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Original Article

Safety measures in the workplace: a case study of Federal Road Safety Corps (FRSC) vehicle plate manufacturing plant, Ojodu – Lagos, Nigeria

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ABSTRACT

Introduction: Hazards associated with vehicle number plate manufacturing processes in developing countries have not been well elucidated. There is a need to investigate hazards in the vehicle number plate manufacturing plant. The study aimed to identify self-reported hazards in the vehicle plate manufacturing factory, explore their effect on workers' health and recommend mitigation strategies.

Methods: A descriptive cross-sectional study of workers in the vehicle plate manufacturing plant was done to identify hazards, protective measures and self-reported effects on workers' health. Biochemical analysis of blood samples was also done and outliers were noted. ANOVA test was performed to determine differences in mean values of selected biochemical parameters. A p-value of less than 0.05 was considered statistically significant.

Results: Exposure to toxic chemicals 38 (69%), excessive noise 36 (65%) and heat 28 (51%) were the major hazards in the factory. Major health problems were stress and fatigue 41 (71%), skin disorders 28 (51%), respiratory problems 18 (33%) and hearing loss 16 (29%). More than one quarter, 17 (30 %) of the workers admitted not using personal protective equipment (PPE) regularly. Periodic medical tests were not done for 13 (24%) of the workers. Potassium (3%), Urea (10%), Creatinine (7%), Aspartate transaminase (18%) and Alanine transaminase (8%) were elevated among the workers but no significant association could be established between elevated levels and work post.

Conclusion: Workers in the plate number manufacturing plant were mostly exposed to toxic chemicals and noise. Elevated electrolyte levels cut across departments. There is a need for better enforcement of safety rules, and periodic medical examinations should be conducted more consistently.

Keywords: Biochemical parameters, Hazards, PPE, Safety and health, Toxic Chemicals

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Introduction

One of the functions of the Federal Road Safety Corps (FRSC) of Nigeria is the production of vehicle plate numbers.[1] The FRSC factories located in different parts of the country manufacture uniform plate numbers for different categories of vehicles.[2]

Potential health hazards associated with number plate manufacture could be biological, chemical, physical, biochemical, or psychosocial. The hazards affecting workers in the vehicle plate manufacturing factory arise from the raw materials used in the production process. The raw materials include aluminum sheets, reflective sheeting, 3M roll coat color 4856 opaque blue and thinner 4954. The process begins with straightening the roll of raw stock aluminum sheets to remove dents. Then the aluminum rolls are cut into individual rectangular-shaped license plates with the aid of a blanking press. Original images such as state and country names, national flags etc. are then printed on the plate. Embossing involves using steel dies to create raised characters such as alphabets and numbers for each flat plate with the aid of a hydraulic embossing press. A roll coating machine is then used to apply solvent-based ink to the raised portions of the embossed plate. 3M™ roll coat inks are used with 3M™ reflective license plate sheeting to produce fully reflective, long-lasting vehicle registration plates. Roll coat inks may be thinned with 3M 4954 thinner for ease of coating. Oven drying is the last step in the process.

Workers are exposed to organic solvents that may cause a variety of symptoms. The symptoms range from transient (euphoria, headache, and dizziness) to serious symptoms (fainting, respiratory and circulatory failure). Toluene and acetone are the most abundant compounds in commercial thinners used in plate manufacturing plants. Cumene 1,2,4 Trimethylbenzene, toluene, and xylenes (BTXs) are known carcinogens and long-term exposure may cause damage to the Central Nervous System (CNS), such as cognitive and emotional deficits. Other less serious but equally important hazards are cuts and bruises from handling the aluminum sheets, noise and vibration from heavy machinery, collisions or falls while driving forklifts used to carry heavy materials, heat from ovens used to dry the plates after coating and ergonomic hazards including musculoskeletal strains from repetitive awkward movements involved in the production process.[3-4] Published statistics of hazards associated with industrial processes are sobering. Every year about 2.3 million people globally die from unintentional injuries at work and work-related diseases. Non-fatal workplace accidents affect some 268 million people annually.[5-6] The annual cost of job accidents to the global economy is a staggering 1.25 trillion dollars and indirect costs can be four to ten times greater than the direct costs.[7] The daily toll of occupational accidents, injury, or ill health is approximately 860,000.[8]

Some of the industries with the highest risk of accidents worldwide are mining, agriculture, including forestry and logging, and construction.[9] Although workplace accidents are a global phenomenon, fatal injury rates are 3–4 times higher in developing countries than the developed.[6] Africa is especially beleaguered with unsafe working conditions in industries.[6] Despite recent improvements in occupational safety and the enactment of worker-friendly labor laws, employers generally assume little responsibility for the protection of workers' health and safety.[10] As a key member of the International Labor Organization (ILO), Nigeria is expected to implement the provisions of the body regarding the safety and health of workers.[7] However, it is not clear to what extent this is being done, largely because of inadequate accident data, poor disease recognition, and sub-optimal or non-existent record-keeping and reporting mechanisms.[10-11]

This study was carried out to identify the specific hazards and risks peculiar to workers in the number plate production factory and to recommend measures that can minimize or eliminate such hazards to reduce the negative impact on the health of the workers.

Methods

The study was conducted in the Federal Road Safety Corps Vehicle Plate Manufacturing Plant, Ojodu – Berger in Ikeja Local Government Area (LGA) of Lagos State, Nigeria. The plant was established in 1993 and currently has a total of 103 workers. The factory produces plate numbers for all categories of vehicles and all states in the federation.

There is a staff clinic located within the FRSC premises where staff can assess healthcare in the event of an accident. In addition, each staff is enrolled under the National Health Insurance Scheme (NHIS) and is entitled to receive medical care for themselves and their families from any hospital of their choice.

The study was done in two phases. One phase was a descriptive cross-sectional study extracting information about the work processes, hazards, protective measures and self-reported effects on the health of workers at the vehicle plates manufacturing factory.

For this aspect of the study, a pre-tested structured self-administered questionnaire designed by the authors based on a literature search was used to collect data from the study participants. Pre-testing was done among 15 workers in the Abuja plate manufacturing plant. The questionnaire had two sections. Section A collected demographic data while Section B addressed issues of hazard exposure, self-reported incidence of accidents, availability and use of Personal Protective Equipment (PPE) and other preventive measures at the disposal of the factory workers. There were no personal details on the questionnaire to ensure confidentiality. Participation was voluntary. The aim of the study was explained to each participant and all who agreed to participate by signing a written informed consent form were enrolled for the study. The take-home, self-administered questionnaires were returned within a few days at the workers' convenience since filling the questionnaire during work hours could disrupt the factory workflow. Completed and usable questionnaires were retrieved for data analysis.

The second phase involved the collection of blood samples from employees for analysis to determine plasma levels of electrolytes and biomarkers of organ damage resulting from exposure to potentially hazardous chemicals. This phase was made mandatory for all workers by the management and therefore all 103 workers employed in the factory participated.

A volume of 2 ml of venous blood was collected aseptically from each participant after an overnight fast (12-16 hours). The sample was dispensed into a red-top Vacutainer and allowed to clot. The sample was then centrifuged at 3000 rpm for 10 minutes using a table centrifuge to separate the serum from the whole blood. The serum was pipetted into sterile containers using a micropipette and stored at 20^{0}C until biochemical analysis could be performed. Serum levels of sodium, potassium, chlorine, uric acid, blood urea, creatinine, aspartate transaminase (AST), alanine transaminase (ALT) and inorganic phosphorus were determined using the Semi-automatic Biochemistry Analyzer Chem 5v3 (Erba Diagnostic Incorporated Mannheim, Germany).[12] The values obtained were compared to standard values and deviations from normal were noted.

The data collected was entered into Microsoft Excel and was double-checked for accuracy. Categorical data was presented as frequency and percentages while continuous data from the biochemical assays were expressed as means and standard deviation. The departments were divided into three groups and a one–way Analysis of Variance (ANOVA) was used to compare mean biochemical values. A p-value of less than 0.05 was considered statistically significant. Outliers were also calculated from the reference ranges given to determine their deviation from normal.

Ethical approval for the study was granted by the Health Research Committee of the Lagos State University Teaching Hospital with ethical approval no. NHRECO4/04/2008. All participants were informed of the objectives and nature of the tests and written informed consent forms were obtained. The participants were also informed that they were free to withdraw at any time.

Results

A total of 103 workers comprising 88 males (85.4%) and 15 females (14.6%) were employed in the factory, but only 80 workers were willing to participate in the questionnaire-based survey since this aspect of the study was not mandatory. Of these, fifty-five (55) questionnaires consisting of 47 (85.5%) males and 8 (14.5%) females were retrieved giving a response rate of 68.8%. The low response rate was because the questionnaires were self-administered and workers were allowed to take them home and return them within a few days in order not to interfere with production processes during working hours. Many workers did not return the questionnaires because of their low level of education and the misunderstanding that their health status was being audited despite explanations to the contrary.

The majority of the workers were males 47 (85.5%) and married 48 (87.3%). The predominant age group was age 31-40 years 21 (38.2%) followed by 41-50 years 18 (32.7%). The highest academic qualification obtained was Bachelor of Science (BSc) 13(23.6%), followed by Higher National Diploma (HND) 11(20%). More than half of the workers had been employed in FRSC for 11-20 years 30 (54.5%). Nearly half, 24(43.6%) had worked for between 6-10 years. Core production departments were Blanking 6 (11%), Screen Printing 6 (11%), Embossing 6 (11%), Packaging and Dispatch 7 (13%), and Coating 4 (7%), (Table 1).

Table 1: Socio-demographic characteristics of factory workers, n = 55

Characteristic	Frequency (%)
Gender	
Male	47 (85.5)
Female	8 (14.5)
Age (years)	
21-30	7 (12.7)
31-40	21 (38.2)
41-50	18 (32.7)
51-60	9 (16.4)
Marital Status	
Single	6 (10.9)
Married	48 (87.3)
Separated/Divorced	1 (1.8)
Level of Education	
School Certificate	10 (18.2)
NCE	5 (9.1)
OND	7 (12.7)
HND	11 (20)
Bachelor	13 (23.6}
Postgraduate	9 (16.4)
Number of working years in the factory	
1-5 years	25 (45.5)
6-10 years	24 (43.6)
10 or more years	6 (10.9)
Departments	
Blanking	6 (10.9)
Embossing	6 (10.9)
Screen Printing	6 (10.9)
Coating	4 (7.3)
Inspection and packing	4 (7.3)
Dispatch	3 (5.5)
Departments outside production	26 (47.2)

A majority, 52 (93%) of the workers agreed that they were mostly exposed to occupational hazards. Of these, 38 (69%) reported being exposed to chemicals considered toxic, 36 (65%) to noise and 28 (51%) to excessive heat, 24 (43%) to poor ventilation, 38 (69%) to toxic chemicals, 16

(29%) to vibrations from heavy machinery and 16 (29%) believed they were excessively exposed to particulate matter of metallic nature.

Additionally, a majority of the workers, 53 (96%) said they were provided with PPE. Specifically, 54 (98%), 22 (39%), 45 (81%) and 42 (77%) were provided with safety boots, helmets, and hand gloves respectively. Also, 36 (66%), 29 (53%), and 18 (32%) were provided with work coats (overalls), ear muffs, and face shields respectively. Although nearly three-quarters 39 (70%) use PPE regularly, 17 (30%) of workers admitted not using PPE. Pre-employment medical test was done for three quarters, 41 (75%) of workers while periodic medical tests were not done for only 13 (24%) of workers.

Stress and fatigue were the most commonly self-reported health problems among factory workers 39 (71%), followed by machine injuries 35 (64%), chemical burns 28 (51%), skin disorders 28 (51%), respiratory problems 18 (33%), hearing impairment 16 (29%), slips, trips and falls 13 (24%), impaired vision, musculoskeletal injuries 12 (22%), and risk of fire, explosions. Actions taken by victims of industrial accidents in the past included receiving treatment in the FRSC Clinic 42, (76%), receiving First Aid on the factory floor 36 (65%), and referral to the hospital 18 (33%). Only 1 (2%) admitted concealing his injuries while 2, 4% did not know what to do.

More than half 32 (58%) of factory workers were aware of safety measures put in place by the company. Some of these interventions mentioned were a provision of one capsule of multivitamins per day for one month 40 (72%), one tin (157 ml) of milk daily for one month 33 (60%), a first aid box 19 (35%), FRSC Clinic/Health and Safety Officer 12 (22%), and fire extinguishers 9 (16%).

Biochemical analyses of blood samples were carried out on all 103 workers in the factory. A majority 88 (85.4%) were males while 15 (14.6%) were females. The results showed outliers outside normal reference values. The clinically significant deviations were sodium (hypernatremia 7%, hyponatremia 9%); potassium (hyperkalemia 3%, hypokalemia 24%); uremia 10%, and elevated creatinine, AST and ALT levels, 7%, 18% and 8% respectively (Figures 1-6). Other deviations include chloride 15%, uric acid (32%) and inorganic phosphorus (12%).

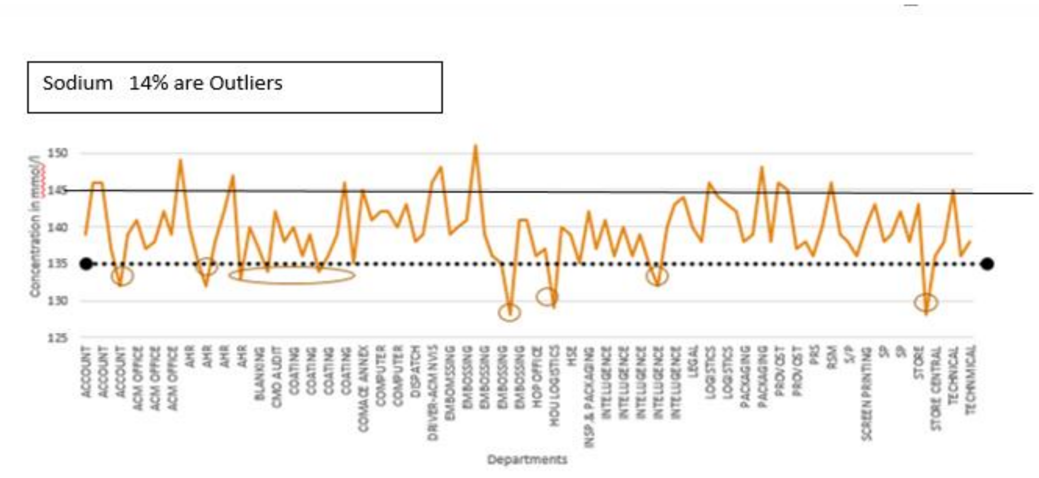

Figure 1: Biochemical analysis of sodium showing 14% outliers from the reference range

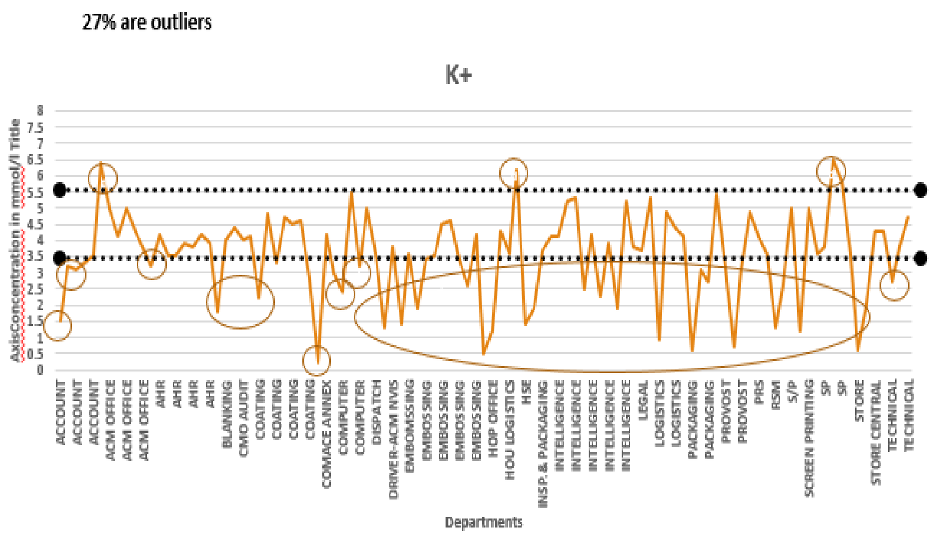

Figure 2: Biochemical analysis of potassium showing 27% outliers from the reference range

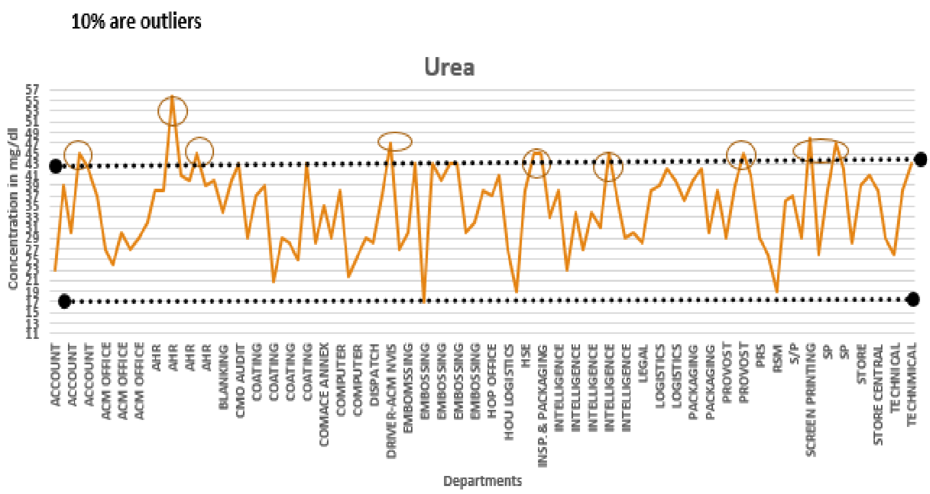

Figure 3: Biochemical analysis of urea showing 10% outliers from the reference range

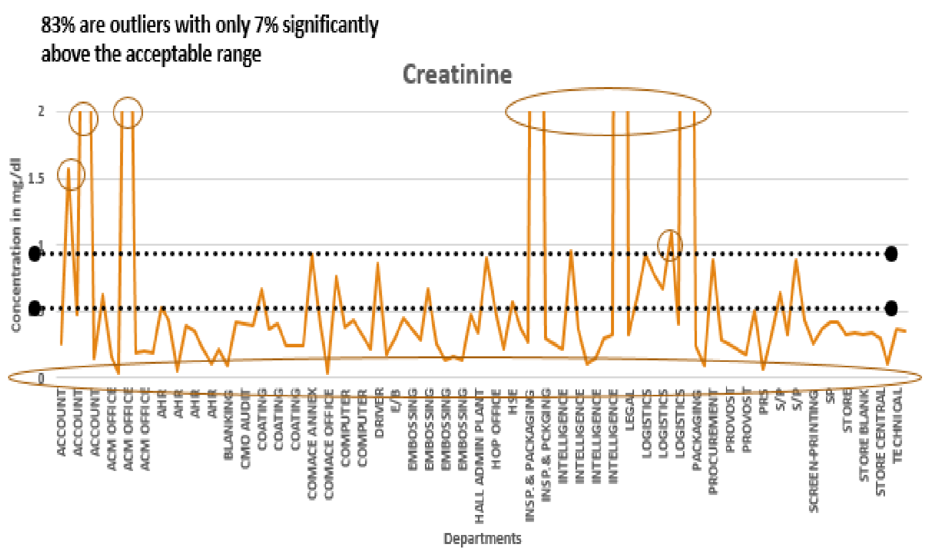

Figure 4: Biochemical analysis of creatinine showing 83% outliers with 7% significantly above the reference range

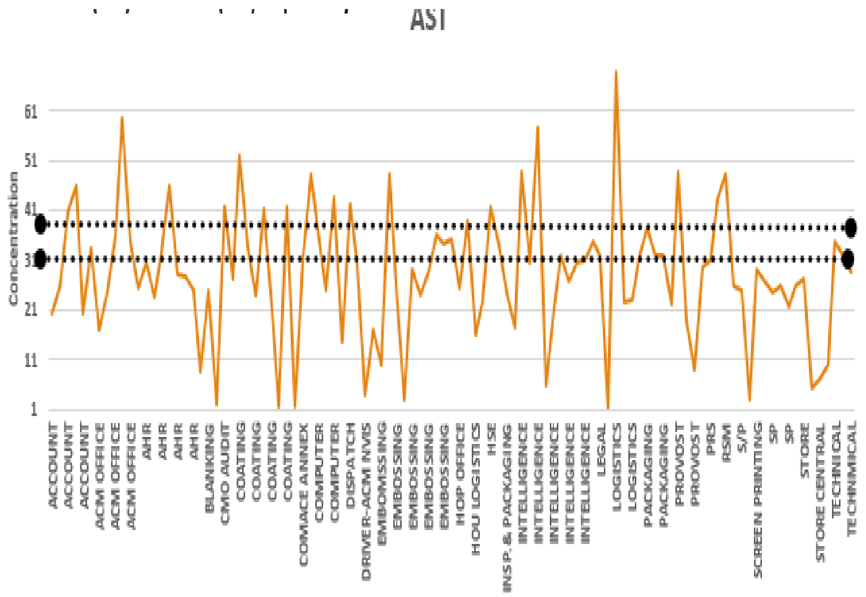

Figure 5: Biochemical analysis of aspartate transaminase(AST) showing 18% outliers

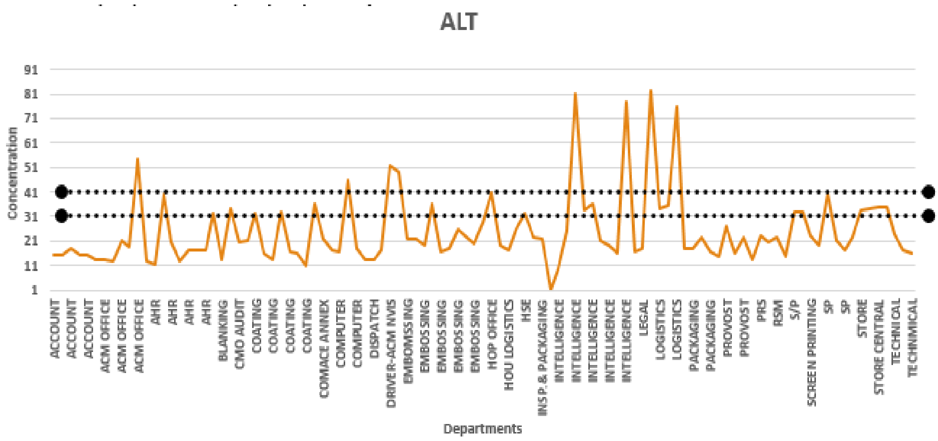

Figure 6: Biochemical analysis of alanine transaminase(ALT) showing 8% outliers

The biochemical values obtained from the biochemical analysis of workers' blood samples stratified by departments are shown below (Table 2).

Except for alanine transaminase, there were no statistically significant differences in mean biochemical values for workers in the production department compared with other units.

Table 2 Biochemical analysis of workers' blood samples stratified by departments n=103

	Departments + Biochemical Values Mean (SD) *			F	p-value
	Production	Logistics	Administration		
Na+	139.08(4.25)	139.32(4.55)	140.03(4.3)	F(2,100)=15	0.86
K+	3.41(1.41)	3.61(1.41)	3.63(1.31)	F(2,100)=0.03	0.97
Cl	96.13(6.33)	97.16(5.15)	96.71(5.35)	F(2,100)=1	0.37
Uric acid	2.82(1.77)	3.09(1.93)	2.91(1.23)	F(2.100)=0.17	3.09

Urea	35.95(7.54)	34.49(6.64)	34.03(8.38)	F(2.100)=0.49	3.09
Creatinine	0.89(2.25)	0.96(3.13)	0.67(1.13)	F(2.99)= 0.12	3.09
AST	26.38(12.43)	27.21(15.54)	31.01(12.08)	F(2.100)=0.94	3.09
ALT	22.94(9.69)	31.40(20.73)	21.21(10.24)	F(2.100)=5.04	0.01
Inorganic Phosphorus	0.40(0.43)	0.40(0.43)	0.79(1.96)	F(2.100)=0.75	0.48

KEY: * Na+: Sodium; K+: Potassium; Cl-: Chlorine; AST: Aspartate transaminase; ALT:Alanine Transaminase

+Production – Blanking, Screen printing,Coating, Inspection and Packaging departments

Logistics - Dispatch department and Store

Administration - Accounts, HSE, Legal Human resource and Medical

Discussion

This study was designed to identify the hazards affecting workers in the vehicle plate manufacturing factory, particularly from the use of raw materials such as aluminum sheets, solvents, thinners and dyes. The common hazards affecting workers were identified to be high light intensity, poor ventilation, heavy machinery, and excessive metal exposure with the highest hazard exposure reported to be toxic chemicals, noise and high-intensity heat.

Toxic chemicals and solvents associated with the processes of screen printing and coating include dyes, toluene, xylene, ketones, alcohols, esters, and glycol ethers.[13] Dyes may cause skin reactions, eye, nose and throat irritations, headache and nausea. They also have the potential to be carcinogenic and teratogenic.[14-15] Some of these symptoms were reported in our study population. Nearly three-quarters of respondents complained of stress and fatigue, skin disorders and chemical burns and more than half reported respiratory symptoms.

Thinners are solvents used to reduce the viscosity of dyes. They have the potential to cause skin or eye irritations, respiratory irritation and central nervous system depression. Solvent exposure is related to adverse disorders of the skin, lung, kidney and nervous system.[16]

Previous studies exploring negative health symptoms associated with factory workers and painters noted an increased incidence of neuropsychological symptoms including impairments of memory, perceptual speed, manual dexterity, psychomotor coordination, nonverbal skills and a decrease in olfactory functions.[17] PPE such as face mask, gloves and coverall should be worn at all times to reduce exposure. Also, women in the reproductive age group should not be allowed to work directly with the dyes and solvents.

Noise-induced hearing loss is one of the commonest occupational health hazards caused either by a one-time exposure to very loud sound or by repeated exposure to various loudness levels over a long period.[18] High noise levels can be a stressor causing hypertension, fatigue, dizziness and headaches. Ear muffs and plugs should be used all the time around noisy machinery. The amount of exposure time should also be limited.

Excessive heat exposure can be from the weather or from heat-generating machines and processes such as in the use of ovens in drying the plates and blanking machines used in cutting the aluminum sheets to size. Excessive heat can lead to mental health problems, and chronic kidney and cardiovascular disease. It can also lead to irritability, fatigue, lack of coordination and concentration.[19] Some helpful preventive measures would be to install fans, and ensure there is adequate cross ventilation. Making available cold drinks and rest areas to enable workers to refresh while taking short breaks could also be helpful.

This study also established that some preventive measures were already in place in the factory. The majority of the respondents agreed that they were provided with PPE such as safety boots, helmets, hand gloves, coveralls, goggles, ear plugs /muffs and face shields while nearly three-quarters agreed they used them. The use of PPE is strongly recommended and is usually in conjunction with one or more of the other control measures.[20-21] The consequences of not following these practice guidelines could be fatal.

A monthly supply of thirty cans of 157 ml evaporated milk and 30 multivitamin capsules was provided for each factory worker. A daily intake of these might be intended to ameliorate the potential effect of lead on workers' health.[22] Lead is a component of most paints and dyes.[23] Leaded compounds most commonly added to solvent-based paints are pigments.[23] Pigments are used to give the paint its color, make the paint opaque (so it covers well), and protect the paint and the underlying surface from degradation caused by exposure to sunlight. Lead-based pigments are sometimes used alone or in combination with other pigments. A study carried out to check the influence of milk on lead toxicity revealed that drinking about 2 bottles of milk per day might have a protective effect against lead-induced peripheral neurotoxicity.[20] Also, multivitamins have been shown to help relieve stress, therefore their use in this instance seems justified.[24]

The results of biochemical analysis on the blood samples of workers showed deviations above and below normal values. Decreased levels of Na^+, K^+ and Cl^- may produce symptoms such as headache, confusion, restlessness, weakness, irregularities in heartbeat and muscle cramps.[25-26] Some workers in this study experienced fatigue and musculoskeletal pains which could be attributable to derangements in electrolyte levels.

Elevated blood levels of urea, creatinine, ALT and AST observed for between 7% - 10% of the workers were not significantly associated with work post. Workers outside the factory were just as likely to have elevations in biochemical parameters as those who worked in the factory. This might be an indication of the effectiveness of safety measures among factory workers but this finding also emphasizes the need for all workers, whether directly involved in production or not, to take precautionary measures whenever they are in the factory environment. Regular visitors would also need to put on complete PPE whenever they are in the work environment.

It was also noted that only about 10% of workers had worked in the factory for 11 and more years. This might indicate that the majority of workers are not left in the factory for too long to break the cycle of exposure to hazards. However, there is a need for more frequent rotation of workers as nearly 50% had spent between 1 and 5 years at their duty post.

The limitations of this study include the fact that hazards identified in the factory were self-reported by the workers. Scientific measurement of hazards using appropriate instruments such as an industrial thermometer, digital sound level monitor, and a vibrometer would have produced a more valid assessment. Also, the low participation and response of workers to the survey aspect of the study arising from the fact that the questionnaire was self-completed instead of interviewer-administered, as well as fear of job loss should they disclose any work-related ailments allows for only a limited generalization of the findings from this study. In addition, the small sample size of the study limits the application of the findings to all factory working environments.

Conclusions

Hazards present at the FRSC vehicle plate manufacturing factory include exposure to toxic chemicals, excessive exposure to heat and noise, stress, fatigue and machine injuries. Safety measures available in the plate manufacturing factory were the adoption of safe procedures and processes, medical check-ups, presence of a health and safety officer, provision of PPE as well as multivitamins and milk supplements. Even though PPE was available, utilization was sub-optimal. Pre-employment, pre-placement and periodic medical checkups were not fully implemented.

To improve workplace safety and mitigate hazards, enforcement of safety measures including regular use of PPE, more frequent periodic medical examinations and rotation of work posts as well as educational interventions to both employees and management are recommended.

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FIGURE LEGENDS:

Figures 1- 6

Output of biochemical assay from the Semi-automatic Biochemistry Analyzer Chem 5v3 (Erba Diagnostic Incorporated Mannheim, Germany). Two ml (2ml) of venous blood was collected aseptically, allowed to clot and centrifuged at 3000 rpm for 10 minutes. The resulting serum was stored in a freezer at 20^{0}C and fed into the analyzer. Dotted lines bounded by the black dots represent the upper and lower median serum levels of respective electrolytes. Peaks outside this range are regarded as outliers. The percentage is obtained by counting the number of peaks that fall outside the reference range.