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OCCUPATIONAL HAZARDS ASSOCIATED WITH BREWING AND BOTTLING BUSINESS IN NIGERIA

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Abstract As developing countries such as Nigeria continue to undergo industrialization, the health care and safety of the employees on whom the success of such processes depends becomes salient. Occupational health and safety continues to receive attention from organizations' management and the State through its regulatory machinery. This has led to increased interest in developing binding regulations and minimum Health and Safety requirements in the key industries of the Nigerian economy which the food and beverages industry is among. The paper thus aims to identify the inherent hazards associated with the brewing and bottling business of the Food and Beverage industry in Nigeria by eliciting information from experienced employees in the industry using in-depth interviewing. Thematic content analysis was used for qualitative data collected with the 4 major themes explored being frequency and likelihood of hazard, the severity of effects, category in terms of being chronic or acute, and hazard class. It was found that certain physical, chemical, ergonomic, and psychosocial high-severity hazards are prevalent in the sector, along with some moderate and low-level severity hazards. Therefore, organizations in the sector need to run proactive safety programs and have actionable, practical preventive measures in place to drop incident rates and improve employee well-being and job satisfaction levels.

Keywords: Occupational; health; safety; ergonomics; hazards; brewing; bottling; industry.

1. INTRODUCTION

Occupational Health and Safety (OHS) refers to health, safety, and welfare affairs in the workplace. It includes all regulations, standards, initiatives, and strategies aimed at making the workplace more conducive for employees and their co-workers, family members, customers, and other stakeholders. It is concerned with addressing the many types of workplace hazards. Occupational health and safety standards are set up to ensure the elimination, reduction, or replacement of job-related hazards [1-3].

The OSH concept came into being with the industrialization and development of societies from agrarian to developed societies, which can be ascribed to the remarkable progress of inventions and innovations of the 18th and 19th centuries. This has led to the expansion of multinationals over the years and the establishment of industries in developing countries like Nigeria. Such expansions usually mean developing countries like Nigeria become recipients of transfer of technology, machinery, and productivity which usually translates to the introduction of new occupational hazards, harmful processes, occupational stress, etc. from multinationals of well-established developed countries, with the developing countries expected to follow international OHS standards. A practice that is common in the brewing and bottling industry [3, 4].

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While employers and company management are obliged both by the duty of care and statutorily to provide a safe working environment for all of their employees in most countries of the world, occupational health and safety facilities are rarely up to standards. The International Labour Organization (ILO) in 2010 estimated work-related accidents and diseases to be about 10 million. The World Health Organization also states that 80% of the 3 billion workers around the world do not have access to adequate OSH facilities [1, 5].

In Nigeria, 238 fatalities and 3461 reported occupational accidents/injuries were recorded across different sectors of the economy between Jan 2014 – September 2016. Despite that the food and beverage industry is a weighty employer of labour in Nigeria, there is currently a paucity of literature and no published data on injury and incident rates. However, that data from the United Kingdom and the Bureau of Labor Statistics of the United States of America shows a high level of incident occurrence in the brewing and bottling industries calls for more attention to be directed towards upholding OSH standards in the Nigerian brewing and bottling industries where legal and statutory backing does not necessarily lead to enforcement or compliance. The United Kingdom incident rate per 100,000 workers for 1996-1997 stood at 3521 for the brewing industry and 1166 for the bottling industry. For the United States, the incident rate of 21.5% was well above that of the manufacturing industry as a whole which stood at 13.2% [1, 4, 5].

Thus, the objectives of the study are to determine the occupational hazards, injuries, and illnesses employees in the brewing and/or bottling industry are exposed to in Nigeria, identify the causes and effects, and recommend possible solutions.

2. MEANING OF OCCUPATIONAL HEALTH AND HAZARDS

2.1. Clarification of Concepts

Occupation: Occupation can be defined as a set of jobs whose main tasks and duties are characterized by a high degree of similarity. Examples are dentistry, medicine, engineering, etc. It is a person's typical work or business, particularly as a means of earning a living or vocation. Anything said to be occupational thus relates to a job, profession, or work-life [1, 3].

Health: The World Health Organization defines health as a state of complete physical, mental and social well-being of individuals (which businesses and the nation rely on for sustainable development), and not merely the absence of disease or infirmity. The three elements it covers (physical, mental and social state) are inseparable [1, 3].

Safety: Safety is a condition of being free from danger or situations that can cause harm. It is relative security from accidental injury or death due to measures designed to guard against accidents. It is a fundamental desire of all human beings regardless of their status, location, affiliation, or calling [2, 3, 6].

Occupational Health and Safety: this refers to the promotion and maintenance of the highest degree of physical, mental, and social well-being of workers in all occupations. It refers to health, safety, and welfare affairs in the workplace and includes all regulations, standards, initiatives, and strategies

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aimed at making the workplace more conducive for employees and their co-workers, family members, customers, and other stakeholders. It is concerned with addressing the many types of workplace hazards [1-4].

Occupational safety and health programs are aimed at promoting safe and healthy occupational environments and protecting the general public who may be affected by the occupational environment. The environment in the workplace context refers to the machinery, equipment, materials, facilities, and activities that must be maintained in a safe state if they must sustain life, living, and planned objectives as expected [3, 4].

However, occupational safety and health (OSH) does not only seek to secure the safety and health of persons at work but consequentially stimulates productivity in the business of establishments. It is, therefore, necessary to uphold Occupational Safety and Health standards and be well-coordinated for effective management [1, 3, 4].

Hazards: refers to anything that can be dangerous or with the potential to cause harm, injury/ or ill health. They are physical situations or conditions that have the potential to cause human injury, damage to property, and the environment or combinations of them. In practical expressions, hazards are often associated with a condition (referred to as unsafe condition) or activity (unsafe act) that can result in injury, illness, or accident occurrence if uncontrolled. Identifying hazards and eliminating or controlling them as early as possible is thus key to accident, injury, or illnesses prevention [2, 3, 6].

Occupational hazards: from the foregoing, occupational hazards can be defined as the dangers to human health and well-being associated with specific occupations. They refer to any working condition that can result in illness, injury, or death [3].

Occupational hazards can be divided into two categories: "Safety and injury hazards" are those that cause accidents that physically injure workers. Safety hazards are usually short-term and acute, with their causes and effects located within the same time and space. In many cases, it is difficult to influence outcomes of safety hazards. "Health and illnesses hazards" on the other hand are those that result in the development of a disease and are usually long-term, they can be defined by acute and chronic phase, and their causes and effects may not be co-located in the same environment, time and location. Also, their outcomes can be influenced by actions such as immunization, nutrition [2, 3, 6].

Hazards can also be classified into 5 classes: physical are those that cause harm with contact, biological originating from living organisms, chemical from non-biological substances, psychosocial with psychological and/or social elements, and ergonomic hazards which relate to postures and musculoskeletal factors [2, 3, 6].

3. DESCRIPTION OF BREWING AND BOTTLING PROCESS WITH METHODOLOGY

3.1. Description of the Brewing and Bottling Process

A brewing and bottling company such as the company under study engages in the manufacturing, bottling, and canning of beer and other alcoholic and non-alcoholic beverages. The workforce in the

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industry range from the low-income unskilled workers involved in the harvesting of raw materials and those engaged as casual staff in manufacturing plants to the skilled and educated personnel involved in the mechanized and automated process.

The brewing process starts with the grains intake for milling at the silos, after which the milled grains are sent to the processing unit to be mixed with water and other appropriate ingredients and additives, and heated to break down the starch in the grain to sugars. After cooking up the mixture in the appropriate vessels that are usually tank-like and made with stainless steel, the solution is transferred to another machine called the mash filter where the wort is extracted and separated from the spent grain. Wort refers to the liquid extracted from the mashing process [7].

The extracted wort is then transferred to another vessel, the wort copper for another boiling to ensure sterility and prevent microbe contamination. Hops, flavours, and other necessary additives are added during this boiling which usually lasts between 80 – 120 minutes before the wort is allowed to cool. After cooling, the next stage is to add yeast to the cooled wort and send it to the giant Fermentation Storage Tanks (FST) which are cylindroconical in shape for fermentation. FSTs can handle both fermenting and conditioning of the cooled wort and usually have a valve opening at the top which serves the purpose of allowing the carbon dioxide naturally created by the yeast to carbonate the beer. It also regulates pressure within the tank to produce different types of beers with more pressure producing more carbonated beers [7]. The processes of milling, mashing, boiling, fermenting, conditioning, and filtering are all done at the Brewing section.

Conditioning refers to the cooling of the FST tanks and evacuating the dead yeast cells also referred to as spent yeast that usually settle at the bottom of the tanks. After conditioning, the beer is filtered to give it a polished look and stabilize its flavor. Filtration involves using an active filtering system, after which the product is passed through calibrated vessels for measurement after cold conditioning and sent to the packaging section for bottling or canning. Tanks and vessels used in the Brew-house are cleaned from time to time using caustic water solution and then heated water [7].

Activities carried out in the packaging section are de-palletizing of return bottles in crates into conveyors that send to the unpacker, a machine that removes the bottles from the crates and sends them to the bottle washer. The bottle washer washes the bottles using caustic soda solution and heated water. After the bottle washing, the conveyor drives the washed bottles to the filling machine where the products received from the brewing sections are filled into bottles, corked, and then pasteurized. In the case of bottling lines, after pasteurizing, the filled bottles are sent to the labeler, also through the conveyor, for labeling, then to the packing machine which packs filled and labeled bottles into crates and sends them to the palletizing machine. After palletizing, the palletized products are moved to the logistics section using forklift trucks for warehousing and distribution.

Asides from the Brewing, Packaging and Logistics departments, the Engineering, and Technological departments are the other two key departments involved in the production processes of the brewing and bottling company under study. The Engineering Department ensures maintenance/upkeep of production assets such as machinery and equipment, buildings, roads, and premises at optimum costs so that they are available for production, and also ensure the provision of utilities such as cooling, steam, carbon dioxide (CO_2), water, compressed air, and electricity necessary for production at

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optimum cost and safety standards. The Technological department ensures adherence to production standards by facilitating quality control procedures and checks at various stages of the production process.

3.2. Methodology

The study was based on responses of 26 employees interviewed across the key departments of the production plants namely; brewing (6), packaging (5), logistics (5), engineering (6), and technological (4). Departments like finance, human resources, ICT, and security were not included due to the general nature of their functions, this is because hazards associated with their functions may not be peculiar or very different from the hazards faced by personnel in the same functions in other industries. All 6 respondents from the brewing, packaging, engineering and logistics sections were male while 2 of the respondents from the technological section were female. Of the 26 respondents, 4 were skilled management staff, 5 skilled non-management staff, 14 semi-skilled non-management staff, and 3 unskilled casual workers. On average, the respondents had worked 8.85 years in the industry.

The respondents used for this research were from Southwestern Nigeria. A semi-structured interview was conducted with open-ended questions asked, allowing for follow-up questions to draw out more specific information. The interview sessions lasted 15 – 30 minutes and the main questions asked centered on job function and description, category of employee, years of work experience in the industry, hazards associated with their roles, causes of those hazards, their effects, factors reducing, promoting, or eliminating them, the likelihood of occurrence, and hazard severity/significance.

Data collected was analysed thematically with themes utilized being hazard likelihood, hazard severity, hazard category as regards being acute or chronic, and hazard type. Verbatim quotes inserted occasionally and where deemed necessary. Above all, ethical issues bothering on the privacy of respondents were duly observed over the course of the study.

4. RESULTS AND DISCUSSION: HAZARDS, CAUSES, AND EFFECTS

A total of 26 employees were interviewed for this study, of this, 12 (46%) of the respondents had 0 - 5 years of work experience in brewing and bottling, 10 (39%) had 11-20+ years of work experience, and 4 (15%) had 6 – 10 years of work experience.

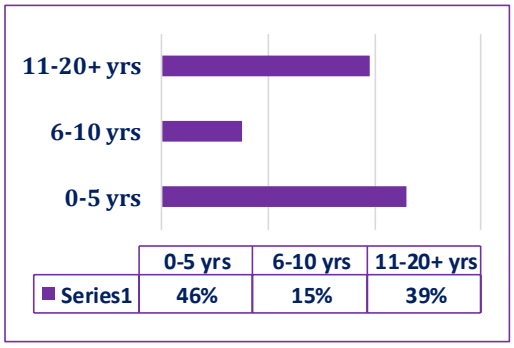

Figure 1. Percentage of respondents by years of work experience.

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Generally, the hazard with the highest mention was bottle explosion with a relative frequency of 13%, followed by fall from height/stairs at 10%, manual handling/posturing 10%, slips and trips 10%, high noise level was at 7%, while collision with moving vehicles, carbon dioxide (CO_2) leakage, and machine entrapment stood at 5%. Thus, it can be stated that these hazards are the most likely to occur in brewing and bottling industry based on the findings of this study. Fig 2 shows the inherent hazards by relative frequency in the responses of interviewees.

According to a skilled management staff with 5 years of experience in the business, "to work in a company like this is to be exposed to the risk of bottle cut injuries. There are bottles all around the operation areas". A non-management staff with 13 years in the business corroborated his point by saying 'most incidents are usually of bottle cuts' and typically require first aid treatment. Such injuries occur through bottle explosions, which are common with filled bottles when agitated such as during conveyor movement or forklift movement, pallet collapse, or stepping on cullet littering or breakages. The company under study enforces the use of eye google or face shield and anti-penetration safety boots in work areas with a likelihood of such incident.

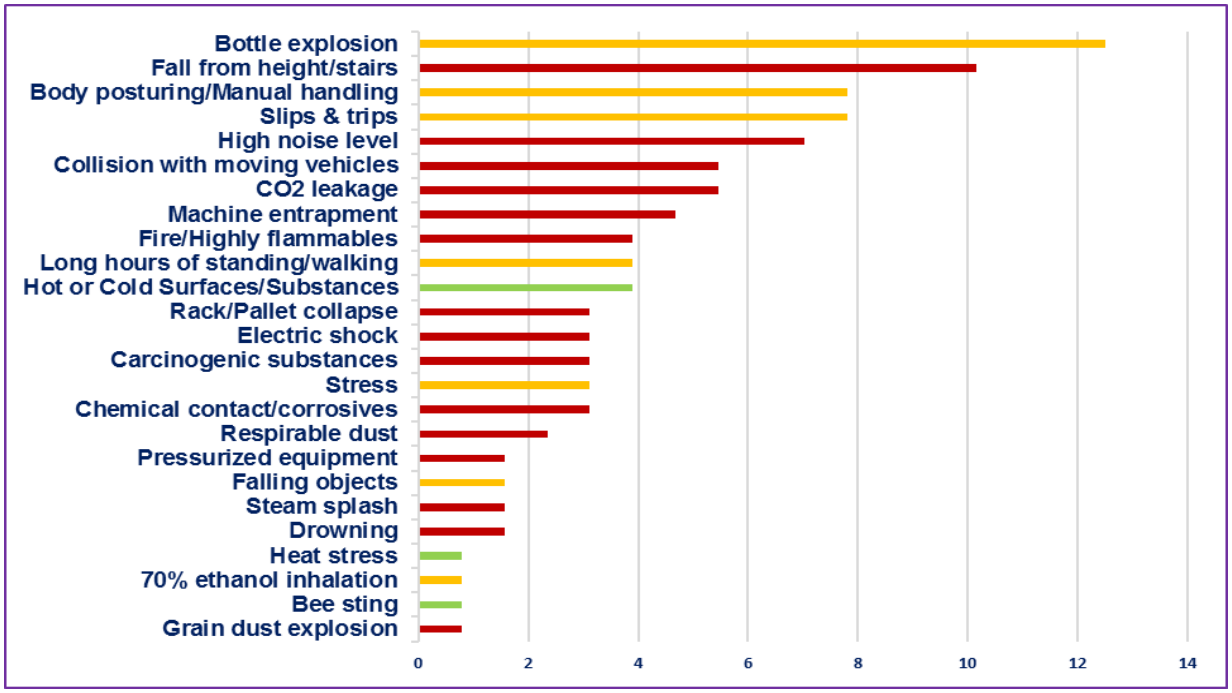

Figure 2. Relative frequency of inherent hazards in the responses of interviewees.

Table 1. Hazard severity.

LEGEND (SEVERITY)		
	HIGH	Fatality; Permanent Disability; Long term chronic diseases
	MODERATE	Accidents; Hospitalization > 3 days ; Temporary disability e.g. severe cuts, broken bones
	LOW	Incident: First Aid Cases/Minor effects such as cuts or bruises or no injury at all

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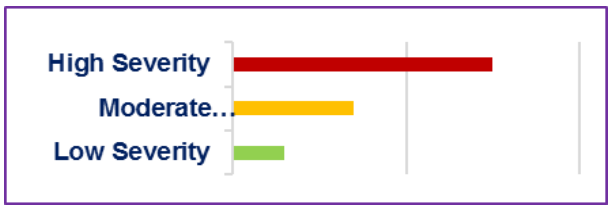

Figure 3. Hazards proportion by severity of effects.

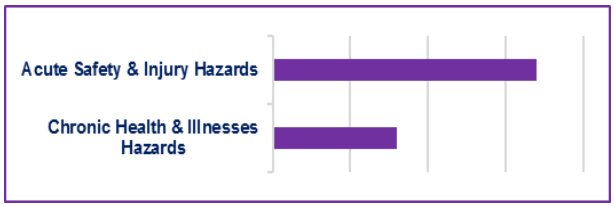

Figure 4. Hazards proportion by type.

Hazards were grouped into 3 classes based on the severity of effects. The high severity hazards are those whose effects can be fatal, lead to permanent disability or long-term chronic diseases. The moderate hazards lead to hospitalization, lost days of over 3 days, or temporary disabilities. Low severity hazards typically require first aid treatment, with only minor effects or no injuries at all. Highly severe hazards are those with red bars in Fig. 2., moderate hazards appear in yellow bars, while the low severity hazards appear in green bars.

Of the 25 hazards mentioned by respondents, 15 (60%) were of high severity, 7 (28%) were of moderate severity, and 3 (12%) were of low severity. This shows that the majority of hazards inherent in the brewing and bottling industry are of high severity with likely effects such as fatality, permanent disability, or long-term chronic diseases. Thus, upholding safety standards should be of utmost priority to avoid continuous accidents and injuries.

The most severe hazards found were falls from height/stairs, high noise level, collision with forklifts or trucks, carbon dioxide (CO_2) leakage which leads to suffocation, machine entrapment, fire outbreaks, collapse of stacked items, electrocution, exposure to carcinogenic substances and corrosives, grain dust explosion, and drowning. Those with moderate severity are bottle cuts, musculoskeletal disorders from manual handling, slips and trips, occupational stress, falling objects, hot surfaces, and possible bee stings at the sugar dissolving plant.

Respondents particularly emphasized the severity of forklift collision and fall from height hazards. A highly skilled logistics personnel with several years of experience in the business described forklifts by saying, “at about 4 tonnes in weight and two sharp protruding forks at the anterior, the forklift qualifies as a weapon of mass destruction and deserves special attention”. Fall from height as well as machine entrapment injuries typically include fractures, permanent disabilities, and death in most cases while carbon dioxide poisoning is especially dangerous by virtue of being an odourless and colourless gas difficult to detect with bare nostrils, unlike other toxic gases like ammonia, hydrogen-sulfide gas (H_2S), etc. These hazards require keen attention and management.

Regarding the hazard category, 17 (68%) of the hazards are safety and injury hazards that cause immediate physical injury to workers while 8 (32%) are chronic and illnesses hazards that result in the development of diseases and are usually long-term. Thus, most of the hazards faced have obvious and immediate impacts. Regarding the classes of hazards, 15 (60%) were physical hazards, 7 (28%)

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chemical, 1 (4%) ergonomic, 1 (4%) psychosocial, and another 1 (4%) biological. This is illustrated in Fig. 10.

Table 2. Hazard register showing hazards recorded, their effects, severity, category and class.

HAZARD REGISTER (GENERAL)					
Hazard	Effects	Relative Frequen	Severi	Categc	Class of Hazar
High noise level	Headache, Elevated blood pressure, fatigue, ear defects	7%	HIGH	Chronic	Physical
Grain dust explosion	Death, Temporary/Permanent Disability	1%	HIGH	Acute	Chemical
Respirable dust	Chronic respiratory disease	2%	HIGH	Chronic	Chemical
Rack/Pallet collapse	Severe bodily injuries	3%	HIGH	Acute	Physical
Drowning	Death	2%	HIGH	Acute	Physical
Fall from height/stairs	Permanent disability, Death	10%	HIGH	Acute	Physical
Machine entrapment	Permanent disability, Death	5%	HIGH	Acute	Physical
CO2 leakage	Suffocation	5%	HIGH	Acute	Chemical
Chemical contact/corrosives	Skin burn, rash; Absorption into blood stream	3%	HIGH	Chronic	Chemical
Steam splash	Extreme skin burns	2%	HIGH	Acute	Physical
Fire/Highly flammables	Skin burn, loss of property, death	4%	HIGH	Acute	Chemical
Carcinogenic substances	Increase the risk of cancer	3%	HIGH	Chronic	Chemical
Pressurized equipment	Temporary/Permanent Disability; Death	2%	HIGH	Acute	Physical
Collision with moving vehicles	Temporary/Permanent Disability; Death	5%	HIGH	Acute	Physical
Electric shock	Burns; Caridac arrest; Electrocution	3%	HIGH	Acute	Physical
Bottle explosion	Deep cuts, Bruises, Lacerations	13%	MODERATE	Acute	Physical
70% ethanol inhalation	Nausea/Unconciousness; Chronic diseases	1%	MODERATE	Chronic	Chemical
Falling objects	Head injury, bruises, fractures, strain	2%	MODERATE	Acute	Physical
Slips & trips	Fractures, Bruises, Cuts	8%	MODERATE	Acute	Physical
Body posturing/Manual handling	Musulosketal disorders	8%	MODERATE	Chronic	Ergonomic
Stress	Depression, Anxiety, High blood pressure	3%	MODERATE	Chronic	Psychosoc ial
Long hours of standing/walking	Higher risk of stroke; Body pains, Fatigue	4%	MODERATE	Chronic	Physical
Hot or Cold Surfaces/Substances	Skin burns, Scalds, Frost bites	4%	LOW	Acute	Physical
Bee sting	Skin reactions, Breathing difficulty	1%	LOW	Acute	Biological
Heat stress	Heat stroke, heat exhaustion, heat cramps, or heat rashes	1%	LOW	Acute	Physical

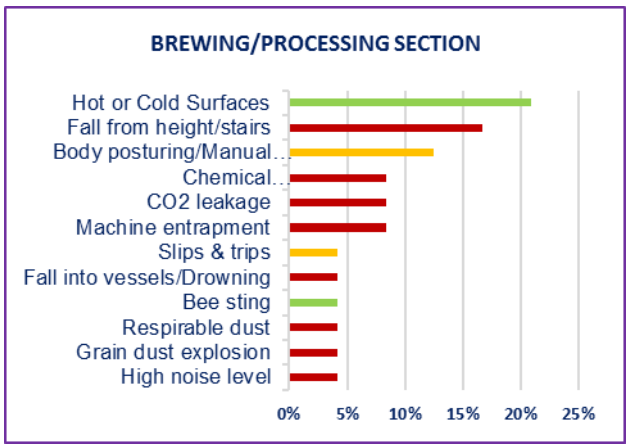

Figure 5. Hazards in processing unit.

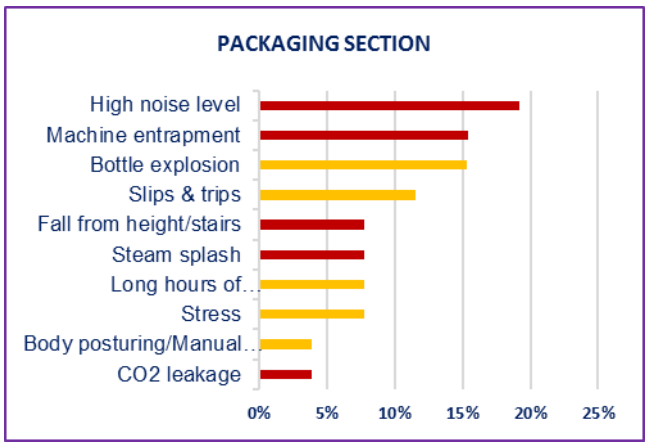

Figure 6. Hazards in packaging unit.

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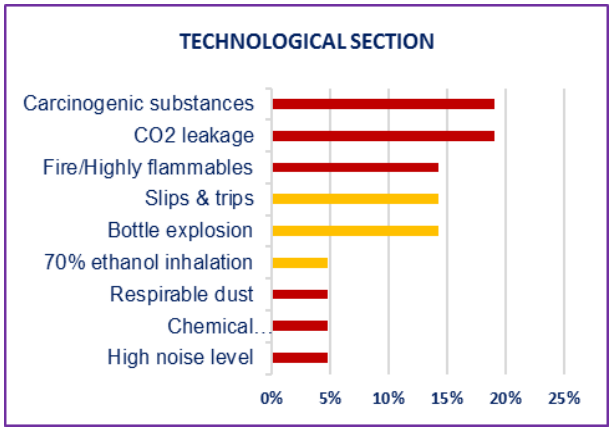

Figure 7. Hazards in technological unit.

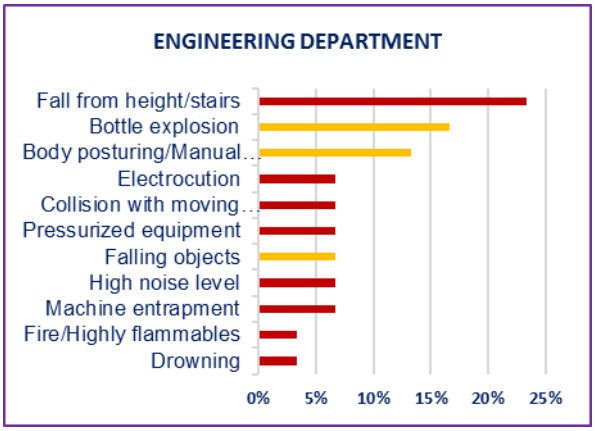

Figure 8. Hazards in engineering unit.

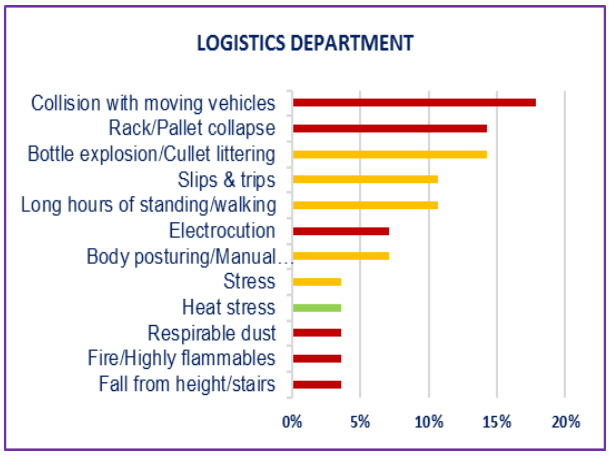

Figure 9. Hazards in logistics unit.

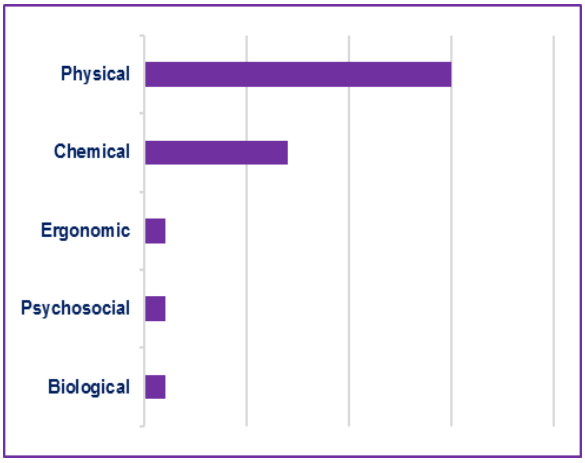

Figure 10. Hazard proportion by category.

The brewing and bottling business relies largely on automation, while some level of manual handling which may require repetitive body motion is required [4]. This explains why the majority of hazards mentioned by respondents are physical, chemical, and ergonomic hazards. Physical hazards which also consists of mechanical hazards include cuts, bruises, and punctures from broken bottles, glass, flying glass, etc. which could result from cullet littering or bottle explosion, fall from height, falls from slippery floors, crushing by forklift or trucks, machine entrapment or confined space injuries, falling objects, pallet collapse, burns, noise from machines due to high-level automation, electric shock, and fire hazards. These hazards are particularly rampant in packaging, engineering, and logistics units.

Chemical hazards include exposure to carbon dioxide (CO_2) leakage and other refrigerant gases like ammonia (NH_3) with workers working in confined spaces, beer tank rooms of the brewing sections, and the bottle and can filling machines of the packaging section particularly exposed to such. Among the hazards are the inhalation of toxic fumes, grain dust and other breathable dust, grain dust

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explosions, exposure to highly corrosive chemicals or carcinogenic substances, as well as inhalation of 70% alcohol. Chemical hazards are particularly rampant in the technological sections which cover the laboratories and quality checks, as well as the brewing sections.

The likelihood of musculoskeletal disorders arising from manual handling/heavy lifting, overreaching, bad posturing, etc. is what is referred to as ergonomic hazards [2]. Ergonomics relates to designs for efficiency and comfort in the working environment. Psychosocial hazards also exist in the industry as a result of mental job demands of certain roles, working long hour shifts for about 50 weeks a year, pressure on the job, work-family role conflicts, and other factors that may lead to job dissatisfaction, anxiety, depression, and in extreme cases, high blood pressure. While biological hazards may occur in form of exposure to organic dust, rodents, and reptile bites, the frequency occurrence is however negligible in the industry going by respondent's responses.

5. CONCLUSION

The paper has centered on inherent hazards in the brewing and bottling company with the most likely and the most severe hazards identified. It is evident from the findings of the study that the majority of the inherent hazards are of high severity with the potential to lead to death, permanent disability, or long-term chronic diseases. Thus, organizations need to have actionable and practical measures for prevention and control. This can be achieved through a proactive safety program with top management commitment.

A proactive safety program anticipates and tries to prevent accidents, and takes place before an accident has occurred. Management has to emphasize accident prevention, appoint a specialist to handle and advise on occupational safety issues, set up OSH committees that will consist of members from various departments, conducts constant inspections and job hazard analysis programs, take on continuous safety education and training that extends to all sections and categories of staff, and accident analysis that focuses on root causes, not apportioning blames when accidents do occur. All these are usually more feasible with a designated department and member(s) of staff that are specialists in the field handling OSH issues.

While the provision of adequate and relevant training is key, other more direct ways of preventing the common incidents/accidents associated with the many inherent hazards in the industry include the provision and ensuring use of safety gears, otherwise known as personal protective equipment (PPE), machine guarding, use of safe work procedures, continuous safety awareness, strategic use of safety signage to communicate OSH rules and information, fixed and mobile gas detection systems, education on fire prevention and provision of fire-fighting equipment.

PPE's such as eye goggles, face shields, and protective clothing can be used in areas with the likelihood of bottle explosion to prevent cuts while earplugs and earmuffs can be used in areas with noise levels of over or around the permissible exposure limits (90 decibels - dB(A) in Nigeria). Protective clothing like laboratory coats or coveralls eye googles, nose masks, and gas masks with

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appropriate particulate or gas filters can prevent workers from exposure to chemicals and carcinogenic substances, especially in the technological or quality department. Use of helmets and a full safety harness/belt should be enforced for workers working at height over 2 meters high while employees should be encouraged to always use handrail while on stairs to prevent a fall from height and falling objects. The use of handrails while on stairs can be communicated through the use of signage at strategic locations. Signage can also be placed on hot or extremely cold surfaces to caution employees on avoiding direct contact with them.

A maintenance plan strictly adhered to, machine guarding and ensuring dangerous machines are properly shut off and are not able to unexpectedly release hazardous energy during maintenance activities by putting a lock on switches, a concept commonly known as Lock-Out-Tag-Out (LOTO), is key to preventing machine entrapment, electrocution, and pressurized equipment hazards. To prevent risks such as suffocation associated with carbon dioxide (CO_2) leakage, fixed gas detection systems that blow warning alarms when dangerous gases exceed acceptable levels should be installed in areas with the likelihood of gas leakages. Workers can also be provided with mobile gas detectors where possible as this will allow for gas testing in confined spaces, where dangerous gases may have accumulated before entry for works. The likelihood of collision with moving vehicles, a common hazard in logistics departments can be reduced by clearly separating pedestrian walkways from driveways and enforcing the use of reflective vests by all within the operating areas for increased visibility. Speed limits are also key to preventing forklift and logistics truck-related accidents.

Above all, accepting that brewing and bottling is a high-risk industry pervaded by high-potential hazards and adopting a pro-active safety program that carries all workers along by providing relevant and continuous safety education and training to all, conducting constant inspection and job hazard analysis programs, implementing countermeasures for hazards identified, rewarding and recognizing involved employees that comply, reporting, and suggesting improvement of OSH standards and using an accountability system that does not tie discipline to accidents is key to accident prevention in the industry.

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