EVALUATION OF SOME LIVER ENZYMES AND ALPHA-FETOPROTEIN IN WORKERS OCCUPATIONALLY EXPOSED TO E-WASTE IN NNEWI, ANAMBRA STATE NIGERIA

Isaac Kanu Abo[1], Nancy Amara Mbachu[1], Mark Matthew Edet[1], Ifeoma Priscillia Ezeugwunne,[1] Nneka Mabel Ugwu[2]

[1]*Department of Human Biochemistry, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi campus, Anambra State Nigeria.*
[2]*Department of Medical Laboratory Sciences, Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Nnewi campus, Anambra State Nigeria*

Corresponding Author:
Mark Matthew Edet
Department of Human Biochemistry,
Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria
Email: mm.edet@unizik.edu.ng

ABSTRACT

BACKGROUND: The advent of electricity has spurred significant technological advancements, leading to the production of numerous electrical and electronic devices. This progress, however, has resulted in a surge of largely irreparable electronic waste (e-waste) being constantly shipped to Nnewi, a metropolitan city with large-scale commercial and industrial activities. E-waste contains thousands of chemicals, many of which are toxic to humans upon exposure.

AIM OF THE STUDY
To evaluate the activities of alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), and serum levels of alpha-fetoprotein (AFP) in workers occupationally exposed to e-waste.

METHODOLOGY: The study comprised 40 e-waste workers (exposed group) and 40 healthy individuals (control group). Approximately 5 ml of venous blood was collected from each participant. The liver enzymes – ALT, AST, and ALP were evaluated colorimetrically, while AFP was assayed by Enzyme-linked Immunosorbent Assay (ELISA) method. Data obtained was statistically analyzed using SPSS windows version 25 with significance set as $p<0.05$ at 95% confidence interval; Independent T-test, descriptive statistics and Pearson correlation were employed where relevant. Results were presented as means ± standard deviation in contingency tables.

RESULT: There was no significant difference ($p>0.05$) in the activities of ALT, AST, ALP and serum level of AFP between the exposed subjects and the control. However, significanly negative correlation was found between age and ALT ($r = -0.294$; $p= 0.024$), while DOE also had negative correlation with ALP ($r= -0.294$; $P= 0.024$) - all among e-waste exposed group.

CONCLUSION: This study has shown that exposure to e-waste may not have a harmful effect on the liver function, since there was no significant difference in the liver function enzymes, and serum levels of AFP. However, age and longer duration of exposure to e-waste could be detrimental to health.

KEYWORDS: *Enzyme, AST, ALT, Liver, fetoprotein, e-waste, electrical materials, LFT.*

INTRODUCTION

The invention of electricity has revolutionized technology in recent years and advancements in technologies have led to the invention and manufacturing of many electrical and electronic equipment (EEE).[1,2] Rapid economic growth, coupled with urbanization, and a growing demand for consumer goods, has led to increased production of electronics.[3] Anki et al.[4] noted that the rapid technological advancement and the quest for more profitability by firms have resulted in the faster introduction of newer and cheaper products. In contrast, the lifespan of EEE has shortened, thus resulting in their discarding even before reaching their useful lifespan[5]. The United Nations Environmental Programme (2019), defined electronic and electrical waste as any "electrical or electronic equipment, which is waste, including all components, subassemblies, and consumables, which are part of the equipment at the time the equipment becomes waste[6]. E-waste includes large, discarded appliances, such as refrigerators, air conditioners, and washing machines, as well as small personal items, including computers, televisions, mobile phones, and many other devices that are operated by electrical currents or batteries.[4,6-8]

Globally, approximately 53.6 million tons of e-waste was generated in 2019. Of this amount generated, less than 13% was recycled and the rest ended up in landfills or incinerators creating enormous environmental and health concerns due to the presence of hazardous materials. While there are several previous studies on e-waste, research findings of the United Nations Global E-waste Report 2020 show that many countries are not sufficiently managing e-waste generated and greater effort is urgently required to ensure smarter and more sustainable e-waste management.[9,10] E-waste from developed countries finds an easy way into developing countries in the name of free trade[1].

Nigeria, a developing country in West Africa, is one of the major destinations of e-waste from developed countries, especially from Europe and America. According to the United Nations Global E-waste Report 2020, Nigeria generated about 0.5 million tons of e-waste in 2019, ranking 10th among African countries and 46th in the world[11]. However, the actual amount of e-waste in Nigeria may be much higher, as there is no reliable data on the importation and illegal dumping of e-waste in the country. Nigeria lacks adequate regulations, infrastructure, and facilities for the proper management of e-waste, leading to environmental pollution and health risks for the population.[9,10]

Anambra State is one of the 36 states in Nigeria, known for its commercial and industrial activities, especially in the sectors of manufacturing, trade, and services[12]. Anambra State also has a high demand for EEE, as it hosts many educational institutions, businesses, and households that rely on EEE for their operations and livelihoods. However, to date, Anambra State also faces the challenge of managing the increasing amount of e-waste generated from the use and disposal of EEE. According to Iguh, Ewulum and Origbakpor[13], the state has many policies or legislation on e-waste management, and has inadequate facilities or sites designated for e-waste collection, treatment, or disposal. The major setback is the implementation of these regulatory documents[13]. Most of the e-waste in Anambra State is either dumped in open spaces, landfills, or water bodies or handled by informal recyclers who use crude and unsafe methods to recover valuable materials from e-waste.[14,15]

Nnewi is a city in Anambra State, Nigeria, known for its industrial activities and entrepreneurial spirit. Extrapolation from previous studies shows that Nnewi is one of the major hubs for waste recycling and dismantling in Nigeria[13-15]. E-waste recycling in the region would involve informal and unregulated processes that expose workers to various health hazards from e-waste components. Workers occupationally exposed to e-waste in Nnewi may face increased risks of developing chronic diseases or disorders related to the heavy metals and other toxic substances found in e-waste.[1]

Growing research has found associations between e-waste recycling and a range of adverse health effects, including negative birth outcomes, impaired neurological and behavioral development, impaired thyroid function, and increased risk of chronic diseases later in life.[8] Ankit et al.[4] maintained that electronic waste contains over 1,000 chemicals, including polychlorinated polyvinylchloride, biphenyls, chlorofluorocarbons, tetrabromo-bisphenol-A, furans, phthalates and its derivatives, dioxins, and potentially toxic metals such as iron, lead, copper, cadmium, chromium, mercury, nickel, manganese, arsenic, zinc, and aluminum all of which have carcinogenic potentials.

The present study aimed to evaluate the levels of alpha-fetoprotein (AFP) and the activities of alanine transaminase (ALT), aspartate transaminase (AST), and alkaline phosphatase (ALP) in population occupationally exposed to e-waste in Nnewi, Nigeria. These biomarkers were selectively studied due to the fact that they can indicate the effects of e-waste exposure on liver function, blood composition, and tumor development.

MATERIALS AND METHODS

ETHICAL APPROVAL

Ethical approval for this study was sought and obtained from the Ethical committee, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Anambra State, Nigeria (NAUTH/CS/66/Vol.16).

STUDY AREA:

This study was carried out in Nnewi - along Owerri road, where many people working on electrical and electronic devices are located. Nnewi is one of the major towns in Anambra South Senatorial District of Anambra State. It's predominantly inhabited by business people, public and civil servants, with few persons involving in agricultural activities.

STUDY PARTICIPANTS

Participants were randomly drawn from Nnewi metropolitan city and included two groups of people – e-waste exposed group and those not exposed. About 5mls of venous blood samples were collected from consenting subjects. The blood was immediately transferred to a plain bottle and separated with a centrifuge to get the serum, which was later stored in the refrigerator till use.

CHEMICALS/REAGENTS AND LABORATORY ANALYSES

All chemicals and reagents used for the study were of analytical quality and reagents were imported overseas through the help of a medical scientist. Laboratory investigations employed standard colorimetric procedures for AST, ALT, and ALP activities, whereas Enzyme-Linked Immunosorbent Assay (ELISA) was used for AFP.

STATISTICAL ANALYSIS

Data were analyzed using Statistical Package for the Social Sciences (SPSS) Windows version 25 (IBM, USA, 2018). Independent T-test, descriptive statistics, and Pearson correlation were used to analyze the data obtained and values were presented using mean and standard deviation. Significant values were set at $P < 0.05$, at 95% confidence interval.

RESULTS

Table 1 compares the age, the activities of liver enzymes (ALT, AST, and ALP), and serum levels of AFP in e-waste occupationally exposed workers versus unexposed group. The mean age of the control subjects (22.69±2.92) was not statistically different from the e-waste exposed workers (24.13±4.77) (*P*>0.05).
ALT (11.89±1.54), AST (11.75±0.85), and ALP (43.14±19.59) activities in e-waste exposed workers were not statistically different from the unexposed subjects (p>0.05). Similarly, serum levels of AFP insignificantly reduced in the e-waste exposed group compared to the unexposed persons (P>0.05).

Table 2 presents the correlation of age and duration of exposure (DOE) with liver enzymes (ALT, AST, and ALP) in e-waste-exposed group. Activities of ALT negatively correlated with age (r= -0.294; P= 0.024), while ALP negatively correlated with DOE (r= -0.294; P= 0.024).
The correlation of AFP with age and DOE among e-waste-exposed group is shown in table 3. Both age and DOE showed no significant correlation with AFP (P>0.05).

Table 1: Comparison of the mean age, activities of liver enzymes (ALT, AST, and ALP), and levels of serum AFP in e-waste exposed group vs unexposed group

Parameters	e-waste exposed group (n = 40)	e-waste unexposed group (n = 40)	t-test	p-value
Age	24.13±4.77	22.69±2.92	0.395	0.168
ALT(U/L)	11.89±1.54	11.79±1.02	0.301	0.765
AST(U/L)	11.75±0.85	11.81±1.07	-0.208	0.836
ALP(U/L)	43.14±19.59	34.95±11.79	1.938	0.580
AFP (ng/mL)	4.71±2.72	5.67±2.67	-1.366	0.177

Table 2: Correlation of age and DOE with the activities of ALT, AST, and ALP among test group

	ALT(U/L)	AST(U/L)	ALP(U/L)
Age	r= -0.294 P= 0.024*	r= -0.106 p= 0.423	r= -0.085 p= 0.521
DOE	r= -0.020 P= 0.919	r= 0.158 P= 0.412	r= -0.294 P= 0.024*
*		Significant	(p<0.05)

Table 3: Correlation of age and DOE with AFP among the test group

	AFP(ng/mL)
Age	r= -0.096 P= 0.471
DOE	r= 0.031 P= 0.875

DISCUSSION

Long term exposure to electronic waste (e-waste) components remains a challenge with respect to the health of individuals occupationally exposed to it. This cross-sectional study was therefore undertaken to investigate the activities of selected liver biomarkers (AST, ALT, and ALP), and serum levels of alpha-fetoprotein to underscore the possible effect of e-waste materials on liver organ as well as the individual's health. Generally, the study found a statistically insignificant difference in the activities of ALT, AST, and ALP, and in serum levels of AFP between the two study groups. However, a subtle difference was noted in the e-waste exposed group – where ALP and ALT activities were elevated and AST, AFP reduced. This finding is in contrast to the work of Yan et al.[16] in China, where significant increase in AST, ALT, and ALP levels were observed among e-waste workers compared to controls. It also contradicted the findings of a Nigerian study where a significant elevated AST, ALT and ALP activities was documented.[3] The present study suggest that under the environment, long term exposure to e-waste materials may not substantively contribute to the alteration of the liver enzyme activities in the population. Although the specific e-waste components were not studied from the outset to ascertain the individual impact of e-waste on the observed result, it is worthy to note that e-waste materials have complex mixtures and can have various degrees of liver toxicity.[4,9-11,17] In addition, alteration of liver enzymes can also occur transiently and may not directly imply chronic liver damage. Therefore, further studies detailing the e-waste exposure assessment is suggested.

Concerning the serum AFP levels, the subtle difference may be due to the effect of heavy metals on the liver, which can affect its function and then leads to decreased AFP levels. For example, previous study by Igharo et al.[3] found that e-waste workers had higher AFP levels compared to controls, which may be associated with the promotion of oxidative stress by liver-stored heavy metals, of which cadmium is a commonly reported culprit in the liver.

In this study, correlation analysis indicated a lower strength of negative relationship of age with ALT, but not AST and ALP in the exposed subjects. This concerning findings implies therefore that the higher the subject's age, the lower the serum activities of ALT in a person with history of e-waste exposure. In Yan et al.[16] study, ALT was found to be increasing with increased age. The variation might be attributable to sexuality and time of exposure factors.

Furthermore, this study observed that DOE statistically correlated negatively with ALP. Although the strength of the relationship is minimal, it reveals that the longer the duration of exposure to e-waste components by virtue of occupation, the lower the serum levels of ALP of the individual. This finding supports the report that duration of exposure can contribute to the alteration of liver function parameters and by extension can be detrimental to health.[16]

CONCLUSION

This study showed that exposure to e-waste may have no effect on the activities of liver enzymes (ALT, AST, and ALP) and the serum levels of AFP, as there were no statistically significant difference recorded. However, the negative correlation of age and DOE respectively with ALT and ALP suggests potential impact and further larger studies to include liver histology is recommended.

REFERENCES

1. Abalansa S, Mahrad BEI, Icely J, .Newton A. Electronic Waste, an Environmental Problem Exported to Developing Countries: The good, the bad and the ugly. Sustainability, 2021; 13, 5302. https://doi.org/10.3390/su13095302
2. Butta MKS, Omar A, Yang X. Electronic waste: A growing concern in today's environment. Econom Res Intl., 2011; (2011), 1-8.
3. Igharo OG, Anetor JI, Osibanjo OO, Osadolor H B, Idomeh FA, Igiewe WO, Kalikwu OU. Liver Damage Risk Assessment Study in Workers Occupationally Exposed to E-waste in Benin City, South-South Nigeria. J Chem Health Risks, 2015; 5(3), 155–166
4. Ankit Saha L, Kumar V, Tiwari J, Sweta Rawat S, Singh J, Bauddh K. Electronic waste and their leachates impact on human health and environment: Global ecological threat and management. Environ Technol Innov. 2021;24(2):102049.
5. Maphosa V, Maphosa MF. E-Waste Management in Sub-Saharan Africa: A Systematic Literature Review. Cogent Bus Manag. 2018;7(1):1.

6. UNEP, 2019. Technical guidelines on transboundary movements of electrical and electronic waste and used electrical and electronic equipment, in particular regarding the distinction between waste and non-waste under the Basel Convention. (Version of 10 May 2019). United Nations Environment Programme (UNEP).

7. Chakraborty S, Qamruzzaman M, Zaman M, Alam M, Hossain D, et al. Metals in e-waste: Occurrence, fate, impacts and remediation technologies. Process Saf Environ Prot. 2022;162.

8. Lebbie ST, Moyebi DO, Asante KA, Fobil J, Brune-Drisse MN, Suk WA, et al. E-Waste in Africa: A Serious Threat to the Health of Children. Int J Environ Res Public Health. 2021;18(16):8488.

9. Andeobu L, Wibowo S, Grandhi S. A systematic review of E-waste generation and environmental management of Asia Pacific countries. Int J Environ Res Public Health. 2021;18(17):9051.

10. Andeobu L, Wibowo S, Grandhi S. An assessment of E-waste generation and environmental management of selected countries in Africa, Europe and North America: A systematic review. Sci Total Environ. 2021;792:148078.

11. Forti V, Baldé P, Kuehr R, Bel G, Adrian S, Drisse M, et al. Quantities, flows, and the circular economy potential The Global E-waste Monitor 2020 [Internet]. 2020. Available from: https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf Accessed 31 March 2024.

12. Udechukwu C. Made in Anambra export strategy [Internet]. 2023 [cited 2024 Mar 30]. Available from: https://anambrastate.gov.ng/wp-content/uploads/Anambra-Export-Strategy_-December-2023.pdf

13. Iguh NA, Ewulum BE, Origbakpor CE. Revisiting the waste management framework in Anambra State under this current dispensation. IBJ [Internet]. 2021 [cited 2024 Mar 30];2:1–12. Available from: https://journals.ezenwaohaetorc.org/index.php/IBJ/article/viewFile/1706/1741.

14. Ononuju AH, Abugu AI, Obayi AN, Bosah CN, Dibiah SIC, Enemuo NK. Solid waste management in anambra state, nigeria: impediments and optimization strategies. EM International [Internet]. 2021 [cited 2024 Mar 30];40(2). Available from: http://www.envirobiotechjournals.com/article_abstract.php?aid=11536&iid=332&jid=4

15. Uzoukwu BA, Onamake OR. Physico chemical studies of soils along the banks of milli shallow stream in Nnewi, Anambra State of Nigeria for evidence of industrial pollution. Global Journal of Pure and Applied Sciences, 2004; 10(1),111-119.

16. Yan X, Li SY, Wang MH, Xu RF, Zheng J, Ren MZ. Liver and Kidney Function of E-waste Dismantling Workers and Potential Influencing Factors. Huan Jing Ke Xue. 2018 Feb 8;39(2):953-960. Chinese. doi: 10.13227/j.hjkx.201708101.

17. Shoukat A, Nurulain, Syed Muhammad, Hussain S, Khan SA, Ahmed H, Muneer Z, et al. Chronic exposure to electronic waste poses risk to liver toxicity with molecular interaction of GSTM1, GSTT1 null variants, and GSTP1. Environmental Pollution [Internet]. 2023;334:122204. Available from: https://www.sciencedirect.com/science/article/pii/S026974912301206X