



## RESEARCH ARTICLE

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

JIRA KONGPRAN, CHAMNONG THANAPOP, UDOMRATANA VATTANASIT

Department of Environmental Health and Technology, School of Public Health, Walailak University, Thailand

## Keywords

Elderly workers • Housing sanitation • Food sanitation • Water sanitation • Indoor air quality

## Summary

**Introduction.** Thailand will become a completely aged society in 2021 and a super-aged society in 2030, resulting in a high proportion of older people. Living environments, especially at home, play an essential health determinant for the elders.

**Methods.** This cross-sectional analytical study evaluated 319 households in Nakhon Si Thammarat Province according to the standard of housing sanitation for elders and assessed biological contamination in food, water, and indoor air in the homes.

**Results.** The housing assessment results revealed some issues that are necessary to be improved, i.e., the wet and dry areas in bathrooms were not separated (89.4%), there was no anti-slip sheet in the bathrooms (97.2%), and handrails were not suitably installed (96.2%). The proportion of coliform bacteria contamination in

the samples of cooked rice, side dish, dish, spoon, elderly hand, and drinking water was 93.3, 83.9, 82.5, 88.1, 78.0 and 97.5%, respectively. The average total bacteria count in bedrooms and kitchens was 111 CFU/m<sup>3</sup> and 149 CFU/m<sup>3</sup>, respectively. The average total fungi count was 83 CFU/m<sup>3</sup> in bedrooms and 93 CFU/m<sup>3</sup> in kitchens. Most indoor air quality parameters complied with the standards.

**Conclusions.** Significant health risks for the elderly workers while living at home were injuries due to slipping fall in the house, especially in the bathroom, as well as foodborne and waterborne diseases. The health risks should be communicated to the elders. Prevention of the risks should be performed by the cooperation of relevant government agencies and the older adults in the study area.

## 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 complete 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 Saudi 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.

$$n = \frac{NZ^2_{\alpha/2}p(1-p)}{[e^2(N-1)] + [Z^2_{\alpha/2}p(1-p)]}$$

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 consisted of 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.

### 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

Tab. I. Characteristics of the elderly samples.

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

Tab. II. Conditions of housing sanitation.

Housing items (n = 319)	No. of passing (percent)
<b>General features of external and internal area</b>	
Strong structure of the house	310 (97.2)
The area around the house is clean and shady	307 (96.2)
In case of raising animals, functional separate and cleaned area	289 (90.6)
No debris scattered inside/outside the house	288 (90.3)
No cobweb inside the house	252 (79.0)
<b>Living room</b>	
Do not place things in the path	280 (87.8)
Suitable of the window height and furniture arrangement for seeing the outside view	283 (88.7)
The room uses bright colors and can be easily maintained	264 (82.8)
<b>Kitchen room</b>	
The room is proportional arranged and cleaned	281 (88.1)
Proper ventilation and sufficient natural light	277 (86.8)
Cabinet/ table is at least 60 cm above the floor	312 (97.8)
Cooked food has concealed containers or store in the pantry/refrigerator	296 (92.8)
<b>Bedroom</b>	
The room is clean and right arrangement	294 (92.2)
The room has the nets to prevent mosquito/ insects	262 (82.1)
Proper ventilation and sufficient natural light	271 (85.0)
Having a telephone or accessible emergency signals	156 (48.9)
The bed has a suitable height to prevent fall	259 (81.2)
The mattress and pillows are not too hard or too soft to prevent back pain/ neck pain	301 (94.4)
<b>Bathroom</b>	
Toilet and water closet are clean and in good condition	311 (97.5)
The water in the bathroom is clean and sufficient	313 (98.1)
Water containers and bowls are in good condition	314 (98.4)
Proper ventilation and sufficient natural light	284 (89.0)
The room is separated between wet and dry zone for anti-slip	34 (10.6)
The floor is cleaned, no residue which can cause slippery	290 (90.9)
Having anti-slip sheets placed on the floor	9 (2.8)
<b>Household facilities</b>	
The door handle and lock are in good condition	306 (95.9)
The door should be at least 90 cm width and easily pushed	308 (96.6)
The power plug is in 45-90 cm above the floor which can be accessible and avoid bending	309 (96.9)
Electrical equipment is ready to use	211 (66.1)
Handrails were installed with right conditions (firm, not slippery and easily cleaned)	12 (3.8)
The ramp is flat, 90-150 cm in width, not over 6 m in length and the slope is not over 1:12	135 (42.3)
The floor has distinct colors	149 (46.7)
The chair has a backrest, and the height is suitable that feet can be placed on the floor	268 (84.0)
Closets are sliding or drawers that cloths can be easily picked up	280 (87.8)
<b>Environmental sanitation</b>	
Solid waste is well separated and collected for further transported and disposed	215 (67.4)
The waste container has a lid, clean and sufficient for the amount of waste	76 (23.8)
Household wastewater is treated before discharging to the environment	82 (25.7)
No waterlogging in containers that may be a breeding site of mosquitoes	214 (67.1)

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

**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	Total		Detection rate* (%)
	No. of household	%	
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.

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/m<sup>3</sup>) was higher than that in the bedroom (111 CFU/m<sup>3</sup>). For total fungi, the average level was 83 CFU/m<sup>3</sup> and 93 CFU/m<sup>3</sup> 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/m<sup>3</sup> 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.

**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 coliform contamination 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/m <sup>3</sup> )	293	0-2.063	111 ± 221
Total bacteria in kitchen (CFU/m <sup>3</sup> )	290	0-1.844	149 ± 262
Total fungi in bedroom (CFU/m <sup>3</sup> )	290	0-835	83 ± 109
Total fungi in kitchen (CFU/m <sup>3</sup> )	287	0-806	93 ± 128

The standard of indoor air quality is 500 CFU/m<sup>3</sup> 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%). 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 many reasons, such as the insufficient hygiene of elderly workers such as hand washing, dishwashing, and heating food before eating [30-32]. During the survey we found that the elderly did not wash their hand before eating food, utensils were not be cleaned right after the meal and food waste was left on them, the holder of washed utensils was not be covered, and vectors (cockroaches, flies) were found in some

houses. Also, most of the houses (76.2%) had the problem of solid waste containers, which was no cover and insufficient for the generated amount. Besides, 74.3% of them were not treated the household wastewater (*i.e.*, dishwashing, laundry, bathing) before discharge into the land nearby the houses. Improper solid waste collecting and waterlogging of wastewater might be breeding sources of insects and vectors such as cockroaches, flies, and rats. This insect and vectors can cause bacteria cross-contamination in food and food contact surfaces [33].

Coliform bacteria contamination in drinking water was also high, with a rate of 97.5%. Only for some bottled water samples (0.6% of big bottled water and 14.3% of small bottled water) found negative results. Other sources of drinking water were 100% contaminated by coliform bacteria. High contamination of coliform bacteria in drinking water was detected in Thailand in previous studies. Their detection was 85% at Phayao province [34], 69.2% at Maha Sarakham province [35], and 53.3% at Nakhon Si Thammarat province [36] for drinking water samples from the vending machine and water purifier. These studies reported the contamination caused 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 tap 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 groundwater 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 Nakhon Si 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.

## Acknowledgements

Funding sources: this study is supported by Walailak University (Grant No. WU62105), the National Research

Council of Thailand, the Ministry of Higher Education, Science, Research and Innovation.

## 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.

## References

- [1] World Health Organization. Ageing and health. Available at: <https://www.who.int/news-room/fact-sheets/detail/ageing-and-health> (accessed on 19/3/2020).
- [2] United Nations. World Population Ageing 2017-Highlights (ST/ESA/SER.A/397). Available at: [https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017\\_Highlights.pdf](https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf) (accessed on 19/3/2020).
- [3] National Statistical Office Ministry of Digital Economy and Society. Report on the 2017 Survey of the Older Persons in Thailand. Available at: [http://www.nso.go.th/sites/2014en/Survey/social/domographic/OlderPersons/2017/Full%20Report\\_080618.pdf](http://www.nso.go.th/sites/2014en/Survey/social/domographic/OlderPersons/2017/Full%20Report_080618.pdf) (accessed on 19/3/2020).
- [4] World Bank. Thailand economic monitor: aging society and economy. Washington, DC: World Bank Group 2016. Available at: <http://documents.worldbank.org/curated/en/830261469638312246/pdf/107267-WP-PUBLIC-Thailand-Economic-Monitor-2016.pdf> (accessed on 19/3/2020).
- [5] UNFPA and HelpAge International. Ageing in the twenty-first century: a celebration and a challenge. Available at: <https://www.unfpa.org/sites/default/files/pub-pdf/Ageing%20report.pdf> (accessed on 19/3/2020).
- [6] Almegbel FY, Alotaibi IM, Alhusain FA, Masuadi EM, Al Sulami SL, Aloushan AF, Almuqbil BI. Period prevalence, risk factors and consequent injuries of falling among the Saudi elderly living in Riyadh, Saudi Arabia: a cross-sectional study. *BMJ Open* 2018;8:e019063. <https://doi.org/10.1136/bmjopen-2017-019063>
- [7] Bergen G, Stevens MR, Burns ER. Falls and fall injuries among adults aged  $\geq 65$  years - United States, 2014. *MMWR Morb Mortal Wkly Rep* 2016;65:993-8. <https://doi.org/10.15585/mmwr.mm6537a2>
- [8] Wu H, Ouyang P. Fall prevalence, time trend and its related risk factors among elderly people in China. *Arch Gerontol Geriatr* 2017;73:294-9. <https://doi.org/10.1016/j.archger.2017.08.009>
- [9] Kannus P, Niemi S, Parkkari J, Mattila V, Sievänen H. Fall-induced hospital-treated traumatic brain injuries among elderly Finns in 1970-2017. *Arch Gerontol Geriatr* 2020;86:103958. <https://doi.org/10.1016/j.archger.2019.103958>
- [10] Ekbrand H, Ekman R, Thodelius C, Möller M. Fall-related injuries for three ages groups - analysis of Swedish registry data 1999-2013. *J Safety Res* 2020. <https://doi.org/10.1016/j.jsr.2020.02.016>
- [11] Sucharitpongpan W, Daraphongsatoporn N, Saloa S, Philawuth N, Chonyuen P, Sriruanthong K, Waiwattana K. Epidemiology of fragility hip fractures in Nan, Thailand. *Osteoporos Sarcopenia* 2019;5:19-22. <https://doi.org/10.1016/j.afos.2019.03.003>

- [12] Medical Advisory S. Prevention of falls and fall-related injuries in community-dwelling seniors: an evidence-based analysis. *Ont Health Technol Assess Ser* 2008;8:1-78.
- [13] World Health Organization. Sanitation. Available at: <https://www.who.int/news-room/fact-sheets/detail/sanitation> (accessed on 25/05/2020).
- [14] United Nations Children's Fund (UNICEF); World Health Organization. Progress on household drinking water, sanitation and hygiene 2000-2017: special focus on inequalities. Available at: [https://www.who.int/water\\_sanitation\\_health/publications/jmp-report-2019/en](https://www.who.int/water_sanitation_health/publications/jmp-report-2019/en) (accessed on 25/05/2020).
- [15] Belachew AB, Abrha MB, Gebrezgi ZA, Tekle DY. Availability and utilization of sanitation facilities in Enderta district, Tigray, Ethiopia. *JPMH* 2018;59:E219-e25. <https://doi.org/10.15167/2421-4248/jpmh2018.59.3.826>
- [16] World Health Organization. Guidelines for drinking-water quality. Available at: [https://apps.who.int/iris/bitstream/handle/10665/44584/9789241548151\\_eng.pdf;jsessionid=4B70B28FA4E2BAC3DF49A111D007EEA4?sequence=1](https://apps.who.int/iris/bitstream/handle/10665/44584/9789241548151_eng.pdf;jsessionid=4B70B28FA4E2BAC3DF49A111D007EEA4?sequence=1) (accessed on 25/05/2020).
- [17] Simoni M, Jaakkola MS, Carrozzi L, Baldacci S, Di Pede F, Viegi G. Indoor air pollution and respiratory health in the elderly. *Eur Respir J* 2003;21(40 suppl):15s. <https://doi.org/10.1183/09031936.03.00403603>
- [18] Almeida-Silva M, Wolterbeek HT, Almeida SM. Elderly exposure to indoor air pollutants. *Atmos Environ* (1994) 2014;85:54-63. <https://doi.org/10.1016/j.atmosenv.2013.11.061>
- [19] Tong X, Wang B, Dai W-T, Cao J-J, Ho SSH, Kwok TCY, Lui K-H, Lo C-M, Ho KF. Indoor air pollutant exposure and determinant factors controlling household air quality for elderly people in Hong Kong. *Air Qual Atmos Health* 2018;11:695-704. <https://doi.org/10.1007/s11869-018-0576-2>
- [20] Department of older persons, ministry of social development and human security. Measures to implement national agenda on aged society. Available at: [http://www.dop.go.th/download/knowledge/th1551432930-155\\_0.pdf](http://www.dop.go.th/download/knowledge/th1551432930-155_0.pdf) (accessed on 26/7/2020).
- [21] Parliamentary Budget Office, The Secretariat of the House of Representatives. Guidelines for managing budgetary expenditures in social welfare for the elderly care. Available at: [https://www.parliament.go.th/ewtadmin/ewt/parbudget/ewt\\_dl\\_link.php?nid=639](https://www.parliament.go.th/ewtadmin/ewt/parbudget/ewt_dl_link.php?nid=639) (accessed on 26/7/2020).
- [22] Wayne WD. *Biostatistics: a foundation for analysis in health sciences*. 6th ed. United States of America: John Wiley and Sons Inc 1995.
- [23] Sang N, Thanapop C, Kongpran J. Evaluation and factors related to residential care for elders, Thasala District, Nakhon Si Thammarat. *PHJBUU* 2019;14:30-43.
- [24] Ministry of Public Health, Department of Health, Bureau of Food and Water Sanitation. Operation guideline of food sanitation surveillance for practitioner. Available at: [http://foodsana.namai.moph.go.th/more\\_news.php?cid=86&filename=index](http://foodsana.namai.moph.go.th/more_news.php?cid=86&filename=index) (accessed on 25/05/2020).
- [25] Ministry of Public Health, Department of Health, Bureau of Food and Water Sanitation. Principle of food sanitation inspector. Available at: [http://foodsana.namai.moph.go.th/download/D\\_Media/FoodInspector57.pdf](http://foodsana.namai.moph.go.th/download/D_Media/FoodInspector57.pdf) (accessed on 09/07/2020).
- [26] Hinds WC. *Aerosol technology: properties, behavior, and measurement of airborne particles*. New York: John Wiley and Sons Inc 1982.
- [27] Institute of Environmental Epidemiology Ministry of the Environment. Good indoor air quality in office premises. Available at: [https://www.bca.gov.sg/GreenMark/others/NEA\\_Office\\_IAQ\\_Guidelines.pdf](https://www.bca.gov.sg/GreenMark/others/NEA_Office_IAQ_Guidelines.pdf) (accessed on 25/05/2020).
- [28] Ministry of Public Health, Department of Health, Bureau of Environmental Health. Operation manual for practitioner in assessment of indoor air quality. Available at: [http://env.namai.moph.go.th/ewt\\_dl\\_link.php?nid=824](http://env.namai.moph.go.th/ewt_dl_link.php?nid=824) (accessed on 10/05/2020).
- [29] Thawa N, Chaivisit P. The environmental management and housing for the elderly in Muang District, Nakhon Si Thammarat. *APHEIT Journal* 2016;5:31-9.
- [30] Dharod JM, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G, Pérez-Escamilla R. Bacterial contamination of hands increases risk of cross-contamination among low-income Puerto Rican meal preparers. *J Nutr Educ Behav* 2009;41:389-97. <https://doi.org/10.1016/j.jneb.2008.11.001>
- [31] Biranjia-Hurdoyal S, Latouche MC. Factors affecting microbial load and profile of potential pathogens and food spoilage bacteria from household kitchen tables. *Can J Infect Dis Med Microbiol* 2016;3574149. <https://doi.org/10.1155/2016/3574149>
- [32] Touré O, Coulibaly S, Arby A, Maiga F, Cairncross S. Improving microbiological food safety in peri-urban Mali; an experimental study. *Food Control* 2011;22:1565-72. <https://doi.org/10.1016/j.foodcont.2011.03.012>
- [33] Black EP, Hinrichs GJ, Barcay SJ, Gardner DB. Fruit flies as potential vectors of foodborne illness. *J Food Prot* 2018;81:509-14. <https://doi.org/10.4315/0362-028x.jfp-17-255>
- [34] Sombatwathanawet M, Ruengorn C. Situation on drinking water quality from vending machines and maintenance system in Chaingmuan District, Phayao Province. *Thai J Pharm Prac* 2020;12:388-98.
- [35] Poophalee T, Arparsithongsakul S, Wongwatthanasathien O, Supuntee M. Quality and safety of drinking water from water vending machine in Maha Sarakham. *Thai J Pharm Prac* 2020;10:356-65.
- [36] Nuengmatcha P, Wongthong S, Panthong P, Chongsawatwatthana. The study of drinking water quality from drinking water service points in Nakhon Si Thammarat Rajabhat University. *Wichcha Journal* 2018;37:25-37.
- [37] Prasertsin T, Waiyaka P, Kornochalert S and Pukumpuang W. Water quality analysis of mountain water supply at Nanglae Nai Village, Nanglae Subdistrict, Muang District, Chiang Rai Province. *KSK* 2017;11:101-13.
- [38] Manoworn W, Inmuong Y and Inmuong U. Assessment of water quality at water supply plant in Sawathee Sub-district, Khon Kaen Province. *KKU Journal for Public Health Research* 2013;6:181-90.
- [39] Sunsitthisawad W, Pitaksanurat S. Contamination of coliform bacteria in rural households drinking water. *KKU Res J* 2011;16:1025-35.
- [40] Lapkham C, Jitbantoeng N, Tongdam S, Pakhamsri A, Jantarade S. Patterns of underground water management for sanitation by community participation in Ban Koawnoi, Tat Sub-district, Warinchamrap District, Ubon Ratchathani Province. *ABC Journal* 2015;7:22-35.
- [41] Pibul P, Jawjit S, Soradach W, Muhammad U. Water quality of roof rainwater harvesting system in Thamyai, Tung Song District, Nakhon Si Thammarat. *Srinakharinwirot University, Journal of Science and Technology* 2018;10:34-45.
- [42] Nimrat S, Vuthiphandchai V. Physical and microbiological qualities of clear bottled drinking water distributed in Nan Province. Ubon Ratchathani University, *Journal of Science & Technology* 2014;16:57-64.
- [43] Nimrat S, Vuthiphandchai V. The Quality of bottled drinking water distributed in Uttaradit Province. Ubon Ratchathani University, *Journal of Science & Technology* 2019;21:199-212.
- [44] Nimrat S, Vuthiphandchai V. Physical and microbiological qualities of clear and opaque bottled drinking water distributed in Ayutthaya Province. Ubon Ratchathani University, *Journal of Science & Technology* 2017;19:193-207.
- [45] Kirby MA, Nagel CL, Rosa G, Iyakaremye L, Zambrano LD, Clasen TF. Faecal contamination of household drinking water in Rwanda: a national cross-sectional study. *Sci Total Environ* 2016;571:426-34. <https://doi.org/10.1016/j.scitotenv.2016.06.226>
- [46] Abera B, Bezabih B, Hailu D. Microbial quality of community



- drinking water supplies: a ten year (2004-2014) analyses in west Amhara, Ethiopia. *Sustainability Water Qual Ecol* 2017;9-10:22-6. <https://doi.org/10.1016/j.swaqe.2016.06.001>
- [47] Davoodi R, Pirsahab M, Karimyan K, Gupta VK, Takhtshahi AR, Sharafi H, Moradi M. Data for distribution of various species of fecal coliforms in urban, rural and private drinking water sources in ten years period - a case study: Kermanshah, Iran. *Data Brief* 2018;18:1544-50. <https://doi.org/10.1016/j.dib.2018.04.053>
- [48] Dehghani M, Sorooshian A, Nazmara S, Baghani AN, Delikhooon M. Concentration and type of bioaerosols before and after conventional disinfection and sterilization procedures inside hospital operating rooms. *Ecotoxicol Environ Saf* 2018;164:277-82. <https://doi.org/10.1016/j.ecoenv.2018.08.034>
- [49] Rajasekar A, Balasubramanian R. Assessment of airborne bacteria and fungi in food courts. *Build Environ* 2011;46:2081-7. <https://doi.org/10.1016/j.buildenv.2011.04.021>

Received on September 25, 2020. Accepted on January 26, 2021.

**Correspondence:** Jira Kongpran, Department of Environmental Health and Technology, School of Public Health, Walailak University, Thailand - E-mail: [jira.ko@mail.wu.ac.th](mailto:jira.ko@mail.wu.ac.th)

**How to cite this article:** Kongpran J, Thanapop C, Vattanasit U. Environmental sanitation and hygiene of elderly workers in Nakhon Si Thammarat Province, Thailand. *J Prev Med Hyg* 2021;62:E152-E163. <https://doi.org/10.15167/2421-4248/jpmh2021.62.1.1611>

© Copyright by Pacini Editore Srl, Pisa, Italy

*This is an open access article distributed in accordance with the CC-BY-NC-ND (Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International) license. The article can be used by giving appropriate credit and mentioning the license, but only for non-commercial purposes and only in the original version. For further information: <https://creativecommons.org/licenses/by-nc-nd/4.0/deed.en>*

## 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			Coliform in spoon			Coliform in hand		
	Negative (52)	Positive (245)	p-value	Negative (35)	Positive (259)	p-value	Negative (68)	Positive (241)	p-value
Gender									
Male	15 (5.1%)	64 (21.5%)	0.686	8 (2.7%)	70 (23.9%)	0.600	27 (8.7%)	59 (19.1%)	0.013
Female	37 (12.5%)	181 (60.9%)		27 (9.2%)	189 (63.4%)		41 (13.3%)	182 (58.9%)	
Education									
Primary school and below	35 (11.8%)	171 (57.6%)	0.724	25 (8.5%)	177 (60.2%)	0.711	41 (13.3%)	171 (53.3%)	0.094
Secondary school and higher	17 (5.7%)	74 (24.9%)		10 (3.4%)	82 (27.9%)		27 (8.7%)	70 (22.7%)	
Monthly income									
≤ 5,000 THB	12 (4.0%)	81 (27.3%)	0.369	14 (4.8%)	79 (26.9%)	0.363	25 (8.1%)	74 (23.9%)	0.639
5,001-10,000 THB	21 (7.1%)	85 (28.6%)		9 (3.1%)	96 (32.7%)		22 (7.1%)	86 (27.8%)	
≥ 10,000 THB	19 (6.4%)	79 (26.6%)		12 (4.1%)	84 (28.6%)		21 (6.8%)	81 (26.2%)	
Career									
Farmer/Fishery	14 (4.7%)	62 (20.9%)	0.153	13 (4.4%)	63 (21.4%)	0.148	18 (5.8%)	63 (20.4%)	0.159
Merchant	11 (3.7%)	55 (18.5%)		4 (1.4%)	60 (21.8%)		10 (3.2%)	55 (17.8%)	
Employee	8 (2.7%)	46 (15.5%)		4 (1.4%)	49 (16.7%)		16 (5.2%)	41 (13.3%)	
Self-employed	9 (3.0%)	62 (20.9%)		8 (2.7%)	63 (21.4%)		13 (4.2%)	61 (19.7%)	
Homemaker	10 (3.4%)	20 (6.7%)		6 (2.0%)	24 (8.2%)		11 (3.6%)	21 (6.8%)	
Religions									
Buddhism	41 (13.8%)	199 (67.0%)	0.692	31 (10.5%)	205 (69.7%)	0.189	58 (18.8%)	193 (62.5%)	0.331
Islam/Christianity	11 (3.7%)	46 (15.5%)		4 (1.4%)	54 (18.4%)		10 (3.2%)	48 (15.5%)	
Housing item No.2									
Not pass	1 (0.3%)	9 (3.0%)	1.000*	1 (0.3%)	8 (2.7%)	1.000*	1 (0.3%)	10 (3.2%)	0.466*
Pass	51 (17.2%)	236 (79.5%)		34 (11.6%)	251 (85.4%)		67 (21.7%)	231 (74.8%)	
Housing item No.3									
Not pass	4 (1.3%)	22 (7.4%)	1.000*	4 (1.4%)	21 (7.1%)	0.517*	7 (2.3%)	18 (5.8%)	0.451
Pass	48 (16.2%)	223 (75.1%)		31 (10.5%)	238 (81.0%)		61 (19.7%)	223 (72.2%)	
Housing item No.4									
Not pass	2 (0.7%)	24 (8.1%)	0.277*	3 (1.0%)	24 (8.2%)	1.000*	3 (1.0%)	26 (8.4%)	0.111
Pass	50 (16.8%)	221 (74.4%)		32 (10.9%)	235 (79.9%)		65 (21.0%)	215 (69.6%)	
Housing item No.5									
Not pass	7 (2.4%)	55 (18.5%)	0.148	7 (2.4%)	54 (18.4%)	0.907	6 (1.9%)	58 (18.8%)	0.006
Pass	45 (15.2%)	190 (64.0%)		28 (9.5%)	205 (69.7%)		62 (20.1%)	183 (59.2%)	
Housing item No.9									
Not pass	4 (1.3%)	27 (9.1%)	0.476	3 (1.0%)	28 (9.5%)	1.000*	3 (1.0%)	32 (10.4%)	0.042
Pass	48 (16.2%)	218 (73.4%)		32 (10.9%)	231 (78.6%)		65 (21.0%)	209 (67.6%)	
Housing item No.10									
Not pass	6 (2.0%)	32 (10.8%)	0.765	3 (1.0%)	34 (11.6%)	0.592*	7 (2.3%)	31 (10.0%)	0.569
Pass	46 (15.5%)	213 (71.7%)		32 (10.9%)	225 (76.5%)		61 (19.7%)	210 (68.0%)	
Housing item No.11									
Not pass	0 (0.0%)	4 (1.3%)	1.000*	0 (0.0%)	4 (1.4%)	1.000*	0 (0.0%)	7 (2.3%)	0.354
Pass	52 (17.5%)	241 (81.1%)		35 (11.9%)	255 (86.7%)		68 (22.0%)	234 (75.7%)	
Housing item No.12									
Not pass	3 (1.0%)	17 (5.7%)	1.000*	3 (1.0%)	17 (5.8%)	0.717*	3 (1.0%)	19 (6.1%)	0.429*
Pass	49 (16.5%)	228 (76.8%)		32 (10.9%)	242 (82.3%)		65 (21.0%)	222 (71.8%)	
Housing item No.13									
Not pass	3 (1.0%)	19 (6.4%)	0.776*	1 (0.3%)	21 (7.1%)	0.491*	5 (1.6%)	19 (6.1%)	0.885
Pass	49 (16.5%)	226 (76.1%)		34 (11.6%)	238 (81.0%)		63 (20.4%)	222 (71.8%)	
Housing item No.15									
Not pass	8 (2.7%)	33 (11.1%)	0.716	4 (1.4%)	36 (12.2%)	0.689*	7 (2.3%)	37 (12.0%)	0.292
Pass	44 (14.8%)	212 (71.4%)		31 (10.5%)	223 (75.9%)		61 (19.7%)	204 (66.0%)	
Housing item No.19									
Not pass	1 (0.3%)	6 (2.0%)	1.000*	0 (0.0%)	7 (2.4%)	1.000*	2 (0.6%)	6 (1.9%)	0.690*
Pass	51 (17.2%)	239 (80.5%)		35 (11.9%)	252 (85.7%)		66 (21.4%)	235 (76.1%)	
Housing item No.20									
Not pass	1 (0.3%)	3 (1.0%)	0.539*	0 (0.0%)	4 (1.4%)	1.000*	1 (0.3%)	4 (1.3%)	1.000*
Pass	51 (17.2%)	242 (81.5%)		35 (11.9%)	255 (86.7%)		67 (21.7%)	237 (76.7%)	
Housing item No.22									
Not pass	2 (0.7%)	27 (9.1%)	0.113	1 (0.3%)	27 (9.2%)	0.222*	2 (0.6%)	30 (9.7%)	0.023
Pass	50 (16.8%)	218 (73.4%)		34 (11.6%)	232 (78.9%)		66 (21.4%)	211 (68.3%)	
Housing item No.24									
Not pass	4 (1.3%)	22 (7.4%)	1.000*	1 (0.3%)	24 (8.2%)	0.332*	2 (0.6%)	25 (8.1%)	0.055
Pass	48 (16.2%)	223 (75.1%)		34 (11.6%)	235 (79.9%)		66 (21.4%)	216 (69.9%)	
Housing item No.35									
Not pass	17 (5.7%)	80 (26.9%)	0.996	10 (3.4%)	85 (28.9%)	0.614	19 (6.1%)	81 (26.2%)	0.378
Pass	35 (11.8%)	165 (55.6%)		25 (8.5%)	174 (59.2%)		49 (15.9%)	160 (51.8%)	
Housing item No.36									
Pass	43 (14.5%)	184 (62.0%)	0.241	26 (8.8%)	197 (67.0%)	0.818	50 (16.2%)	183 (59.2%)	0.684
Not pass	9 (3.0%)	61 (20.5%)		9 (3.1%)	62 (21.1%)		18 (5.8%)	58 (18.8%)	
Housing item No.37									
Not pass	40 (13.5%)	182 (61.3%)	0.691	28 (9.5%)	190 (64.6%)	0.400	41 (13.3%)	188 (60.8%)	0.003
Pass	12 (4.0%)	63 (21.2%)		7 (2.4%)	69 (23.5%)		27 (8.7%)	53 (17.2%)	

\* Fisher's exact test coefficient, number of housing item corresponded to Table II 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	Coliform in cooked rice			Coliform in side dish			Coliform in drinking water		
	Negative (12)	Positive (168)	p-value	Negative (9)	Positive (47)	p-value	Negative (8)	Positive (303)	p-value
Gender									
Male	1 (0.6%)	49 (27.2%)	0.183*	3 (5.4%)	14 (25.0%)	1.000*	4 (1.3%)	82 (26.4%)	0.223*
Female	11 (6.1%)	119 (66.1%)		6 (10.7%)	33 (58.9%)		4 (1.3%)	221 (71.1%)	
Education									
Primary school and below	7 (3.9%)	125 (69.4%)	0.308*	5 (8.9%)	30 (53.6%)	0.715*	3 (1.0%)	210 (67.5%)	0.114*
Secondary school and higher	5 (2.8%)	43 (23.9%)		4 (7.1%)	17 (30.4%)		5 (1.6%)	93 (29.9%)	
Monthly income									
≤ 5,000 THB	5 (2.8%)	57 (31.7%)	-	1 (1.8%)	13 (23.2%)	-	0 (0.0%)	98 (31.5%)	-
5,001-10,000 THB	5 (2.8%)	61 (33.9%)		4 (7.1%)	18 (32.1%)		3 (1.0%)	108 (34.7%)	
≥ 10,000 THB	2 (1.1%)	50 (27.8%)		4 (7.1%)	16 (28.6%)		5 (1.6%)	97 (31.2%)	
Career									
Farmer/Fishery	4 (2.2%)	46 (25.6%)	-	1 (1.8%)	20 (35.7%)	-	0 (0.0%)	84 (27.0%)	-
Merchant	3 (1.7%)	39 (21.7%)		3 (5.4%)	6 (10.7%)		1 (0.3%)	65 (20.9%)	
Employee	1 (0.6%)	24 (13.3%)		2 (3.6%)	8 (14.3%)		2 (0.6%)	54 (17.4%)	
Self-employed	3 (1.7%)	41 (22.8%)		2 (3.6%)	9 (16.1%)		4 (1.3%)	69 (22.2%)	
Homemaker	1 (0.6%)	18 (10.0%)		1 (1.8%)	4 (7.1%)		1 (0.3%)	31 (10.0%)	
Religions									
Buddhism	9 (5.0%)	138 (76.7%)	0.463*	9 (16.1%)	41 (73.2%)	0.575*	5 (1.6%)	247 (79.4%)	0.179*
Islam/Christianity	3 (1.7%)	30 (16.7%)		0 (0.0%)	6 (10.7%)		3 (1.0%)	56 (18.0%)	
Housing item No.2									
Not pass	0 (0.0%)	9 (5.0%)	1.000*	0 (0.0%)	1 (1.8%)	1.000*	0 (0.0%)	10 (3.2%)	1.000*
Pass	12 (6.7%)	159 (88.3%)		9 (16.1%)	46 (82.1%)		8 (2.6%)	293 (94.2%)	
Housing item No.3									
Not pass	1 (0.6%)	19 (10.6%)	1.000*	0 (0.0%)	2 (3.6%)	1.000*	1 (0.3%)	26 (8.4%)	0.521*
Pass	11 (6.1%)	149 (82.8%)		9 (16.1%)	45 (80.4%)		7 (2.3%)	277 (89.1%)	
Housing item No.4									
Not pass	2 (1.1%)	16 (8.9%)	0.342*	0 (0.0%)	3 (5.4%)	1.000*	0 (0.0%)	28 (9.0%)	1.000*
Pass	10 (5.6%)	152 (84.4%)		9 (16.1%)	44 (78.6%)		8 (2.6%)	275 (88.4%)	
Housing item No.5									
Not pass	2 (1.1%)	42 (23.3%)	0.733*	3 (5.4%)	10 (17.9%)	0.419*	1 (0.3%)	64 (20.6%)	1.000*
Pass	10 (5.6%)	126 (70.0%)		6 (10.7%)	37 (66.1%)		7 (2.3%)	269 (86.8%)	
Housing item No.9									
Not pass	3 (1.7%)	22 (12.2%)	0.222*	1 (1.8%)	7 (12.5%)	1.000*	2 (0.6%)	32 (10.3%)	0.214*
Pass	9 (5.0%)	146 (81.1%)		8 (14.3%)	40 (71.4%)		6 (1.9%)	271 (87.1%)	
Housing item No.10									
Not pass	3 (1.7%)	18 (10.0%)	0.151*	0 (0.0%)	2 (3.6%)	1.000*	2 (0.6%)	37 (11.9%)	0.264*
Pass	9 (5.0%)	150 (83.3%)		9 (16.1%)	45 (80.4%)		6 (1.9%)	266 (85.5%)	
Housing item No.11									
Not pass	1 (0.6%)	4 (2.2%)	0.295*	0 (0.0%)	1 (1.8%)	1.000*	0 (0.0%)	6 (1.9%)	1.000*
Pass	11 (6.1%)	164 (91.1%)		9 (16.1%)	46 (82.1%)		8 (2.6%)	297 (95.5%)	
Housing item No.12									
Not pass	1 (0.6%)	11 (6.1%)	0.575*	0 (0.0%)	3 (5.4%)	1.000*	1 (0.3%)	20 (6.8%)	0.432*
Pass	11 (6.1%)	157 (87.2%)		9 (16.1%)	44 (78.6%)		7 (2.3%)	283 (91.0%)	
Housing item No.13									
Not pass	3 (1.7%)	13 (7.2%)	0.077*	0 (0.0%)	3 (5.4%)	1.000*	1 (0.3%)	22 (7.1%)	0.463*
Pass	9 (5.0%)	155 (86.1%)		9 (16.1%)	44 (78.6%)		7 (2.3%)	281 (90.4%)	
Housing item No.15									
Not pass	4 (2.2%)	26 (14.4%)	0.118	1 (1.8%)	7 (12.5%)	1.000*	1 (0.3%)	43 (13.8%)	1.000*
Pass	8 (4.4%)	142 (78.9%)		8 (14.3%)	40 (71.4%)		7 (2.3%)	260 (83.6%)	
Housing item No.19									
Not pass	0 (0.0%)	6 (3.3%)	1.000*	0 (0.0%)	1 (1.8%)	1.000*	0 (0.0%)	7 (2.3%)	1.000*
Pass	12 (6.7%)	162 (90.0%)		9 (16.1%)	46 (82.1%)		8 (2.6%)	296 (95.2%)	
Housing item No.20									
Not pass	0 (0.0%)	4 (2.2%)	1.000*	0 (0.0%)	0 (0.0%)	**	0 (0.0%)	6 (1.9%)	1.000*
Pass	12 (6.7%)	164 (91.1%)		9 (16.1%)	47 (83.9%)		8 (2.6%)	297 (95.5%)	
Housing item No.22									
Not pass	2 (1.1%)	16 (8.9%)	0.342*	0 (0.0%)	3 (5.4%)	1.000*	1 (0.3%)	32 (10.3%)	0.597*
Pass	10 (5.6%)	152 (84.4%)		9 (16.1%)	44 (78.6%)		7 (2.3%)	271 (87.1%)	
Housing item No.24									
Not pass	2 (1.1%)	20 (11.1%)	0.644*	0 (0.0%)	8 (14.3%)	0.329*	2 (0.6%)	26 (8.4%)	0.156*
Pass	10 (5.6%)	148 (82.2%)		9 (16.1%)	39 (69.6%)		6 (1.9%)	277 (89.1%)	
Housing item No.35									
Not pass	4 (2.2%)	65 (36.1%)	1.000*	1 (1.8%)	21 (37.5%)	0.074*	4 (1.3%)	94 (30.2%)	0.266*
Pass	8 (4.4%)	103 (57.2%)		8 (14.3%)	26 (46.4%)		4 (1.3%)	209 (67.2%)	
Housing item No.36									
Pass	8 (4.4%)	138 (76.7%)	0.244*	7 (12.5%)	38 (67.9%)	1.000*	8 (2.6%)	228 (73.3%)	0.206*
Not pass	4 (2.2%)	30 (16.7%)		2 (3.6%)	9 (16.1%)		0 (0.0%)	75 (24.1%)	
Housing item No.37									
Not pass	10 (5.6%)	130 (72.2%)	1.000*	6 (10.7%)	36 (64.3%)	0.676*	6 (1.9%)	225 (72.3%)	1.000*
Pass	2 (1.1%)	38 (21.1%)		3 (5.4%)	11 (19.6%)		2 (0.6%)	78 (25.1%)	

\* Fisher's exact test coefficient, means 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 Conditions of Housing Sanitation.

