  |         |                   |         |                  |         |
| Buddhism        | 41 (16.3%)       | 0.451   | 68 (26.5%)        | 0.451   | 68 (26.5%)        | 0.451   |
| Islam/Christian | 11 (4.1%)        | 0.406   | 17 (5.7%)         | 0.406   | 17 (5.7%)        | 0.406   |
| **Monthly Income** |       |         |                   |         |                  |         |
| Not pass        | 1 (0.3%)         | 0.105   | 10 (3.4%)         | 0.105   | 10 (3.4%)        | 0.105   |
| Pass            | 15 (1.5%)        | 0.062   | 72 (26.3%)        | 0.062   | 72 (26.3%)        | 0.062   |
| **Education**   |                  |         |                   |         |                  |         |
| Not pass        | 4 (1.3%)         | 0.004   | 25 (8.8%)         | 0.004   | 25 (8.8%)        | 0.004   |
| Pass            | 242 (81.1%)      | 0.159   | 455 (60.2%)       | 0.159   | 455 (60.2%)       | 0.159   |
| **Religion**    |                  |         |                   |         |                  |         |
| Not pass        | 223 (75.1%)      | 0.055   | 232 (78.6%)       | 0.055   | 232 (78.6%)       | 0.055   |
| Pass            | 241 (81.1%)      | 0.292   | 235 (78.6%)       | 0.292   | 235 (78.6%)       | 0.292   |

* P-value's exact test coefficient, number of housing item corresponded to Table 5 conditions of housing sanitation.
### Tab. SII. Correlation between environmental sanitation (coliform contamination in food and drinking water) and factors of characteristics of the elderly workers and housing sanitation.

| Characteristics | Conform in cooked rice | Conform in side dish | Conform in drinking water |
|-----------------|------------------------|----------------------|---------------------------|
| **Gender**      |                        |                      |                           |
| Male            | 1 (0.6%)               | 1 (0.6%)             | 24 (13.9%)                |
| Female          | 11 (6.1%)              | 9 (5.6%)             | 88 (53.9%)                |
| **Education**   |                        |                      |                           |
| Primary school and below | 7 (9.9%) | 5 (6.9%) | 86 (52.8%) |
| Secondary school and higher | 5 (2.8%) | 4 (7.1%) | 17 (10.4%) |
| **Monthly Income** |               |                      |                           |
| ≤ 5,000 THB     | 3 (5.2%)               | 5 (9.9%)             | 15 (25.2%)                |
| > 5,000-10,000 THB | 2 (1.1%) | 4 (7.1%) | 16 (26.8%) |
| > 10,000 THB    | 1 (0.6%)               | 1 (0.8%)             | 20 (33.3%)                |
| **Career**      |                        |                      |                           |
| Homemaker       | 1 (0.6%)               | 2 (3.6%)             | 9 (16.1%)                 |
| Self-employed   | 1 (0.6%)               | 2 (3.6%)             | 9 (16.1%)                 |
| **Religion**    |                        |                      |                           |
| Islam/Christianity | 9 (5.0%) | 9 (16.1%) | 47 (76.0%) |
| Buddhism        | 5 (1.7%)               | 4 (7.1%)             | 15 (25.2%)                |
| **Monthly Income** |               |                      |                           |
| ≤ 5,000 THB     | 11 (6.1%)              | 9 (16.1%)            | 88 (53.9%)                |
| > 5,000-10,000 THB | 12 (7.1%) | 24 (41.6%) | 277 (226.3%) |
| > 10,000 THB    | 14 (8.4%)              | 18 (31.6%)           | 297 (226.3%)              |
| **Housing Sanitation** |            |                      |                           |
| Farmer/Fishery | 4 (2.2%)               | 4 (7.1%)             | 16 (26.8%)                |
| Merchant        | 3 (1.7%)               | 1 (1.8%)             | 3 (5.4%)                  |
| Employee        | 1 (0.6%)               | 2 (3.6%)             | 9 (16.1%)                 |
| Self-employed   | 5 (1.7%)               | 1 (1.8%)             | 4 (7.1%)                  |
| Non-householder | 1 (0.6%)               |                      |                           |
| **Statistical Analysis** |            |                      |                           |
| *Fisher’s exact test coefficient, mean more than 20% of the expected values in cells are less than 5; ** no statistics are computed because it is a constant. Number of housing item corresponded to Table II.
The Correlation between Indoor Air Quality and Characteristics of the Elderly Workers and Housing Sanitation.

| Characteristics | Bacteria in bedroom | p-value | Bacteria in kitchen | p-value | Fungus in bedroom | p-value | Fungus in kitchen | p-value |
|-----------------|---------------------|---------|---------------------|---------|-------------------|---------|-------------------|---------|
| Gender          |                     |         |                     |         |                   |         |                   |         |
| Male            | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| Female          | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| Age             |                     |         |                     |         |                   |         |                   |         |
| <50             | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| 50-64           | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| >64             | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| Education       |                     |         |                     |         |                   |         |                   |         |
| Primary school  | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| secondary school| 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| and higher     | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| Monthly income  |                     |         |                     |         |                   |         |                   |         |
| <5,000 THB      | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| 5,001-10,000 THB| 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| >10,000 THB     | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| Occupation      |                     |         |                     |         |                   |         |                   |         |
| Farmer/ Fisher  | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| Merchant        | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| Employee        | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| Self-employed   | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| Homemaker       | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| Religion        |                     |         |                     |         |                   |         |                   |         |
| Buddhism        | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| Islam/Christian | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| Housing status  |                     |         |                     |         |                   |         |                   |         |
| Not pass        | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| Pass            | 26 (8.1%)           | 0.256   | 7.9 (5.7%)          | 0.055   | 25 (8.5%)         | 0.312   | 7.0 (5.9%)        | 0.057   |
| Housing item 24 |                     |         |                     |         |                   |         |                   |         |
| No.              |                     |         |                     |         |                   |         |                   |         |
| No.22            | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| No.13            | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| No.25            | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| No.26            | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |
| No.27            | 165 (48.6%)         | 62 (21.4%) | 162 (55.5%)         | 56 (19.5%) | 78 (26.9%) | 74 (25.9%) | 62 (21.6%) | 40 (16.6%) |

* Fisher's exact test coefficient, number of housing item corresponded to Table 6 Characteristics of housing sanitation.