

## Original Article

# Urinary toluene levels and adverse health symptoms among automotive garage workers, Nakhon Si Thammarat province, Thailand

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## Abstract

To determine their urinary toluene levels, to describe the workers' hygiene behaviors and the prevalence of adverse health symptoms among automotive garage workers exposed to chemical substances. A cross-sectional descriptive study was conducted by interviewing among automotive garages located in the Nakhon Si Thammarat province, Thailand. During between 1 November 2020 and 31 December 2020. A total of 140 automotive garages workers were selected using a purposive sampling method. The questionnaire was conducted via face-to-face interview and the toluene was quantified using gas chromatography. Descriptive statistics were computed for the variables. Risk factors were evaluated using multiple logistic regression analysis. Adjusted odds ratio (OR<sub>adj</sub>) and 95% confidence interval (CI) were presented as statistically significant when the p value was < 0.05. The Mann-Whitney U test was used to compare the medians of continuous variables of the two groups. The prevalence of skin effects (60.71%); respiratory tract irritation (49.29%); nausea (46.43%); and dizziness (40.71%) was remarkable in the automotive garage workers. Several socio-demographic variables were significantly associated with increased skin effects, respiratory tract irritant, nausea, and dizziness. The median urinary toluene level of the automotive garage workers was 145 µg/L (range, 12.0-958.0 µg/L) which the median urinary levels and demographic characteristics, occupational lifestyle, personal protective equipment used, hygiene behavior, and adverse health symptoms had significantly different ( $p < 0.05$ ). Urine is one of the most useful a sample for biomonitoring of occupational exposure to toluene. Personal hygiene is important for the automotive garage workers, and it should be emphasized in education programs.

**Keywords:** Urinary toluene levels, Adverse health symptoms, Automotive garage workers

## Introduction

The current economic situation is contributing to the opening of garage businesses. In 2018-2020, domestic car sales are likely to expand continuously in line with the economic direction while cars aged 5 years or more will turn to general car repair services instead of going to the repair center more [1]. Automotive garage businesses perform repairs and maintenance, tapping, and painting of cars. Each of these processes use many organic chemicals and solvents in different stages, which cause automotive garage workers to be exposed to organic chemicals and solvents that are related to adverse health symptoms and can result in environmental contamination. Workers who work in automotive garages are exposed to dust, air pollutants [2], heavy metals [3,4], and organic solvents [5,6]. Exposure to different chemical substances in automotive garages may cause respiratory disorders in exposed workers. Diseases of the respiratory system induced by occupational dust, gas, and vapours, are influenced by the type of dust, gas, or vapour, as well as duration of exposure [7]. Some studies have shown a high prevalence of respiratory symptoms [8], cardiovascular health effects [9]. In addition, renal failure, encephalopathy, hepatotoxicity [10], liver and kidney [11,12], lung function [13] can be seen among workers who were exposed to various toxicants from working as garage attendants. Besides, as reported, there were higher prevalence of self-reported chronic respiratory symptoms and dermal symptoms in workers inside the greenhouse compared to those in the controls [9]. Therefore, the different groups of auto-technicians came in contact with fuel while working, which may have numerous negative health consequences that include dermatitis, skin sensitization, eczema, and oil acne [14]. An automotive garage is undermined by poor working environments (i.e., dirty workplaces). Poor section workplace has been found across all sectors, with associated health hazards. Exposure to mixtures of organic solvents may be associated with the prevalence of hypertension in car-manufacturing workers [15]. In addition, factors influencing adverse health symptoms in workers may include long working hours [16], kind of personal protective equipment used, and habits, such as smoking, drinking, eating, chewing khat, and taking showers at work, respectively. Some studies have shown the variation in the level of

toluene in each work location can be due to the number of productions, type of raw materials used, work methods, inadequate ventilation, and workstation either indoor or outdoor [17,18]. In addition, the lack of proper storage of waste materials and poor personal hygiene is causes of high levels of toluene in the work environment [19,20].

The purpose of the present study was to determine their urinary toluene levels, to describe the workers demographic characteristics, occupational lifestyle, personal protective equipment used, personal hygiene and the prevalence of adverse health symptoms among automotive garage workers exposed to chemical substances in the automotive garages of Southern Thailand.

## **Materials and Methods**

### **Study population and samples**

The Ethics Committee of the Institute of Research and Development, Thaksin University, approved this research. This cross-sectional descriptive study was conducted between November 1, 2020 and December 31, 2020 in automotive garages located in three districts, including the Phipun, Chawang, and Tham Phannara districts in the Nakhon Si Thammarat province, Thailand were 30 automotive garages to determine the sample size by using the Krejcie & Morgan formula [21]. A total of 28 automotive garages were selected using a purposive sampling method. All the automotive garages were small enterprises categorized by their service capacity of approximately 20–50 cars/month and the number of workers in each shop (5-12 workers). There were accepted to participate in the study. The participant automotive garage workers were recruited by purposive selection. A total of 140 (out of 230) of all the workers at these 28 automotive garages agreed to participate in the study. Inclusion criteria for the participant automotive garage workers were being 20-62 years old and in occupational contact with automotive garages for at least 1 year. Cooperative letters and informed verbal consent were obtained from all study participants.

### **Sample collection**

Socio-demographics, adverse health symptoms, and personal hygiene behaviour were collected by a questionnaire. Five experts approved the validity of this instrument. The content of this instrument had a validity score of 0.89 and a Kuder-Richardson 20 (KR-20) reliability score > 0.94. The questionnaire was conducted via face-to-face interview. Information on the following variables was collected: general information (gender, age, education, smoking status, and alcohol consumption), worker characteristics (duration of work in contact with automotive garages and days worked per week) and personal hygiene behaviour while working in automotive garages (Personal Protective Equipment used (PPE), consumption of food and/or beverages in the work area, whether hands were washed before lunch, and whether clothes were changed after work). Respondents were asked about the practices that they performed and the frequencies of those activities, which were categorized into 'sometimes' or 'always' and 'yes' or 'no'.

The occurrence of adverse health symptoms amongst the automotive garage workers was also observed. Adverse health symptoms included headache, dizziness, nausea, vomiting, coughing spasms, chest tightness, a sensation of being unable to breathe, progressive memory loss, fatigue, poor concentration, irritability, persistent headaches, muscular weakness, redness and blisters, irritation of the nose and lower airways, feelings of intoxication and respiratory tract irritation [21]. The adverse health symptoms were noted either during the initial study time or during a 3 month recall period. Information was also collected among automotive garage workers by self-reported complaints and the diagnoses of consultant doctors. Respondents were asked about the occurrence of each adverse health symptom and were required to reply with 'yes' or 'no'.

### **Urine samples collection**

Urine samples of the 140 participants were collected at the end of shift. Spot urine samples were collected at the end of shift after 2 days exposure. Urine samples were collected in polyethylene bottles, and they were stored at -20 °C until analysis. Urinary toluene levels were analyzed by a gas chromatograph (GC) (Model GC-148; Shimadzu, Tokyo, Japan).

### **Determination of urinary toluene levels**

Urine samples were analyzed within a few days with periodical vortexing for 2h before analysis. Two mL of headspace was injected onto a 0.5 mL loop of the gas chromatograph [22]. Sodium chloride and toluene (99.9%) were used. Stock solutions of each of the above organic compounds were prepared in methanol (Mallinckrodt Baker Inc., Phillipsburg, USA) at a concentration of 1000 mg L<sup>-1</sup>, and stored at 4 °C in sealed amber vial until use. gas chromatography technique using a DB-1 capillary column (30 m -0.53 mm inner diameter; J&W Scientific) and flame ionization detector with an oven temperature of 200 °C, injector, and detector temperature of 250 °C and a helium flow rate of 10 mL/min. Calibration curves were obtained spiking blank urine samples with six different concentrations of each solvent (5 replicates per concentration), toluene between 92 and 560 µg L<sup>-1</sup> when CAR-PDMS fibers were used.

## Statistical analysis

Data were collected by questionnaire and analysed using a software program. For descriptive statistics, percentages and frequency values were computed for the variables. Risk factors were evaluated using multiple logistic regression analysis. Adjusted odds ratio (OR<sub>adj</sub>) and 95% confidence interval (CI) were presented as statistically significant when the *p* value was < 0.05. The Mann-Whitney *U* test was used to compare the medians of continuous variables of the two groups.

## Results

### Socio-demographics among automotive garage workers

The study subjects consisted of 140 automotive garage workers from Southern Thailand. A substantial portion of the workers were older than 42 years of age (60.0%). All workers were Buddhist. The largest group had less than a secondary school-level education (56.4%). The subjects consisted of 98 smokers (70.00%) and 42 non-smokers (30.00%), and 88.6% disclosed they consumed alcohol.

The majority (81.4%) of automotive garage workers worked more than 8 hours per day, worked 6 days per week (79.3%), and worked for more than 16 years (57.9%). Most subjects used neither cotton masks (51.4%) nor gloves (70.7%) when doing their work. All subjects (100.0%) washed their hands before lunch, but 47.1% of them did not use detergents when washing their hands. More than half (62.1%) ate lunch in the working areas, and 82.9% of all subjects did not change their clothes after work every day (Table 1).

### Prevalence of health symptoms among automotive garage workers

The prevalence of self-reported adverse health symptoms in the preceding 3 month is shown in (Table 2). The prevalence of skin effects, such as irritation, dermatitis, skin sensitization, eczema, oil acne, redness and blisters (60.71%); respiratory tract irritation (49.29%); nausea (46.43%); and dizziness (40.71%) was remarkable in the automotive garage workers. The different socio-demographic independent variables, including age, education level, smoking status, alcohol consumption, hours worked per day, days worked per week, duration of work, use of PPE and personal hygiene, and the relationship between these above symptoms is shown in Table 2.

**Table 1.** Subject socio-demographic characteristics among automotive garage workers.

<b>Characteristic</b>	<b>n = 140</b>	<b>(%)</b>
<b>Gender</b>		
Male	140	100
<b>Age (yrs)</b>		
≤42	56	40.0
>42	84	60.0
Mean±SD, 42.31±5.20 yrs		
<b>Education</b>		
≤ Secondary school / vocational certificate or equivalent	79	56.4
> Secondary school / vocational certificate or equivalent	61	43.6
<b>Behavioral</b>		
Smokes cigarettes		
Yes	98	70.0
No	42	30.0
Drink alcohol		
Yes	124	88.6
No	16	11.4
<b>Occupational lifestyle</b>		
Hours worked per day		
8	26	18.6
≥8	114	81.4
Worked days per week		
6	113	79.3
>6	29	20.7
Duration of work (years)		
16	63	42.1
>16	77	57.9
Mean±SD, 16.41±5.70 yrs. Max 32 yrs, Min 10 yrs.		
<b>Personal protective equipment</b>		
Cotton mask		
Yes	68	48.6
No	72	51.4
Gloves		
Yes	99	70.7
No	41	29.3
<b>Personal hygiene</b>		
Washed hands before lunch		
	140	100
Washed hands with detergents		
Yes	74	52.9
No	66	47.1
Consumption of food and/or beverages in the work area		
Yes	87	62.1
No	53	37.9
Whether clothes were changed after work		
Yes	24	17.1
No	116	82.9

**Table 2.** Prevalence (percent) of adverse health symptoms among automotive garage workers during the preceding 3 months (n=140).

Parameter	Count (n=140)	(%)
Headache	25	17.86
Dizziness	57	40.71
Persistent headaches	8	5.71
Nausea	65	46.43
Vomiting	9	6.43
Coughing spasms	7	5.00
Chest tightness	15	10.71
Respiratory tract	69	49.29
Fatigue	11	7.86
Skin effects; irritation; dermatitis, skin sensitization, eczema, oil acne, redness, and blisters	85	60.71
Progressive memory loss	13	9.29
Poor concentration	17	12.14
Irritability	22	15.71
Muscular weakness	8	5.71
Feelings of intoxication	18	12.86

Several socio-demographic variables were significantly associated with increased skin effects (Table 3), including age (OR<sub>adj</sub> = 2.7; 95% CI = 1.01-4.93), smoking cigarettes (OR<sub>adj</sub> = 2.3; 95% CI = 1.08-4.09), drinking alcohol (OR<sub>adj</sub> = 2.6; 95% CI = 1.28-4.98), hours worked per day (OR<sub>adj</sub> = 2.5; 95% CI = 1.26-4.88), duration of work (OR<sub>adj</sub> = 2.5; 95% CI = 1.26-4.91), cotton mask use (OR<sub>adj</sub> = 2.4; 95% CI = 1.21-4.83), glove use (OR<sub>adj</sub> = 2.7; 95% CI = 1.21-4.99), washing hands with detergent (OR<sub>adj</sub> = 2.4; 95% CI = 1.15-4.63), consumption of food and/or beverages and/or smokes cigarettes in the work area (OR<sub>adj</sub> = 2.3; 95% CI = 1.13-4.67), and whether clothes were changed after work (OR<sub>adj</sub> = 2.3; 95% CI = 1.12-4.71), respectively. Additionally, age (OR<sub>adj</sub> = 2.3; 95% CI = 1.12-5.08), smoking cigarettes (OR<sub>adj</sub> = 2.4; 95% CI = 1.18-4.39), drinking alcohol (OR<sub>adj</sub> = 2.5; 95% CI = 1.25-4.81), days worked per week (OR<sub>adj</sub> = 2.4; 95% CI = 1.25-4.89), duration of work (OR<sub>adj</sub> = 2.5; 95% CI = 1.21-4.77), cotton mask use (OR<sub>adj</sub> = 2.6; 95% CI = 1.11-4.89), glove use (OR<sub>adj</sub> = 2.7; 95% CI = 1.20-4.91), washing hands with detergent (OR<sub>adj</sub> = 2.4; 95% CI = 1.10-4.89), consumption of food and/or beverages and/or smokes cigarettes in the work area (OR<sub>adj</sub> = 2.3; 95% CI = 1.18-4.77), and whether clothes were changed after work (OR<sub>adj</sub> = 2.3; 95% CI = 1.15-4.78) were significantly associated with increased respiratory tract irritation (Table 3).

The multiple variable logistic regression analysis, when controlling for age, smoking cigarettes, drinking alcohol, hours worked per day, duration of work, cotton mask use, glove use, washing hands with detergent, consumption of food and/or beverages and/or smokes cigarettes in the work area, and whether clothes were changed after work, showed that statistically significant risk factors related to skin effects amongst automotive garage workers were age (OR<sub>adj</sub> = 2.7; 95% CI = 1.01-4.93), smoking cigarettes (OR<sub>adj</sub> = 2.7; 95% CI = 1.08-4.09), drinking alcohol (OR<sub>adj</sub> = 2.7; 95% CI = 1.28-4.98), hours worked per day (OR<sub>adj</sub> = 2.5; 95% CI = 1.26-4.88), duration of work (OR<sub>adj</sub> = 2.5; 95% CI = 1.26-4.91), cotton mask use (OR<sub>adj</sub> = 2.4; 95% CI = 1.21-4.83), glove use (OR<sub>adj</sub> = 2.7; 95% CI = 1.21-4.99), washing hands with detergent (OR<sub>adj</sub> = 2.4; 95% CI = 1.15-4.63), consumption of food and/or beverages and/or smokes cigarettes in the work area (OR<sub>adj</sub> = 2.3; 95% CI = 1.13-4.67), and whether clothes were changed after work (OR<sub>adj</sub> = 2.3; 95% CI = 1.12-4.71). Additionally, the statistically significant risk factors related to respiratory tract irritation amongst automotive garage workers were age (OR<sub>adj</sub> = 2.3; 95% CI = 1.12-5.08), smoking cigarettes (OR<sub>adj</sub> = 2.4; 95% CI = 1.18-4.39), drinking alcohol (OR<sub>adj</sub> = 2.5; 95% CI = 1.25-4.81), days worked per week (OR<sub>adj</sub> = 2.4; 95% CI = 1.25-4.89), duration of work (OR<sub>adj</sub> = 2.5; 95% CI = 1.21-4.77), cotton mask use (OR<sub>adj</sub> = 2.6; 95% CI = 1.11-

4.89), glove use ( $OR_{adj} = 2.7$ ; 95% CI = 1.00-4.91), washing hands with detergent ( $OR_{adj} = 2.4$ ; 95% CI = 1.10-4.89), consumption of food and/or beverages and/or smokes cigarettes in the work area ( $OR_{adj} = 2.3$ ; 95% CI = 1.18-4.77), and whether clothes were changed after work ( $OR_{adj} = 2.3$ ; 95% CI = 1.15-4.78).

Several socio-demographic variables were significantly associated with increased nausea (Table 4), including age ( $OR_{adj} = 2.5$ ; 95% CI = 1.21-4.89), hours worked per day ( $OR_{adj} = 2.2$ ; 95% CI = 1.16-4.57), days worked per week ( $OR_{adj} = 2.4$ ; 95% CI = 1.79-2.79), cotton mask use ( $OR_{adj} = 2.5$ ; 95% CI = 1.18-4.98), consumption of food and/or beverages and/or smokes cigarettes in the work area ( $OR_{adj} = 2.5$ ; 95% CI = 1.13-4.87), and whether clothes were changed after work ( $OR_{adj} = 2.4$ ; 95% CI = 1.11-4.91). Finally, the variables that were significantly associated with increased dizziness (Table 4) included age ( $OR_{adj} = 2.4$ ; 95% CI = 1.15-4.70), drinking alcohol ( $OR_{adj} = 2.2$ ; 95% CI = 1.13-4.77), days worked per week ( $OR_{adj} = 2.5$ ; 95% CI = 1.99-3.04), cotton mask use ( $OR_{adj} = 2.5$ ; 95% CI = 1.12-4.85), consumption of food and/or beverages and/or smokes cigarettes in the work area ( $OR_{adj} = 2.2$ ; 95% CI = 1.18-4.57), and whether clothes were changed after work ( $OR_{adj} = 2.4$ ; 95% CI = 1.18-4.99).

Additionally, the statistically significant risk factors related to nausea amongst automotive garage workers (Table 4) included age ( $OR_{adj} = 2.4$ ; 95% CI = 1.19-4.87), hours worked per day ( $OR_{adj} = 2.2$ ; 95% CI = 1.11-4.79), days worked per week ( $OR_{adj} = 2.4$ ; 95% CI = 1.67-2.99), cotton mask use ( $OR_{adj} = 2.4$ ; 95% CI = 1.14-4.97), consumption of food and/or beverages and/or smokes cigarettes in the work area ( $OR_{adj} = 2.4$ ; 95% CI = 1.15-4.99), and whether clothes were changed after work ( $OR_{adj} = 2.3$ ; 95% CI = 1.12-4.87). Finally, the variables that were significantly associated with increased dizziness (Table 4) included age ( $OR_{adj} = 2.3$ ; 95% CI = 1.14-4.97), drinking alcohol ( $OR_{adj} = 2.2$ ; 95% CI = 1.12-4.61), days worked per week ( $OR_{adj} = 2.5$ ; 95% CI = 1.97-3.15), cotton mask use ( $OR_{adj} = 2.4$ ; 95% CI = 1.11-4.92), consumption of food and/or beverages and/or smokes in the work area ( $OR_{adj} = 2.3$ ; 95% CI = 1.16-4.59), and whether clothes were changed after work ( $OR_{adj} = 2.3$ ; 95% CI = 1.10-4.97).

**Table 3.** Prevalence of skin effects and respiratory tract irritant among automotive garage workers in the preceding 3 months.

Characteristics	n = 140	Skin effects (n=85)				Respiratory tract irritant (n=69)			
		Count	Prevalence (%)	OR <sub>adj</sub> (95% CI)	P- value	Count	Prevalence (%)	OR <sub>adj</sub> (95% CI)	P- value
Socio-demographic									
Gender									
Male	140	85	100			69	100		
Age (yrs)									
≤42	54	26	48.15	2.7 (1.01-4.93)	<0.001*	18	33.33	2.3 (1.12-5.08)	<0.001*
>42	86	59	68.60	1.0		51	59.30	1.0	
Education									
≤ Secondary school / vocational certificate or equivalent	79	48	60.76	1.5 (0.79-2.05)	0.314	35	44.30	1.2 (0.75-2.23)	0.225
> Secondary school / vocational certificate or equivalent	61	37	60.66	1.0		34	55.74	1.0	
Behavioral									
Smokes cigarettes									
Yes	98	68	69.39	2.3 (1.08-4.09)	<0.001*	59	60.20	2.4 (1.18-4.39)	<0.001*
No	42	17	40.48	1.0		10	23.81	1.0	
Drink alcohol									
Yes	124	82	66.13	2.6 (1.28-4.98)	<0.001*	65	52.42	2.5 (1.25-4.81)	<0.001*
No	16	3	18.75	1.0		4	28.57	1.0	
Hours worked per day									
8	26	10	38.46	2.5 (1.26-4.88)	<0.001*	11	42.31	1.5 (0.23-0.79)	0.245
≤8	114	75	65.79	1.0		58	50.88	1.0	
Occupational lifestyle									
Days worked per week									
6	113	67	59.29	1.4 (1.09-1.99)	0.231	59	52.21	2.4 (1.25-4.89)	<0.001*
>6	27	18	66.67	1.0		10	37.04	1.0	

**Table 3.** (continued)

Duration of work (years)									
16	63	27	42.86	2.5 (1.26-4.91)	<0.001*	25	39.68	2.5 (1.21-4.77)	<0.001*
≤16	77	58	68.24	1.0		44	57.14	1.0	
Mean ± SD, 16.41 ± 5.70 yrs.									
Personal protective equipment									
Cotton mask									
Yes	68	33	48.53	2.4 (1.21-4.83)	<0.001*	8	11.76	2.6 (1.11-4.89)	<0.001*
No	72	52	72.22	1.0		61	84.72	1.0	
Gloves									
Yes	99	44	44.44	2.7 (1.21-4.99)	<0.001*	32	32.32	2.7 (1.20-4.91)	<0.001*
No	41	41	100.00	1.0		37	90.24	1.0	
Personal hygiene									
Washed hands before lunch									
Yes	140								
Washed hands with detergents									
Yes	75	33	44.00	2.4 (1.15-4.63)	<0.001*	20	26.67	2.4 (1.10-4.89)	<0.001*
No	65	52	80.00	1.0		49	75.38	1.0	
Consumption of food, smokes cigarettes and/or beverages in the work area									
Yes	87	62	71.26	2.3 (1.13-4.67)	<0.001*	53	60.92	2.3 (1.18-4.77)	<0.001*
No	53	23	43.40	1.0		16	30.19	1.0	
Whether clothes were changed after work									
Yes	24	5	20.83	2.3 (1.12-4.71)	<0.001*	7	29.17	2.3 (1.15-4.78)	<0.001*
No	116	80	68.97			61	52.59	1.0	

\*significantly at 0.05

**Table 4.** Prevalence of nausea and dizziness among automotive garage workers in the preceding 3 months.

Characteristics	n = 140	Nausea(n=65)				Dizziness (n=57)			
		Count	Prevalence (%)	OR <sub>adj</sub> (95% CI)	P- value	Coun	Prevalence (%)	OR <sub>adj</sub> (95% CI)	P- value
Socio-demographic									
Gender									
Male	140	65	100.00			57	100.00		
Age (yrs)									
≤42	54	20	37.01	2.5 (1.21-4.89)	<0.001*	15	27.78	2.3 (1.14-4.97)	<0.001*
>42	86	45	52.33	1.0		42	48.84	1.0	
Education									
≤ Secondary school /vocational certificate or equivalent	79	32	40.51	1.3 (0.84-2.20)	0.308	30	52.63	1.1 (0.63-2.20)	0.298
> Secondary school / vocational certificate or equivalent	61	33	54.10	1.0		27	44.26	1.0	
Behavioral									
Smokes cigarettes									
Yes	98	42	42.86	1.3 (0.79-1.51)	0.089	38	38.78	1.3 (0.55-1.79)	0.093
No	42	23	54.76	1.0		19	45.24	1.0	
Drink alcohol									
Yes	124	57	49.97	1.3 (0.70-1.55)	0.357	49	39.52	2.2 (1.12-4.61)	0.012*
No	16	8	50.00	1.0		8	50.00	1.0	
Occupational lifestyle									
Hours worked per day									
8	26	6	23.08	2.2 (1.16-4.57)	<0.001*	9	34.62	1.2 (0.76-2.59)	0.059
≤8	114	59	51.75	1.0		48	42.11	1.0	
Days worked per week									
6	111	38	34.23	2.4 (1.79-2.79)	<0.001*	32	28.32	2.5 (1.97-3.15)	<0.001*
>6	29	27	93.10	1.0		25	92.59	1.0	

**Table 4.** (continued)

Duration of work (years)					<b>1.4</b> <b>(0.71-1.69)</b>					
16	59	34	57.63	1.0	0.254	26	41.27	1.2 (0.36-2.39)	0.358	
≤16	81	31	38.27			31	40.26	1.0		
Mean ± SD, 16.41 ± 5.70 yrs.										
Personal protective equipment										
Cotton mask										
Yes	68	17	25.00	2.5 (1.18-4.98)	<0.001*	12	17.65	2.4 (1.11-4.92)	<0.001*	
No	72	48	66.67	1.0		45	62.50	1.0		
Gloves										
Yes	99	48	48.48	1.4 (0.61-1.72)	0.159	42	42.42	1.3 (0.57-1.79)	0.159	
No	41	17	41.46	1.0		15	36.59	1.0		
Personal hygiene										
Washed hands before lunch										
Yes	140									
Washed hands with detergents										
				1.2 (0.56-1.82)						
Yes	75	32	42.67	1.0	0.143	28	37.33	1.3 (0.49-1.79)	0.177	
No	65	33	50.77			29	44.62	1.0		
Consumption of food and/or beverages in the work area										
Yes	87	54	62.07	2.5 (1.13-4.87)	<0.001*	41	47.13	2.3 (1.16-4.59)	<0.001*	
No	53	11	20.75	1.0		16	30.19	1.0		
Whether clothes were changed after work										
Yes	24	6	25.00	2.4 (1.11-4.91)	<0.001*	2	8.33	2.3 (1.10-4.97)	<0.001*	
No	116	59	50.86	1.0		55	47.41	1.0		

\*significantly at 0.05

### Urinary toluene levels among automotive garage workers, and demographic characteristics, occupational lifestyle, personal protective equipment used, hygiene behavior, and health symptoms among automotive garage workers

The median urinary toluene level of the automotive garage workers was 145 µg/L (range, 12.0-958.0 µg/L). It was found that median urinary toluene levels and demographic characteristics (age and education level) had significantly different ( $p < 0.05$ ). Automotive garage workers who had older than 42 years of age had significantly higher urinary levels than those who had less than or equal 42 years of age ( $p < 0.05$ ). Automotive garage workers who had less than a secondary school-level education had significantly higher urinary levels than those who had more than a secondary school-level education ( $p < 0.05$ ). Automotive garage workers who smokers had significantly higher urinary levels than those who did not smokers ( $p < 0.05$ ). Automotive garage workers who had worked more than 8 hours per day had significantly higher urinary levels than those who had worked less than or equal 8 hours per day ( $p < 0.05$ ). Automotive garage workers who had worked 6 days per week had significantly higher urinary levels than those who had worked less than or equal 6 days per week ( $p < 0.05$ ). Automotive garage workers who had worked for more than 16 years had significantly higher urinary levels than those who had worked less than or equal 16 years ( $p < 0.05$ ). Automotive garage workers who used a mask, and/or wore gloves, had significantly lower urinary levels than those who did not ( $p < 0.001$  for both). Automotive garage workers who ate snacks while working had significantly higher urinary levels than those who did not ( $p < 0.001$ ). Automotive garage workers who did not used detergents when washing their hands had significantly higher urinary levels than those who used detergents ( $p < 0.001$ ), and automotive garage workers who did not change their clothes after work every day had significantly higher urinary levels than those who change their clothes after work every day ( $p < 0.001$ ). Automotive garage workers who reported symptoms of skin effects, such as irritation, dermatitis, skin sensitization, eczema, oil acne, redness, and blisters; respiratory tract irritation; nausea; and dizziness had significantly higher urinary levels than those who did not have symptoms ( $p < 0.001$  for all) (Table 5).

**Table 5** Comparison between urinary toluene levels, and characteristics of automotive garage workers (n = 140).

Characteristics	n = 140	Toluene in urine (µg/L)		
		Median	Interquartile range (Range, min-max)	P-value
<b>Socio-demographic</b>				
Gender				
Male	140	145.00	531.0 (946.0, 12.0-958.0)	
Age (yrs)				
≤42	56	63.5	139.0 (463.0, 12.0-475.0)	<0.001*
>42	86	582.0	739.0 (946.0, 12.0-958.0)	
Education				
≤ Secondary school / vocational certificate or equivalent	79	587.0	622.0 (946.0, 12.0-958.0)	<0.001*
> Secondary school / vocational certificate or equivalent	61	52.0	67.5 (463.0, 12.0-475.0)	
<b>Behavioral</b>				
Smokes cigarettes				
Yes	98	405.0	673.0 (946.0, 12.0-958.0)	<0.001*
No	42	49.5	44.8 (75.0, 12.0-87.0)	
Drink alcohol				
Yes	124	225.0	538.0 (946.0, 12.0-958.0)	0.548
No	16	220.5	524.0 (946.0, 14.0-958.0)	
<b>Occupational lifestyle</b>				
Hours worked per day				
8	26	26.0	45.0 (75.0, 12.0-87.0)	<0.001*
≥8	114	225.0	529.5 (946.0, 12.0-958.0)	
Days worked per week				
6	111	87.0	202.0 (936.0, 12.0-948.0)	<0.001*
>6	29	687.0	375.0 (946.0, 12.0-958.0)	
Duration of work (years)				
16	59	58.0	86.0 (884.0, 12.0-896.0)	<0.001*
≥16	81	475.0	656.0 (946.0, 12.0-958.0)	

**Table 5.** (continued)

Personal protective equipment					
Cotton mask					
Yes	68	54.0	53.0 (313.0, 12.0-325.0)	<0.001*	
No	72	587.0	624.0 (856.0, 102.0-958.0)		
Gloves					
Yes	99	62.0	134.0 (936.0, 12.0-948.0)	<0.001*	
No	41	788.0	443.5 (733.0, 225-958.0)		
Personal hygiene					
Washed hands with detergents					
Yes	74	56.0	72.0 (313.0, 12.0-325.0)	<0.001*	
No	66	596.0	533.3 (838.0, 120.0-958.0)		
Consumption of food, smokes cigarettes and/or beverages in the work area					
Yes	87	595.0	534.5 (839.0, 120.0-959.0)	<0.001*	
No	53	57.0	72.5 (314.0, 12.0-326.0)		
Whether clothes were changed after work					
Yes	24	55.0	70.5 (310.0, 12.0-320.0)	<0.001*	
No	116	590.0	530.0 (844.0, 115.0-959.0)		
Adverse health symptoms					
Skin effects; irritation; dermatitis, skin sensitization, eczema, oil acne, redness and blisters					
Yes	85	476.5	654.0 (946.0, 12.0-958.0)	<0.001*	
No		28.0	43.5 (789.0, 12.0-958.0)		
Respiratory tract					
Yes	69	587.0	640.0 (871.0, 87.0-958.0)	<0.001*	
No		56.0	65.3 (789.0, 12.0-801.0)		
Nausea					
Yes	65	596.0	646.0 (871.0, 87.0-958.0)	<0.001*	
No		56.0	72.0 (789.0, 12.0-801.0)		
Dizziness					
Yes	57	596.0	424.5 (838.0, 120.0-958.0)	<0.001	
No		58.0	88.0 (789.0, 12.0-801.0)		

<sup>1</sup> The statistical analysis is Mann - Whitney U Test.

<sup>2</sup>\* significantly at 0.05.

## Discussion

The results of this study show skin effects (such as irritation, dermatitis, skin sensitization, etc.) in 60.71% of automotive garage workers. This result is in line with many previous studies [24,25]. Automotive garage workers are exposed to different chemicals in their workplaces, which is supported by El-Saadawy MS et al. (2011) [26] who found garage workers are exposed to skin irritants in their workplaces [26-28], such as oils, greases, solvents, and detergents. Respiratory tract irritation was found in 49.29% of automotive garage workers, which is in line with a previous report [29] that reported workers exposed to VOCs presented lower levels of FVC, VC, and PEF than the control group, except FEV1/FVC%, FEV1, FEF2575 and FEV1/VC%. Automotive mechanics are also at increased risk for inhaling aromatic hydrocarbons, which can cause serious health issues in workers. In this study, automotive garage workers reported having nausea (46.43%) and dizziness (40.71%), which was supported by the WHO [30]. These toxic aromatic hydrocarbons may be dispersed during the production process, having effects on health and subsequent chronic effects of organic solvents on the central nervous system of exposed workers. The adverse health symptoms predominated in automotive garage workers over 42 years of age. Regarding the sociodemographic of this study, more than half of automotive garage workers (61.43%) in this study were older than 42 years of age, with a duration of work > 16 years in more than half (55%).

In addition, the associations of adverse health symptoms with the period hours worked per day and days worked per week were supported by Wong et al. (2019) [31], who reported that the potential long weekly working hours and country of origin were shown to adversely affect the occupational health of workers. Many studies have shown the negative effects of long working hours on the risks of directly or indirectly [32], and significant decrease in physical activity for workers on

overtime [16]. Thus, for automotive garage workers, longer working hours may expose them to more toxic materials during work [31].

Personal protective equipment (PPE) used among the automotive garage workers were statistically significantly associated with the prevalence of adverse health symptoms. In this study, cotton mask use and glove use were evaluated. The automotive garage workers who did not use PPE had a higher prevalence of adverse health symptoms when compared with the workers who used PPE. From previous research, the main reason for not using PPE (cotton mask and gloves) was found to be a lack of provision of the PPE by the owners of the garages and discomfort. This result was supported by Ataro et al. (2018) [33] who observed most participants (80%) were found to be working without any proper PPE and use of PPE was found to be poor, with three workers using special shoes (boots), two workers using both gloves and a cotton mask, and one worker using a hat. Bull N, Riise T, Moen B. (2012) [34] showed that the subjects who used PPE had reductions in accidents and health effects at work. In this study, washing hands with detergent had an influence on reducing chemical contamination of the body, leading to a reduction in adverse health effects (such as skin irritation and respiratory tract irritation). This was supported by the WHO [35,36] that confirmed hand hygiene is the primary measure to reduce both infections and toxicity. The factors influencing behaviour depend on patterns of hand hygiene and self-protection. Besides, many chemical toxicants used in the automotive garage can be absorbed through the body, such as toluene, causing systemic toxicity by ingestion, inhalation, and being slowly absorbed through the skin [26-28, 37]. Thus, hand hygiene behaviour with detergents can reduce exposures to chemicals and reduce risk exposure.

Consumption of food and/or beverages and/or smoking cigarettes in the work area were statistically significantly associated with the prevalence of adverse health symptoms. This result was supported by the ATSDR [37], which confirmed a certain amount of a harmful chemical must enter your body. Harmful chemicals can enter the bodies of workers if they breathe, eat, or drink or if they are absorbed through their skin [26,27] [38-40]. Thus, a suggested way they can reduce their exposure (and that of their families) to chemicals at home, at work, and at play is to change clothes after work. In this study, the automotive garage workers who did not change their clothes after work had a higher prevalence of adverse health symptom when compared with the workers who changed their clothes after work. One hundred and nine of 140 automotive garage workers (77.9%) had urinary toluene levels that exceeded the accepted safe standard (30 µg/L, biological exposure index) recommended by the American Conference of Governmental Industrial Hygiene (ACGIH) [41]. In this study we measured toluene levels in urine, because urinary toluene as best biomarkers of occupational exposure to toluene.

A present study found that many factors influence increased urinary toluene levels. Cigarette smoking enhanced elimination of toluene [42], and its relationship to urinary toluene levels showed statistically significant difference between smokers and non-smokers. EPA [42], reported the highest concentrations of toluene usually occur in indoor air from the use of common household product, and cigarette smoking. However, the present study differs from Decharat S [43], who showed no statistically significant difference between the exposed and non-exposed group. With regard to working duration, it was found the median urinary toluene levels differed significantly. This is supported by Hormozi et al [44], who reported a significant correlation between working years in the printing industry and urinary levels of HA ( $r = 0.363$ ,  $P = 0.02$ ) in the exposed group.

Toluene is also flammable, and its vapor can be ignited by flames spars or other ignition source. The automotive garage workers can be exposed to toluene by breathing, swallowing, getting it on their skin or into their eyes. In this study found that automotive garage workers who used a mask and/or gloves, had significantly lower urinary toluene levels compared to those who did not. The author noted that the types of PPE in use in these automotive shops were inappropriate for this type of work. Most automotive garage workers used a cotton mask to protect themselves during work. Toluene may enter a cotton mask and penetrate a worker's airway. Automotive garage workers using these inappropriate protective devices may also mistakenly believe that they are protected. Thus, the employers identify all the potential safety hazards and choose the proper PPE and correspond to the nature of their work. This guideline recommended by the CDC [45]" that shown in page 13/16.

The results presented that automotive garage workers who had poor protective practices (such as did not use detergents when washing their hands, ate lunch in the working areas, and did not change their clothes after work every day) had a urinary toluene level up to 958.0 µg/L (range, 946.0, 12.0-958.0). These automotive garage workers normally did not use a cotton mask and gloves and had poor personal hygienic practice and was therefore the highest exposed workers of the group [43]. This result supported by the ATSDR [46], that recommended persons whose clothing or skin is contaminated with liquid toluene can cause secondary contamination by direct contact or through off gassing vapor. Thus, work environments should be made safe, favorable and conducive to enhance productivity and economic prosperity for both employer and employee. This result was supported by the Kuranchie FA et al [47].

A limitation of this study is that automotive garage workers' exposure to mix chemicals, although this study is specified for toluene exposure. Thus, future study suggests the evaluation the chemical co-exposure. In addition, the author did not control the external factor of the occurrence of adverse health symptoms which the weakness in this research.

The training program is a critical tool in reducing occupational health disparities such as a program designed to teach automotive garage workers about the chemical hazards present in their workplace, etc. This concept was supported

by the O'Connor, T et al [48], who presents that worker can implement what they learn, is essential if trainings hope to have an impact on health and safety outcomes or workplace practices.

## Conclusions

Automotive garage workers are exposed to toluene. Urine is one of the most useful ways for biomonitoring of occupational exposure to toluene [42]. This compound presents a good correlation with the level of exposure. In this study, air samples were not collected, so this may be a disadvantage in this research. In addition, the research area was partially selected. Thus, the sample group in this research may therefore be small group. At the same time, demographic characteristics (age and education levels), behavioral (smoked cigarettes), occupational lifestyle (hours worked per day, days worked per week, and duration of work), personal protective equipment (cotton mask and gloves used), and personal hygiene (washed hands with detergents, consumption food in the area, and whether clothes were changed after work) are important for the automotive garage workers, and it should be emphasized in education programs.

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## Conflict of interest

No potential conflict of interest relevant to this article was reported.

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