ORIGINAL ARTICLE

Factors influencing the hematological parameters among laborers at a gas service station in Rayong Province, 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, Chonburi, Thailand

Corresponding Author Anamai Thetkatuek **Email:** anamai@buu.ac.th

Received: 28 February 2022 **Revised:** 17 April 2022 **Accepted:** 18 April 2022 **Available online:** September 2022
DOI: 10.55131/jphd/2022/200304

ABSTRACT

The purpose of this cross-sectional study was to investigate the factors that influenced the hematological parameters among gasoline station service workers. The sample comprised a total of 200 people split between those working at a fuel dispenser and those working outside the fuel dispenser. Interview forms, urine sample collection devices, and blood analysis samples were used to analyze Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) metabolites and hematological parameters. The study showed that the employees had been exposed to metabolites of benzene (t,t-MA) exceeding the standard, which was 29.5 percent. The metabolites of toluene, ethylbenzene, and xylene were all within the standard limit. Information concerning hematology found that MCV was below the standard level, which was 37.5 percent, while the mean cell hemoglobin (MCH) and hematocrit (HCT) were also below the standard limit (36.5 and 32.0 percent, respectively). The results of the logistic regression analysis revealed that the factors influencing hematology parameters were statistically significant (p<0.05). Affected females were reported as having abnormal MCH (OR=2.94; 95% CI=1.58, 5, 47), mean cell hemoglobin concentration (MCHC) (OR=2.68; 95% CI= 1.03, 6.98) and red cell distribution width (RDW) (OR=2.16; 95% CI=1.04, 4.49). Body mass index (BMI) affected MCH (OR=1.86; 95% CI=1.03, 3.35) and MCHC (OR=1.89; 95%CI=1.04, 3.43). Gasohol refueling affected red blood cells (RBC) (OR=2.35; 95% CI=1.19, 4.67) and hemoglobin (HB) (OR=1.95; 95% CI =1.01, 3.79). White blood cell count (WBC) was also affected by the refueling of more than 11 vans per day (OR=3.59; 95% CI=1.25, 12.48). In conclusion, personal factors as well as employment at gas stations put workers at risk for RBC, HB, and WBC abnormalities. This study identified groups of workers who were at high risk of hematology effects, particularly female workers and those with a BMI greater than the average. Furthermore, gasohol refueling should be carried out carefully to minimize any potentially negative effects on the blood system when exposed to vapors.

Key words:
hematology; BTEX; gasohol; gasoline stations; factors

Citation:
Chan Pattama Polyong[1], Anamai Thetkathuek[2]. Factors influencing the hematological parameters among laborers at a gas service station in Rayong Province, Thailand. J Public Hlth Dev. 2022;20(3):43-57 (https://doi.org/10.55131/jphd/2022/200304)

INTRODUCTION

Exposure to Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) present a health risk for gas service station employees. In previous studies, exposure indicators were assessed among fuel service workers after work, and average BTEX metabolizes, including trans, trans-muconic acid (t,t-MA), hippuric acid (HA), mandelic acid (MA), and methyl- hippuric acid (MHA), were 0.59, 6.55, 1.91, and 1.20 mg/g Cr, respectively.[1] Additionally, Geraldino et al.[2] discovered that those who refueled and worked at convenience stores located in gas service station areas had no difference in t,t- MA exposure. Furthermore, Fakhrinnur et al.[3] discovered that time spent at the gas station was associated with elevated levels of t, t-MA exposure ($r = 0.805$). The data indicated that individuals working at gas service stations, including gas station attendants, station food salespersons, and convenience store employees, were at risk of BTEX exposure.[2,4]

BTEX can affect many body systems, particularly hematology, because hematomas are highly susceptible to changes in fuel exposure.[5] The fuel-exposed group was found to have a higher number of neutrophil leukocytes than the non-exposed group. Neutrophil release is an immune response that uses phagocytosis to destroy foreign bodies.[6] If an individual is continually exposed to BTEX, it could affect bone marrow function, resulting in decreased blood cell production. It has been reported that people who suffered from BTEX exposure located near petrochemical sites had lower mean corpuscular hemoglobin concentration (MCHC) and platelet counts.[7] Also, the chemicals in gasoline could cause significant chronic toxic effects such as anemia, leukopenia, thrombocytopenia[8] and leukemia.[9]

Thailand's hematology situation has not yet been reported. However, one significant report found that the majority of hematology parameters were normal in a generally healthy population aged 18–60 years. Red blood cell and component counts, white blood cell and component counts, and platelet counts were all quantified. However, differences between males and females were discovered.[10] In Rayong Province, a survey of 6,733 healthy residents in the Map Ta Phut area was conducted by previous studies. The majority of hematology parameters were found to be normal. However, hemoglobin prevalence was abnormal at 25.6 percent, and the white blood cell count was abnormal at 9.2 percent. Additionally, there have been reports that the distance from the Map Ta Phut factory has an effect on benzene exposure.[11] It is widely known that the majority of industry in Map Ta Phut region is heavy industry, including petrochemicals, chemicals, and oil refineries. As a result, people who are exposed to fuel chemical products may be subjected to adverse effects on their hematopoietic system.

Hematological changes could be caused by a variety of factors, including personal factors[12], health behavior[13], and work factors.[14] Participants' gender and age have different effects on blood cell volume.[12] Furthermore, a study in Greece[13] revealed that smoking and being exposed to smoking within an hour increased white blood cell, lymphocyte, and granulocyte counts. However, there was inconsistency with previous research by Alses and Alzeer,[15] which reported that smoking and alcohol consumption behaviors were not correlated among refueling workers. Thus, further research is needed in this area. In terms of work factors, it was discovered that more years spent working in gas stations were associated with lower RBC, hemoglobin, and hematocrit.[14] As a result, these factors should be considered when determining hematotoxicity from BTEX exposure.

The chemicals in gasoline pose a serious threat to human health. Thailand has a policy of solving issues through the

reduction of hazardous substances in mixtures, such as fuel that do not contain lead. Aromatic substances, olefins, and benzene concentrations in all types of fuel must not exceed 35.0, 18.0, and 1.0 % vol., respectively,[16] which is lower than in previous years. Additionally, the Department of Energy[17] has implemented strategies to enhance safety, health, and service which can incentivize fuel stations to maintain high standards of quality by establishing a project with "quality, safe, and serviceable pumps." As previously stated, previous policies prioritized service users. In terms of the health of the fuel industry's workers, no government agency or project bears direct accountability. As a result, basic health information of gas station employees is scarce.

The issue of research interest was that BTEX exposure at gas stations was low (1 ppm), and the biological markers of exposure as well as the effects on receptors were unclear.[18,19,20] Hematological changes have been reported to occur in the 5–10 ppm benzene exposure range.[21] However, previous hematology studies found contradictory results.[5,22,23,24] Furthermore, hematology studies were not done at gas stations in other occupational categories, such as convenience stores and coffee shops, which were also among the occupations at risk of BTEX exposure.[2] As a result, the study of BTEX exposure and the factors affecting hematology among gas station workers was prioritized as a guideline for health screening and confirmation of the health effects on these groups of employees.

METHODS

Study Design and Sample

This cross-sectional study focused on a group of 100 workers in a working group at a fuel dispenser and a group of 100 working outside a fuel dispenser, with a total of 200 people. The cluster sampling method was used for those who volunteered at the stations because the operations in each station were similar. The samples were collected at 8 gasoline stations. The inclusion criteria for the sample group were a minimum of 6 months of working time, no chronic diseases relating to the blood system, and willingness to participate in the research project. The exclusion criteria included any illness or absence from work on the sample collection dates. This research was approved by the IRB at Burapha University. (Certification 019/2020)

Research Instrument

The research instrument consisted of three components: 1) **A question interview** with three sections including (a) seven general questions about gender, age, height, weight, status, education, and income, (b) five health-related questions about alcohol consumption, smoking habits, personal health protection behavior, and rest time, and (c) questions about employment history, such as length of employment, location, primary fuel type used, and the number of vehicles serviced. The information questionnaire was obtained from a review of previous studies and through a content validity assessment by 3 occupational medicine and occupational health as well as safety specialists, and obtained the index of Item Objective Congruence (IOC) greater than 0.5 for all questions. The second component was **2) Urine sample** collection equipment, which included a plastic cup, a 50 ml polyethylene urine sample, a foam box, and ice packs, while the third component was **3) Blood sample** collection equipment, which included a tourniquet, dry cotton, alcohol, needle, 10 ml EDTA blood tube, a Transpore surgical tape, and a bag for contaminated trash.

Data collection and interpretation

1) Interviews were conducted by the researcher and a team for data collection by using the area around the gas service stations that the owners had prepared for interviews, and would take approximately 10- 15 minutes per participant. For the interpretation of personal protection behaviors such as masks, gloves, and long sleeve wearing, the variables were divided into two groups (those who did not wear them or only wore them for less than 3 hours, and those who wore them for more than 3 hours), and the interpretation of the amount of serviced cars was done by separating the vehicle type and then divided into two groups: cars that refilled gas less than the average amount and cars that refilled gas more than the average amount.

2) Urine Samples were collected by the researcher by providing sample collection equipment to the workers while they were working. It was explained that the samples should be collected at the end of their shifts and that it should be mid-stream urine that was collected in the plastic cups, which would then be poured into a 50 ml polyethylene tube for further study in a lab. The study would publish the results of analyzing the metabolites of BTEX, and the interpretation of the results based on the American Conference of Governmental Industrial Hygienists (ACGIH)[27] used a cut-off point (standard normal), which included trans, trans-muconic acid (t, t-MA <500.00 µg/g Cr), toluene in urine (TU < 0.03 mg/L), hippuric acid (HA < 1.60 g/g Cr), methylhippuric acid (MHA <1.50 g/g Cr), and mandelic acid (MA < 0.15 g/g Cr).The quantity of the samples was analyzed by using column type C18, mobile phase, containing water/acetonitrile at a ratio of 50:50 v/v, the flow rate of 1.0 mL/min at 37.0 ° C, sample solvent by methanol, and ultraviolet detection at 254 nm wavelength,[25] and extracted using the method of Onchoi et al. [26], followed by analysis using High Performance Liquid Chromatography (HPLC).

3) Blood samples were collected from workers after their work shifts in the amount of 3 ml, which would be collected at the same location as the interview by medical technicians and nurses into EDTA blood tubes to analyze red blood cell parameters; the criteria set by the Thai Society of Hematology[28] were used for the cut- off point (normal range), such as hemoglobin (HB) (Male (M) = 13.0-17.0; Female (F) = 12.0.-15.0 g/dl), hematocrit (HCT) (M = 38.0-50.0; F = 36.0-45.0 %), red blood cells (RBC) (M = 4.4-6.0; F = 4.2-5.5 $\times 10^6$ cells/mm^3), mean cell volume (MCV) (80-96 fl), mean cell hemoglobin (MCH) (27. 5- 33. 2 pq), mean cell hemoglobin concentration (MCHC) (33.4-35.5 g/dl), RBC distribution width (RDW) (11. 5- 14. 5 %), and white blood cell parameters including white blood cell count (WBC) (4. 0- 10. 0 $\times 10^3$ cells/ mm^3), neutrophil (NE) (40-80 %), lymphocyte (LY) (20-40 %), monocyte (MO) (2-10 %), eosinophil (EO) (1-6 %), and basophil (BA) (0-2 %) and platelets (PLT) (150-450 $\times 10^3$ cells/mm^3). The parameters were analyzed using the automatic flow cytometry technique instrument, Sysmex XN 500 Japan instrument, standard according to the Thai Department of Medical Sciences. [29] The urine and blood laboratory was also certified by ISO 15189: 2012 No. 4247/63.

Data Analysis

The data analysis was divided into two parts, which were 1) descriptive statistics (a) calculated as percentage for qualitative variables such as gender, smoking habits, alcohol consumption, and personal protection behavior and complete blood counts (CBC), (b) calculated as mean and standard deviation for quantitative variables when the data is in normal distribution while conducting the Kolmogorov- Smirnov test, such as age, BMI, and frequency of work, and (c) calculated as geometric mean, median,

minimum, and maximum for the variables when the distributed value is not normal, such as the metabolites of BTEX in urine. For the second part, 2) inferential statistics were used for testing various factors that impacted hematology, with the univariate logistic regression analysis statistics displaying the OR value and 95% Cl.

RESULTS

General Information

For the workers at gas service stations in this study, about 2 in 3 (68.5%) were females aged between 20-29 years old (43.5%); the average age was equal to 30.25±11.01 years and the average BMI was equal to 23.63±5.25 kg/ sqm. Approximately half (52.5%) were single and had completed junior high school (31.0%). They received an average monthly salary of 12,053.25±4,406.18 baht per month (or 385.54±140.94 USD; 1 USD = 31.26 THB). Most workers did not smoke (66.0%). In terms of alcohol consumption behavior, it was discovered among a majority of the study participants (45.5%).

Employment History

The workers at gas service stations had an average of 2.44±4.06 years of work experience, with the frequency of working duration being an average of 8.98±1.62 hours per day and 6 days per week (55.0%). A dispenser worker's average number of pickup trucks serviced per day was 32.65±24.80, which was close to the number of motorcycles and personal 4-wheel vehicles serviced per day, which were around 31.51±30.43 and 28.52±20.27 vehicles, respectively.

Personal Hygiene

Employees typically drank water and ate at the workplace every day (67.0 % and 40.0 %, respectively), similar to workers not at dispensers; the top two negative routine behaviors were drinking and eating (49.0 % and 32.0 %, respectively). Workers at the dispensers and those who did not work at the dispensers both wore masks for more than 6 hours per day (66.0 % and 55.0 %, respectively), whereas other types of personal protective equipment (PPE) were worn with only a few pieces of PPE or not at all.

Exposure to BTEX

The amount of t,t-MA discovered Geometric Mean (GM) ±GSD = 375.83±1.71 µg/g Cr. The workers' t,t-MA levels were 29.5 percent higher than the standard level (> 500 µg/ g Cr). For exposure to toluene (TU and HA metabolize), TU at 0.011 mg/L was found to be lower than the standard level. For every participant, HA found that GM = 0.323±1.435 g/ g Cr and the amount of MHA has GM = 0.402±1.273 g/ g Cr and for MA, GM = 0.060±1.025 µg/g Cr. Both the MA and MHA were not higher than the standard level. Exposure among workers at the dispensers and those not at dispensers was different.

Hematology Data

The analysis of CBC included RBC, WBC, and PLT. The results showed that the workers at gas stations had the same average parameter as the normal amount. When the ratio was considered according to the parameters, however, it was discovered that the MCV amount in the workers' CBC had the most abnormalities (37.5 %), with the MCH parameter and HCT parameter being 36.5% and 32.0%, respectively, which were red blood cell parameters. As for the white blood cells, it was observed that the ratios for EO, NE, and LY were abnormal (10.5, 5.0, and 4.5%, respectively). Moreover, the platelets were abnormal (6.5%).

Factors Influencing the Hematological Parameters

Concerning the parameters for red blood cells, females showed affected MCH (OR = 2.94; 95% CI = 1.58, 5.47), MCHC (OR = 2.68; 95% CI = 1.03, 6.98) and RDW (OR = 2.16; 95% CI = 1.04, 4.49). High BMI affected MCH (OR = 1.86; 95% CI = 1.03, 3.35) and MCHC (OR = 1.89; 95% CI = 1.04, 3.43), and working as gasohol refilling attendants showed affected RBC (OR = 2.35; 95% CI = 1.19, 4.67) and HB (OR = 1.95; 95% CI = 1.01, 3.79).

The factors that affected the parameters for the white blood cells were refilling gas in more than 11 vans per day, which increased WBC (OR=3.59; 95% CI= 1.25, 12.48). However, the study revealed a reverse causality effect; refilling gasoline in more than 28 private cars per day could influence the level of EO (OR=0.37; 95% CI= 0.13, 1.00), and refilling gasoline in more than 31 motorcycles per day affected the level of BA (OR=0.08; 95% CI= 0.01, 0. 56) . In the PLT, no factors were influenced. (Table 1)

Table 1. Factors influencing the hematological parameters

Factor	Red blood cells parameter							White blood cells parameter						Platelets
	RBC	HB	HCT	MCV	MCH	MCHC	RDW	WBC	LY	MO	NE	EO	BA	
	Crude OR : 95%CI (Lower, Upper)													
Gender														
Female	1.02 (0.50, 2.06)	1.26 (0.63, 2.50)	0.88 (0.46, 1.68)	1.68 (0.91, 3.10)	2.94 (1.58, 5.47)*	2.68 (1.03, 6.97)*	2.16 (1.04, 4.49)*	1.32 (0.45, 3.84)	0.60 (0.12, 3.01)	1.08 (0.09, 12.23)	0.52 (0.10, 2.56)	1.73 (0.69, 4.36)	1.46 (0.23, 8.99)	1.95 (0.62, 6.07)
Age														
> 30	1.14 (0.59, 2.23)	0.68 (0.35, 1.32)	0.54 (0.30, 0.99)*	1.21 (0.68, 2.17)	1.47 (0.82, 2.66)	1.71 (0.62, 4.71)	2.01 (0.93, 4.34)	0.96 (0.36, 2.50)	1.53 (0.37, 6.32)	0.37 (0.03, 4.16)	1.13 (0.31, 4.16)	0.52 (0.21, 1.31)	3.09 (0.33, 28.16)	2.66 (0.70, 9.97)
Body mass index														
Overweight-obese	0.77 (0.40, 1.48)	1.01 (0.52, 1.94)	0.63 (0.35, 1.16)	1.85 (1.02, 3.34)*	1.89 (1.04, 3.42)*	1.08 (0.41, 2.83)	1.57 (0.74, 3.30)	0.72 (0.27, 1.91)	1.60 (0.39, 6.60)	<0.01 (0.00)	0.50 (0.13, 1.85)	2.11 (0.78, 5.69)	1.18 (0.19, 7.24)	0.46 (0.14, 1.48)
Status														
Married/ couple	0.83 (0.43, 1.59)	0.78 (0.41, 1.50)	0.78 (0.43, 1.42)	1.36 (0.76, 2.43)	1.64 (0.91, 2.94)	1.62 (0.61, 4.30)	1.41 (0.68, 2.91)	0.99 (0.38, 2.56)	0.71 (0.18, 2.73)	0.44 (0.04, 5.01)	0.37 (0.09, 1.47)	1.53 (0.60, 3.88)	0.59 (0.09, 3.64)	2.13 (0.63, 7.16)
Education														
Lower secondary school	0.57 (0.27, 1.22)	0.55 (0.26, 1.17)	0.48 (0.24, 0.95)*	0.66 (0.35, 1.25)	0.71 (0.37, 1.33)	0.97 (0.35, 2.70)	0.43 (0.17, 1.05)	0.61 (0.23, 1.61)	1.06 (0.25, 4.40)	4.35 (0.38, 48.93)	0.90 (0.22, 3.62)	2.10 (0.84, 5.24)	1.43 (0.23, 8.77)	0.94 (0.27, 3.17)
Income														
< 10,000	0.75 (0.38, 1.47)	0.90 (0.47, 1.74)	1.01 (0.55, 1.84)	1.59 (0.89, 2.83)	1.45 (0.81, 2.59)	1.18 (0.46, 3.06)	1.68 (0.82, 3.45)	0.66 (0.25, 1.71)	1.04 (0.27, 3.99)	2.63 (0.23, 29.54)	0.85 (0.23, 3.14)	0.48 (0.18, 1.30)	0.31 (0.03, 2.88)	1.56 (0.50, 4.82)

Factor	Red blood cells parameter							White blood cells parameter					Platelets
	RBC	HB	HCT	MCV	MCH	MCHC	RDW	WBC	LY	MO	NE	EO	BA	
	Crude OR : 95%CI (Lower, Upper)													
Smoking														
Yes	0.78 (0.39, 1.54)	1.52 (0.74, 3.12)	1.33 (0.70, 2.53)	1.15 (0.62, 2.12)	0.89 (0.48, 1.63)	0.87 (0.32, 2.32)	1.09 (0.51, 2.33)	0.33 (0.09, 1.19)	1.03 (0.25, 4.25)	1.03 (0.09, 11.57)	2.12 (0.43, 10.31)	0.65 (0.26, 1.64)	0.76 (0.12, 4.70)	1.77 (0.47, 6.68)
Drink alcohol														
Yes	1.31 (0.67, 2.54)	1.73 (0.88, 3.38)	1.61 (0.88, 2.97)	0.60 (0.33, 1.07)	0.55 (0.30, 0.99)*	1.48 (0.55, 3.94)	0.75 (0.36, 1.53)	0.67 (0.25, 1.78)	1.04 (0.27, 4.01)	0.41 (0.03, 4.61)	0.82 (0.23, 2.95)	0.73 (0.29, 1.81)	0.54 (0.09, 3.35)	1.36 (0.43, 4.31)
Personal protective behavior														
Do not use/ use for 1-3 hours	0.91 (0.45, 1.85)	1.08 (0.53, 2.21)	1.18 (0.61, 2.27)	1.34 (0.71, 2.52)	0.83 (0.45, 1.56)	0.72 (0.28, 1.95)	1.22 (0.55, 2.72)	2.23 (0.85, 5.81)	0.53 (0.13, 2.05)	0.21 (0.01, 2.40)	0.64 (0.17, 2.36)	0.86 (0.33, 2.26)	0.10 (0.01, 0.94)*	1.49 (0.39, 5.64)
Personal hygiene														
No	1.60 (0.70, 3.69)	1.85 (0.82, 4.19)	1.83 (0.84, 3.97)	0.85 (0.38, 1.88)	0.63 (0.27, 1.46)	0.59 (0.13, 2.69)	0.40 (0.11, 1.41)	0.99 (0.31-3.17)	0.64 (0.07, 5.34)	11.13 (0.97, 126.6)	1.33 (0.27, 6.59)	1.75 (0.59, 5.20)	<0.01 (0.00)	2.52 (0.72, 8.76)
Work experience														
1 year or more	0.80 (0.37, 1.73)	1.19 (0.58, 2.45)	0.78 (0.39, 1.57)	1.25 (0.66, 2.39)	1.19 (0.62, 2.28)	0.99 (0.33, 2.89)	1.42 (0.65, 3.09)	2.03 (0.56, 7.28)	0.78 (0.15, 3.90)	5.72 (0.50, 64.48)	0.68 (0.14, 3.31)	1.44 (0.55, 3.80)	0.68 (0.07, 6.29)	1.25 (0.36, 4.24)
Bed time														
< 8 hours	1.34 (0.69, 2.61)	1.12 (0.58, 2.16)	1.37 (0.75, 2.51)	1.24 (0.69, 2.20)	1.14 (0.64, 2.04)	1.51 (0.57, 4.03)	1.73 (0.82, 3.64)	0.65 (0.24, 1.75)	0.66 (0.17, 2.56)	1.71 (0.15, 19.24)	0.84 (0.23, 3.01)	0.93 (0.37, 2.30)	0.20 (0.02, 1.87)	1.39 (0.43, 4.41)
Working period														
> 8 hours	1.45 (0.75, 2.79)	0.88 (0.45, 1.70)	0.81 (0.44, 1.49)	1.29 (0.72, 2.30)	1.28 (0.72, 2.29)	1.16 (0.45, 2.99)	1.25 (0.61, 2.57)	1.79 (0.65, 4.93)	2.65 (0.64, 10.94)	0.63 (0.05, 7.08)	0.52 (0.13, 2.10)	0.94 (0.38, 2.36)	0.84 (0.13, 5.17)	0.78 (0.24, 2.48)

Factor	Red blood cells parameter							White blood cells parameter					Platelets
	RBC	HB	HCT	MCV	MCH	MCHC	RDW	WBC	LY	MO	NE	EO	BA	
	Crude OR : 95%CI (Lower, Upper)													
Work station area														
Gas service stations	1.78 (0.91, 3.50)	1.66 (0.85, 3.24)	1.21 (0.66, 2.20)	1.21 (0.68, 2.15)	1.22 (0.68, 2.18)	1.24 (0.47, 3.23)	0.92 (0.45, 1.88)	1.01 (0.39, 2.62)	1.11 (0.29, 4.27)	1.78 (0.16, 20.04)	0.88 (0.24, 3.14)	1.89 (0.72, 4.90)	0.95 (0.90, 1.00)	2.08 (0.62, 7.01)
Most types of fuel to fill														
Diesel	1.49 (0.76, 2.89)	1.25 (0.65, 2.40)	0.88 (0.49, 1.61)	1.41 (0.79, 2.50)	1.55 (0.86, 2.77)	1.02 (0.39, 2.65)	1.44 (0.70, 2.99)	1.22 (0.47, 3.16)	1.16 (0.30, 4.45)	1.86 (0.16, 20.87)	0.91 (0.25, 3.27)	1.26 (0.50, 3.14)	0.95 (0.91, 1.00)	1.51 (0.47, 4.80)
Petrol/ Gasoline	1.47 (0.71, 3.00)	0.80 (0.37, 1.72)	0.81 (0.41, 1.63)	1.31 (0.69, 2.50)	1.25 (0.65, 2.39)	1.35 (0.48, 3.77)	1.25 (0.57, 2.77)	0.73 (0.26, 2.05)	1.44 (0.34, 6.01)	1.43 (0.12, 16.12)	0.70 (0.14, 3.40)	1.88 (0.73, 4.85)	4.46 (0.72, 27.53)	1.86 (0.58, 5.97)
Gasohol	2.35 (1.19, 4.66)*	1.95 (1.01, 3.79)*	1.31 (0.72, 2.39)	1.47 (0.82, 2.61)	1.76 (0.98, 3.15)	1.42 (0.54, 3.69)	1.59 (0.77, 3.29)	1.12 (0.43, 2.89)	2.06 (0.50, 8.49)	2.02 (0.18, 22.64)	1.53 (0.41, 5.60)	1.11 (0.45, 2.75)	4.12 (0.45, 37.57)	1.17 (0.38, 3.64)
E20	1.08 (0.55, 2.10)	1.62 (0.84, 3.12)	0.91 (0.49, 1.68)	1.39 (0.77, 2.50)	1.37 (0.76, 2.47)	0.69 (0.25, 1.92)	1.62 (0.79, 3.33)	2.59 (0.82, 8.12)	0.43 (0.08, 2.13)	0.77 (0.06, 8.74)	1.04 (0.28, 3.82)	0.95 (0.37, 2.43)	2.40 (0.39, 14.69)	1.36 (0.44, 4.23)
Type and quantity of vehicles to fill														
> 10 trucks	1.23 (0.52, 2.91)	1.06 (0.46, 2.43)	0.80 (0.38, 1.67)	0.56 (0.27, 1.13)	0.31 (0.15, 0.64)*	0.89 (0.28, 2.87)	0.49 (0.21, 1.10)	1.11 (0.34, 3.55)	0.84 (0.16, 4.21)	0.47 (0.04, 5.41)	0.96 (0.19, 4.74)	0.56 (0.20, 1.56)	0.96 (0.10, 8.91)	1.35 (0.28, 6.38)
> 11 vans	1.83 (0.51, 6.55)	0.94 (0.32, 2.74)	1.10 (0.40, 3.03)	0.70 (0.27, 1.79)	0.67 (0.26, 1.71)	0.36 (0.10, 1.22)	0.48 (0.17, 1.36)	3.95 (1.25, 12.47)*	0.88 (0.10, 7.45)	0.21 (0.01, 2.46)	0.41 (0.08, 2.12)	0.63 (0.16, 2.35)	0.43 (0.04, 4.06)	1.35 (0.16, 11.02)

Factor	Red blood cells parameter							White blood cells parameter					Platelets
	RBC	HB	HCT	MCV	MCH	MCHC	RDW	WBC	LY	MO	NE	EO	BA	
	Crude OR : 95%CI (Lower, Upper)													
>33 pickup trucks	0.90 (0.36, 2.29)	0.93 (0.37, 2.36)	0.99 (0.42, 2.33)	0.55 (0.24, 1.22)	0.44 (0.19, 0.98)*	1.42 (0.31, 6.53)	0.80 (0.30, 2.15)	1.74 (0.53, 5.69)	1.31 (0.15, 10.95)	0.31 (0.02, 3.62)	1.49 (0.18, 12.24)	0.65 (0.20, 2.12)	1.03 (1.00, 1.05)	2.02 (0.25, 16.21)
> 28 private cars	1.59 (0.62, 4.12)	1.65 (0.64, 4.25)	1.21 (0.54, 2.71)	0.66 (0.31, 1.38)	0.47 (0.22, 0.98)*	0.55 (0.18, 1.66)	1.11 (0.42, 2.92)	2.41 (0.85, 6.88)	0.73 (0.14, 3.67)	0.41 (0.03, 4.73)	0.47 (0.11, 1.92)	0.37 (0.13, 1.00)*	0.30 (0.04, 1.90)	0.68 (0.17, 2.64)
> 31 motorcycles	1.80 (0.58, 5.53)	1.06 (0.40, 2.81)	1.66 (0.63, 4.37)	0.66 (0.28, 1.52)	0.52 (0.23, 1.20)	0.51 (0.15, 1.70)	2.72 (0.89, 8.32)	2.72 (0.89, 8.32)	1.20 (0.14, 10.04)	0.29 (0.02, 3.32)	1.36 (0.16, 11.22)	1.47 (0.32, 6.72)	0.08 (0.01, 0.56)*	0.46 (0.12, 1.82)
t,t-MA														
> 500	0.77 (0.36, 1.62)	1.11 (0.55, 2.25)	1.13 (0.59, 2.15)	0.80 (0.42, 1.51)	0.68 (0.35, 1.31)	0.61 (0.19, 1.92)	1.18 (0.55, 2.55)	1.19 (0.40, 3.47)	0.28 (0.03, 2.34)	1.19 (0.10, 13.47)	1.02 (0.25, 4.10)	1.54 (0.60, 3.94)	0.96 (0.93, 1.00)	1.06 (0.31, 3.61)
HA														
> 0.319	0.50 (0.25, 0.98)*	0.84 (0.44, 1.62)	0.80 (0.44, 1.46)	0.61 (0.34, 1.08)	0.78 (0.44, 1.40)	1.17 (0.45, 3.02)	0.57 (0.27, 1.19)	0.85 (0.33, 2.19)	0.50 (0.12, 2.07)	5101 (0.00)	0.681 (0.18, 2.49)	0.94 (0.38, 2.32)	0.25 (0.02, 2.30)	1.72 (0.54, 5.46)

The reference group *included* ***personal factors*** *(male, less than 30 years old, good proportions, single status, middle school or higher education, more than 10,000-baht per month income),* ***health behavioral factors*** *(non-smoker, non-drinker, and practice personal hygiene), and* ***working factors*** *(use PPE for more than 4 hours per day, less than 1 year employment, 8-hour work per day, less than 8 hours of sleep, not working at a dispenser, not refueling diesel, not refueling benzene, not refueling gasohol, not refueling E20, serviced < 10 trucks, serviced < 11 vans, serviced < 33 pickup trucks, serviced < 28 personal cars, serviced < 31 motorcycles, t,t-MA less than 500, and HA lower than 0.319 (a median used to separate the data for HA)); showed the value of Crude OR and 95% CI (Lower, Upper) : *statistically significant (p<0.05).*

DISCUSSION

The results for the factors influencing hematological parameters found that females exhibited an effect on RDW and MCH. Being overweight/obese had an effect on MCH and MCV, while being aged over 30 years and having at least a secondary education level had an effect on HB. Some red blood cell abnormalities were caused by employees' personal factors, such as females' proclivity for red blood cell variability, resulting in varying sizes, including blood loss during menstruation, and eating a diet lacking in iron or folate, both of which were insufficient to increase blood cell production. As a result, the risk of abnormalities in RDW and MCH was higher in females than in males.[30] The influence of BMI factors on MCH and MCV was low, which was consistent with Tanaka et al.[31], who found that being overweight was linked to inflammation and increased oxidative stress, according to the study. This process was connected to the formation of red blood cells, known as RBC shrinkage, and was the primary cause of microtosis.

In terms of work factors, the research on fuel type and blood cell counts is highlighted in this study. The laborers worked exclusively at specific dispensers, which was where their primary duties were conducted at the gas station. When there were no vehicles to service in their area of responsibility, they could assist each other with filling other dispensers. Workers who refueled the gasoline for cars were more likely to have abnormal RBC and HB levels. However, gasoline and ethanol were present in gasoline fuel. It contained ingredients such as gasohol 91 and 95 with 10% ethanol, according to the formula. Up to now, there have been no studies on the type of oil and its effects on hematopoietic cells. There have been, however, studies similar to that conducted by Lee et al.[32], who investigated the effects of ethanol on human red blood cells. The findings revealed that ethanol concentrations of 0.1 and 0.3 percent v/v had a greater impact on the structure of red blood cells (exhibiting cell sphericity) than normal cells that were not subjected to ethanol. Despite the fact that the amount of ethanol given was less than these amounts, it had no effect on red blood cell changes. In addition, there are numerous gas stations in the nearby area. More research on this topic should be conducted in the future.

The amount of HA in urine was less than 0.319 g/g Cr, which was associated with more abnormal RBC than labor exposure (OR = 0.50), and there was a reverse casualty effect. In the case of toluene, which has previously been reported in neurotoxicity,[33] vision, and preterm birth.[27] There was no consistency in the outcome of red blood cells. In addition to animal studies, rats were divided into four groups and given a different concentration of toluene in each. The results showed no difference in red blood cell count for each group,[34] and a case study of acute toluene exposure was reported in humans, in which CBC examinations revealed that all CBC parameters were normal.[35] Thus, the effects of toluene on hematopoietic are unclear.

A study of leukocyte-related factors discovered that workers who refueled more than 11 vans per day had an abnormal effect on WBC. The most variable parameters could be said to be white blood cells and their components. Furthermore, the chemistry of the fuel activated an inflammatory mechanism that affected leukocyte release much more initially than later.[6] Tiu[36] conducted a study on the complete blood counts of refueling workers and discovered that refueling workers had a statistically significant increase in white blood cell counts above the control group (p<0.05). WBC values for the refueling and

control groups were 8.2±1.3 and 7.0±1.4 $\times 10^9$/L, respectively, indicating that refueling engines may result in an increase in WBC.

The platelet study found no factors influencing platelet volume, which was consistent with previous studies [23,36,37,38] that compared platelet counts between refueling workers and a control group. There were no differences in platelet count between the two groups, despite a previous study in Thailand finding that the relationship between t,t-MA, and platelets was unconnected.[39] Furthermore, there have been some reports of platelet growth in the lungs. They are initially produced and released from bone marrow as megakaryocytes, after which they mature into full platelets in the lungs.[40] Platelets were not recommended as a screening indicator among people with low exposure because they may not be a parameter chemically sensitive to fuel.

RECOMMENDATIONS

In this risk factor study, researchers discovered personal and work-related risk factors for abnormal hematology. Gender and BMI are personal factors, while gasoline refueling and filling up more than 11 vans per day are work factors. As a result, workers must take care of their health in order to maintain a normal BMI. Service stations should implement health-promoting policies, such as wearing appropriate types of respiratory masks at work to protect them from fuel exposure.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to the Public Health System Research Institute for funding this research (Contract No. 63-070). This work was also supported by Burapha University. Gratitude is extended to the staff of Rayong Hospital in honor of Her Royal Highness Princess Maha Chakri Sirindhorn for allowing the collection of samples and for their participation.

REFERENCES

1. Mukherjee AK, Chattopadhyay BP, Roy SK, Das S, Mazumdar D, Roy M, et al. Work-exposure to PM(10) and aromatic volatile organic compounds, excretion of urinary biomarkers and effect on the pulmonary function and heme-metabolism: A study of petrol pump workers and traffic police personnel in Kolkata City, India. J Environ Sci Health A Tox Hazard Subst Environ Eng. 2016;51(2):135-49. doi: 10.1080/10934529.2015.1087740.
2. Geraldino BR, Nunes RFN, Gomes JB, Giardini I, da Silva PVB, Campos É, et al. Analysis of Benzene Exposure in Gas Station Workers Using Trans, Trans-Muconic Acid. Int J Environ Res Public Health. 2020;17(15). doi: 10.3390/ijerph 17155295.
3. Fakhrinnur F, Tri M, Linda D. Factor Associated with Urine Trans, Trans-Muconic Acid (tt-MA) levels of Gas Station Workers. International Journal of Advanced Engineering, Management and Science. 2016;2(6).
4. 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.
5. Moro AM, Brucker N, Charão MF, Sauer E, Freitas F, Durgante J, et al. Early hematological and immunological alterations in gasoline station attendants exposed to benzene. Environ Res. 2015;137:349-56. doi: 10.1016/j.envres.2014.11.003.
6. Zamanian Z, Sedaghat Z, Mehrifar Y. Harmful Outcome of Occupational Exposure to Petrol: Assessment of Liver Function and Blood Parameters among Gas Station Workers in Kermanshah City, Iran. Int J Prev Med.

2018;9:100. doi: 10. 4103/ ijpvm. IJPVM_296_16
7. Chen Q, Sun H, Zhang J, Xu Y, Ding Z. The hematologic effects of BTEX exposure among elderly residents in Nanjing: a cross-sectional study. Environ Sci Pollut Res Int. 2019;26(11):10552-61. doi: 10.1007/ s11356-019-04492-9.
8. Maciel LA, Feitosa SB, Trolly TS, Sousa AL. Genotoxic effects of occupational exposure among gas station attendants in Santarem, Para, Brazil. Rev Bras Med Trab. 2019;17(2):247-53. doi: 10.5327/ Z1679443520190382.
9. International Agency for Research on Cancer (IARC). Benzene volume 120: IARC monographs on the evaluation of carcinogenic risks to humans [Internet]. [cited 2021 Aug 6]. Available from: https: / / www. iarc. who. int/ news-events/ iarc- monographs- volume- 120-benzene/
10. Wongkrajang P, Chinswangwatanakul W, Mokkhamakkun C, Chuangsuwanich N, Wesarachkitti B, Thaowto B, et al. Establishment of new complete blood count reference values for healthy Thai adults. Int J Lab Hematol. 2018;40(4):478-83. doi: 10.1111/ijlh.12843
11. Iamkulworaphong S. Benzene Exposure and Health Effects on Residents in Mab Ta Phut Pollution Control Area, Rayong Province. J Health Sci. 2013;22(5):802-16.
12. Park SH, Park CJ, Lee BR, Kim MJ, Han MY, Cho YU, et al. Establishment of Age- and Gender-Specific Reference Ranges for 36 Routine and 57 Cell Population Data Items in a New Automated Blood Cell Analyzer, Sysmex XN-2000. Ann Lab Med. 2016;36(3):244-9. doi: 10.3343/alm. 2016.36.3.244.
13. Flouris AD, Poulianiti KP, Chorti MS, Jamurtas AZ, Kouretas D, Owolabi EO, et al. Acute effects of electronic and tobacco cigarette smoking on complete blood count. Food Chem Toxicol. 2012;50(10):3600-3. doi: 10.1016/ j.fct.2012.07.025.
14. Teklu G, Negash M, Asefaw T, Tesfay F, Gebremariam G, Teklehaimanot G, et al. Effect of Gasoline Exposure on Hematological Parameters of Gas Station Workers in Mekelle City, Tigray Region, Northern Ethiopia. J Blood Med. 2021;12:839-47. doi: 10.2147/JBM.S286743.
15. Alses M, Alzeer S. Evaluation of some biological parameters of gasoline station attendants in Damascus, Syria. Heliyon. 2021;7(5):e07056. doi: 10.1016/j.heliyon.2021.e07056.
16. Thai Government Gazette. Announcement of the Department of Energy Business. Subject: Determination of Characteristics and Quality of Gasohol. 2014;131(53).
17. Department of Energy Business. Quality, safe, and serviceable pump project [Internet]. [cited 2022 Apr 12]. Available from: https://www. doeb.go.th/bfbs/
18. Liang B, Chen Y, Yuan W, Qin F, Zhang Q, Deng N, et al. Down-regulation of miRNA-451a and miRNA-486-5p involved in benzene-induced inhibition on erythroid cell differentiation in vitro and in vivo. Arch Toxicol. 2018;92(1):259-72. doi: 10.1007/s00204-017-2033-7.
19. Jalai A, Ramezani Z, Ebrahim K. Urinary Trans, Trans-Muconic Acid is Not a Reliable Biomarker for Low-level Environmental and Occupational Benzene Exposures. Saf Health Work. 2017;8(2):220-5. doi: 10.1016/j.shaw. 2016.09.004.
20. Mansi A, Bruni R, Capone P, Paci E, Pigini D, Simeoni C, et al. Low

occupational exposure to benzene in a petrochemical plant: modulating effect of genetic polymorphisms and smoking habit on the urinary t,t-MA/SPMA ratio. Toxicol Lett. 2012;213(1):57-62. doi: 10.1016/j.toxlet.2011.02.001.
21. Arnold SM, Angerer J, Boogaard PJ, Hughes MF, O'Lone RB, Robison SH, et al. The use of biomonitoring data in exposure and human health risk assessment: benzene case study. Crit Rev Toxicol. 2013;43(2):119-53. doi: 10.3109/10408444.2012.756455.
22. Elkhalifa AME. Haematological changes in benzene exposed workers in Sudan. Research Square. 2020. doi.org/10.21203/rs.3.rs-63501/v1.
23. Neghab M, Hosseinzadeh K, Hassanzadeah J. Hematological study of petrol station workers exposed to unleaded petrol. Toxicological & Environmental Chemistry. 2014;96(6): 951-61. doi: https://doi.org/10.1080/02772248.2014.979828.
24. Wiwanitkit V, Soogarun S, Suwansaksri J. A correlative study on red blood cell parameters and urine trans, trans-muconic acid in subjects with occupational benzene exposure. Toxicol Pathol. 2007;35(2):268-9. doi: 10.1080/01926230601156278.
25. Perkin Elmer Inc. Environmental: BTEX on brownlee analytical C 18, Aromatics HPLC. United States of American. 2013.
26. Onchoi C, Kongtip P, Yoosook W, Chantanakul S. High performance liquid chromatography for determination of urinary metabolites of toluene, xylene and styrene and its application. Southeast Asian J Trop Med Public Health. 2008;39(6):1164-71.
27. American conference of governmental industrial hygienists (ACGIH) . TLVs and BEIs. 2021.
28. The Thai Society of Hematology. Manual interpretation of hematopoietic integrity results [Internet]. [cited 2021 Aug 17]. Available from: http://www.tsh.or.th/knowledge_detail.php?id=34
29. Department of Medical Science. Quality assessment of hematology analysis manual. Bureau of Laboratory quality standards. Ministry of public health. Nontaburi. 2017.
30. Lippi G, Salvagno GL, Guidi GC. Red blood cell distribution width is significantly associated with aging and gender. Clin Chem Lab Med. 2014; 52(9):e197-9. doi: 10.1515/cclm-2014-0353.
31. Tanaka M, Okada H, Hashimoto Y, Kumagai M, Nishimura H, Fukui M. Association of mean corpuscular volume with sarcopenia and visceral obesity in individuals without anemia. J Diabetes Investig. 2021;12(7):1287-92. doi: 10.1111/jdi.13466.
32. Lee SY, Park HJ, Best-Popescu C, Jang S, Park YK. The Effects of Ethanol on the Morphological and Biochemical Properties of Individual Human Red Blood Cells. PLOS ONE. 2015;10(12):e0145327. doi: 10. 1371/journal.pone.0145327.
33. Agency for Toxic Substances and Disearch Registry. Toxicogical profile for toluene. Department of health and human services [Internet]. [cited 2021 Sept 3]. Available from: https://www.atsdr.cdc.gov/toxprofiles/tp56.pdf
34. Obinna VC, Agu GO. Haematological Effect of Toluene in Wistar Rats. JSRR 2019;25(4):1-7.
35. Yasar S, Yildirim E, Koklu M, Gursoy E, Celik M, Yuksel UC. A case of reversible cardiomyopathy associated with acute toluene exposure. Turk J Emerg Med. 2016;16(3):123-5. doi: 10.1016/j.tjem.2016.09.002.
36. Tiu DN, Dubey P. Study of WBC count and its association with blood pressure in petrol pump filling workers of Barabanki city, Uttarpradesh. JAMDSR Amritsar. 2017;5(4):87-90.

37. Eze A, Eluke BC, Eluke CC, Ezigbo E, Uzoma I. The Effect of Chronic Occupational Exposure to Petroleum Products on Haematological and Biochemical Parameters of Petrol Attendants. JAMMR. 2019;28(6):1-8. doi: 10.9734/JAMMR/2018/31745.
38. Mistry HA, Mathur A, Parmar D, Dixit P. Study of red blood cell count, hemoglobin concentration and platelets in petrol pump workers of Surat city. Natl J Physiol Pharm Pharmacol. 2016;6(2):167-9. doi: 10.5455/njppp. 2016.6.04122015105
39. Wiwanitkit V, Suwansaksri J, Soogarun S. The urine trans, trans muconic acid biomarker and platelet count in a sample of subjects with benzene exposure. Clin Appl Thromb Hemost. 2004;10(1):73-6. doi: 10.1177/ 107602960401000113.
40. Lefrançais E, Ortiz-Muñoz G, Caudrillier A, Mallavia B, Liu F, Sayah DM, et al. The lung is a site of platelet biogenesis and a reservoir for haematopoietic progenitors. Nature. 2017;544(7648):105-9. doi: 10.1038/ nature21706.