Kesmas

Volume 18
Issue 3 *August*

Article 3

8-31-2023

Comparison of Prevalence and Associated Factors of Multisystem Health Symptoms Among Workers in the Gas Station Area, Thailand

Chan Pattama Polyong
Faculty of Science and Technology, Bansomdejchaopraya Rajabhat University, chan.bsru@gmail.com

Anamai Thetkathuek
Faculty of Public Health, Burapha University, anamai@buu.ac.th

Recommended Citation

Polyong CP , Thetkathuek A . Comparison of Prevalence and Associated Factors of Multisystem Health Symptoms Among Workers in the Gas Station Area, Thailand. *Kesmas*. 2023; 18(3): 168-176
DOI: 10.21109/kesmas.v18i3.6924
Available at: https://scholarhub.ui.ac.id/kesmas/vol18/iss3/3

Polyong, *et al. Kesmas: Jurnal Kesehatan Masyarakat Nasional (National Public Health Journal)*. 2023; 18 (3): 168-176
DOI: 10.21109/kesmas.v18i3.6924

Kesmas: Jurnal Kesehatan Masyarakat Nasional (Kesmas: National Public Health Journal)

Comparison of Prevalence and Associated Factors of Multisystem Health Symptoms Among Workers in the Gas Station Area, Thailand

Chan Pattama Polyong[1], Anamai Thetkathuek[2*]

[1]Occupational Health and Safety Program, Faculty of Science and Technology, Bansomdejchaopraya Rajabhat University, Bangkok, Thailand,
[2]Department of Industrial Hygiene and Safety, Faculty of Public Health, Burapha University, Chon Buri, Thailand

Abstract

This cross-sectional study aimed to compare the prevalence of multisystem health symptoms (MHS) of workers in gas station areas before and after their employment and examine the factors affecting the MHS of workers. Data were collected by an interview questionnaire from 200 workers inside and outside refueling areas at eight gas stations in Rayong Province, Thailand. This study found that employees had a statistically significant increase in the prevalence of current MHS in comparison to before starting work (p-value<0.05), with 31.5%. Working overtime for more than 6 hours per week led to respiratory symptoms (OR = 2.63, 95% CI = 1.14–6.07) and psychological symptoms (OR = 2.69, 95% CI = 1.12–6.49). Wearing respiratory protective equipment for less than three hours affected ear/throat/nose systems (OR = 4.26, 95% CI = 1.43–12.65). Petrol refueling resulted in liver (OR = 2.32, 95% CI = 1.4–12.65) and eye symptoms (OR = 2.57, 95% CI = 1.10–5.39). Therefore, gas station owners should set up enclosed rooms to reduce the duration of fuel exposure, and workers should wear personal protective equipment when refueling or near the dispenser.

Keywords: BTEX, gas stations, multisystem health symptoms, prevalence, risk factors

Introduction

The global gasoline and diesel fuel vehicle fleets substantially impact human health.[1] Therefore, individuals working at gas stations (GS) are at the highest risk of exposure and experiencing multisystem health symptoms (MHS), which refers to the occupational awareness of individuals who can perceive their symptoms across various systems of the body, such as the respiratory system, visual system, integumentary system, and mental state, among others.[2] In a study conducted by Al-Harbi, dominant symptoms reported by gasoline station workers were headache, depression, fatigue, and throat irritation at 50, 40, 25, and 20%, respectively.[3] Furthermore, studies conducted in Thailand have confirmed the occurrence of neurotoxic symptoms. There have been reports of individuals encountering chemicals associated with fuel oil and experiencing symptoms related to headache, dizziness, and stress/irritability at 49, 42.5, and 38.5%, respectively.[4] A recent study has provided clear evidence of neurotoxicity; however, when it comes to other symptoms, various studies have documented a range of different manifestations, such as sore throat, drowsiness, muscle weakness, and unconsciousness.[5]

The Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX) will impact the human body, especially for workers at the GS, because 50% of the BTEX inhaled throughout their lifetimes will be absorbed into the body.[6] Moreover, workers had a low level of safe behavior while working; for example, clothes wet with fuel, not wearing a respiratory protection mask, and putting their faces close to the tank were 62.7, 62.2, and 25.5%, respectively.[7] Therefore, exposure to such substances can affect workers' multisystem health, resulting in acute and chronic damage to the target organs. In terms of acute damage, poisoning affects the nervous system, thereby causing headaches and dizziness,[4,6,8] skin symptoms such as eye irritation and allergic skin rash,[9] respiratory symptoms such as coughing,[10] and psychological symptoms such as irritability, insomnia, inattentiveness, and lack of concentration, which were significantly higher than those in the non-exposed group.[11] Additionally, renal symptoms, such as difficulty urinating and less output,[12] have been found. If workers are continuously exposed, significant chronic effects can occur. Importantly,

Correspondence: Anamai Thetkathuek, Faculty of Public Health, Burapha University, Chonburi Province 20131, Thailand, E-mail: anamai@buu.ac.th, Phone: +66-16-921013*

Received : May 20, 2023
Accepted : August 29, 2023
Published : August 31, 2023

benzene is a human carcinogen. It was reported that exposure to benzene at an airborne concentration of 1 μg/m^3 causes approximately six cases of leukemia per million inhabitants.[13]

Prevention of exposure to BTEX aims to reduce the adverse health effects on workers. It is important to take occupational health precautions to avoid exposure to vapors while providing fuel services.[14] For example, protection at the source can be implemented by installing a vapor recovery system (VRS), which can reduce the level of BTEX in the atmosphere by 60.9–76.5%.[15] In Thailand, however, there are still obstacles to preventing exposure to BTEX; for instance, the general lack of VRS systems in use in stations, inadequate personal protection against fuel such as not using personal protective equipment (PPE), or using the equipment incorrectly.[7,16,17] In addition, individual behavioral factors such as smoking,[18] as well as demographic characteristics like sex,[10,19] and age,[20] are risk factors for exposure to BTEX.

Workers in GS are regarded as an important force in the economic development of the service sector in the Eastern Economic Corridor area of Thailand; however, this group of workers still lacks equality in health care,[21] and there is concern regarding their health conditions. Therefore, early health prevention should be sought by evaluating exposure and health effects. The impact assessment by abnormal symptom interviews is a simple tool for self-assessing unusual health-related sensations. Therefore, this study's inquiry revolves around identifying the prevalence of health symptoms arising from employment at the GS and understanding the associated factors. The aim was to study the MHS of workers in the refueling area by comparing the symptoms before and after their employment. Additionally, this study aimed to determine which factors affected the employees' health symptoms at the GS. In the past, it was mainly confirmed by neurological symptoms.[4,6,8] In this study, however, the knowledge of other systemic symptoms, such as respiratory, skin, psychological, liver, and kidney disorders, was added. The benefits of this study can be used for comprehensive health screening against acute toxicity of BTEX in the future.

Method

A sample of 200 workers was calculated based on the proportion from a previous study.[22] It was found that 83.7% of the workers at the GS had adverse reactions (p-value = 0.837). Error was 5% (e = 0.05), with 95% confidence (Z = 1.96), using cluster sampling until all numbers were reached. This was done because each GS' job position and environment were similar. There were two sample groups–with the first consisting of 100 inside fuel dispenser areas (I-FDA), including those filling and cashiers, and the second consisting of 100 outside fuel dispenser areas (O-FDA), including those working in offices, convenience stores, coffee shops, and food vendors in GS–working for over threemonths and voluntarily agreeing to join the project. The exclusion criteria were illness on the day of the sample collection or exacerbation due to existing underlying diseases, such as migraines, allergies, asthma, and so forth, and being absent from work on the data collection date.

This study had a data collection period from October to November 2020, and laboratory analyses and results were reported from November 2020 to March 2021. This study complied with the Declaration of Helsinki; protecting the rights of the individuals in the sample was an important concern. Consequently, this study's objectives were explained to all participants, who were free to choose whether or not to participate voluntarily. No coercion was applied, and participants could withdraw from the trial at anytime.

This study used two research tools: an interview questionnaire and a urinary collection device. The details of each tool are as follows.

1. The interview questionnaire was divided into general information, work records, and health symptoms. General information included six items: sex, age, weight, height, smoking, and drinking alcohol. Work records included eight items: job positions, duration of work, working overtime, personal hygiene, behavior of wearing PPE, types of vehicles that were serviced each day, and number of vehicles that were serviced each day. Health symptoms in eight systems, with 36 items related to eyes, ears/throat/nose, respiratory tract, skin, psychological, liver, kidney, and anemia symptoms.

The MHS were identified from the literature review,[2] and previous studies involving symptoms of BTEX poisoning.[9-12] The questionnaire was found to have an Item Objective Congruence value greater than 0.5 for all questions. For the interview questionnaire collection, the authors coordinated with GS managers. Sample group participants interested in being volunteers were invited through public relations. The data were collected after the end of work. The interview took about 20 minutes per person within the GS area.

2. The equipment for collecting urine included plastic cups, polyethylene jars (50 ml), temperature-insulating foam boxes, and ice packs. For analytical instruments, such as high-performance liquid chromatography, the laboratory has passed international quality control standards (ISO 15189: 2012) and the Thai Ministry of Public Health standards. The laboratory reported the analysis results in the metabolized form of BTEX. The quantity was analyzed using column type C18, mobile phase, containing water/acetonitrile at a ratio of 50:50 by volume (50:50v/v), flow rate of 1.0 mL/min at 37.0°C, sample

solvent by methanol, and ultraviolet detection at 254 nm wavelength.[23] This study's results used the intersection of the ACGIH standard.[24]

For the urine samples, a sample collection device was provided to the workers during their work. They clarified that the urine samples should be collected at the end of the work shift and that the mid-stream urine should be collected into a polyethylene jar of at least 25 milligrams and immediately packed in a cool box. After that, the samples were sent for laboratory analysis.

The data were analyzed by descriptive and inferential statistics, such as discrete variables, with analysis by frequency and percentage. A depiction with mean and standard deviation (SD) was used for the continuous variables for normally distributed data. If the distribution was abnormal, the depiction with median and interquartile range (IQR) was applied. The proportion of symptoms in the non-independent data was compared using the McNemar test. The analysis of factors affecting MHS classified by health system was performed with logistic regression statistics showing the crude odds ratio (OR) and 95% CI (confidence interval) were statistically significant (p-value<0.05).

Result

The results of the demographic description of 200 workers showed that approximately 2 in 3 (68.5%) were females, and mostly over 30 years old (56%) and had an income of more than 305 USD per month (56.5%) (1 USD = 32.8 THB at the time of the study). In respect to the health behaviors, there was smoking or smelling cigarettes from another person (34%), drinking alcohol (45.5%), and having rest of less than or equal to eight hours (54%). The workers had work experience of one year or more (73.5%), workers worked every day a week (55.5%), more than eight hours of work per day (56%), and additional overtime of six hours per week (86.5%). The workers followed proper hygiene practices (79%) and wore PPE for more than three hours a day (69.5%).

The interviews with 100 I-FDA employees on Table 1 found that those wear personal protective equipment (PPE), which was classified as wearing trousers covering the ankles (98%) and masks (95%). Moreover, those who refueled provided the information that diesel was the fuel filled the most (72%), followed by gasohol (20%). On average, 4-wheel pickup trucks were filled at 32.65±24.80 vehicles per day, and motorcycles account-

Table 1. Work Records of Inside Fuel Dispenser Areas Workers (n = 100)

Variable	Category	n	%	Mean±SD (Car/Day)
Types of PPE	Long pants covering the ankles	98	98.0	
	Mask	95	95.0	
	Closed-toe shoes	58	58.0	
	Long-sleeved shirt	38	38.0	
	Gloves	12	12.0	
	Glasses	5	5.0	
Types of oil refueled	Diesel	72	72.0	
	Gasohol 91, 95	20	20.0	
	Petrol	14	14.0	
	Gasohol E20	5	5.0	
Types of cars refueled	Bus			4.16±4.68
	Truck with more than 4 wheels			9.68±8.67
	Van			10.62±8.90
	Pickup truck with 4 wheels			32.65±24.80
	Personal car with 4 wheels			28.52±20.27
	Motorcycle			31.51±30.43

Notes: PPE = Personal Protective Equipment, SD = Standard Deviaton

Table 2. Comparison of Total Health Symptoms Before and After the Employment (n = 200)

Health Symptom	Symptoms Presently Occurring in the Past Three Months	Symptoms Before Working at the Gas Station	χ^2	p-value
No	42 (21.0)	105 (52.5)	41.14	<0.001**
Yes (more than one symptom)	158 (79.0)	95 (47.5)		
1–5 symptoms	80 (40.0)	66 (33.0)		
6–10 symptoms	34 (17.2)	16 (8.0)		
>10 symptoms	44 (22.0)	13 (6.5)		

Note: **p-value<0.001

Table 3. Comparison of Multisystem Health Classified by Symptoms Before and After the Employment (n = 200)

Health Symptom		Symptoms Presently Occurring in the Past Three Months	Symptoms Before Working at the Gas Station	Change in Past and Present Symptom	p-value
Eye system	Blurred vision	53 (26.5)	24 (12.0)	+29 (14.5)	<0.001**
	Dry/itchy/irritated eyes	43 (21.5)	17 (8.5)	+26 (13.0)	<0.001**
Ear, nose, and throat system	Sore throat/dry throat/irritated throat	75 (37.5)	41 (20.5)	+34 (17.0)	<0.001**
	Stuffy nose	70 (35.0)	38 (19.0)	+32 (16.0)	<0.001**
	Runny nose	68 (34.0)	40 (20.0)	+28 (14.0)	<0.001**
	Tinnitus	30 (15.0)	8 (4.0)	+22 (11.0)	<0.001**
	Ear pain	12 (6.0)	5 (2.5)	+7 (3.5)	<0.001**
	Ringing in the ears	6 (3.0)	3 (1.5)	+3 (1.5)	0.375
Respiratory system	Cough with mucus	58 (29.0)	32 (16.0)	+26 (13.0)	<0.001**
	Chest tightness	31 (15.5)	13 (6.5)	+18 (9.0)	<0.001**
	Panting	25 (12.5)	10 (5.0)	+15 (7.5)	0.001**
	Wheezing	25 (12.5)	9 (4.5)	+16 (8.0)	<0.001**
	Chest pain when breathing	20 (10.0)	9 (4.5)	+11 (5.5)	0.003*
Skin system	A red rash that appears on various parts of the skin	30 (15.0)	14 (7.0)	+16 (8.0)	0.002*
	A red rash on the hands and arms	12 (6.0)	4 (2.0)	+8 (4.0)	0.021*
Psychological symptom	Insomnia, difficulty sleeping	69 (34.5)	31 (15.5)	+38 (19.0)	<0.001**
	Loss of appetite	50 (25.0)	18 (9.0)	+32 (16.0)	<0.001**
	Mood swings	50 (25.0)	21 (10.5)	+29 (14.5)	<0.001**
	Heart palpitations	33 (16.5)	11 (5.5)	+22 (11.0)	<0.001**
	Feel depressed	30 (15.0)	11 (5.5)	+19 (9.5)	<0.001**
	Restless	22 (11.0)	10 (5.0)	+12 (6.0)	<0.001**
	Sweating without a known cause	21 (10.5)	9 (4.5)	+12 (6.0)	<0.001**
	Panting without exertion	10 (5.0)	3 (1.5)	+7 (3.5)	0.016*
	Being in a happy mood without drinking alcohol	7 (3.5)	2 (1.0)	+5 (2.5)	0.063
Liver symptom	Nausea, vomiting	20 (10.0)	11 (5.5)	+9 (4.5)	0.012*
	Abdominal pain under the ribcage	16 (8.0)	9 (4.5)	+7 (3.5)	0.016*
	Yellow eyes, jaundice	14 (7.0)	6 (3.0)	+8 (4.0)	0.008*
Kidney symptom	Back pain	91 (45.5)	36 (18.0)	+55 (27.5)	<0.001**
	Profuse urination	25 (12.5)	10 (5.0)	+15 (7.5)	<0.001**
	Infrequent urination	19 (9.5)	9 (4.5)	+10 (5.0)	0.002*
	Pain when urinating	17 (8.5)	5 (2.5)	+12 (6.0)	<0.001**
	Swelling of the eyelids, face, feet, and legs	10 (5.0)	4 (2.0)	+6 (3.0)	0.109
	Blood in the urine	3 (1.5)	1 (0.5)	+2 (1.0)	0.500
Anemia symptom	Eyes/body yellow	8 (4.0)	5 (2.5)	+3 (1.5)	0.250
	Bleeding easily throughout the body	7 (3.5)	4 (2.0)	+3 (1.5)	0.250
	Enlarged liver with hemorrhage	0 (0.0)	0 (0.0)	-	-

Notes: *p-value<0.05, **p-value<0.001

ed for 31.51±30.43 vehicles per day.

The results of the measurement of urinary metabolites of BTEX showed that employees had t,t-MA higher than the standard (29.5%), with the highest t,t-MA exceeding the standard almost 3 times (1,482.46 µg/g Cr) (Median = 393.40, IQR = 244.59). The levels of HA, MA, and MHA were detected as being lower than the standard (HA; Median = 0.31, IQR = 0.14: MA; Median = 0.06, IQR = 0.02: and MHA; Median = 0.4, IQR = 0.2, respectively).

When comparing health symptoms occurring within the past three months to those before starting work at the gas station, the results of the total MHS of the interviews with workers revealed that prior to working at this GS, they had experienced at least one health symptom (out of 36) (47.5%), with an increase in overall health symptoms of 31.5%. The largest segment of employees had 1–5 symptoms (40.0%) (Table 2).

The results of MHS classified 36 symptoms revealed that employees had the highest prevalence of back pain at 45.5%, followed by sore throat/dry throat/irritated throat, and stuffy nose at 37.5 and 35.0%, respectively, in the past three months. The workers had a statistically significant increase in health symptoms (p-value<0.05), with 29 symptoms after employment. The top three symptoms that changed the most were back pain, insomnia/difficulty sleeping, and sore throat/dry throat/irritated throat (Table 3).

The factors affecting the current health symptoms were statistically significant (p-value<0.05), according to the factors as health behaviors, amount of work and wearing PPE, and refueling service (Table 4A and B). For health behaviors, sleeping less than or equal to eight hours per day affects the symptoms of the ear/throat/

nose system (OR = 2.21, 95% CI = 1.02–4.80), psychological symptoms (OR = 2.08, 95% CI = 1.18–3.66), and liver symptoms (OR = 1.80, 95% CI = 1.03–3.17).

For the amount of work and wearing PPE, working for more than eight hours per day affected the psychological symptoms (OR = 1.93, 95% CI = 1.09–3.39); working overtime more than six hours per week affected respiratory symptoms (OR = 2.63, 95% CI = 1.14–6.07) and psychological symptoms (OR = 2.69, 95% CI = 1.12–6.49); wearing a respiratory protective device for less than three hours had an effect on ear/ throat/nose symptoms (OR = 4.26, 95% CI = 1.43–12.65); and wearing closed-toe shoes affected the eye symptoms (OR = 2.36, 95%CI = 1.04–5.35), ear/throat/nose symptoms (OR = 8.12, 95% CI = 3.00–21.93), respiratory symptoms (OR = 2.81, 95% CI = 1.57–5.02), liver symptoms (OR = 2.70, 95% CI = 1.25–5.83) and kidney symptoms (OR = 1.98, 95% CI = 1.12–3.48).

Regarding the refueling service, most of the refueling employees were affected by liver symptoms (OR = 2.32, 95% CI = 1.43,12.65); refueling more than 10 trucks affected the eye symptoms (OR = 2.57, 95% CI = 1.10–5.39), and refueling more than 33 pickup trucks per day affected the respiratory symptoms (OR = 2.36, 95% CI = 1.04–5.35) (Table 4B).

Discussion

The factors affecting MHS found that regarding health behaviors, sleeping less than or equal to eight hours per day affected the symptoms of the ear/throat/

Table 4A. Factors Affecting Multisystem Health Symptoms (n = 200)

Variable	Multisystem Health Symptoms[a]							
	Eye	Ear/Throat/Nose	Respiratory	Skin	Psychological	Liver	Kidney	Anemia
Sex								
Female	4.92 (0.25–9.54)	0.86 (0.36–1.79)	0.63 (0.34–1.16)	3.39 (1.25–9.19)	1.14 (0.63–2.08)	1.10 (0.50–2.41)	1.46 (0.80–2.65)	1.01 (0.03–3.04)
Age (years)								
>30	1.42 (0.79–2.55)	0.81 (0.38–1.70)	0.96 (0.54–1.69)	0.93 (0.45–1.94)	0.84 (0.48–1.48)	0.49 (0.23–1.07)	0.71 (0.40–1.24)	1.03 (0.36–2.89)
BMI (kg/m²)								
Overweight-obese	1.01 (0.57–1.02)	1.10 (0.49–2.09)	1.24 (0.46–1.41)	2.26 (0.21–3.93)	1.04 (0.59–1.81)	1.87 (0.89–3.92)	1.70 (0.62–1.87)	0.11 (0.70–6.30)
Income per month (USD)								
305	0.74 (0.41–1.33)	0.91 (0.43–1.89)	0.65 (0.37–1.16)	0.59 (0.27–1.26)	0.69 (0.39–1.21)	0.86 (0.41–1.78)	0.62 (0.35–1.10)	1.32 (0.47–3.69)
Currently smoking								
Yes	1.41 (0.76–2.63)	0.77 (0.37–1.63)	0.69 (0.38–1.27)	1.69 (0.74–3.82)	0.77 (0.43–1.38)	0.94 (0.44–1.38)	0.81 (0.45–1.47)	0.85 (0.29–2.43)
Currently drinking alcohol								
Yes	1.39 (0.78–2.50)	0.53 (0.26–1.11)	0.57 (0.32–1.02)	2.17 (1.00–4.68)	0.89 (0.51–1.55)	0.75 (0.37–1.53)	1.15 (0.66–2.02)	0.82 (0.29–2.29)
Sleep time per day (hours)								
<8	1.57 (0.87–2.82)	2.21* (1.02–4.80)	0.91 (0.52–1.60)	1.08 (0.52–2.23)	2.08* (1.18–3.66)	1.80* (1.03–3.17)	1.46 (0.51–4.19)	0.55 (0.15–2.01)
Work experience (year)								
1 or more	0.70 (0.36–1.38)	0.62 (0.25–1.52)	0.77 (0.41–0.45)	0.91 (0.39–2.08)	0.41 (0.21–0,79)	0.59 (0.24–1.45)	0.65 (0.36–1.27)	1.75 (0.60–5.07)
Working time per day (hours)								
>8	1.59 (0.89–2.86)	1.17 (0.57–2.42)	1.22 (0.69–2.77)	1.34 (0.65–2.77)	1.93* (1.09–3.39)	1.64 (0.80–3,37)	1.26 (0.72–2.20)	2.27 (0.79–6.50)
Working period per week (days)								
Every day	0.92 (0.51–1.64)	0.58 (0.28–1.20)	0.86 (0.45–1,51)	1.00 (0.49–2.07)	0.75 (0.43–1.32)	1.22 (0.59–2.52)	0.90 (0.52–1.58)	1.85 (0.62–5.53)
Working overtime per week (hours)								
>6	1.39 (0.58–3.34)	1.89 (0.54–6.64)	2.63* (1.14–6.07)	0.96 (0.34–2.73)	2.69* (1.12–6.49)	0.99 (0.35–2.83)	1.45 (0.64–3.29)	0.65 (0.17–2.45)
Personal hygiene								
No	0.91 (0.41–2.03)	1.34 (0.53–3.39)	1.28 (0.58–2.78	1.66 (0.68–4.08)	1.57 (0.72–3.38)	1.95 (0.81–4.67)	2.25* (1.01–5.04)	2.64 (0.85–8.20)
Wearing respiratory protection equipment (hours/day)								
≤3	1.89 (0.97–3.68)	4.26* (1.43–12.65)	0.82 (0.44–1.53)	1.17 (0.52–2.61)	0.65 (0.35–1.19)	1.45 (0.64,3.31)	0.68 (0.37–1.25)	3.30 (0.72–1.51)

Notes: [a] = Crude Odd Ratio (95% Confidence Interval), *p-value<0.05, BMI = Body Mass Index

Table 4B. Factors Affecting Multisystem Health Symptoms (n = 200)

Variable	Multisystem Health Symptoms[a]							
	Eye	Ear/Throat/Nose	Respiratory	Skin	Psychological	Liver	Kidney	Anemia
Type of fuel refilled								
Diesel	0.52 (0.29–0.93)	0.60 (0.29–1.39)	0.79 (0.45–1.39)	0.79 (0.38–1.63)	0.66 (0.38–1.16)	0.96 (0.47–1.97)	0.81 (0.46–1.41)	0.91 (0.33–2.54)
Petrol	0.50 (0.24–1.02)	0.63 (0.26–1.56)	0.90 (0.20–1.31)	0.51 (0.20–1.31)	0.90 (0.47–1.69)	2.32* (1.01–4.92)	0.96 (0.51–1.82)	1.32 (0.43–4.01)
Gasohol 91,95	0.59 (0.33–1.06)	0.57 (0.27–1.20)	1.04 (0.59–1.82)	1.00 (0.48–2.05)	0.85 (0.48–1.48)	0.93 (0.45–1.91)	1.04 (0.59–1.81)	1.31 (0.47–3.67)
Gasohol E20	0.90 (0.50–1.64)	0.94 (0.47–2.08)	1.10 (0.62–1.96)	0.86 (0.40–1.82)	0.91 (0.52–1.62)	1.24 (0.60–2.55)	1.04 (0.56–1.77)	1.23 (0.44–3.47)
Type of cars refueled								
Trucks >10	2.57* (1.10–5.39)	1.62 (0.59–4.40)	1.56 (0.77–3.14)	2.17 (0.71–6.55)	1.38 (0.68–2.79)	1.05 (0.42–2.60)	1.56 (0.77–3.16)	0.71 (0.21–2.32)
Vans >11	1.78 (0.62–5.12)	0.87 (0.27–2.76)	1.12 (0.44–2.84)	1.27 (0.35–4.59)	1.57 (0.61–4.02)	0.65 (0.22–1.91)	1.39 (0.55–3.53)	0.76 (0.16–3.61)
Pickup trucks >33	1.82 (0.73–4.52)	0.78 (0.29–2.07)	2.36* (1.04–5.35)	0.78 (0.29–2.07)	1.18 (0.53–2.63)	0.81 (0.30–2.15)	1.23 (0.51–2.50)	0.45 (0.13–1.51)
Motorcycles >31	0.89 (0.38–2.07)	0.91 (0.32–2.60)	0.68 (0.29–1.62)	0.85 (0.34–2.14)	0.70 (0.31–1.61)	0.45 (0.18–1.13)	0.94 (0.41–2.15)	1.05 (0.23–4.91)
Types of PPE worn								
Glasses (no)	0.54 (0.15–1.94)	2.03 (0.24–16.56)	0.56 (0.14–2.25)	0.87 (0.17–4.28)	0.41 (0.10–1.63)	2.10 (0.25–17.14)	0.26 (0.05–1.26)	0.44 (0.05–3.92)
Mask (no)	1.47 (0.68–3.17)	2.48 (1.05–5.84)	0.60 (0.28–1.28)	0.42 (0.12–1.47)	1.00 (0.47–2.13)	1.02 (0.47–2.13)	0.76 (0.35–1.63)	0.73 (0.15–3.39)
Gloves (no)	0.78 (0.39–1.57)	1.12 (0.45–2.78)	1.01 (0.51–2.02)	1.12 (0.45–2.78)	0.61 (0.30–1.22)	1.17 (0.47–2.89)	1.00 (0.50–1.98)	1.94 (0.42–8.91)
Closed shoes (no)	2.27* (1.25–4.12)	8.12* (3.00–21.93)	2.81* (1.57–5.02)	1.25 (0.60–2.58)	1.49 (0.85–2.60)	2.70* (1.25–5.83)	1.98* (1.12–3.48)	3.133 (0.97–10.07)
Long-sleeved shirt (no)	1.36 (0.71–2.61)	2.32 (0.91–5.92)	0.40 (0.20–0.78)	0.91 (0.41–2.00)	0.82 (0.44–1.51)	0.52 (0.25–1.10)	0.63 (0.34–1.18)	0.65 (0.22–1.89)
Long pants that cover the ankles (no)	1.48 (0.73–3.03)	3.53 (1.60–7.82)	1.61 (0.77–3.37)	0.99 (0.40–2.47)	1.06 (0.52–2.14)	1.17 (0.49–2.81)	1.21 (0.60–2.46)	0.56 (0.12–2.60)
t,t-MA								
>500	0.79 (0.41–1.56)	0.76 (0.33–1.73)	0.75 (0.41–1.39)	1.68 (0.79–3.57)	0.71 (0.39–1.31)	0.61 (0.26–1.42)	0.83 (0.45–1.52)	0.83 (0.45–1.52)

Notes: [a] = Crude Odd Ratio (95% Confidence Interval), *p-value<0.05, PPE = Personal Protective Equipment

nose, psychological, and liver symptoms by 2.21, 2.08, and 1.80 times, respectively. These findings aligned with a study in New York City that investigated sleep and psychological symptoms and found that the subjects had an average sleep duration of 5.8±1.2 hours per night, with a prevalence of short-term sleep duration (<6 hours/day), which was 38.8%.[25] The sample group had psychological symptoms that occurred as follows: insomnia, acute stress, depression, and anxiety, which were 72.8, 57.9, 33.8, and 48.2%, respectively.[25]

Concerning the amount of work and wearing PPE, it was found that the workers who worked more than eight hours per day were affected by their psychological symptoms 1.93 times. Overtime work of more than six hours per week affected respiratory and psychological symptoms at 2.63 and 2.69 times, respectively. Workers may have a common exposure to various chemicals in fuel, particularly those working long hours or overtime. These findings were consistent with the Agency for Toxic Substances and Disease Registry report stating that exposure to very high levels of benzene in the air (10,000–20,000 ppm) in a short period (5–10 minutes) can cause death. At low concentrations (700–3,000 ppm), however, it can cause drowsiness, nausea, hallucinations, and depression.[26]

Wearing respiratory protective equipment for less than three hours affected ear/throat/nose symptoms 4.26 times. Wearing closed-toe shoes affects the eyes, ear/throat/nose, respiratory, liver, and kidneys at 2.36, 8.12, 2.81, 2.70, and 1.98 times, respectively. These findings were consistent with a previous study that found significant exposure in GS, in which the workers exposed to low concentrations were associated with a prevalence of hearing impairment or loss.[27] There are more studies conducted on ototoxicity from exposure to various organic solvents, such as toluene and styrene, leading to effects on hearing.[24] This study's results provided more supporting evidence in the form of an interview on ear

abnormality in workers who work around the fuel dispenser, which found that the highest number of ear-related symptoms were tinnitus, ear pain, and ringing in the ears at 12, 4, and 2%, respectively.

Another important finding from this study was that the health symptoms of the employees who did not wear closed-toe shoes could be affected. It can also be caused by spills or splashes of fuel on their feet while refueling. A previous study found that in 1 week of work, 64.1% of fuel filler workers suffered skin accidents.[28] The spill can cause the evaporation of oil into the air, resulting in the presence of vapors in the vicinity,[29] because the organic solvents in the fuel easily evaporate into the air. Therefore, evaporation has the potential for employees to touch their eyes and affect their respiratory and ear/nose/throat systems, which will increase the symptoms that can occur even more.

During the interviews, participants were asked about the type of fuel added, which is important regarding health symptoms linked with the various fuel categories. In the past, no studies have been focused on this factor. This study indicated that petrol refueling affected liver symptoms 2.32 times, as the chemicals in the fuel can affect liver function. There is further evidence supporting an effect on increased liver function enzymes, as it was found that the exposure to benzene among fuel workers was 0.79±0.26 μg/m^3 and significantly correlated with AST and ALT statistically.[12]

It is generally known that the process of metabolites of oils and compounds in fuels forms 1,2,4-benzene triol and j-benzoquinone, which interacts with adipose tissue in hepatocytes to form lipid peroxide and ROS consisting of hydroxyl and superoxide radicals, wherein reactive oxygen and lipid peroxidation cause the destruction of biomembranes.[30] This process causes the leakage of various components in the liver cells.[12] Therefore, liver dysfunction should be assessed with the liver function enzyme level, as mentioned above, since the evidence shows prolonged exposure to BTEX compounds in the fuel. In this study, however, the sample group only had a working period of approximately 1 year.

Refueling more than 10 trucks had effects on eye symptoms 2.57 times, and refueling more than 33 trucks per day had effects on respiratory symptoms 2.36 times; however, the study area is an economic province of Thailand with investment in the country's heavy industry.[21] It links sea transportation from a deep-sea port to road and rail transportation. In addition, the way of life of the local community is linked with agriculture and fruit plantations. Therefore, the trucks and pickup trucks are the vehicles that use many service stations, and both vehicles have larger fuel tanks than personal vehicles. Therefore, it takes a long time to add fuel to each vehicle, which may also affect the oil's evaporation.[21] This study found that refueling these two types of vehicles leads to eye and respiratory symptoms. The most common eye symptoms were dry/itchy/irritated eyes and blurred vision at 18.0% and 17.0%, respectively. These findings were consistent with a study by Sirdah, *et al.*, that found a statistically significant increase in eye itches, redness, and pain among employees working at liquefied petroleum GS in the Gaza Territory.[31] Hence, GS workers may be at a higher risk of visual impairment in the future, so they should be cautious about their health regarding regular visual abnormalities.

Adding gas to pickup trucks can result in respiratory symptoms due to the composition of the fuel, causing significant damage to the respiratory system. This can occur in both the upper and lower respiratory tracts, thereby causing mucosal irritation, inflammation, swelling, and acute bronchitis.[32] In this study, occupational workers had the most productive cough, at 29%. It has previously been reported that exposure to fuel vapor at a concentration of 900 ppm for an hour caused symptoms of irritation of the eyes, nose, and throat. Fuel exposure at 10,000 ppm causes nose and throat irritation within 2 minutes and dizziness within 4 minutes.[2] Employees' exposure to fuel vapors through direct inhalation can lead to respiratory function impairment.[33] Therefore, continuous health surveillance should be emphasized.

The highlight of this study was that the interviews about the health symptoms retrospectively before and after employment which was considered to control various confounding factors. As a result, there was reliability of the outcomes in the occurrence of symptoms. In addition, the sample size was sufficient to answer the study objectives more effectively than many previous studies on the same issue. The weakness of this study was that the assessment of health symptoms was done using an interview form for the evaluation of the symptoms without a medical examination; however, the interview forms had been evaluated for validity in terms of content by occupational medicine physicians, and the validity is following the measurement and evaluation criteria.

Conclusion

The factors affecting MHS with statistical significance include working for more than eight hours per day, working overtime more than six hours per week, wearing respiratory protection equipment for less than three hours, refueling mostly petrol, refueling more than 10 trucks, and refueling more than 33 pickup trucks per day. Therefore, the results show that these risk factors are preventable. This study recommends the GS workers to stay away from the dispensers or stay in an enclosed room to reduce exposure time. Additionally, PPE should be worn while refueling or standing near the dispenser, and those who refuel should be careful when refueling vehi-

cles with large fuel tanks, such as trucks and pickups, by not standing near the fuel dispenser for an extended period.

Abbreviations

GS: Gas Stations; MHS: Multisystem Health Symptoms; BTEX: Benzene Toluene Ethylbenzene Xylenes; VRS: Vapor Recovery System; PPE: Personal Protective Equipment; I-FDA: Inside Fuel Dispenser Area; O-FDA: Outside Fuel Dispenser Area; SD: Standard Deviation; IQR: Interquartile Range; OR: Odds Ratio.

Ethics Approval and Consent to Participate

This study was conducted with the approval of the Burapha University Institutional Review Board for Protection of Human Subjects in Research (BUU-IRB) (certificate no. 019/2020). Before beginning the survey, informed consent was obtained from all the study participants.

Competing Interest

The authors declared that there are no significant competing financial, professional, or personal interests that might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

All study data are available upon reasonable request to the corresponding author. The identities of the participants remain classified.

Authors' Contribution

CPP and AT led the design of the work. CPP analyzed and interpreted the data and is a major contributor to writing the manuscript. AT conducted review and editing, project administration, and funding acquisition. All authors read and approved the final manuscript.

Acknowledgment

The authors thank the Health System Research Institute for funding (Contract No. 63-070) and Burapha University for supporting this study. The authors also thank the staff of Rayong Hospital in honor of Her Royal Highness Princess Maha Chakri Sirindhorn for allowing the authors to collect the samples, and the participants volunteered to participate in this study.

References

1. Huang Y, Unger N, Harper K, et al. Global Climate and Human Health Effects of the Gasoline and Diesel Vehicle Fleets. Geo Health. 2020; 4 (3): e2019GH000240. DOI: 10.1029/2019GH000240
2. Ekpenyong CE, Asuquo EA. Recent Advances in Occupational and Environmental Health Hazards of Workers Exposed to Gasoline Compounds. Int J Occup Med Environ Health. 2017; 30: 1-26. DOI: 10.13075/ijomeh.1896.00800
3. Al-Harbi M, Alhajri I, Al-Awadhi A, et al. Health Symptoms Associated with Occupational Exposure of Gasoline Station Workers to BTEX Compounds. Atmos Environ. 2020; 241: 117847. DOI: 10.1016/j.atmosenv.2020.117847
4. Polyong PC, Thetkatuek A. Factors Affecting Prevalence of Neurological Symptoms among Workers at Gasoline Stations in Rayong Province, Thailand. Environ Anal Health Toxicol. 2022; 37 (2): e2022009-0. DOI: 10.5620/eaht.2022009
5. Chaiklieng S, Suggaravetsiri P, Kaminski N, et al. Exposure to Benzene and Toluene of Gasoline Station Workers in Khon Kaen, Thailand and Adverse Effects. HERA 2021; 27 (7): 1823-1837 DOI: 10.1080/10807039.2021.1910010
6. Chauhan SK, Saini N, Yadav VB. Recent Trends of Volatile Organic Compounds in Ambient Air and Its Health Impacts: A review. Int J Sci Res Eng Technol. 2014; 1 (8): 667-78.
7. Alves L, Vieira D, Nunes L, et al. Relationship between Symptoms, Use of PPE and Habits Related to Occupational Exposure to BTEX Compounds in Workers of Gas Stations in Bahia, Brazil. J Environ Protect. 2017; 8 (5): 650-661. DOI: 10.4236/jep.2017.85042
8. Tunsaringkarn T, Soogarun S, Palasuwa A. Occupational Exposure to Benzene and Changes in Hematological Parameters and Urinary Trans, Trans-muconic Acid. Int J Occup Environ. 2013; 4 (1): 45–49
9. Ayyadhi NA, Akhtar S. Prevalence and Risk Factors Associated with Self-rated Morbidities among South Asian Migrant Gas Station Workers in Kuwait. J Immigr Minor Health. 2018; 20 (6): 1324-1331. DOI: 10.1007/s10903-018-0701-1
10. Solanki RB, Bhise AR, Dangi BM. A Study on Spirometry in Petrol Pump Workers of Ahmedabad, India. Lung India. 2015; 32 (4): 347-352. DOI: 10.4103/0970-2113.159567
11. Rasoul GMA, Salem EA, Allam HK, et al. Neurobehavioral and Hematological Health Disorders among Fuel Supply Station Workers. J Environ Publ Health. 2017; 30 (4): 1103-1109. DOI: 10.4103/mmj.mmj_252_17
12. Neghab M, Hosseinzadeh K, Hassanzadeah J. Hematological Study of Petrol Station Worker's Exposure to Unleaded Petrol. J Toxicol Environ Chem. 2015; 96 (6): 951-961. DOI: 10.1080/02772248.2014.979828
13. Moro AM, Brucker N, Charao M, et al. Early Hematological and Immunological Alteration in Gasoline Station Attendants Exposed to Benzene. Environ Res. 2015; 137 (1): 349-356. DOI: 10.1016/j.envres.2014.11.003
14. Kuranchie FA, Angnunavuri PN, Attiogbe F, et al. Occupational Exposure of Benzene, Toluene, Ethylbenzene and Xylene (BTEX) to Pump Attendants in Ghana: Implications for Policy Guidance. Cogent Environ Sci. 2019; 5: 1603418. DOI: 10.1080/23311843.2019.1603418
15. Chaiklieng S. Comparison of BTEX Exposure between Operative and Inoperative Vapor Recovery System during Loading Fuel into the Storage Tanks at Gasoline Stations. Thai J Toxicol. 2020; 35 (2): 30-42.
16. Thetkathuek A, Jaidee W, Saowakhontha S, et al. Neuropsychological Symptoms among Workers Exposed to Toluene and Xylene in Two Paint Manufacturing Factories in Eastern Thailand. Adv Prev Med. 2015; 183728. DOI: 10.1155/2015/183728
17. Naik AV, Ferreira AM. A Cross Sectional Study of Occupational Hazards among Petrol Pump Attendants of Panjim City in Goa. IJoPCCM. 2020; 6 (1): 15-19.
18. Fenga C, Gangemi S, Teodoro M, et al. 8-Hydroxydeoxyquanosine as a Biomarker of Oxidative DNA Damage in Workers Exposed to Low-dose Benzene. Toxicol Reports. 2017; 4 (1): 291-295.

DOI: 10.1016/j.toxrep.2017.05.008
19. Tuakuila J. S-phenymercapturic Acid (S-PMA) Levels in Urine as an Indicator of Exposure to Benzene in the Kinshasa Population. Int J Hyg Environ Health. 2013; 216 (4): 494-498. DOI: 10.1016/j.ijheh.2013.03.012
20. Chaiklieng S, Suggaravetsiri P, Kaminski N, et al. Factors Affecting Urinary tt-Muconic Acid Detection among Benzene Exposed Workers at Gasoline Stations. Int J Environ Res Publ Health. 2019; 16 (21): 4209. DOI: 10.3390/ijerph16214209
21. Thetkathuek A, Polyong CP. Health Status and Factors Influencing Access to Healthcare Services by Workers in Petrol Stations in Rayong Province, Thailand. Rocz Panstw Zakl Hig. 2022; 73 (3): 351-364. DOI: 10.32394/rpzh.2022.0215
22. Chaiklieng S, Nantanuch, R. Factors Associated with Adverse Symptoms Related to Benzene Toxicity among Workers at Gasoline Station. Srinagarind Med J. 2015; 30: 458-466.
23. PerkinElmer, Inc. Environmental: Aromatics on Brownlee Analytical C 18. Waltham, MA: PerkinElmer, Inc; 2013.
24. American Conference of Governmental Industrial Hygienists. TLV/BEIs Guidelines. Cincinnati, OH: American Conference of Governmental Industrial Hygienists; 2023.
25. Diaz F, Cornelius T, Bramley S, et al. The Association Between Sleep and Psychological Distress among New York City Healthcare Workers During the COVID-19 Pandemic. J Affect Disord. 2022; 298 (1): 618-624. DOI: 10.1016/j.jad.2021.10.033
26. Agency for Toxic Substances and Disease Registry. Benzene Overview, Benzene, Also Known as Benzol, is a Colorless Liquid with a Sweet Odor; 2021.
27. Hormozi M, Ansari-Moghaddam A, Mirzaei R, et al. The Risk of Hearing Loss Associated with Occupational Exposure to Organic Solvents Mixture with and without Concurrent Noise Exposure: A Systematic Review and Meta-analysis. Int J Occu Environ health. 2017; 30 (4): 521-535. DOI: 10.13075/ijomeh.1896.01024
28. Polyong CP, Yingratanasuk T, Sirivarasai J, et al. Comparison of Trans, Trans-Muconic Acid Between Groups of Gas Station Attendants, with and without Skin Contact with Fuel Oil in Rayong province. Dis Control J. 2021; 47 (1): 687-699. DOI: 10.14456/dcj.2021.61
29. Alyami AR. Occupational Exposure Assessment to Gasoline Vapours under Various Conditions at Public Gasoline Stations. Athens J Sci. 2017; 4 (1): 323-342. DOI: 10.30958/ajs.4-4-4
30. Al-Olayan EM, El-Khadragy MF, Aref AM, et al. The Potential Effect of Physalis Peruviana L. Against Carbon Tetrachloride Induced Hepatotoxicity in Rats is Mediated by Suppression of Oxidative Stress and Down Regulation of MMP-9 Expression. Oxid Med Cell Longev. 2014; 381413. DOI: 10.1155/2014/381413
31. Sirdah MM, Al-Laham NA, El-Madhoun RA. Possible Health Effects of Liquefied Petroleum Gas on Workers at Filling and Distribution Stations of Gaza Governorates. East Mediterr Health J. 2013; 19 (3): 289-294. DOI: 10.4236/ojrd.2023.133005
32. Obazee E, Aiwuyo H, Kweki A, et al. Lung Function Impairment among Gasoline Attendants: A Cross-Sectional Study. Open J Respir Dis. 2023; 13 (3): 48-63. DOI: 10.4236/ojrd.2023.13300
33. Sinha A, Patil SN. Pulmonary Function Tests in Petrol Pump Workers in Karad Town. Int J Biol Med Res. 2014; 5 (4): 260–263.