ISSN: 2536-7153 SJMLS

Sokoto Journal of Medical Laboratory Science 2023; 8(2): 37 - 44

SJMLS - 8 (2) - 004

Haematological Parameters of Workers Exposed to Printing Chemicals: A Study in Calabar, Southern Nigeria

Patience A. Akpan[1]*, Enosakhare A. Asemota[1], Deborah A. Akepu[2], Genevieve A. Effiong[1]
Department of Haematology and Blood Transfusion Science, Faculty of Medical Laboratory Science, University of Calabar, P.O. Box 1115, Calabar, Cross-River State, Nigeria [1], Department of Medical Laboratory Science (Haematology Unit), College of Health Technology, Calabar [2].
Author for Correspondence *: apu0520@unical.edu.ng/+2348027321305/ ORCID number: 0000-0002-4571-8804. https://dx.doi.org/10.4314/sokjmls.v8i2.4

Abstract
Printing involves the use of chemicals which could affect the human body and cause ill health. The aim of this study was to assess the red blood cell, white blood cell and platelet parameters of printing press workers in Calabar. A total of 100 subjects were enrolled comprising 50 male and female printing press workers and 50 non-printing press workers were monitored as controls. A structured questionnaire was used to obtain demographic and work-related data. Red blood cell count (RBC), packed cell volume (PCV), haemoglobin (Hb), mean cell volume (MCV), mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC), red cell distribution width (RDW), total and differential white cell count, platelet count, plateletcrit, mean platelet volume and platelet distribution width were determined using the automatic haemoanalyser ERMA INC model PCE-210N. Data obtained were analyzed using the student's t-test with significance set at $p \leq 0.05$. Results show that most of the printing press workers were males (76%) with 90% exposed to printing chemicals for 12-16 hours per day. Less than 50% of the printing press workers use personal protective equipment while working. It was observed that the RBC, PCV, HB, MCV, MCH and monocyte-eosinophil-basophil count of printing press workers were significantly higher ($P<0.05$) while the platelet count, platelet crit, mean platelet volume and platelet distribution width were significantly lower ($P<0.05$) when compared to values obtained for control. Years of work experience did not affect the parameters studied ($p>0.05$). This study has shown that red blood cell parameters were higher while platelet parameters were lower for printing press workers thus implying that the chemicals used in the printing industry affect these parameters. It is recommended that protective wear should be worn by printing press workers to reduce exposure and regular checks of blood parameters should be encouraged.

Keywords: Haematological parameters, exposure, printing chemicals, workers

Introduction

Printing is the process of reproducing texts and images via the use of templates or master forms. It is the act or product of one that prints (Gunaratne 2001; Merriam-Webster, 2023). The printing press workers are individuals who have the tasks of producing books, journals, magazines, self-adhesive vinyl, flex banners and so on, using a printing press. Modern large-scale printing is typically done using printing press offset machines, large format machines, direct imaging printers, etc, while small-scale printing is done using screen printing. Though paper is the most commonly used media for printing, printing is also frequently done on metals, plastics, cloth, self-adhesive vinyl, flex tarpaulin materials and composite materials. There are varying chemicals used in the printing industry which include inks, solvents, cleaning agents, photosensitive coated plates, and more. Most of these inks also contain solvents or need diluting solvents that contain volatile organic compounds and traces of heavy metals such as cadmium, hexavalent chromium, lead, and mercury (Viegas, 2011; European Printing Ink Association, 2013). These solvents are complex chemical mixtures containing different hydrocarbon types such as alkanes, alcohol, ketones, aldehydes, esters, and small aromatic molecules that evaporate and become incorporated into the environment. Consequently,

a considerable amount of toluene, xylene, alcohols, and other air-borne organic compounds are emitted indoor in a printing press environment (Leung *et al.,* 2005; Mendoza-Cantu, 2006). Exposure to these chemicals through inhalation or contact with the skin can be detrimental to health as a number of them have been reported to be toxic to the body. Some solvents and inks can cause skin allergies and dermatitis, dizziness and damage to internal organs when inhaled over a long period of time; corrosive acids cause skin burns and damage to the eyes. There have also been reports of a link between volatile organic compound exposure and health defects such as impaired colour vision, liver dysfunction, cancers, and neurologic symptoms (Leung *et al*., 2005; Carll *et al*., 2020). Workers exposed to printing chemicals should be aware of the level of safety of each chemical as well as the hazards of exposure (Tsai *et al*., 2016).

Although several studies have been conducted on the effect of these chemicals on the general physiology of the body, little has been done on the effect of these chemicals on the blood especially the red cell indices, white blood cells and platelet parameters, hence the need for this study. The aim of this research is to assess the red blood cell, white blood cell and platelet parameters of printing press workers in Calabar metropolis.

Materials and Methods

Study area and design

The study area for this research is Calabar, the capital of Cross River State, Nigeria. A cross-sectional study design and convenience sampling was adopted for this research.

Ethical approval/informed consent

Ethical approval was obtained from the Cross River State Ministry of Health. Letters were written to the management of each printing press explaining the need for the study and requesting permission to enroll the staff for the research purpose. Informed consent was also sought and obtained from each participant.

Selection of subjects

Subjects comprised of fifty (50) apparently healthy male and female workers, 5 each selected from 10 printing press located in Calabar. All printing press workers enrolled had been working for at least one year in this occupation. Printing press workers with known ailments, those on medication and those who did not give consent, were excluded from the study. Fifty (50) apparently healthy males and females, resident in Calabar were recruited to serve as control. It was ensured that they did not work in any job which involved exposure to chemicals at any given interval or period.

Sample collection and analysis

Demographic data and information on the use of personal protective equipment (PPEs) was obtained using a structured questionnaire. Blood samples were collected into dipotassium ethylene diamine tetra acetic acid (EDTA) container to a final concentration of 2mg/ml; they were transported in cold chain to the Haematology Laboratory at the University of Calabar Teaching Hospital and analyzed within 4 hours of collection. The red blood cell count, packed cell volume, haemoglobin, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, red cell distribution width, total and differential white cell count, platelet count, plateletcrit, mean platelet volume and platelet distribution width were determined using the automatic haemoanalyser ERMA INC (China) model PCE-210N (2015) based on the principle of electrical impedance and flow cytometry.

Data analysis

Demographic data are presented as frequencies and percentages while other results are expressed as mean ± standard deviation. Statistical analysis was done using the students' t-test on statistical package for social sciences (SPSS) version 21. A p-value of less than or equal to 0.05 was considered statistically significant.

Results

The red blood cell, white blood cell and platelet parameters of 50 printing press workers (test subjects) and 50 non-printing press workers (control subjects) were assessed in this study. Table 1 shows the demographic data of printing press workers and non-printing press workers. The printing press workers and control were comparable with respect to age and gender, however, the test subjects comprised of more males (76%) than females (24%). The test and control subjects were mostly singles (76% and

82%). Whereas sixty-six percent of the test subjects had secondary level of education, seventy-six percent of the control subjects had attained tertiary status. Fifty-six percent of the printing press workers had worked for less than or equal to 5 years while fifty-eight percent worked for twelve hours each working day. Figure 1 shows the frequency of printing press workers that use nose masks (12), hand gloves (18), overalls (25) and safety boots (20) in comparison to those that do not use PPEs.

The haematological parameters of printing press workers and non-printing press workers is presented in Table 2. It was observed that the red blood cell count, packed cell volume and haemoglobin levels of printing press workers were significantly higher ($P<0.05$) than the values obtained for control. Similarly, the mean corpuscular volume and mean corpuscular haemoglobin of the test were significantly higher ($P<0.05$) versus the control. No significant differences ($P>0.05$) were observed for mean corpuscular haemoglobin concentration and red cell distribution width between the test and control. The monocyte-eosinophil-basophil count of the test subjects was significantly higher ($P<0.05$) while the platelet count, plateletcrit, mean platelet volume and platelet distribution width were observed to be significantly lower ($P<0.05$) when compared to the control. There was no difference ($P>0.05$) in the total white blood cell, granulocyte and lymphocyte count between the two groups. Table 3 presents the red blood cell, white blood cell and platelet parameters of printing press workers based on the duration of work. No significant difference ($P>0.05$) was observed between those who had worked for ≤ 5 years and > 5 years for all the parameters studied.

Table 1: Demographic parameters of printing press workers and non-printing press workers

Parameters	Printing press workers (N=50)	Non-printing press workers (N=50)
Mean age (years)	27.85±5.94	26.70±2.60
Gender		
Males	38 (76%)	35 (70%)
Females	12 (24%)	15 (30%)
Marital status		
Single	38 (76%)	41 (82%)
Married	12 (24%)	9 (18%)
Educational level		
Primary	0 (0%)	0 (0%)
Secondary	33 (66%)	12 (24%)
Tertiary	17 (34%)	38 (76%)
Work duration (years)		
≤5	28 (56%)	-
>5	22 (44%)	-
Daily exposure (hours)		
8	5 (10%)	-
12	29 (58%)	-
16	16 (32%)	-

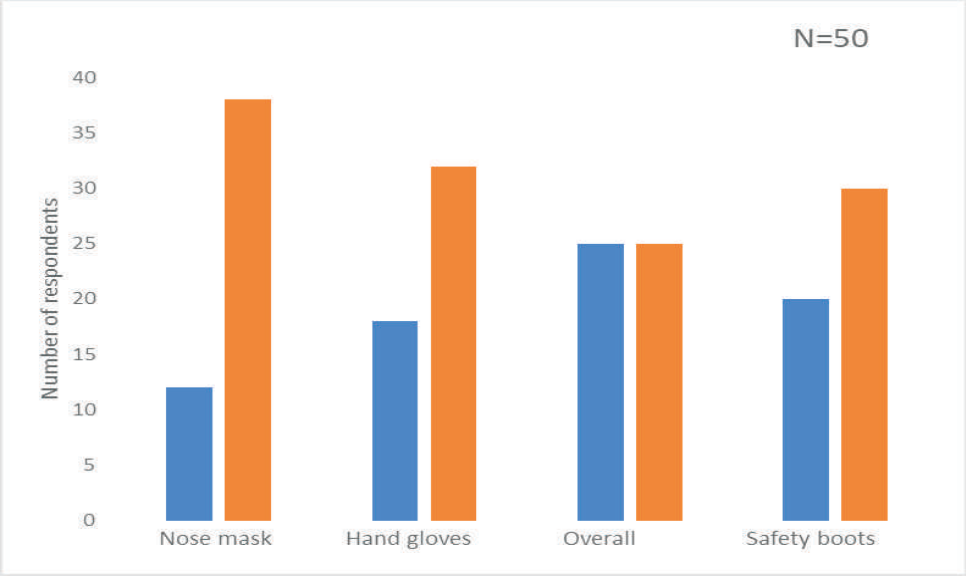

Figure 1: Use of personal protective equipment by printing press workers
Key: ***Blue= Yes response, Orange= No response***

Table 2: Haematological parameters of printing press workers and non-printing press workers

Parameters	Printing press workers (N=50)	Non-printing press workers (N=50)	Significance
Red cell count (x10^9/L)	5.87 ± 0.65	5.30 ± 0.64	S
Packed cell volume (L/L)	0.46 ± 0.05	0.38 ± 0.05	S
Haemoglobin (g/L)	156.1 ± 16.7	129.8 ± 17.7	S
Mean corpuscular volume (fl)	76.69 ± 5.62	72.61 ± 6.49	S
Mean corpuscular haemoglobin (pg)	26.19 ± 2.23	24.56 ± 2.83	S
Mean corpuscular haemoglobin concentration (g/dl)	33.96 ± 1.11	33.79 ± 1.28	NS
Red cell distribution width (%)	16.01 ± 0.80	15.59 ± 1.54	NS
Total white blood cell count (× 10^9/L)	4.03 ± 0.98	3.76 ± 0.98	NS
Granulocyte count (× 10^9/L)	1.86 ± 0.70	1.69 ± 0.66	NS
Lymphocyte count (× 10^9/L)	1.60 ± 0.51	1.60 ± 0.47	NS
Monocyte, eosinophil, basophil count (× 10^9/L)	0.55 ± 0.17	0.46 ± 0.16	S
Platelet count (× 10^9/L)	203.04 ± 52.50	281.90 ± 83.63	S
Plateletcrit (%)	0.18 ± 0.05	0.27 ± 0.08	S
Mean platelet volume (fL)	8.90 ± 0.59	9.51 ± 0.59	S
Platelet distribution width (%)	12.44 ± 2.51	13.46 ± 2.25	S

S = Significant difference ($P \leq 0.05$); NS = No significant difference ($P > 0.05$)

Table 3: Haematological parameters of printing press workers based on duration of work

Parameters	≤5 Years (n=28)	>5 Years (n=22)	Level of significance
Red cell count (x10^9/L)	5.78 ± 0.60	5.98±0.70	NS
Packed cell volume (L/L)	0.45±0.05	0.47±0.05	NS
Haemoglobin (g/L)	154.2±15.5	158.4±18.1	NS
Mean corpuscular volume (fl)	76.91±3.95	76.41±7.31	NS
Mean corpuscular haemoglobin (pg)	26.46±1.59	25.85±2.86	NS
Mean corpuscular haemoglobin concentration (g/dl)	34.13±1.26	33.75±0.86	NS
Red cell distribution width (%)	15.87±0.72	16.17±0.88	NS
Total white blood cell count (× 10^3/μL)	4.25±0.94	3.72 ± 0.98	NS
Granulocyte count (× 10^3/μL)	1.99±0.77	1.68 ± 0.58	NS
Lymphocyte count (× 10^3/μL)	1.66 ±0.46	1.52 ± 0.57	NS
Monocyte-eosinophil-basophil count (× 10^3/μL)	0.58±0.17	0.50 ± 0.17	NS
Platelet count (× 10^3/μL)	206.50 ±53.81	198.43 ± 51.64	NS
Plateletcrit (%)	0.18 ± 0.05	0.18 ± 0.05	NS
Mean platelet volume (fL)	8.89 ± 0.56	8.92 ± 0.63	NS
Platelet distribution width (fL)	12.25 ± 2.25	12.70 ± 2.86	NS

NS= No significant difference (P>0.05)

Discussion

In this study, it was observed that most of the printing press workers were males. This could be due to the long hours required as 90% of the workers put in between 12-16 hours per day (table 1). Furthermore, the tedious nature of printing operations may be more suited to the male gender which explains the observation that very few females are found in this kind of job. The long hours also account for the fact that most of the workers are single as individuals who are married may not be able to cope due to family responsibilities. The entry-level for recruitment in most printing jobs is secondary education; this explains why most printing press workers fell into this category. In this study, it was observed that the number of printing press workers who use nose masks, hand gloves, overalls and safety boots was less than or equal to 50%. This implies that the workers are exposed to the printing chemicals through inhalation and possibly, contact with the skin and this might have detrimental effects on the health of these workers. It is pertinent to use personal protective

equipment when working in an occupation with a high level of exposure to toxic substances such as the chemicals used in the printing industry (Safety Culture, 2023) and exposure to printing chemicals has been reported to occur mostly through inhalation (Alabdulhadi *et al.,* 2019).

The red blood cell count (RBC), packed cell volume (PCV), haemoglobin (Hb), mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) of printing press workers were found to be significantly higher ($p<0.05$) when compared to non-printing press workers (table 2) although the values are all within the reference range. A similar finding was earlier reported (Ahmet *et al*., 2013). These elevations are likely compensatory reactions due to exposure to volatile organic compounds creating a chronic state of hypoxia in the cells. This may intensify the production of erythropoietin, which is a glycoprotein cytokine, by interstitial cells found in the proximal convoluted tubule of the kidneys. Erythropoietin in turn stimulates the production of red blood cells by the bone marrow (Sherwood *et al*., 2005; Metcalf, 2008) hence the higher values of these red cell parameters observed for printing press workers. Exposure of blood to low oxygen tension for a long period of time will cause growth induction, differentiation, and production of a greatly increased number of erythrocytes (Guyton and Hall, 2011; Maekawa and Kato, 2015). A positive association has been reported between volatile organic compounds and haemoglobin (Cakmak *et al*., 2020). In contrast, one study reported a decrease in red cell numbers, haemoglobin and haematocrit as a consequence of exposure to heavy metals emitted from printing presses (Abdulateef and Talib, 2016).

Higher monocyte-eosinophil-basophil count was observed for printing press workers with no difference in total white cell counts when compared to non-printing press workers although values were within the reference range. Our finding although at variance with a previous report which indicated a decrease in total white cell counts (Abdulateef and Talib, 2016), it is however consistent with another report which observed a higher white cell counts among individuals exposed to chemicals and other volatile organic compounds in the auto repair mechanic workshops (Kamal and Malik, 2012; Cakmak *et al*., 2020). The higher levels of monocyte, eosinophil and basophil observed in this study may be due to a state of inflammation induced by exposure to the toxic effects of chemical compounds used in printing. It has been reported that inflammation is one of the hazardous effects of exposure to printing chemicals (Zou *et al*., 2020). Indeed, volatile organic compounds which include some chemicals used in printing, have been implicated as proinflammatory activators (Ogbodo *et al*., 2022). Furthermore, the increase in eosinophils observed may be due to allergic reactions to the volatile organic chemicals used in printing as most workers in the printing presses sampled do not use nose/face masks and other protective equipment. This may expose them to inhalation of these chemicals and skin contact which could cause allergic reactions and increase eosinophil count. Printing press workers showed significantly lower values of platelet parameters ($P<0.05$) when compared to non-printing press workers. This contrasts with increased platelet numbers associated with exposure to volatile organic compounds as reported previously (Cakmak *et al*., 2020) and consistent with low platelet counts as observed in exposed mice by Wang and Colleagues (2016). The lower platelet count, plateletcrit, mean platelet volume and platelet distribution width observed for workers exposed to printing chemicals may be due to platelet consumption following activation which is a result of an induced state of chronic inflammation. Exposure to chemicals such as the ones used for printing has been observed to be proinflammatory (Zou *et al*., 2020; Ogbodo *et al*., 2022).

In this study, it was observed that the exposure leading to an increase or decrease in the parameters studied was not time-based as the duration of work had no effect on these parameters (table 3). The years of working in the printing press showed no statistical significance ($p > 0.05$) and this may be due to the body being able to adapt to the chemical agents used in printing over a period of time.

Conclusion and recommendation

This study has shown that the red blood cell count, packed cell volume, haemoglobin, mean corpuscular volume, mean corpuscular

haemoglobin and monocyte-eosinophil-basophil count of printing press workers were significantly higher while the platelet count, platelet crit, mean platelet volume and platelet distribution width were significantly lower versus non-printing press workers thus implying that exposure to the chemicals used in the printing industry affect these parameters. It is recommended that protective wear should be worn by printing press workers to reduce exposure and regular checks of blood parameters should be encouraged for these workers.

Conflict of interest: The authors declare that there is no conflict of interest.

Acknowledgements
We appreciate the management of the selected printing presses for granting access to their staff and we thank the printing press workers and control subjects who consented to participate in the study.

References

Abdulateef, Z.N. and Talib, A.H. (2016). Impacts of Printing Presses Emissions Upon Occupationally Exposed workers Health *International Journal of Current Microbiology and Applied Sciences;* **5(4)**: 757-771.

Ahmet, C., Neriman, A., Birgul, O., Edibe, S., Hattice, S., Mehmet, O., Selim, B. and Metin, K. (2013). Elevated red blood cell distribution width and inflammation in printing workers. *Medical Science Monitor;* **19**:1001-1005.

Alabdulhadi, A., Ramadan, A., Devey, P., Boggess, M. and Guest, M. (2019). Inhalation exposure to volatile organic compounds in the printing industry *Journal of the Air & Waste Management Association;* **69(10):** 1142-1169.

Cakmak, S., Cole, C., Hebbern, C., Andrade, J. and Dales, R. (2020). Associations between blood volatile organic compounds and changes in hematologic & biochemical profiles in a population-based study *Environment International;* **145**:106121.

Carll, A.P., Salatini, R., Pirela, S.V., Wang, Y., Xie, Z., Lorkiewicz,, P., Naeem, N., Qian, Y., Castranova, V., Godleski, J.J. and Demokritou, P. (2020). Inhalation of printer-emitted particles impairs cardiac conduction, hemodynamics, and autonomic regulation and induces arrhythmia and electrical remodeling in rats *Particle and Fibre Toxicology;* **17(7)**:1-21.

European Printing Ink Association (2013). Environmental impact of printing inks **2**:12 Retrieved from *www.eupia.org* on 20th March, 2023.

Gunaratne, S.A. (2001). Paper, printing and the printing press: a horizontal integrative microhistory analysis *Gazette;* **63(6)**: 459-479.

Guyton, A.C. and Hall, J.E. (2011). *Textbook of Medical Physiology* 12th ed. Saunders Elsevier, Philadelphia: 201-226.

Kamal, A. and Malik, R.N. (2012). Hematological Evidence of Occupational Exposure to Chemicals and other factors among Auto-Repair workers in Rawalpspindi, Pakistan *Osong Public Health and Research Perspectives;* **3(4):** 229-238.

Leung, M., Chun-Ho, L. and Han, A. (2005). Occupational exposure to volatile organic compounds and mitigation by push-pull local exhaust ventilation in printing press plants. *Journal of Occupational Health;* **47**: 540-547.

Maekawa, S. and Kato, T. (2015). Diverse of Erythropoiesis Responding to Hypoxia and Low Environmental Temperature in Vetebrates *Biomed Research International*; 747052: 9.

Mendoza-Cantu, A., Castorena-Torres, F., de Leon, M. B., Cisneros, B., Lopez-Carillo, L., Rojas-Garcia A.E., Aguilar-Salinas, A., Manno, M. and Albores, A. (2006). Occupational toluene exposure induces cytochrome P450 2E1 mRNA expression in peripheral lymphocytes. *Environmental Health Perspectives;* **114**:494-499.

Merriam-Webster (2023). Printing, Definition & Meaning *www.merriam-webster.com.*

Metcalf, D. (2008). "Hematopoietic Cytokines". *Blood;* **111(1)**: 485-491.

Ogbodo, J.O, Arazu, A.V, Iguh, T.C. Onwodi, N.J. and Ezike, T.C. (2022). Volatile organic compounds: A proinflammatory activator in autoimmune diseases Frontiers in Immunology; **13:** 928379.

Safety Culture (2023). Personal Protective

Equipment (PPE) Safety www.safetyculture.com.
Sherwood, L., Klansman, H. and Yance, P. (2005). *Animal Physiology*. New York: Cole Cengage Learning.
Tsai, C., Mao, I., Ting, J.,Young, C.,Lin, J. and Li, W. (2016). Quality of Chemical Safety Information in Printing Industry. *Annals of Occupational Hygiene*; **60(3):** 361-370.
Viegas, S. (2011). Occupational exposure to volatile organic compounds in the Portuguese printing industry. *WIT Transactions on Biomedicine and Health*; **15:**233-239.
Wang, F., Liu, F., Liu, H., Chen, W., Si, X. and Ma, X. (2016). Effects of immunological and hematological parameters in mice exposed to mixture of volatile organic compounds. *Inhalation Toxicology;* **28**:164-169.
Zou, C., Yang, H., Cui, L., Cao, X., Huang, H. and Chen, T. (2020). Potential Hazardous effects of printing room PM 2.5 exposure include promotion of lung inflammation and subsequent injury. *Molecular Medicine Reports;* **22(4)**: 3213-3224.

Citation: Patience A. Akpan, Enosakhare A. Asemota, Deborah A. Akepu, Genevieve A. Effiong. Haematological Parameters of Workers Exposed to Printing Chemicals: A Study in Calabar, Southern Nigeria. ***Sokoto Journal of Medical Laboratory Science*; 8(2): 37 - 44.**
https://dx.doi.org/10.4314/sokjmls.v8i2.4