Original Research

HYPERGLYCEMIA PREVALENCE AMONG ARTISANS AND WORKERS IN SELECTED FACTORIES IN LAGOS, SOUTHWEST, NIGERIA

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ABSTRACT

The increased global prevalence of hyperglycemia is linked partly to increasing industrial emission exposure, necessitating risk evaluations of various categories of workers worldwide. This study measured the blood glucose levels of selected non-obese artisans and workers from three companies (Imperio International, Mouka Foam, and Continental Iron) in Lagos, Nigeria. The participants' demographic data were collected using structured questionnaires, after which their blood glucose levels were measured using a glucometer. The results were compared with the World Health Organization (WHO) standards (88–126 mg/dL). On average, Imperio International participants were 32 years old, Mouka Foam and Continental Iron were 28 years old, and the artisans were 32 years old. Most of the participants were male secondary school graduates who worked an average of nine hours per day, six days a week. Artisans had the highest hyperglycemic population (46.15%), followed by Imperio International and Continental Iron (33% each), and Mouka Foam (29.41%). Smokers accounted for 10.53% of the hyperglycemic population, followed by alcoholics (36.84%), those who drank and smoked (42.11%), and those who did not drink or smoke (10.53%). Age class ≥41 accounted for 36.84% of the hyperglycemic population, class 31-40 (34.21%), and class 21-30 (28.95%). Participants with secondary school education constituted 63.16% of the hyperglycemic population, primary education (18.42%), individuals having no education (13.16%), and tertiary education (5.26%). The findings indicate that workplace pollutants predispose workers to hyperglycemia and that smoking and alcohol increase the risks. The findings necessitate exposure reduction and healthy lifestyles in the workplace.

***Keywords**: Alcohol use; healthy lifestyles; hyperglycemia; industrial emission; pollutants*

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Highlights:

1. Workplace pollutants predispose people to hyperglycemia through beta cell dysfunction and insulin resistance.
2. The risk is increased by unhealthy lifestyles such as smoking and drinking.
3. Aging, due to mitochondrial function decline, also promotes hyperglycemia.

INTRODUCTION

The rising global prevalence of high blood glucose is associated with increasing industrial pollution exposure, necessitating risk evaluations of various categories of workers worldwide. Glucose is the primary energy source for the body's cells, which is transported from the liver or intestines or absorbed through a hormone known as insulin (Gailliot & Baumeister 2007, Yahaya et al. 2021). The glucose concentration in the bloodstream, termed the blood glucose level, is regulated through insulin actions and other mechanisms (Ogbonna et al. 2018, Yahaya et al. 2019). Glucose levels are usually lowest before the first meal in the morning, termed the fasting level, and rise after meals for an hour or two by a few millimolar (Ogbonna et al. 2018). Normal fasting blood glucose levels are maintained within a narrow physiological range of 63–99 mg/dL (Güemes et al. 2015). However, certain medical conditions can disrupt blood glucose homeostasis, causing either low or high blood glucose (Ceriello et al. 2013). High blood glucose, also known as hyperglycemia, is defined as blood glucose levels greater than 126 mg/dL while fasting and greater than 180 mg/dL two hours after eating (Villegas-Valverde et al. 2018). Factors contributing to hyperglycemia include reduced insulin secretion, decreased glucose utilization, and increased glucose production (Mouri & Badireddy 2020). Prolonged hyperglycemia may cause diabetes mellitus (DM) and multi-organ damage involving the kidney, eyes, nerves, heart, and blood vessels (Piero et al. 2014, Yahaya & Salisu 2020).

Hyperglycemia and DM have exploded over the last two decades due to increased obesity, physical inactivity, and an aging population (Mouri & Badireddy 2020). About 463 million people worldwide were diagnosed with DM in 2020, of which around 2,743,800 cases were recorded among adults in Nigeria (International Diabetes Federation 2020). The deaths resulting from hyperglycemia and DM are also high. For instance, in 2020, DM was the direct cause of 4.2 million adult deaths worldwide (International Diabetes Federation 2019). In Nigeria, at least 63,957.7 people between the ages of 20 and 79 died from DM in 2019 (Federation, 2019b).

Furthermore, the global financial burdens of DM are high. The estimated global direct health expenditure on DM in 2019 is USD 760 billion and is projected to increase to USD 825 billion by 2030 and USD 845 billion by 2045 (Williams et al. 2020). In Nigeria, the national direct costs of DM are estimated at $1.071 billion to $1.639 billion per year (Mapa-Tassou et al. 2019). Indeed, the prevalence of hyperglycemia and DM has reached epidemic proportions, and studies are necessary to identify the cause of the increasing prevalence and stem it. To this end, pollutant exposure has been identified as a cofactor in the rising incidence of these diseases, most noticeably after industrialization began in some parts of Europe and North America around the mid-29th century (Gale 2002, Yahaya et al. 2017). Thus, it has become imperative to conduct a risk evaluation of various workers worldwide. To our knowledge, such a study has not been conducted in most workplaces in Nigeria. This study, therefore, measured the blood glucose levels of some artisans and factory workers in Ogba, Lagos, Nigeria. The findings of this study will provide primary data for controlling blood glucose among factory workers in Nigeria.

MATERIALS AND METHODS

Description of the study site

This study was carried out in Ogba, Lagos State, Nigeria (Figure 1). The state is located between latitudes 6° 30′ N and 6° 40′ N and longitudes 3° 00′ E and 4° 00′ E (Balogun et al. 2017). It is bordered on the south by the Atlantic Ocean, on the west by the Benin Republic, and the north and east by Ogun State. The state has tropical vegetation, with a short dry season from December to February and a long rainy season from March to November. The state's dense population is projected to exceed 20 million people by 2025 (Oketola & Osibanjo 2009). Lagos is Nigeria's economic capital, with over 70% of the country's industries based there. Ogba is one of the state's most industrialized areas, and its location in Ikeja, the state capital, has earned it the moniker "heart of Lagos." The state's rapid population growth and urbanization have increased environmental pollution.

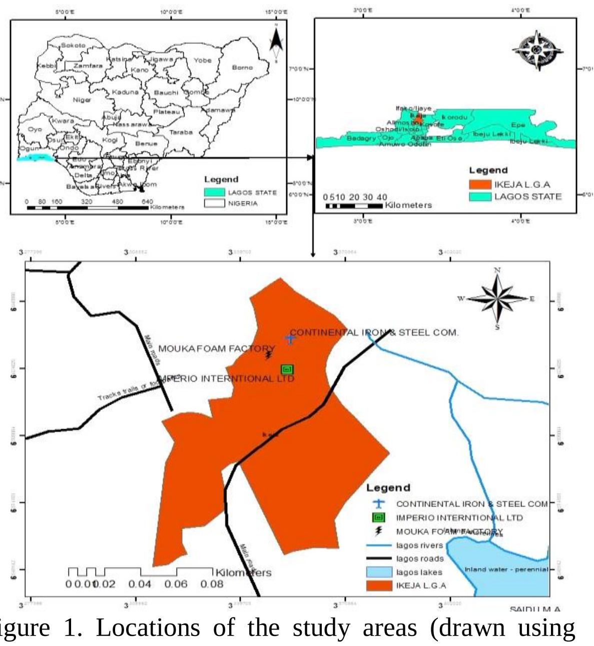

Figure 1. Locations of the study areas (drawn using ArcGIS 10.3 software)

Study population and data collection

Ninety-six (96) non-obese factory workers and artisans were enrolled in the study, comprising 12 participants from Imperio International, 17 from Mouka Foam, and 15 from Continental Iron and Steel. Fifty-two (52) artisans, mainly welders, mechanics, and carpenters, also participated in the study. After giving informed consent, each participant was given a questionnaire to indicate demographic data such as sex, age, drinking and smoking status, work hours, level of education, and work department. After that, the raw materials used in each company were recorded, after which blood samples were taken from the participants, and their blood glucose levels were measured.

Determination of blood glucose levels

The fasting blood glucose of the participants was measured using a Fantastik-Accu Glucose Meter (IVD version 180705-1) as described by Yahaya (2017b). The participants were made to fast for 8 hours, after which a drop of blood was taken from them and applied to a test strip. The strip was inserted into the glucose meter, and the reading was displayed on the instrument in mg/dL.

Ethics Statement

The Ethics and Research Committee of the National Open University of Nigeria, Lagos, approved the study. The participants also consented to the study.

Criteria for selection of participants

Participants must have agreed to participate in the study, have worked in the industry for at least two years, have no history of DM prior to working in the factory, and have not worked anywhere else. Excluded participants were those with a body mass index above 30 and individuals with a family history of DM.

Data analysis

Descriptive statistics were used to present values as numbers and percentages and mean ± standard errors (SE). The student's t-test was used to test the significance level among variables, in which $p \leq 0.05$ was considered statistically significant.

RESULTS

Some toxic materials used in the selected factories and artisans' workshops

Table 1 presents some materials used for production in the selected factories and artisans' workshops. Coal tars, ethanol, bisphenol A, phthalate, and brominated flame retardants were some of the toxic materials used by Imperio International. In contrast, Mouka Foam used polyurethane foam, antimony, toluene, and polybrominated diphenyl ethers (PBDEs). Continental Iron and Steel uses iron ore, limestone, nickel, and coal, while artisans used steel, cast iron, gasoline, engine oil, lubricants, anti-knock agents, and lead-acid batteries.

Demographic information on age, sex, education, and lifestyles of the workers of the selected factories and artisans

The participants from Imperio International comprised four females and eight males (a total of 12), with ages ranging between 22 and 44 (Table 2). Most of them worked in the production/ packaging unit and had at least a secondary school education, except for one participant who had none. Five of the participants were alcoholics; 3 of them smoked and drank, and 4 of them did neither drink nor smoke. The lowest blood glucose level among the participants was 88 mg/dL, while the highest was 162 mg/dL. Four participants had blood glucose levels above normal (>126 mg/dL).

Table 1. Some of the toxic materials used for production by Imperio International, Mouka Foam, Continental Iron and Steel, and Artisans in Ogba, Lagos, Nigeria

Company	Solid materials	Liquid materials	Gaseous by-products
Imperio International	Coal tars	Ethanol, Bisphenol A, phthalate, brominated flame retardant	Benzene, Acetylene
Mouka Foam	Polyurethane Foam, Antimony	Toluene, Polybrominated diphenyl ethers (PBDEs)	Volatile organic compounds
Continental Iron and Steel	Iron ore, Limestone, Nickel, Coal	Water	Carbon monoxide, Nitrogen
Artisans	Steel, Cast Iron, Sawdust	Gasoline, Engine oil Lubricants, Antiknock agents, lead-acid batteries	Argon, Helium

The total participants from Mouka Foam comprised 17 people, of which 15 were males, and 2 were females (Table 3). Their ages ranged from 21 to 34, and they all worked in the production/packaging unit with at least a secondary school certificate. Three participants were alcoholics, 2 were smokers, 7 were alcoholics and smokers, and 5 did neither drink nor smoke. The lowest blood glucose among the participants was 92 mg/dL, while the highest was 182 mg/dL. Five participants had blood glucose levels above normal values (>126 mg/dL).

The total number of Continental Iron and Steel participants was 15, and they were all males (Table 4). The participants were within the 21–34 age range, and all worked in the production unit with at least a primary education except for one person. Five participants were alcoholics; 1 was a smoker, four smoked and drank, and five did not drink nor smoke. The lowest blood glucose level among the participants was 81 mg/dL, and the highest was 142 mg/dL. Five participants had blood glucose levels above normal (>126 mg/dL).

Table 5 revealed that the selected artisans comprised 52 males, mainly mechanics, carpenters, and welders, between the ages of 16 and 60. Twenty-one participants were alcoholics, 7 were smokers, 12 were alcoholics and smokers, and 12 did neither drink nor smoke. The lowest blood glucose in the group was 85 mg/dL, while the highest was 189 dL. Twenty-four participants had blood glucose levels above normal (>126 mg/dL). The majority had primary and secondary education, except five, who had none.

Table 2. Demographic data on sex, age, education level, and lifestyles of the participants from the Imperio International, Ikeja Industrial Estate, Ogba, Lagos, Nigeria

S/N	Gender	Age	Work hours	Department	Education level	Drinking status	Smoking status	Blood glucose levels (mg/dL)
1	F	38	9	Supervisor	Tertiary	No	No	110
2	F	44	9	Supervisor	Tertiary	No	No	162*
3	F	26	9	Packaging	Secondary	Yes	No	88
4	F	27	12	Security	Secondary	Yes	No	101
5	M	30	9	Production	Primary	Yes	Yes	129*
6	M	28	9	Production	Secondary	Yes	No	121
7	M	31	9	Production	None	Yes	Yes	135*
8	M	50	7	Engineering	Tertiary	Yes	No	116
9	M	22	9	Production	Secondary	No	No	95
10	M	26	9	Packaging	Secondary	Yes	Yes	118
11	M	34	12	Security	Secondary	Yes	No	103
12	M	33	9	Sales rep	Secondary	No	No	127*

*= values above WHO limit (>126 mg/dL)

Table 3. Demographic data on sex, age, education level, and lifestyles of the participants from the Mouka Foam Limited, Ikeja Industrial Estate, Ogba, Lagos, Nigeria

S/N	Gender	Age	Work hours	Department	Education level	Drinking status	Smoking status	Blood glucose level (mg/dL)
1	F	22	9	Packaging	Secondary	No	No	95
2	F	27	9	Packaging	Tertiary	Yes	Yes	110
3	M	21	9	Packaging	Secondary	Yes	No	106
4	M	28	9	Packaging	Tertiary	Yes	Yes	112
5	M	27	9	Packaging	Secondary	Yes	Yes	102
6	M	31	9	Packaging	Secondary	Yes	No	152*
7	M	26	9	Production	Secondary	No	No	108
8	M	32	9	Production	Secondary	No	Yes	128*
9	M	34	9	Production	Secondary	Yes	No	118
10	M	25	9	Production	Technical	Yes	Yes	97
11	M	30	9	Production	Technical	No	No	126
12	M	31	9	Production	Secondary	Yes	Yes	182*
13	M	29	9	Production	Tertiary	Yes	Yes	145*
14	M	23	9	Production	Secondary	No	No	92
15	M	34	9	Production	Secondary	No	No	116
16	M	32	9	Production	Secondary	No	Yes	151*
17	M	28	9	Production	Secondary	Yes	Yes	10

*= values above WHO limit (>126 mg/dL)

Table 4. Demographic data on sex, age, education level, and lifestyles of the participants from the Continental Iron and Steel, Ikeja Industrial Estate, Ogba, Lagos, Nigeria

S/N	Gender	Age	Work hours	Department	Education level	Drinking status	Smoking status	Blood glucose level (mg/dL)
1	M	22	9	Production	Secondary	Yes	Yes	128*
2	M	27	9	Production	Primary	No	No	100
3	M	21	9	Production	Secondary	Yes	No	135*
4	M	28	9	Production	None	Yes	No	92
5	M	27	9	Production	Technical	No	No	101
6	M	31	9	Production	Secondary	No	No	81
7	M	26	9	Production	Secondary	Yes	Yes	142*
8	M	32	9	Production	Secondary	Yes	Yes	138*
9	M	34	9	Production	Secondary	Yes	No	111
10	M	25	9	Production	Secondary	No	Yes	122
11	M	30	9	Production	Secondary	No	No	96
12	M	31	9	Production	Secondary	No	No	87
13	M	29	9	Production	Primary	Yes	No	104
14	M	23	9	Production	Technical	Yes	Yes	129*
15	M	34	9	Production	Secondary	Yes	No	106

*= values above WHO limit (>126 mg/dL)

Table 5. Demographic data on sex, age, education level, and lifestyles of the selected artisans in Ogba, Lagos, Nigeria

S/N	Age	Occupation	Education level	Drinking status	Smoking status	Blood glucose level (mg/dL)
1	55	Carpenter	None	Yes	No	182*
2	48	Carpenter	Primary	Yes	No	135*
3	40	Carpenter	Secondary	Yes	Yes	162*
4	42	Carpenter	None	No	No	120
5	25	Carpenter	Secondary	Yes	No	91
6	28	Carpenter	Secondary	Yes	Yes	122
7	21	Carpenter	Secondary	Yes	No	108
8	18	Carpenter	Primary	Yes	No	102
9	25	Carpenter	Secondary	No	No	110
10	60	Carpenter	Primary	Yes	No	172*
11	58	Carpenter	Secondary	Yes	No	145*
12	25	Carpenter	Secondary	Yes	Yes	128*
13	26	Carpenter	Primary	No	Yes	121
14	19	Carpenter	Secondary	No	No	85
15	16	Carpenter	Primary	No	No	88
16	18	Carpenter	Secondary	Yes	No	97
17	24	Carpenter	Secondary	No	Yes	120
18	23	Carpenter	Secondary	No	Yes	102
19	57	Carpenter	Primary	Yes	Yes	142*
20	33	Mechanic	None	Yes	Yes	158*
21	30	Mechanic	Primary	Yes	No	126
22	22	Mechanic	Secondary	Yes	No	122
23	32	Mechanic	Secondary	No	No	125
24	28	Mechanic	Secondary	Yes	Yes	135*
25	18	Mechanic	Secondary	No	No	105
26	25	Mechanic	Primary	No	No	98
27	27	Mechanic	Primary	Yes	No	88
28	16	Mechanic	Primary	No	No	92
29	20	Mechanic	Secondary	Yes	Yes	110
30	21	Mechanic	Secondary	Yes	Yes	117
31	15	Mechanic	Primary	No	No	98
32	32	Mechanic	Secondary	Yes	Yes	126
33	45	Mechanic	Secondary	Yes	No	140*
34	39	Mechanic	Secondary	Yes	No	158*
35	41	Mechanic	Secondary	Yes	Yes	172*
36	40	Mechanic	Secondary	Yes	Yes	180*
37	27	Mechanic	Primary	No	No	128*
38	26	Mechanic	Secondary	Yes	No	126

39	52	Mechanic	None	No	No	162*
40	54	Mechanic	Secondary	Yes	No	178*
41	55	Mechanic	Secondary	Yes	No	189*
42	45	Welder	Secondary	Yes	No	180*
43	42	Welder	Primary	Yes	Yes	179*
44	30	Welder	Secondary	Yes	No	170*
45	35	Welder	Secondary	No	Yes	161*
46	18	Welder	Secondary	No	Yes	123
47	16	Welder	Primary	No	No	100
48	21	Welder	Secondary	Yes	No	102
49	20	Welder	Secondary	No	Yes	125
50	51	Welder	None	Yes	No	183*
51	33	Welder	Secondary	Yes	No	147*
52	37	Welder	Primary	No	Yes	172*

*= values above WHO limit (>126 mg/dL)

Comparison of blood glucose levels and age of participants from the selected factories and artisans

Continental Iron and Steel participants had the lowest mean age (28±9.1), while Imperio International had the highest (32±2.3). Continental Iron and Steel participants had the lowest blood sugar levels (81 mg/dL), while artisans had the highest (189 mg/dL). Mouka Foam had the lowest percentage of participants (29.41%) having blood glucose levels above normal levels, while artisans had the highest (46.15%) (Table 6).

Influence of smoking and alcohol consumption on blood glucose levels

In Imperio International, none of the participants who smoked or drank were hyperglycemic. However, participants who combined smoking and drinking accounted for 50% of the hyperglycemic population, while participants who neither drank nor smoked also accounted for 50%. In Mouka Foam, smokers accounted for 40% of the hyperglycemic population, alcoholics accounted for 20%, and participants whom neither drank nor smoked accounted for 40%. In Continental Iron and Steel, alcoholics accounted for 20% of the hyperglycemic population, while participants who smoked and drank accounted for 80%. Among the artisans, smokers accounted for 8.33%, alcoholics (50%), participants who smoked and drank (33.33%), and participants who neither smoked nor drank (8.33%). Overall, smokers accounted for 10.53% of the hyperglycemic population, alcoholics (36.84%), participants who drank and smoked (42.11%), and participants whom neither drank nor smoked (10.53%) (Table 7).

Influence of age on the blood glucose levels of the participants

In Imperio and Mouka, age class 31–40 accounted for the highest proportion of the hyperglycemic population, while class 21–30 was the highest in Continental Iron, and class 41 and above was the highest among artisans. Overall, those aged 41 and above had the highest proportion of the hyperglycemic population, followed by those aged 31–40 and those aged 21–30 (Table 8).

Influence of education qualification on blood glucose levels of the participants

Across all the companies, secondary school certificate holders accounted for the highest proportion of the hyperglycemic population, except in Imperio International. Overall, secondary school certificate holders accounted for the highest proportion of hyperglycemia, while tertiary education had the least (Table 9).

Table 6. Comparison of blood glucose levels and age of participants from Imperio International, Mouka Foam, Continental Iron and Steel, and Artisans in Ogba, Lagos, Nigeria

Company	Mean age	Mean work hour	Lowest blood sugar level (Mg/Dl)	Highest blood sugar level (Mg/Dl)	Mean blood sugar level (Mg/Dl)	Percentage hyperglycemic (>126 Mg/Dl)	WHO blood glucose limits (Mg/Dl)
Imperio International	32 ± 2.3	9.3 ± 0.4	88	162	117 ± 5.8	33.33	72-126
Mouka Foam	28 ± 1.1	9 ± 0.0	92	182	120 ± 6.1	29.41	72-126
Continental Iron and Steel	28 ± 1.1	9 ± 0.0	81	142	111 ± 5.0	33.33	72-126
Artisans	32 ± 1.9	-	85	189	133 ± 4.3	46.15	72-126

Table 7. Influence of smoking and alcohol consumption on blood glucose levels of participants from Imperio International, Mouka Foam, Continental Iron and Steel, and Artisans in Ogba, Lagos, Nigeria

Company	Number of hyperglycemic individuals	Individuals who smoked (%)	Individuals who drank (%)	Individuals who smoked and drank (%)	Individuals who neither drank nor smoked (%)
Imperio International	4	0	0	50	50
Mouka Foam	5	40	20	40	0
Continental Iron and Steel	5	0	20	80	0
Artisans	24	8.33	50	33.33	8.33
Overall Percentage Hyperglycemic	38	10.53	36.84	42.11	10.53

Table 8: Influence of Age on the Blood Glucose Levels of Participants from Imperio International, Mouka Foam, Continental Iron and Steel, and Artisans in Ogba Lagos, Nigeria

Company	Number of hyperglycemic individuals	Age class 21 – 30 (%)	Age class 31 – 40 (%)	Age class >41 (%)	p-values
Imperio International	4	25	50	25	0.09786
Mouka Foam	5	20	80	nil	0.01822*
Continental Iron and Steel	5	60	40	nil	0.04857*
Artisans	24	25	20.83	54.17	0.06628
Overall Percentage Hyperglycemic	38	28.95	34.21	36.84	-

* $p < 0.05$ = significantly different; $P > 0.05$ = not significantly different; nil = no participant

Table 9. Influence of education qualification on the blood glucose levels of participants from Imperio International, Mouka Foam, Continental Iron and Steel, and Artisans in Ogba, Lagos, Nigeria

Company	Number of hyperglycemic individuals	Individuals with no education (%)	Individuals with primary education (%)	Individuals with secondary education (%)	Individuals with tertiary education (%)
Imperio International	4	25	25	25	25
Mouka Foam	5	0	0	80	20
Continental Iron and Steel	5	0	0	100	0
Artisans	24	16.67	25	58.33	0
Overall Percentage Hyperglycemic	38	13.16	18.42	63.16	5.26

DISCUSSION

This study measured the blood glucose levels of randomly selected non-obese workers of Imperio International, Mouka Foam, Continental Iron and Steel, and artisans in Ogba, Lagos, Nigeria. The study investigated the strength of the link between industrial pollution exposure and the prevalence of hyperglycemia. The prevalence of hyperglycemia among the participants from Imperior International was 33.33%, Mouka Foam Industries (29.41%), Continental Iron and Steel Company (33.33%), and artisans (46.15%) (Tables 2, Table 6). These proportions are too high and contradict a review by Adeloye et al. (2017), which reported a 5.8% prevalence of hyperglycemia among Nigerians. It also contradicts a systematic review by Uloko et al. (2018), who put the overall prevalence of DM in Nigeria at 5.77%. However, the findings were consistent with those of Nwafor and Owhoji (2001), who reported a 23.4% prevalence of DM among the higher socioeconomic classes in Port Harcourt, Nigeria. Meo et al. (2018) also reported a 63.30% and 23.74% incidence of prediabetes and typed 2 diabetes mellitus (T2DM) among workers in the plastic industry. In a steel company in China, the overall prevalence of DM and prediabetes was 7.5% and 16.8%, respectively (Yang et al. 2015).

Some toxic raw materials used by the selected companies in the present study could be partly responsible for the high prevalence of hyperglycemia among the participants (Table 1). Imperior International uses known endocrine disruptors such as bisphenol A (BPA) and phthalate to produce plastics. Over time, BPA can trigger the release of almost double the insulin needed, desensitizing the body to the hormone and culminating in weight gain and DM (Lynne 2012). A prospective cohort study also reported that urinary BPA and butyl phthalate were associated with T2DM (Jeon et al. 2015). Dioxins are formed during the combustion of plastics, which has been linked with insulin resistance (Chang et al. 2016).

Mouka Foam Industry employs polybrominated diphenyl ethers (PBDEs). This fire retardant accumulates in adipose tissues and predisposes people to obesity, insulin resistance, and diabetes (Le Magueresse-Battistoni et al. 2017, Siddiqi et al. 2003). Antimony, another material used in foam industries, is also reported to increase DM risk (Feng et al. 2015). Continental Iron and Steel Company uses nickel, coal, limestone, and iron ore, which could predispose to high blood glucose. Nickel can disrupt glucose uptake and change networks of activities that maintain glucose balance (Serdar et al. 2009). Iron is required for normal functioning of the system, but iron overload may induce oxidative stress, causing β-cell failure and insulin resistance, resulting in high blood glucose (Simrox & McClain 2013, Sung et al. 2019). Long-term exposure to nitrogen dioxide, one of steel production's by-products, causes oxidative stress (Strak et al. 2017). Carbon monoxide from iron and steel burning can cause inflammatory and immunological reactions in the pancreas, predisposing humans to DM (Huang et al. 2017). The artisans' constant exposure to manganese from anti-knock agents and welding can disrupt metabolic activities, resulting in insulin resistance and T2DM (Li & Yang 2018). Through spray painting, soldering, welding, and lead-acid batteries, artisans may be exposed to lead, disrupting metabolic functions, including insulin metabolism (Leff et al. 2018).

Furthermore, Table 2, 3, 4, 5 showed that all the participants worked at least 9 hours daily and six days weekly, which could have contributed to the observed high prevalence of hyperglycemia. Although this study did not examine the relationship between exposure duration and blood glucose levels because all the participants worked nearly the exact durations, similar studies have established the link. In a study that investigated the occurrence of prediabetes and T2DM among non-smoking plastic industry workers, the prevalence was associated with the duration of work exposure (Meo et al. 2018). Chang et al. (2016) also found that men with the highest dioxin levels due to prolonged exposure had insulin resistance five-fold higher than those with the lowest levels.

Another factor contributing to the high blood glucose among the participants is their lifestyle. Tables 4a and b showed that hyperglycemia was more prevalent among smokers and alcoholics than among participants who combined the two, compared with non-smokers and non-alcoholics. Oladoyinho et al. (2019) reported an increased risk of DM among artisans who indulged in alcohol consumption. Yang et al. (2017) also stated that industrial pollutant exposure and heavy smoking are independent risk factors for DM, and the two may interact to raise the disease's risk.

Moreover, the distribution of hyperglycemia in this study varies with age, class, and education qualifications (Tables 8 and 9). Hyperglycemia was more prevalent in those aged 41 and above, possibly due to an age-related decline in metabolic function. According to Huizen (2019), being over 45 is a risk factor for T2DM. In a study by Al Mansour (2020), DM was more prevalent among the older respondents than the younger age group. Aging reduces mitochondrial function, resulting in decreased insulin sensitivity and hyperglycemia Suastika et al. (2012). Regarding educational qualifications, hyperglycemia was least common among those with tertiary education and most common among those with secondary education. This is consistent with Aldossari et al. (2018), who observed that, aside from old age and smoking, a lack of education increases the risk of hyperglycemia.

Strength and limitation

The study results could have been better and more convincing with a more significant number of participants. However, the companies were not too comfortable with the research because of the fear of the unknown, so access to some staff was denied. Some of the staff were unwilling to participate for the same reasons mentioned above.

CONCLUSION

The results showed that hyperglycemia was more prevalent among the participants than in the general population of Nigeria. Hence, long-term exposure to pollutants from the studied factories and artisans' workshops increases the risk of hyperglycemia. The risk was higher among smokers, alcoholics, older people, and individuals with less education. At the same time, we recommended further studies to confirm our claims. There was an urgent need for health-boosting lifestyles and pollutant exposure-reducing strategies in the studied workplaces and elsewhere in Nigeria.

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Conflict of interest

None.

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Author contribution

All authors conceived the idea of the study. EGO and DMS ware analysis data. ALA, NS and BMU ware study design. TOY revised the manuscript . TOY, MOS, JDK and JDK have final content and agreetment.

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