ORIGINAL RESEARCH

Occupational health risk of working in garages: comparative study on blood pressure and hematological parameters between garage workers and Haramaya University community, Harar, eastern Ethiopia

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Background: Occupational exposure to chemicals in garages causes a wide range of biological effects, depending upon the level and duration of exposure. In Ethiopia, there have been few studies conducted to assess the exposure of garage workers to chemicals. Preceding studies have not explored the effect of working in garage on blood pressure and hematological parameters. Therefore, this study aimed to assess differences in blood pressure and hematological parameters among garage workers compared to the Haramaya University community, Harar, eastern Ethiopia.

Materials and methods: A comparative cross-sectional study was conducted in Harar town, eastern Ethiopia. Thirty garage workers were selected and compared with 30 age- and sex-matched controls comprising of teachers and students. Demographic and occupational data were collected by using a structured questionnaire by a trained data collector. Blood pressure was measured using sphygmomanometry. Hematological parameters were measured with an automated hematology analyzer. Data were analyzed using Stata version 13.

Results: The majority of the garage workers did not implement effective preventive or control measures for workplace chemical exposure. Statistically significant increases were found in systolic (128.67 ± 18.14 vs 106.33 ± 9.27 mmHg, $P<0.0001$), diastolic blood pressure (90.33 ± 11.29 vs 75.67 ± 5.68 mmHg, $P<0.0001$), total white blood cells (7.9 ± 1.51 vs $6.72\pm2.04\times10^9$ cells/L, $P=0.0138$), and platelets (323.20 ± 48.82 vs $244.1\pm47.3\times10^9$ cells/L, $P<0.0001$) in garage workers compared to the control group. On the other hand, statistically significant decreases were found in red blood cells (5.13 ± 0.38 vs $5.46\pm0.36\times10^{12}$ cells/L, $P=0.0006$), hemoglobin (14.89 ± 0.71 vs 15.45 ± 0.87 g/dL, $P=0.0062$), hematocrit ($43.98\%\pm1.99\%$ vs $46.4\%3\pm2.32\%$, $P<0.0001$), and mean corpuscular volume (83.19 ± 2.93 vs 85.11 ± 3.87 fL, $P=0.0353$) among garage workers compared to the control group.

Conclusion: There were significant differences in blood pressure and hematological parameters between garage workers and the control group. Therefore, appropriate and effective safety measures need to be taken by the workers to prevent possible chemical exposure during routine tasks.

Keywords: garage workers, blood pressure, hematological parameters, Harar, Ethiopia

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Introduction

Automobile garages are a small-scale industry composed of skilled workers, such as mechanics, spray-painters, panel beaters, welders, battery recyclers, and radiator and air-conditioner repairers. They are situated along roadsides and in interiors of

informal settlements to service motor vehicles that break down on the roads. These workshops have been identified as major sources of environmental pollution, because of the unregulated practices of these workers.[1]

A distinctive feature of garages is that workers deal with dirt as part of their routine work. Because of the interaction between garage workers and the cars that they service, repair, and maintain, garage work is considered "dirty". Unlike the modern clean factory in which new car parts are being assembled, the workers in garages get dirty as they work and different substances contaminate the environment continually.[2] A study explored the overall health hazards of automobile-repair-shop wastewater on workers who randomly handled toxic wastewater during battery, car, and oil/grease washing. The water is polluted by lead and cadmium, and in the course of their work they are exposed to these exogenous elements, which puts them in a susceptible position.[3] Workplace safety is undermined by poor working environments, ie, dirty workplaces. Poor workplace organization has been found across all sectors, with associated tripping hazards.[4]

Garage workers are exposed to a wide range of chemicals, including heavy metals, contained in brake fluids, degreasers, detergents, lubricants, metal cleaners, benzene, solvents, and asbestos (from brake repair), as well as welding fumes and car exhausts.[5,6] A study showed significantly increased levels of lead, cadmium, chromium, zinc, and copper in mechanics, spray-painters and battery recyclers compared with unexposed controls.[1,3,7,8]

Biological monitoring of chemical exposure in the workplace has become increasingly important in the assessment of health risk as an integral part of the overall occupational health and safety strategy. Biological monitoring is an important tool in the prevention of occupational diseases related to those exposed to chemicals on a regular basis. In order to evaluate workplace conditions on a continuous basis, emphasis should be placed on environmental monitoring, complemented by biological monitoring.[9]

The major ultimate objective of an occupational-exposure assessment is to evaluate health risk for the exposed population and to implement control measures if the risk is considered unacceptable. Biological monitoring of chemical exposure is the evaluation of the internal dose (internal exposure) by a biological method with the view of assessing the associated health risk.[10] Estimation of the internal dose has usually relied on two categories of tests: those based on the determination of the chemical and/or its metabolites in various biological media, and those based on the quantification of a nonadverse biological effect, the intensity of which is related to the internal dose. Biomarkers are generally classified into three categories: biomarkers of exposure, biomarkers of early biological effects, and biomarkers of susceptibility.[11,12]

A brief history of biological monitoring and reference values of biomarkers for occupational-exposure chemicals has been established by different professional organizations.[9] The American Conference of Governmental Industrial Hygienists[13] and German Research Foundation[14] publish annual lists of biological monitoring guidelines for those substances. Biological-exposure indices are reference values intended as guidelines for the evaluation of potential health hazards in the practice of occupational hygiene.[10]

Activities in small-scale industries are occupationally risky, due to lack of regulation, supervision, and application of standards by concerned authorities.[4] In low-income countries, the number of temporary and unauthorized garages is high, and most workers are illiterate and work without any safety measures.[3] Most of them are involved in jobs that expose them to gradual health risks from exposure to a wide range of chemicals without having any idea about the materials they are handling.[15,16]

Many chemicals to which garage workers are occupationally exposed have toxicity in hematopoietic organs. Various researchers have identified different types of effects on workers, and these include hematological disorders and increased blood pressure.[6,17] Assessment of benzene exposure extent in different South Korean industries showed a high risk of hematopoietic disorders.[18] Decreased erythrocyte, hemoglobin, hematocrit, and platelet levels have been reported among car mechanics in Zagazig, Egypt.[6] Aromatic solvent exposure results in decreased mean red blood cell (RBC) and hemoglobin values among automobile-repair workers.[19] On the other hand, exposure to lead, benzene, and mixtures of organic solvents results in increased systolic and diastolic blood pressures.[20,21] These results show that chemical exposure in garage workers affects the health of the workers.

In developing countries, exposure to hazardous chemicals is common. A study conducted in Nigeria indicated increased exposure to premium motor-spirit fumes among automobile mechanics and petrol-station attendants. Mean packed-cell volume was lower in automobile mechanics (33.3%) than subjects from the general population (40.8%).[22] It was also indicated that hazardous stationary emissions of petroleum air and soil pollutants in automobile workshops led to higher risk of hematological dysfunctions.[23] A study from Iran indicated that exposure to mixtures of organic solvents may be associated with the prevalence of hypertension in car-manufacturing workers.[21]

In Ethiopia, there are indications that garage workers in small-scale garages are exposed to lead.[7,24] Studies have shown high blood lead levels in exposed garage workers compared to controls. Although there are many small- and large-scale industries that may pose health risks to workers in the country, there are no workplace regulations for chemical exposure. No data are available from labor departments on workers of small-scale units and chemical poisoning.[24]

Further, to the best of the investigators' knowledge, the laboratory profile of garage workers as a result of their occupational exposure has not been investigated. Therefore, this study was carried out to describe blood pressure and hematological parameters and to determine their differences among garage workers compared to the Haramaya University community in Harar, Ethiopia.

Materials and methods
Study design
A comparative cross-sectional study was carried out among garage workers between May and August, 2016 in Harar, eastern Ethiopia.

Subjects
Study subjects comprised 30 occupationally exposed garage workers and 30 occupationally unexposed university students and teachers at the College of Health and Medical Sciences, Haramaya University as a control group.

Inclusion and exclusion criteria
Garage workers directly involved in automobile-repair works and working in the garage for at least 1 year were included. Garage workers with a previous history of hypertension or known chronic illnesses, such as diabetes mellitus and cardiovascular diseases, were excluded from the study. The unexposed (control) group comprised apparently healthy individuals matching the exposed group in age and sex.

Sample size
Sample size was calculated based on a formula for comparison of two sample means. From a study carried out in Pakistan among garage workers, we got mean hemoglobin levels of 14.7±0.6 g/dL in garage workers and 15.21±0.7 g/dL in the control group.[19] We used Stata software to estimate sample size with specified significance level (0.05), power (80%), and proportion of 1:1 for cases and controls. From this, we got n_1=26 and n_2=26. By including a 15% nonresponse rate, we get n_1=30 and n_2=30. Therefore, our study subjects

comprised 30 occupationally exposed garage workers and 30 occupationally unexposed controls.

Sampling
Selection of garage workers
A preliminary assessment was conducted to establish the number of garages and number of workers in Harar. We found that there were a total of 112 garage workers working in 28 garages. Of these 112 workers, 98 fulfilled the inclusion criteria and were used as the sample frame. Thirty garage workers that fulfilled the inclusion criteria were selected randomly. The randomization process took place by assigning a number for each garage worker and selecting them by a table of random numbers.

Selection of control group
Controls were selected from students and teachers at the College of Health and Medical Sciences, Haramaya University. Lists of students and teachers were obtained from the departments/schools of the college. From these lists, those individuals that fulfilled the inclusion criteria for controls were identified. The College of Health and Medical Sciences contains five schools and two departments consisting of a total of 154 teachers. For the purpose of selecting students, the Department of Medical Laboratory Sciences was selected randomly by lottery. There are 98 students in this department. The sampling frame for the control group consisted of 154 teachers and 98 students. Then, each of the students and teachers in the sampling frame was assigned a unique number and 30 selected randomly using a table of random numbers.

Data collection
After obtaining consent from study subjects, demographic and occupational data were collected using a structured questionnaire, and subjects were interviewed by trained data collector (nurse). The questionnaire included age, sex, marital status, work duration, use of personal protective equipment, alcohol-consumption, smoking, khat chewing and eating habits, and taking showers at the workplace.

Prior to blood collection, resting blood pressure was measured by nurses using sphygmomanometry. Blood samples were collected from workers during their routine working hours. About 4 mL blood samples were collected using venipuncture techniques into a Vacutainer tube containing potassium EDTA-K3 from the antecubital area of study participants. All specimens were labeled and checked to ensure that stoppers were securely closed. The tubes were

then placed in a holder or rack and placed/stored undisturbed in a container (cold box) at an appropriate temperature (4°C–8°C). Then, specimens were transported to the laboratory using the cold box. For collection and transport of blood specimens, standard guidelines from the National Committee for Clinical Laboratory Standards (now the Clinical and Laboratory Standards Institute) were used.[25] All samples were analyzed as quickly as possible (within 4 hours of blood collection). Analyses of hematological parameters were performed using an automated hematology analyzer (KX-21N; Sysmex, Kobe, Japan).

Data processing and analysis

All the data were cleaned, double-entered into Microsoft Excel spreadsheets and analyzed using Stata software version 13 (StataCorp, College Station, TX, USA). Descriptive summaries were presented in terms of means, SD, and proportions depending on the scale of the variable. Unpaired Student's t-tests were used to test the statistical significance of differences in selected parameters between the garage workers and the control group. Multiple linear regression analysis was used to test the association between each of the dependent variables (hematological parameters and blood pressure) and behavioral characteristics, with job-related parameters as independent variables. Medical outcomes were the dependent variable and age, working duration, smoking at the workplace (0 = no, 1 = yes), drinking at workplace (0 = no, 1 = yes), chewing khat at work place (0 = no, 1 = yes), personal protective equipment use (0 = user, 1 = nonuser), and taking showers at the workplace (0 = no, 1 = yes) as the independent variables.

For each outcome variable, simple linear regression was done using each independent variable. Then, we selected those variables with $P > 0.2$ and ran multiple regression for each outcome variables. Multiple linear regression analyses were applied to determine whether there were increases or decreases in hematological measures with increasing exposure. All assumptions for linear and multiple regressions were checked. Diagnostics for multicollinearity among the independent variables were done on all equations using the variance inflation factor. Those independent variables with variance inflation-factor values >10 were taken as indicative of multicollinearity and removed from the multiple linear regressions. $P < 0.05$ was considered statistically significant.

Ethical considerations

The study proposal was approved by the Institutional Research and Ethics Review Committee of College of Health and Medical Sciences, Haramaya University. All participants gave informed written consent to take part in this study. Only those individuals willing to participate were recruited. They were informed clearly about the purpose of investigations and expected outcomes. The results of the laboratory tests were given to the study participants.

Results
General characteristics

Personal characteristics of the garage workers and control group are presented in Table 1. They were comparable with regard to age and sex. All of the garage workers were males. The age of the workers was 18–53 years, with mean ± SD of 30.4±8.2. Most of the workers (20 [66.67%]) were found to have worked in their garage for ≤7 years. Protective measures were poorly followed during work in garages. The majority of the workers (24 [80%]) did not use any kind of personal protective equipment. Eleven (36.67%), 19 (63.33%), 13 (43.33%), 22 (73.33%), and 14 (46.67%) workers had a habit of smoking, drinking, eating, chewing khat, and taking showers at work, respectively. We observed that all the garage workplaces were dusty and the workers did not follow safety measures (Figure 1).

Regarding possible routes of chemical entry into the body, 16 (53.3%) workers mentioned that inhalation was the route of entry, followed by 15 (50%) who reported that ingestion was the route, and 13 (43.3%) who claimed that skin was the route of entry. A total of 12 (40%) workers had knowledge about the effects of chemicals on human health. Workers had neither attended training courses nor had health professionals visit their station.

Blood pressure and hematological parameters

Mean systolic blood pressure (128.67±18.14 vs 106.33 ±9.27 mmHg, $P < 0.0001$) and diastolic blood pressure (90.33±11.29 vs 75.67 ±5.68 mmHg, $P < 0.0001$) were significantly increased in garage workers compared to the control group (Table 2). Statistical analysis showed that significant decreases in RBCs, hemoglobin, hematocrit, and mean corpuscular volume (MCV) were observed among garage workers compared to the control group. In contrast, total white BC (WBC) count and platelet values were found to be higher in garage workers than controls. There were no significant differences in mean corpuscular hemoglobin (MCH) or MCH concentration (MCHC) between the two groups (Table 3).

Table 1 Personal characteristics of garage workers and controls in Harar

Characteristics		Garage workers (n=30), n (%)	Control group (n=30), n (%)
Age (years)	Mean (range)	30.36 (18–53)	29.66 (19–49)
Age-group (years)	18–27	12 (40)	12 (40)
	28–37	13 (43.33)	13 (43.33)
	38–53	5 (16.67)	5 (16.67)
Sex	Male	30	30
	Female	–	–
Educational status	Write and read only	4 (13.33)	–
	Primary	8 (26.67)	–
	Secondary	17 (56.67)	–
	Tertiary	1 (3.33)	30 (100)
Khat chewing	Yes	8 (26.67)	5 (16.67)
	No	22 (73.33)	25 (83.33)
Smoking status	Yes	11 (36.67)	0
	No	19 (63.33)	30 (100)
Work duration (years)	≤7	20 (66.67)	–
	>7	10 (33.33)	–
PPE use during work	Yes	6 (20)	–
	No	24 (80)	–
Drinking at workplace	Yes	19 (63.33)	–
	No	11 (36.67)	–
Eating at workplace	Yes	13 (43.33)	–
	No	17 (56.67)	–
Showering at workplace	Yes	14 (46.67)	–
	No	16 (53.33)	–

Abbreviation: PPE, personal-protection equipment.

Figure 1 Partial view of working practice in one of the garages.
Note: Workers are engaged in routine activities without proper personal protective equipment, in a dusty place, and have a habit of chewing khat and drinking water during work.

Table 2 Systolic and diastolic blood pressures of garage workers and control group in Harar

	Garage workers (n=30), mean ± SD	Control group (n=30), mean ± SD	Change	*P*-value
Systolic blood pressure	128.67±18.14	106.33±9.27	↑21.01%	<0.0001
Diastolic blood pressure	90.33±11.29	75.67±5.68	↑19.37%	<0.0001

Table 3 Hematological parameters of garage workers and control group in Harar

	Garage workers (n=30), mean ± SD	Control group (n=30), mean ± SD	Change	*P*-value
WBCs ($\times 10^9$/L)	7.9±1.51	6.72±2.04	↑17.56%	0.0138
RBCs ($\times 10^{12}$/L)	5.13±0.38	5.46±0.36	↓6.04%	0.0006
Platelets ($\times 10^9$ cells/L)	323.2±48.82	244.1±47.3	↑32.4%	<0.0001
Hemoglobin (g/dL)	14.87±0.71	15.45±0.87	↓3.75%	0.0062
Hematocrit (%)	43.98±1.99	46.43±2.32	↓5.28%	<0.0001
MCV (fL)	83.19±2.93	85.11±3.87	↓2.26%	0.0353
MCH (pg)	27.99±1.44	28.33±1.73	↓1.2%	0.4206
MCHC (%)	32.86±1.03	33.27±0.97	↓1.23%	0.1109

Abbreviations: WBCs, white blood cells; RBCs, red BCs; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, MCH concentration.

Regression analysis

Of the independent variables, working duration was found to be a significant predictor of decreases in hemoglobin, hematocrit, MCV, and MCHC and a significant predictor of increases WBCs. Increased systolic blood pressure was also predicted by working duration. Smoking was found to be a significant predictors of RBC decrease (Table 4).

Discussion

Garage workers are exposed to different chemicals in their workplaces. Studies have found that they are exposed to heavy metals like lead, chromium, and cadmium,[1,3,26] volatile organic compounds (VOCs), such as benzene,[27] and skin-irritating substances, such as oils, greases, solvents, and detergents.[6] Higher blood levels of lead (4.74 vs 0.74 µg/dL), cadmium (1.17 vs 0.41 µg/dL), chromium (5.21 vs 0.98 µg/dL), zinc (153.56 vs 83.22 µg/dL), and copper (113.74 vs 85.42 µg/mL) have been reported among auto-repair garage workers compared with unexposed control subjects.[1] A study found that garage wastewater was found to be highly contaminated with lead and cadmium, with average concentrations of 4.22 and 1.32 mg/L, respectively. Due to this exposure, garage workers had increased blood lead and cadmium levels compared to the unexposed control group.[3] Those who work near VOC sources, motor-vehicle exhaust, and gasoline-vapor emissions are also suspected to be exposed to highly elevated VOC levels during their work time.[27]

In Ethiopia, workers' safety and surveillance is a neglected subject. The body concerned does not facilitate heath care. Besides the poor efforts made by the body concerned to ensure the safety of occupational workers, the extent of exposure is worsened by working practices and behavior of the garage workers. Furthermore, the workers are not aware of occupational and environmental health hazards. Lack of protective equipment has been singled out in focus-group discussions as the main observed reason for health problems.[28] On the other hand, a follow-up study showed that use of personal-protection equipment (PPE) reduced accidents at work.[29] In the present study, the majority of participants (80%) were found to be working without any proper PPE. Use of PPE was found to be poor, with only six (20%) of the garage workers using it, of which three used special shoes (boots), two both gloves and mask, and one a hat. The main reason for not using PPE was found to be lack of provision of the PPE by owner of the garages and discomfort.

Mean RBC count (5.13±0.38 vs 5.46±0.36×10^{12} cells/L, *P*<0.001), hemoglobin level (14.89±0.71 vs 15.45±0.87 g/dL, *P*<0.01), hematocrit level (43.98%±1.99% vs 46.43%±2.32%, *P*<0.0001), and MCV (83.19±2.93 vs 85.11±3.87 fL, *P*<0.05) values of garage workers were significantly lower than those of the control group, while mean WBC (7.9±1.51 vs 6.72±2.04×10^9 cells/L, *P*<0.05) and platelet (323.2±48.82 vs 244.1±47.1×10^9 cells/L, *P*<0.0001) counts were significantly higher among garage workers. This difference may be due to exposure of different chemicals in the occupational group. Similar hematological findings have been reported from other studies in which garage workers were exposed to different chemicals.[6,19,20,26,30]

Table 4 Multiple regression analysis for predictor and outcome variables (blood pressure and hematological parameters) of garage workers in Harar

	Predictors	Coefficient (β)	SE	P-value	95% CI of β		R^2	F-value
					Lower	Upper		
RBCs	Work duration	−0.013	0.009	0.169	−0.033	0.006		
	Smoking (yes)	−0.397	0.135	0.005	−0.667	−0.126	0.263	0.0002
	Constant	5.411	0.053					
WBCs	Work duration	0.079	0.044	0.075	0.008	0.168		
	Drinking (yes)	0.634	0.620	0.311	−0.609	1.876	0.176	0.012
	Chewing khat (yes)	0.579	0.578	0.321	−0.579	1.736		
	Constant	6.593	0.315					
Hemoglobin	Work duration	−0.054	0.024	0.029	−0.103	−0.006		
	Smoking (yes)	−0.519	0.297	0.086	−1.115	0.075	0.234	0.002
	Taking shower (yes)	0.278	0.268	0.304	−0.259	0.815		
	Constant	15.36	0.119					
Hematocrit	Work duration	−0.181	0.06	0.004	−0.302	−0.061	0.264	0.0002
	Smoking (yes)	−1.096	0.844	0.199	−2.786	0.594		
	Constant	44.99	0.329					
MCV	Work duration	−0.212	0.079	0.01	−0.369	−0.054	0.149	0.01
	PPE (nonuser)	2.324	1.428	0.109	−0.536	5.184		
	Constant	82.741	1.383					
MCH	Work duration	−0.089	0.043	0.041	−0.174	−0.004		
	Smoking (yes)	−0.106	0.597	0.859	−1.303	1.089	0.103	0.045
	Constant	28.469	0.232					
MCHC	Work duration	−0.069	0.025	0.007	−0.119	−0.019		
	Smoking (yes)	−0.47	0.349	0.184	−1.169	0.229	0.244	0.0004
	Constant	33.376	0.136					
SBP	Work duration	1.761	0.398	<0.001	0.964	2.558		
	Smoking (yes)	5.171	4.888	0.295	−4.621	14.964	0.562	<0.0001
	Taking shower (yes)	10.822	4.41	0.017	−1.986	19.658		
	Constant	108.363	1.952					
DBP	Work duration	0.917	0.224	<0.001	0.469	1.366		
	Taking shower (yes)	10.689	2.875	<0.001	4.932	16.447	0.518	<0.0001
	Constant	87.555	1.262					

Abbreviations: WBCs, white blood cells; RBCs, red blood cells; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, MCH concentration; SBP, systolic blood pressure; DBP, diastolic blood pressure; PPE, personal-protection equipment.

Consistently with our results, decreased erythrocyte (4.39 ± 0.64 vs $5.2 \pm 0.54 \times 10^9$ cells/L, $P<0.0001$), hemoglobin (12.97 ± 2.31 vs 14.7 ± 0.74 g/dL, $P<0.0001$), and hematocrit ($38.38\% \pm 5.49$ vs $43.66\% \pm 2.03\%$, $P<0.0001$) levels have been reported among car mechanics in Zagazig.[6] Similarly, the effect of automobile workshops on the health status of automechanics was studied in Pakistan, and significant decreases were observed in hemoglobin (9.63 ± 0.24 vs 11.42 ± 0.26 g/dL, $P<0.05$).[26]

Auto-repair workers in Pakistan exposed to aromatic solvents (benzene) showed mean RBCs (4.75 ± 0.7 vs $5.12 \pm 0.4 \times 10^9$ cells/L, $P<0.05$) and hemoglobin (14.7 ± 0.6 vs 15.21 ± 0.7 g/dL, $P<0.05$) significantly lower than controls, whereas mean WBC count, MCV, and packed-cell volume were higher among car mechanics compared to controls, though the differences were not statistically significant.[19] This is in agreement with our study for mean RBC, hemoglobin,

and WBC levels. An association between benzene exposure and lowering of RBC counts has been also reported.[31,32]

In a study conducted in Iran among lead-exposed workers of a car-battery industry, MCH and MCHC were negatively correlated with blood lead concentration. However, they failed to detect decreased hemoglobin and hematocrit concentrations in workers.[30] Similarly, lead exposure among automobile workers showed decreased hemoglobin (13.14 ± 1.36 vs 14.85 ± 1.46 g/dL, $P<0.001$), hematocrit ($43.65\% \pm 3.05\%$ vs $45.5\% \pm 3.8\%$, $P<0.05$), MCV (83.1 ± 4.23 vs 85.94 ± 5.29 fL, $P<0.05$), MCH (26.63 ± 1.85 vs 28.23 ± 2.44 pg, $P<0.01$), MCHC (30.3 ± 1.44 vs 32.82 ± 1.44 g/dL, $P<0.001$), and RBC (5.03 ± 0.52 vs $5.89 \pm 0.76 \times 10^9$ cells/L, $P<0.001$) counts and increased total WBC counts (7.5 ± 1.39 vs $6.73 \pm 1.82 \times 10^9$ cells/L, $P<0.05$) compared to controls. It was indicated that the absorption of lead is higher in automobile workers and affects heme biosynthesis and hematological parameters.[20]

In this study, mean platelet value was increased among garage workers compared to the control group. However, this result is contrary to previous studies,[33,34] which showed a negative association of such exposure with platelets, along with other parameters. Significantly increased total WBC counts in these automobile workers could be due to more exposure to dust or fumes of toxic chemicals. This WBC increase may also be due to certain inflammatory and infectious conditions, because an essential function of WBCs is to provide primary defense.[19]

Significantly decreased hemoglobin, MCV, and RBC counts in automobile workers identified by this study might be due to decreased heme concentration, iron absorption, or maturation of RBCs by different toxic chemicals. Different chemical exposure times affect the hematopoietic system and result in altered hematological parameters. For example, lead impairs the rate of incorporation of iron into mature and immature RBCs in cases of human lead poisoning.[20] Benzene is well known for its hematological and leukemogenic properties, as prolonged benzene exposure can induce bone-marrow toxicity, which is expressed in decreased BC counts.[35]

Several studies have reported increases in blood pressure among workers exposed to lead concentrations. Occupational exposure to higher ambient lead is related to increased systolic and diastolic blood pressures. Blood lead values correlated significantly with systolic and diastolic blood pressures.[36] A general population exposed to very low lead levels showed increased blood lead was associated with small increases in blood pressure.[37] It has been described that significant blood pressure rises with increased blood lead concentrations in 36 male subjects with an occupational exposure to lead of 39.5 µg/dL.[38] A cross-sectional study of male workers exposed to lead examined the association between environmental lead and blood pressure, and showed that systolic blood pressure rose with increasing blood lead from 127 mmHg in subjects with blood lead <21 µg/dL to 133 mmHg in those with blood lead >50 µg/dL.[39]

Increased systolic blood pressure (128.67±18.14 vs 106.33±9.27 mmHg, $P<0.0001$) and diastolic blood pressure (90.33±11.29 vs 75.67±5.68 mmHg, $P<0.0001$) in garage workers compared to controls in this study indicate that occupational chemical exposure alters blood pressure. Among different chemicals, it is reported that blood lead levels contribute independently to increased systolic and diastolic blood pressures.[20] Significantly high rates of hypertension were reported in the group with high exposure to benzene compared to the group with less exposure. A possible mechanism of benzene-induced hypertension could be disturbance of the nitric oxide process, subsequently leading to hypertension.[40] Similarly, a significant association was observed between hypertension and exposure to a mixture of organic solvents in a study conducted in Iran among car-manufacturing workers. Significantly higher mean elevation values of 7 mmHg in systolic blood pressure and 6.9 mmHg in diastolic blood pressure among workers exposed to mixture of organic solvents compared to the control group were observed.[21] From this, it can be concluded that increased blood pressure is prominent in garage workers known to be chronically exposed to different chemicals.

In the present study, regression analyses showed that smoking was a significant predictor of decrease in RBCs. A similar finding was obtained from a study conducted in Pakistan, where smokers showed decreased mean RBC and hemoglobin counts compared to nonsmokers.[19] Smoking has been found to be an important factor in direct exposure to different chemicals, such as benzene[41] and other aromatic VOCs.[27] In addition to smoking having a direct effect on the hematopoietic system, it enhances effects of exposure to different chemicals.

In the present study, working duration was also found to be an important predictor of most hematological parameters. Declines in hemoglobin, hematocrit, MCH, and MCHC were predicted by work duration. These findings are in agreement with those of studies conducted in Pakistan, where garage workers with longer exposure experienced more adverse effects on hematological parameters (mainly RBCs and hemoglobin).[19] It has been reported that hematotoxicity, genotoxicity, and acute myelogenous leukemia are enhanced by long exposure.[42] Several studies have shown positive correlations between blood levels of chemical contaminants with duration of exposure.[43,44] All of these studies show that health risk is directly associated with prolonged toxin exposure. This is explained by the fact that the longer duration of work, the higher the level of exposure to different affecting agents.

This study has some limitations. We evaluated the picture of blood pressure and hematological parameters in garage workers exposed to a mixture of different chemicals. We did not measure the specific chemicals to which the garage workers were exposed nor did we define the effects of a single chemical. It would be better to assess types of occupational chemical exposure and their effect on health in future studies. Furthermore, there were no records for baseline and periodic examination of blood pressure or hematological parameters of garage workers to identify changes that could be attributed to occupational chemical exposure.

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Conclusion

The majority of the workers were unaware of the hazardous effects of chemicals and did not use any kind of personal protective equipment during their work in the station. To minimize chemical exposure at workplaces, placement of proper preventive and control measures need to be taken by the concerned body. Specifically, the local health bureau and different concerned health professionals should develop and enforce strict regulations, instructions, and guidelines for occupational health and safety to protect workers.

The findings regarding blood pressure and hematological parameters showed there were decreased mean RBC counts, hemoglobin levels, hematocrit levels, and MCV and increased mean WBC counts, platelet counts, systolic blood pressure, and diastolic blood pressure among the garage workers compared to the control group. Therefore, regular screening and monitoring of garage workers is important to reduce the long-term adverse effects of occupational chemical exposure. Furthermore, long-term prospective studies of garage workers would help to gain a more comprehensive picture of long-term effects of chemical exposure and identify the specific types of chemicals to which the workers are exposed.

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Author contributions

ZA designed the study, participated in data collection, analysis, and drafted the manuscript. FU and AG participated in study design, analysis, write-up, and critically revised the manuscript. All authors gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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