Full Length Research Paper

Effect of automobile workshop on the health status of automechanics in N. W. F. P., Pakistan

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Automobile workers are at high risk for lung, urinary tract, brain and skin cancers due to their direct exposure to polycyclic aromatic hydrocarbons (PAH) and lead (Pb) toxicity. The current study was aimed to assess the effect of automobile workshop environment on health of auto mechanics in N. W. F. P. Pakistan. A questionnaire was designed and blood samples were collected from the auto mechanics and students. Students of University of Malakand were selected as control, that is, that were not exposed to automobile workshop environment. Serum glutamate pyruvate transaminase (SGPT), uric acid, calcium, bilirubin, haemoglobin levels and the prevalence of hepatitis B and C were observed. The results of the workers showed an increase in concentrations of SGPT (104.4 ± 49.46 IU/L), calcium (18.96 ± 0.04877 mg/dl), bilirubin direct (0.877 ± 0.206 mg/dl) and bilirubin indirect (0.986 ± 0.324 mg/dl) as compared to students. Significant decrease was observed in haemoglobin (9.635 ± 0.2405 mg/dl) level. The mean value of uric acid was (6.93 ± 1.077 mg/dl), 50% of the workers had high uric acid level and 12% had low level of uric acid as compared to control group. The percentage of occurrence of hepatitis B and C in the workers was 10 and 18% respectively and 4% of the workers were positive for both. The results for uric acid, SGPT, calcium, bilirubin and haemoglobin were in normal range in students. The prevalence rate of hepatitis was zero among the control group. We concluded that workshop environment has significant ill effect on liver and kidney function. However, further studies should be done on large population size to avoid all these risks to the workers of such environment.

Key words: Liver function, kidney function, automobile workshop.

INTRODUCTION

Automobile workshop workers are a class of labour prone to long-term lead toxicity due to their routine works such as motor vehicle assembly, spray painting, burning of petrol, welding, brazing and repairing of radiators. The outfits of automobile workshop workers serve as a source of lead exposure to their family members, young children in particular arise the occupational toxicity to a community problem. Drastic increase in the number of automobile vehicles in last two decades incremented the exposure of this labour class to lead (Pachathundikani

and Varghese, 2006). Auto mechanic are exposed to residual used gasoline engine oils (UGEO) that accumulate on automobile parts, tools, workbenches, floors and equipment. Given the carcinogenic potential of UGEO, they are encouraged to wash their hands regularly to remove these contaminants. Polycyclic aromatic hydrocarbons (PAH) compounds can be readily absorbed through the skin and for automotive mechanics this may be the major route of entry. The increased cancer risk may be directly related to the constant contact of the hands and forearms of automotive mechanics to these carcinogenic substances. Workers exposed to PAH are at an increased risk for lung, urinary tract, brain and skin cancers (Boffetta et al., 1997). In general, chlorinated hydrocarbons are considered to be potential

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hepato and nephro toxicants in humans (Torkelson and Rowe 1985; Lauwerys et al., 1985).

This study was aimed to analyze the effects of automobile workshop environment on health status of the automotive mechanics. The adverse effects of the toxicants in such environment, is a common phenomenon in developing countries. But awareness about this problem is lacking in Pakistan, particularly in N. W. F. P. The evaluation of projects and policy reform for environmental effects in Pakistan has been rare. Therefore the present study was focused to assess the adverse effects of automobile workshop environment on health status of the automotive workers and develop awareness for proper safety measures in this regard.

MATERIALS AND METHODS

Description of the study area

Pakistan is a federation of four provinces (Balochistan, North West Frontier Province (N. W. F. P), Punjab and Sindh), a capital territory and federally administered tribal areas. The N. W. F. P. is the smallest of the four provinces of Pakistan and has an area of 74,521 km². In the province, majority of the population is Pashtuns, locally referred to as Pakhtuns, and other smaller ethnic groups. The principal language is Pashto (locally referred to as Pakhto) and the provincial capital is Peshawar (locally referred to as Pekhawar). Peshawar, Abbottabad, Kohat, DI Khan, Mardan, Swat etc are the important cities of the province. The literacy rate was 49.9% in 2008. Most people having their own vehicles which creates burden on the automobile workshops. It attracts the lower class people to work in automobile workshops for earning money.

Study design

A survey of the study area was conducted during which different automobile workshops were visited and primary data was collected. Fifty worker were randomly selected for study irrespective of their age and working hours from Workshop workers (n = 50). Students of University of Malakand (n = 10) were selected as controls that were not exposed to automobile workshop environment.

A printed questionnaire regarding the age, socioeconomic status, health status and duration of stay at work place was completed by each participant before the blood sample was collected after written informed consent. The study protocol was approved by the university ethical committee.

Blood sample collection

The blood samples of 3 ml were collected from each person in vacutainer and after 30 min, the collected samples were centrifuged at 6000 rpm for 2 min for serum separation. The collected serum was used for analysis of various biochemical tests. Shimadzu UV-Visible double beam Spectrophotometer 1700 Pharma (Japan) was used for analysis of different biochemical parameters.

Biochemical analysis

The following biochemical parameters were measured in order to study the effect of automobile workshop effect on the health status of workers.

Serum glutamate pyruvate transaminase (SGPT) level

The Crescent diagnostic kits (Saudi Arabia) were used for estimation of serum glutamate pyruvate transaminase (SGPT) by following the procedure given in the kit protocol.

Uric acid level

Uric acid level was estimated by enzymatic colorimetric test using CRESCENT diagnostic kit (Saudi Arabia) according to the procedure given in the kit protocol.

Bilirubin (both direct and indirect)

The bilirubin level was estimated using DIALAB diagnostic kit for Bilirubin Direct/Total (Austria) as described by the manufacturer.

Calcium level

The AXIOM Gestllschaft for Dignostica and Biochemica mBH kit (Deutschland) was used to measure the level of Calcium in the serum samples of both workers and control groups.

Haemoglobin (Hb) level

Sahli's method was used for the estimation of haemoglobin. In this test, N/10 HCl is used as a diluting fluid. It haemolyses the RBCs and frees the haemoglobin. This released Hb is stabilized by HCl, by conversion of Hb to acid haematin, which is a stable form of Hb and is tan in colour. The colour of acid haematin is matched with standard.

Screening for hepatitis B virus (HBV) and hepatitis C virus (HCV)

All the samples were screened for HBV and HCV positive persons by using one step test Device package. It is a rapid chromatographic immunoassay for the qualitative detection of antibody to HBV and HCV in serum or plasma.

Data analysis

Data obtained were subjected to statistical computer software Graphpad Prism downloaded from the site www.graphpad.com.

RESULTS AND DISCUSSION

History of workers

A questionnaire was designed to collect the information about the age, economic status, health status and exposure time of the workers in the workshops as summarized in Table 1. The workers were of different age groups ranging from 10 – 50 years. All of the workers belonged to lower class of the society. Among the workers, 36% were narcotics users. They used different kinds of narcotics including snuff, cigarettes, hashish etc. The information about their health status revealed that

Table 1. History of workers.

Age group (years)	No. of samples	Economic status	Health status (%)	Narcotics users (%)	Exposure time (months)
10 - 20	27	Lower class	66.66 Anaemic 11.11 Allergic 11.11 Both	29.63	6 – 96
21 - 30	14	Lower class	57.14 Anaemic 14.28 Allergic 14.28 Both	35.71	12 – 192
31 - 40	06	Lower class	33.33 Anaemic 0 Allergic 16.66 Both	66.66	120 – 288
41 - 50	03	Lower class	-Nil-	33.33	336 – 360
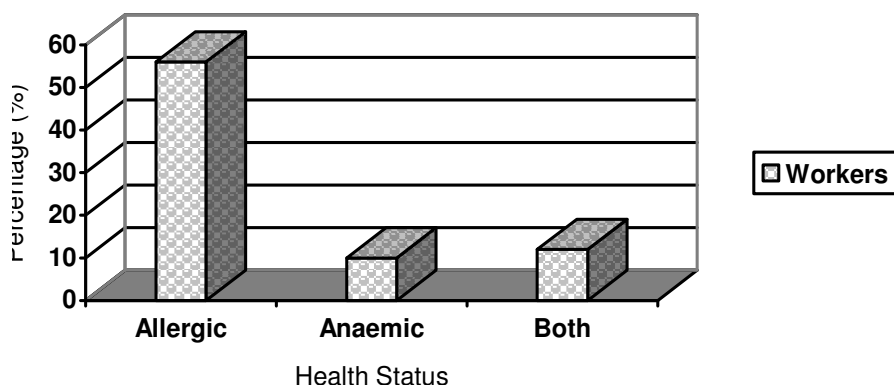
Figure 1. Health status of workers.

56% of workers were anaemic, 10% had some kinds of allergies and 12% had both as shown in the Figure 1. Their exposure time in the workshop was in the range of 6 – 360 months.

Analysis of serum glutamate pyruvate transaminase (SGPT) level

SGPT level of the control as well as workers were calculated as summarized in Figure 2. The mean level of SGPT for the control was 40.63 ± 0.36 IU/L with a range of 21.98 ± 0.31 to 83.60 ± 0.46 IU/L and for workers was 104.4 ± 49.46 IU/L with a range of 28.16 ± 1.04 to 190.6 ± 1.25 IU/L (Table 2). The SGPT level of control group was in normal rang. While the SGPT level of workers was greater and thus shows that the liver function has been affected by the hydrocarbons and heavy metal used in automobile workshop.

Analysis of uric acid level

The uric acid level for both the control and workers groups were measured (Figure 3). The mean value of uric acid for the control was 5.34 ± 1.49 mg/dl with a range of 4.17 ± 0.13 to 5.65 ± 0.15 mg/dl as compared to workers which was 6.93 ± 1.07 mg/dl with a range of 2.17 ± 0.13 to 8.72 ± 0.14 mg/dl as mentioned in Table 2. The uric acid level of control was normal while high uric acid level was observed in 50% of the workers and 12% of the workers had low level of uric acid. The kidney function of those workers who had high exposure time was significantly affected.

Analysis of bilirubin (direct/indirect) level

The bilirubin (direct and indirect) level of control as well as workers was calculated (Figure 4). Mean value for
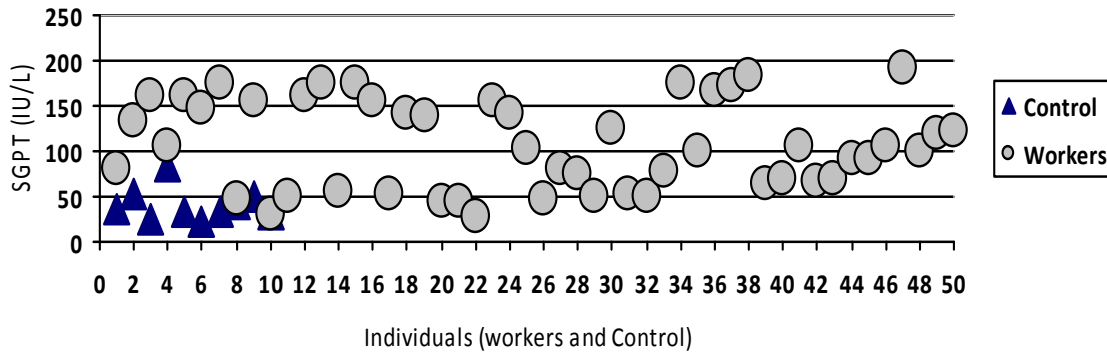
Figure 2. The observed SGPT levels of the control and workers.

Table 2. Blood biochemical parameter of the students (control group) and workers.

Group	Rang	SGPT[*1] (iu/l)	Uric acid (mg/dl)	Biluribin (mg/dl)		Calcium (mg/dl)	Hb[*2] (mg/dl)
				Direct	Indirect		
Control	Lower	21.98 ± 0.31	4.17 ± 0.13	0.55 ± 0.04	0.57 ± 0.02	1.17 ± 0.01	8.93 ± 0.11
	Upper	83.60 ± 0.46	5.65 ± 0.15	0.78 ± 0.02	1.05 ± 0.01	13.54 ± 0.02	13.33 ± 0.42
	G.M[*1]	40.63 ± 0.36	5.34 ± 1.49	0.63 ± 0.07	0.70 ± 0.14	6.17 ± 0.01	11.42 ± 0.26
Worker	Lower	28.16 ± 1.04	2.17 ± 0.13	0.057 ± 0.04	0.69 ± 0.01	2.77 ± 0.01	6.33 ± 0.11
	Upper	190.6 ± 1.25	8.72 ± 0.14	1.55 ± 0.02	2.48 ± 0.01	67.64 ± 0.33	12.33 ± 0.41

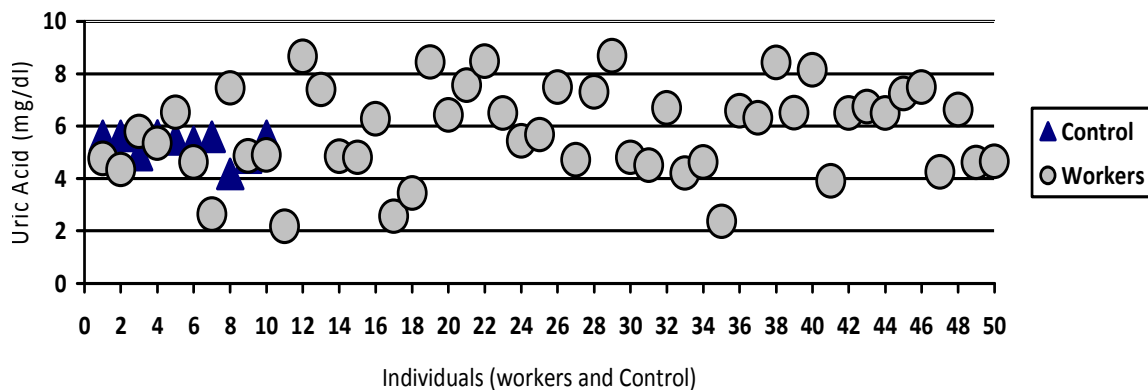[*1], Serum glutamate pyruvate transaminase; [*2] Haemoglobins.

Figure 3. The observed Uric Acid levels of the control and workers.

direct bilirubin level of control group was 0.63 ± 0.07 mg/dl with a range of 0.55 ± 0.04 to 0.78 ± 0.02 mg/dl while of workers was 0.88 ± 0.20 mg/dl with a range of 0.057 ± 0.04 to1.55 $\pm$ 0.02 mg/dl (Table 2). Mean value for indirect bilirubin level of control group was 0.70 ± 0.14 mg/dl with a range of 0.57 ± 0.02 to 1.05 ± 0.01 mg/dl as compared to worker which was 0.986 ± 0.324 mg/dl with a range of 0.69 ± 0.01 to 2.48 ± 0.01 mg/dl (Table 2). Bilirubin level was also affected due to automobile workshop environment as concluded from results.

Analysis of calcium level

Calcium level of the control as well as worker group was analyzed (Figure 5). The mean value of calcium for control was 6.17 ± 0.01 mg/dl with a range of 1.17 ± 0.01 to 13.54 ± 0.02 mg/dl as compared to workers which was 18.96 ± 0.048 mg/dl, with a range of 2.77 ± 0.01 to 67.64 ± 0.33 mg/dl (Table 2). It was observed that 88% of the workers had high calcium level and 4% had low level of calcium. It was concluded that workshop environment led
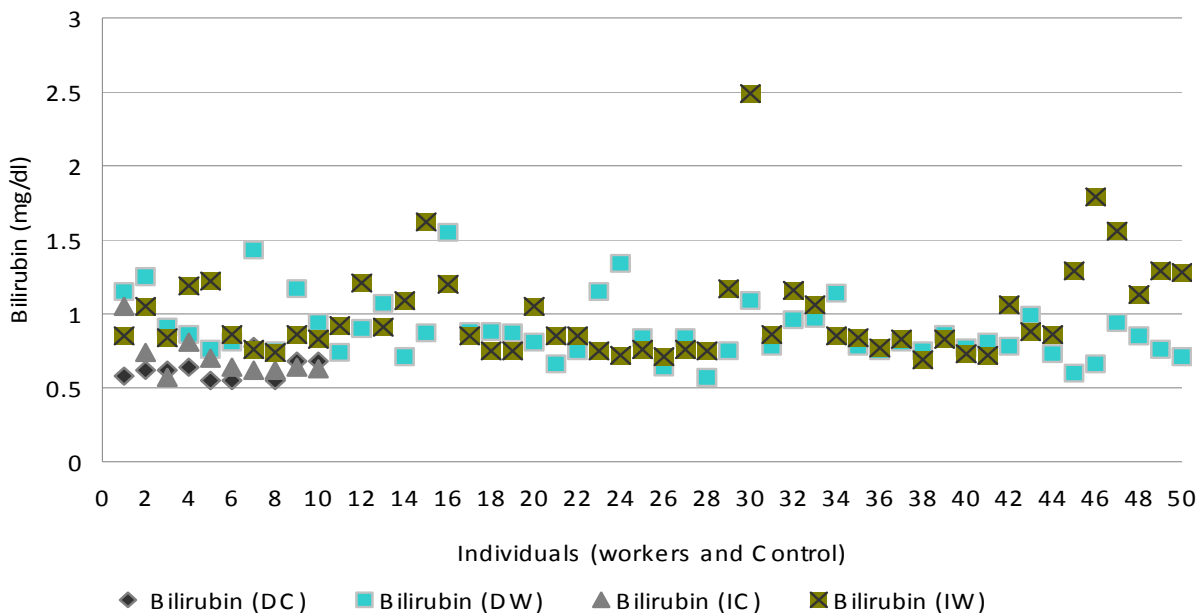
Figure 4. The observed bilirubin (direct and indirect) levels of the control and workers.
Bilirubin (DC), Bilirubin direct for control; bilirubin (DW) bilirubin direct for workers;
bilirubin (IC), bilirubin indirect for control; bilirubin (IW) bilirubin indirect for workers.
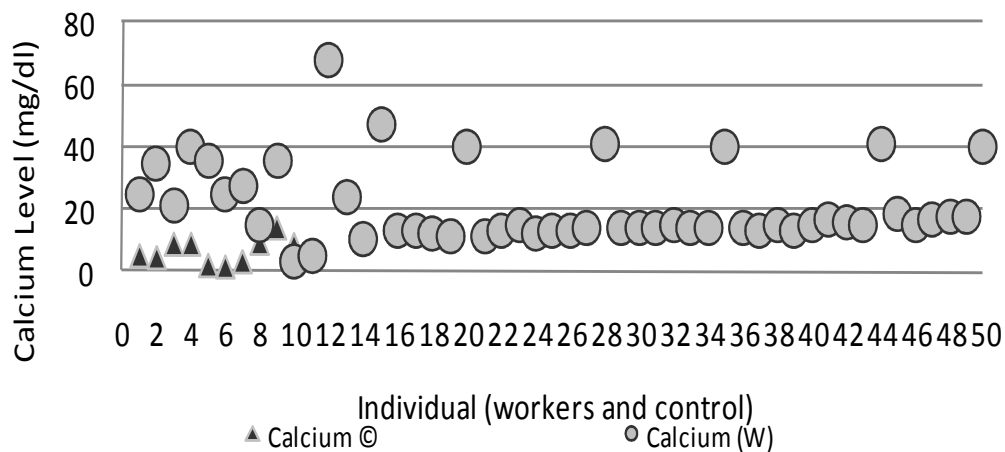
Figure 5. The observed calcium levels of the control and workers.

to an increase in calcium level.

Analysis of haemoglobin (Hb) level

Haemoglobin level of workers and control was analyzed using Salhi's apparatus (Figure 6). The mean value for haemoglobin level of control was 11.42 ± 0.26 mg/dl with a range of 8.93 ± 0.11 to 13.33 ± 0.42 mg/dl (Table 2). The haemoglobin level of the control was higher than that of workers. The mean value for haemoglobin level of workers was 9.63 ± 0.24 mg/dl with a range of 6.33 ± 0.11 to 12.33 ± 0.41 mg/dl (Table 2). From the results, it

was estimated that the workshop environment led to decrease in haemoglobin level of workers.

Prevalence of Hepatitis B and C among workers and Control

Tests were conducted, using hepatitis diagnostic kits to check the occurrence of hepatitis in workers and in the control groups. Out of 50 workers, 5 were positive for hepatitis B, 9 were positive for hepatitis C and 2 were positive for both B and C hepatitis (Table 3). The percentage of occurrence of hepatitis B and C in the
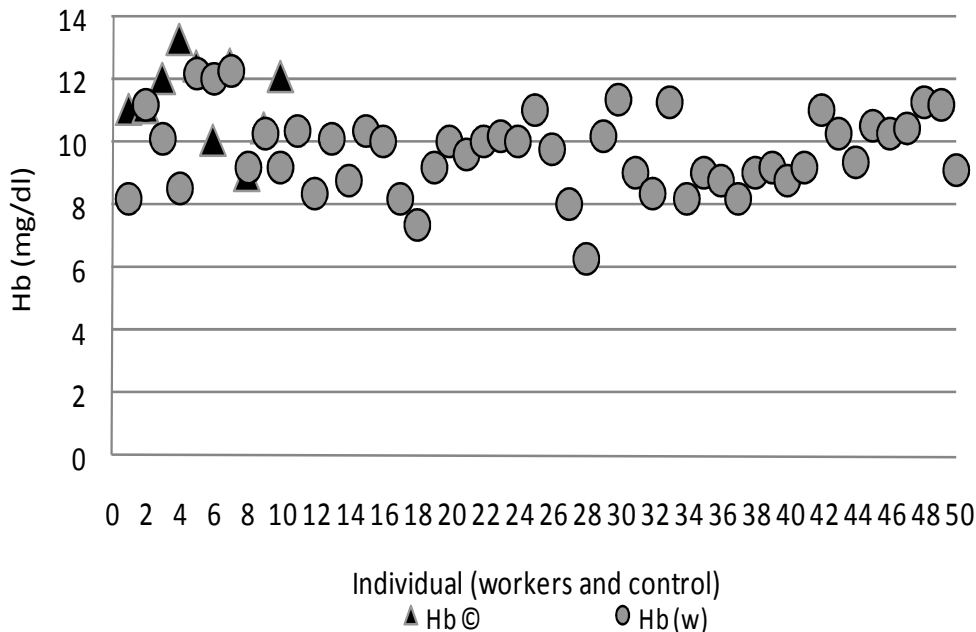
Figure 6. The observed haemoglobin (Hb) levels of the control and workers.

Table 3. Age-wise prevalence of hepatitis B and C among control as well as workers.

Age group	No. of samples	Hepatitis B (%) among control	Hepatitis C (%) among control	Hepatitis B (%) among workers	Hepatitis C (%) among workers
10-20	27	0	0	7.4	11.11
21-30	14	0	0	7.14	21.42
31-40	06	0	0	16.66	33.33
41-50	03	0	0	33.33	33.33

workers was 10 and 18% respectively while 4% of the workers were positive for both (Figure 7).

Prevalence of hepatitis was calculated by using the following formula:

$$\text{Prevalence} = \frac{\text{No. of infected persons} \times 100}{\text{No. of total samples}}$$

Age wise prevalence of hepatitis B and C among control and workers has been given in Table 3.

DISCUSSION

Automotive mechanics are exposed to residual used gasoline engine oils (UGEO) that accumulates on auto-mobile parts, tools, workbenches, floors and equipment (Boffetta et al., 1997; Ahmad, 2001). The major toxicants present in automobile workshop environment are polycyclic hydrocarbons and lead. Best-known and best-studied toxic effect of lead has on heme synthesis (Habal, 2008). In general, chlorinated hydrocarbons are considered to be potential hepato and nephro toxicants in humans (Torkelson and Rowe, 1985; Lauwerys et al., 1985). Present study was aimed to assess the effects of automobile workshop environment on health status of the workers.

All types of liver inflammation can cause raised SGPT. Cell damage will cause elevations of SGPT due to leakage. The elevation of the enzyme correlates with the number of cells damaged (Johnston, 1999; Ahmad, 2001; Fleming, 2006). In the present study, mean SGPT level for workers was 104.4 ± 49.46 IU/L, much higher than control group which were not exposed to such environ-ment. Similar observations of high SGPT levels have also been mentioned by Lundberg et al. (1994) among the painters. The present results are also in correlation with the study of Dioka et al. (2005), in which it was reported that additives in petroleum solvents have adverse health effects. The activities of alanine aminotransferase (ALT) in occupationally exposed artisans were higher compared with unexposed subjects. Same results have also been observed by Patil et al. (2007), studying the effect of occupational lead exposure in battery manufacturing
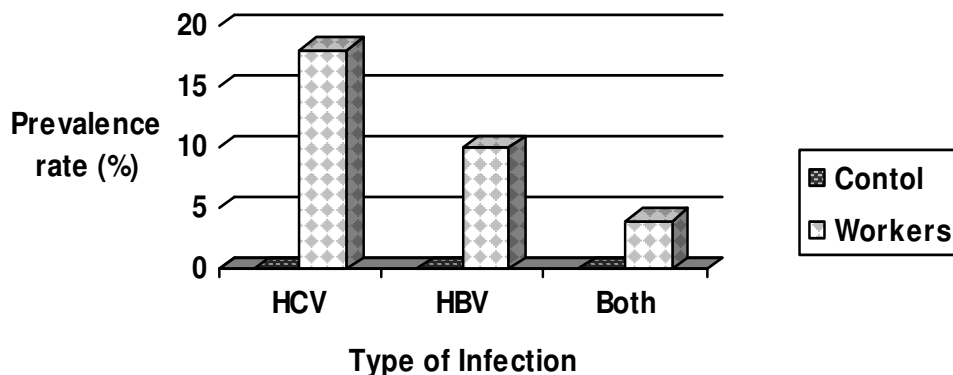
Figure 7. Prevalence rate of HCV and HBV among the control and worker groups.

workers (BMW), silver jewellery workers and spray painters (SP) on liver and kidney. It was found that SGPT activities were significantly increased in SP as compared to control. Similarly Boogaard and colleagues observed biochemical alterations in renal and hepatic functions of operators employed in a chemical plant producing chlorinated hydrocarbons (Boogaard et al., 2005).

Lower serum values of uric acid have been associated with multiple sclerosis (Toncev et al., 2002). An elevation in circulating serum uric acid is strongly associated with the development of hypertension and renal disease (Mazzali et al., 2001). The mean value for uric acid level of workers was 6.93 ± 1.07 mg/dl, 50% of the workers had high uric acid level and 12% had low level of uric acid. The results showed that exposure to automobile workshop environment may affect the uric acid level of workers. Same results have also been reported by Dioka et al. (2004). They reported that occupational exposure of human subjects to lead in petrol increases the concentrations of uric acid (357 ± 123 µmol/L) in exposed subjects compared with unexposed subjects. Similarly, Hernandez-Serrato et al. (2006) found that hyperuricemia was associated with blood lead concentrations above 40 microg/dL. Patil et al. (2007) has also reported significant increase in blood urea among Battery Manufacturing Workers. The present study is also in correlation with study of Wang et al. (2002). It was found that there was significant increase in uric acid level among lead battery workers. From the present data of uric acid and its comparison with control group and previous study it has been concluded that automobile workshop has adverse effects on the kidney function of the workers.

The mean value for haemoglobin level of workers was 9.63 ± 0.24 mg/dl. The mean value for haemoglobin level of control was 11.42 ± 0.26. The results showed that there is significant decrease in haemoglobin level of workers. Decreased haemoglobin level in automobile station workers have been reported by Ray et al. (2007). The present study is also in correlation with the study of Onunkwor et al. (2004). Reduced level of haemoglobin was reported in workers exposed to lead in petrol station

attendants and auto-mechanics in Abeokuta, Nigeria. Same results have been reported by Hoffman et al. (1981). It was found that haemoglobin level was reduced due to lead in bald eagles. Similarly, Ureme et al. (2003) also reported adverse effects on haemoglobin level of Petrol Station Attendants in Enugu Metropolis. The present study is also in correlation with the study of Anetor et al. (2005). They reported significant reduction in haemoglobin concentration of lead workers. Suplido and Ong (2000) also found decreased levels of haemoglobin in battery repair/recycling shop workers, radiator repair shop workers and children living in the immediate vicinity of these shops.

Similarly, Pachathundikani and Varghese (2006) also reported that automobile workshop environment leads to lowering of haemoglobin level.

Bilirubin concentrations are elevated in the blood either by increased production due to the increase degradation of haemoglobin, conjugation, decreased secretion by the liver, or blockage of the bile ducts (Guyton and Hall, 2006). Mean value for direct and indirect bilirubin level of workers was 0.877 ± 0.206 and 0.986 ± 0.324 mg/dl respectively. Whereas observed direct and indirect bilirubin level for the control group was 0.626 ± 0.074 and 0.702 ± 0.139 mg/dl respectively. The results showed that bilirubin levels among automobile workers were high as compared to control group. The present study is in correlation with the study of Patil et al. (2007). Significant increase in bilirubin level was reported among Battery Manufacturing Workers. Paiva and Siqueira (2005) also reported an increase level of total bilirubin in Brazilian workers exposed to solvents in car repainting shops. The present study also correlates with the study of Neghab and Stacey (1997). They observed elevated serum bile acids in rats due to toluene. The present study is not in correlation with the study of Boogaard et al. (1993). His results showed that there was no difference between total bilirubin level of control and hydrocarbons exposed group. The difference in the results may be due to difference in exposure time. He selected healthy workers; all those workers were excluded from the study that has

nephropathies, urinary tract diseases or systemic disease with possible renal sequelae. While in present study, samples were collected randomly, this may also be one of the reasons that present study showed deviation from the said study. It has been concluded that chemicals used in automobile workshop also alter the bilirubin level by altering the liver functions.

The mean value of calcium for workers was 18.96 ± 0.048 mg/dl while for control was 6.169 ± 0.010 mg/dl. Calcium level of workers was high as compared to control. The present study is in correlation with the study of Toda et al. (1984). Workers who had been exposed to cadmium oxide fume, that is, engaged in welding work with cadmium containing silver solder in an automobile parts manufacturing factory was examined. Remarkable increase was found in calcium level among exposed workers. Oktem et al. (2004) also reported increased in calcium level among workers in auto repair workshops.

Tests were conducted, using hepatitis diagnostic kits to check the presence of hepatitis in workers and in the control group. Out of 50 samples, 5 samples were positive for hepatitis B, 9 were positive for hepatitis C and 2 were positive for both B and C hepatitis. The percentage of occurrence of hepatitis B and C in the workers was 10 and 18% respectively while 4% of the workers were positive for both. The percentage of prevalence of hepatitis B and C in control group was zero. No reported data is available regarding occurrence of hepatitis in such workers. The high prevalence rate of hepatitis B and C among the workers might be due to lack of awareness or low socioeconomic status which has also been reported to be associated with the prevalence of many infectious diseases.

Conclusion

All the studied facts led to the conclusion that automobile workshop environment has adverse effects on health status of workers. Biochemical tests (SGPT, uric acid, calcium, bilirubin and haemoglobin) for workers showed that such environment have ill effects on workers' health. SGPT, uric acid, calcium and bilirubin levels of workers were high and there was a decrease in haemoglobin level. High SGPT, bilirubin and uric acid level showed that there is an adverse effect on liver and kidney function. Such environment can cause bone deformity in the children below 18 years of age due to immobilization of calcium. Workers in automobile workshop were anaemic because there was significant decrease in haemoglobin. High prevalence rate of hepatitis B and C were observed among the workers as compared to control which might be due to lack of health education, poverty, illiteracy and the most important one is the use of infected syringes as we have observed that 36% were narcotics users. These ill effects are due to lack of safety measures, poor hygiene and lack of basic health awareness.

RECOMMENDATIONS

Few of the recommendations are: workers should be educated about the harmful effects of automobile workshop environment, proper cleaning/washing of hands in workshop environment should be practiced before eating and drinking. The workers should follow safety measures to protect themselves from infectious dieses like hepatitis, vaccines should be given to those workers who are not infected with hepatitis B. There should be proper treatment by government for infected persons. Government should make policies to reduce adverse effects of such environment.

REFERENCES

Ahmad M (2001). Essentials of Medical Biochemistry. Chp 7. Merit Publishers Multan p. 157.
Anetor JI, Akingbola TS, Adeniyi FAA, Taylor GO (2005). Decreased total and ionized calcium levels and haematological indices in occupational lead exposure as evidence of the endocrine disruptive effect of lead. Ind. J. Occup. Environ. Med. 9(1): 15-21.
Boffetta P, Jourenkova N, Gustavsson P (1997). Cancer risk from occupational and environmental exposure to polycyclic aromatic hydrocarbons. Cancer Causes Control 8(3): 444-472.
Boogaard PJ, Rocchi PSJ, Sittert NJV (1993). Effects of exposure to low concentrations of chlorinated hydrocarbons on the kidney and liver of industrial workers. B. J. Ind. Med. 50: 331-339.
Dioka CE, Orisakwe OE, Adeniyi FAA, Meludu SC (2004). Liver and Renal Function Tests in Artisans Occupationally Exposed to Lead in Mechanic Village in Nnewi, Nigeria. Int. J. Environ. Res. Public Health 1: 21-25.
Fleming S (2006). Liver disease. http://www.cannin-epilepsyguardlanangle.com/diagnostic_test ing.html.
Guyton AC, Hall JE (2006a). Text Book of Medical Physiology. Published by Elseveir, a division of Reed Elsevier India Private Ltd p. 859.
Guyton AC, Hall JE (2006b). Text Book of Medical Physiology. Published by Elseveir, a division of Reed Elsevier India Private Ltd p. 307.
Guyton AC, Hall JE (2006c). Text Book of Medical Physiology. Published by Elseveir, a division of Reed Elsevier India Private Ltd, p. 863.
Habal R (2008). Toxicity, Lead. http://www.emedicine.com/med/byname/ToxIcIty.Lead.html.
Hernandez-Serrato MI, Fortoul TI, Rojas-Martinez R, Mendoza-Alvarado LR, Canales-Trevino L, Bochichio-Riccardelli T, Avila-Costa MR, Olaiz-Fernandez G (2006). Lead blood concentrations and renal function evaluation: study in an exposed Mexican population. Environ. Res. 100(2): 227-233.
Hoffman DJ, Pattee OH, Wiemeyer SN, Mulhern B (1981). Effects of lead shot ingestion on delta-aminolevulinic acid dehydratase activity, hemoglobin concentration, and serum chemistry in bald eagles. J. Wildlife Diseases 17(3): 423-443.
Jhonston DE (1999). Special Considerations in Interpreting Liver Function Tests. A. Fam. Phys. 59(8): 58-77.
Lauwerys R, Bernard A, Viau C, Buchet JP (1985). Kidney disorders and hematoxicity from organic solvent exposure. Scand. J. Work Environ. Health 11: 83-90.
Lundberg I, Nise G, Hedenborg G, Hogberg M, Vesterberg O (1994). Liver function tests and urinary albumin in house painters with previous heavy exposure to organic solvents. Occupational Environ. Med. 51: 347-353.
Mazzali M, Hughes J, Kim YG, Jefferson JA, Kang DH, Gordon KL, Lan HY, Kivlighn S, Johnson RJ (2001). Elevated Uric Acid Increases Blood Pressure in the Rat by a Novel Crystal-Independent Mechanism. Am. Heart Assoc. Inc. 38: 1101.

Neghab M, Stacey NH (1997). Toluene-Induced Elevation of Serum Bile Acids: Relationship to Bile Acid Transport. J. Toxicol. Environ. Health 52(3): 249-268.

Oktem F, Arslan M, Dundar B, Delibas N, Gultepe M, Ilhan IE (2004). Renal effects and erythrocyte oxidative stress in long-term low-level lead-exposed adolescent workers in auto repair workshops. Arch. Toxicol. 78(12): 681-687.

Onunkwor B, Dosumu O, Odukoya OO, Arowolo T, Ademuyiwa O (2004). Biomarkers of lead exposure in petrol station attendants and auto-mechanics in Abeokuta, Nigeria: effect of 2-week ascorbic acid supplementation. Environ. Toxicol. Pharmacol. 17(3): 169-176.

Pachathundikani SK, Varghese ET (2006). Blood zinc protoporphyrin, serum total protein and total cholesterol levels in automobile workshop workers in relation to lead toxicity: Our experience. Ind. J. Clin. Biochem. 21: 114-117.

Paiva M, Siqueira M (2005). Increased serum bile acids as a possible biomarker of hepatotoxicity in Brazilian workers exposed to solvents in car repainting shops. Biomarkers 10(6): 456-463.

Patil AJ, Bhagwat VR, Patil JA, Dongre NN, Ambekar JG, Das KK (2007). Occupational lead exposure in battery manufacturing workers, silver jewelry workers, and spray painters in Western Maharashtra (India): effect on liver and kidney function. J. Basic Clin. Physiol. Pharmacol. 18(2): 87-100.

Ray MR, Lahiri T, Roychoudhury S, Mukherjee S (2007). Occupational benzene exposure from vehicular sources in India and its effect on hematology, lymphocyte subsets and platelet P-selectin expression. Toxicol. Industrial Health 23(3): 167-175.

Suplido ML, Ong CN (2000). Lead Exposure among Small-Scale Battery Recyclers, Automobile Radiator Mechanics, and Their Children in Manila, the Philippines. Environ. Res. 82(3): 231-238.

Toda K, Mori Y, Koike S, Ohmori K, Yamaga S (1984). Chronic rena0l dysfunction in workers exposed to cadmium oxide fume. Medical examinations of welders using cadmium containing silver solder. Sangyo Igaku. 26(3): 212-223.

Toncev G, Milicic B, Toncev S, Samardzic G (2002). Serum uric acid levels in multiple sclerosis patients correlate with activity of disease and blood-brain barrier dysfunction. Eur. J. Neurol. 9(3): 221-226.

Torkelson TR, Rowe VK (1985). Halogenated aliphatic hydrocarbons containing chlorine, bromine and iodine. In: Clayton G D, Clayton FE, eds. Patty's industrial hygiene and toxicology. New York Wiley pp. 3433-3601.

Ureme SO, Maduka IG, Azubuike GA (2003). Blood Concentrations of Methaemoglobin, Carboxyhaemoglobin and some Haematological parameters in Petrol Station Attendants in Enugu Metropolis. J. Med. 3(1): 65-68.

Wang VS, Lee MT, Chiou JY, Guu CF, Wu CC, Wu TN, Lai JS (2002). Relationship between blood lead levels and renal function in lead battery workers. Int. Arch. Occup. Environ. Health 75(8): 569-575.