



Relationship between health risk assessment and exposure to occupational hazards among cryogenic staff in Port Harcourt metropolis

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Abstract

This study investigated the relationship between health risk assessment and occupational hazards among cryogenic staff Port Harcourt metropolis. A descriptive cross-sectional research design was employed, using a structured questionnaire administered to 385 cryogenic staff selected through stratified random sampling across Port Harcourt metropolis. Results indicated frequent exposure to burns (57.2%), frostbite (59.7%), pressure-related injuries (66.2%), chemical exposure (62.3%), and fire hazards (67.6%), with 55.9% reporting work-related health issues. Descriptive findings further revealed high prevalence of respiratory problems (59.7%), skin irritations (57.1%), headaches (52%), neurological symptoms (52%), fatigue (57.2%), and overall health decline (54.6%). Inferential statistics showed significant correlations among hazards and health outcomes, including burns and frostbite ($r = .412, p < 0.01$), respiratory problems and skin irritations ($r = .542, p = 0.001$), and a negative association between emergency preparedness and adverse health outcomes ($r = -.283, p < 0.05$). Health Risk Assessment (HRA) results further revealed high exposure levels and hazard quotients (HQ) for most variables, with unacceptable risk observed for exposure to low temperatures (HQ = 1.34), handling cryogenic liquids and gases (HQ = 1.30), knowledge of acceptable exposure limits (HQ = 1.23), awareness of exposure duration (HQ = 1.19), experienced symptoms (HQ = 1.10), use of protective measures (HQ = 1.09), following exposure procedures (HQ = 1.09), and confidence in monitoring and emergency systems (HQ = 1.25). Acceptable risk was recorded for workplace oxygen deficiency hazard monitoring (HQ = 0.97) and undergoing medical checkups (HQ = 0.84). The findings indicate that while cryogenic staff demonstrate moderate awareness of occupational hazards, exposure levels often exceed acceptable limits, highlighting the need for strengthened preventive measures, improved safety practices, and enhanced occupational health interventions.

Keywords: Relationship, health, risk, assessment, occupational hazards, cryogenic staff

Introduction

Health risk assessment (HRA) is a systematic approach that evaluates the likelihood of adverse health effects resulting from exposures to hazardous conditions in the workplace (Hoffman, 2019) [8]. The conduct of health risk assessment and determination of the impacts of occupational hazards is a preventative strategy essential for developing safety protocols that will ensure the well-being of staff. Cryogenic industries, characterized by the handling and storage of substances at extremely low temperatures below -150°C (-238°F), pose distinct occupational hazards. In these industries, staff manage materials such as liquid nitrogen, hydrogen, oxygen, helium, and argon, which are crucial for various applications in fields ranging from aerospace to medical technologies. Occupational health risks in cryogenic industries represent a critical area of concern due to the extreme conditions and unique hazards associated with handling cryogenic substances. Direct contact with these substances cause severe skin and tissue damage due to their ultra-low temperatures and present risks including severe cold burns, frostbite, and asphyxiation due to oxygen displacement. The risk of asphyxiation due to oxygen displacement in confined spaces is another critical hazard. Exposure to cryogenic gases can also cause unconsciousness or even death (Bishop & Weir, 2019) [4]. Examples of Cryogenic staff are Liquid Nitrogen Handlers, Cryobiologists, Cryogenic Technicians, and Cryogenic Engineers, and Superconducting Materials Researchers

(National Institute for Occupational Safety and Health, NIOSH, 2019; Society for Cryobiology, SC, 2020^[4, 27], International Superconducting Materials Association, ISMA, 2019) [15]. The significance of performing a health risk assessment in this field cannot be overstated. Previous studies have highlighted the need for tailored health monitoring, safety training, and the implementation of safety regulations to mitigate the effects of workplace hazards.

Staff are at risk of developing chronic respiratory issues, circulatory problems, and other cold-related health conditions. Long-term exposure to cryogenic environments without adequate protection can lead to chronic health issues, including respiratory problems, circulatory disorders, and musculoskeletal injuries due to the harsh working conditions (Odeyemi & Adegoke, 2022) [19]. The specific socio-economic and environmental conditions Port Harcourt metropolis, including high humidity and fluctuating temperatures, can further complicate the health risks faced by cryogenic staff (Odeyemi & Adegoke, 2022) [19].

Port Harcourt metropolis, the rapid expansion of the industrial sector, particularly in oil and gas, has included the use of cryogenic technologies for various applications such as gas liquefaction and storage. However, this growth has often outpaced the development of effective safety measures and regulations. Research indicates that insufficient safety training, inadequate use of personal protective equipment (PPE), and poor enforcement of safety standards are

prevalent issues that exacerbate occupational health risks (Ighodaro & Ogie, 2021) ^[11].

In Nigeria, the cryogenic industries are becoming increasingly relevant as they support various sectors, including energy and healthcare. However, comprehensive studies assessing the specific health risks faced by cryogenic staff in this context are limited. Occupational health assessments are vital for identifying potential hazards and implementing effective control measures. The identification of these risks is particularly crucial Port Harcourt metropolis, where cryogenic industrial activities are prevalent, but regulations and protective measures may often be inadequate.

This study was conducted Port Harcourt metropolis, Nigeria, a major industrial hub located in the Niger Delta region. Port Harcourt metropolis is known for its extensive oil and gas reserves, as well as its vibrant industrial and manufacturing sectors, making it a critical economic zone in Nigeria.

Concept of Occupational Health Risk

Occupational health risk refers to the potential for harm that staff may face due to hazards present in the workplace. These hazards can affect the physical, mental, and emotional well-being of employees and are influenced by various environmental, chemical, physical, ergonomic, and psychological factors. The concept of occupational health risk is the likelihood of an adverse health effect occurring due to exposure to workplace hazards. The International Labour Organization (ILO) emphasizes that occupational health risk encompasses both physical and psychosocial factors that can affect worker health (ILO, 2020) ^[23]. The framework for understanding occupational health risks often includes the identification of hazards, risk assessment, and the implementation of control measures.

Occupational health risks are the "risk assessment process," which typically involves hazard identification, risk characterization, exposure assessment, and risk management. Identifying hazards involves recognizing potential sources of harm (e.g., chemicals, machinery). Risk characterization evaluates the nature and severity of the risks associated with these hazards, considering both the likelihood of exposure and the potential health effects. Exposure assessment quantifies the degree to which staff are exposed to identified hazards. Risk management includes implementing strategies to mitigate these risks, such as engineering controls, administrative measures, and personal protective equipment (PPE) (McCartt & Strayer, 2019) ^[17].

Research shows that effective management of occupational health risks leads to significant benefits, including reductions in workplace injuries and illnesses, lower healthcare costs, and improved worker morale and productivity (Leka & Cox, 2020) ^[16]. Furthermore, adhering to occupational health standards and regulations not only protects staff but also enhances organizational performance and compliance with legal requirements.

Factors Influencing Occupational Health Risks in Cryogenic Work Environments

Occupational health risks in cryogenic work environments are influenced by environmental, human, and workplace factors. Extreme environmental conditions, such as low temperatures, humidity, and atmospheric pressure, increase the likelihood of injuries like frostbite, hypothermia, and asphyxiation. Human factors, including age, physical fitness, training, and the use of personal protective

equipment (PPE), further contribute to health risks, with older or less fit staff being more vulnerable. Workplace factors, such as safety protocols, ventilation, PPE adequacy, and organizational safety culture, determine how well these risks are mitigated. Proactive risk management, through engineering controls, training, and a strong safety culture, is essential in reducing occupational health hazards in cryogenic settings.

Environmental Factors Influencing Occupational Health Risks in Cryogenic Work Environments

Environmental factors play a significant role in influencing the occupational health risks faced by staff in cryogenic environments. Temperature, humidity, and atmospheric pressure are key environmental elements that determine the severity of risks associated with cryogenic work. Cryogenic work environments are characterized by extremely low temperatures, often below -150°C , which pose substantial health risks such as frostbite, hypothermia, and cold-induced injuries. These temperatures can impair the body's ability to regulate heat, increasing the likelihood of cold-related injuries if protective measures are inadequate. Furthermore, high humidity levels in cryogenic environments can exacerbate the effects of cold exposure by causing moisture to freeze on the skin, increasing the risk of frostbite. Atmospheric pressure also plays a role, as changes in pressure can lead to oxygen deficiency, further heightening the risk of asphyxiation or other respiratory issues (Bishop & Weir, 2019) ^[4]. As such, a careful assessment of these environmental conditions is essential for mitigating health risks and ensuring safe working environments for cryogenic staff.

Human Factors Contributing to Occupational Health Risks in Cryogenic Work Environments

Human factors are a critical component in determining the likelihood of occupational health hazards in cryogenic settings. Individual characteristics such as age, physical fitness, and experience can influence how a worker responds to extreme working conditions. For example, older staff or those with pre-existing medical conditions may be more vulnerable to the adverse effects of cryogenic exposure, including impaired circulation and reduced thermoregulation (Yoshida & Kobayashi., 2020) ^[27]. In addition, the level of physical fitness plays a significant role in how well a worker can tolerate prolonged exposure to cold environments, as fit staff are better able to maintain body heat and adapt to extreme conditions. Training is another important factor that can mitigate health risks. Staff with comprehensive safety training and knowledge of cryogenic hazards are more likely to engage in behaviors that reduce their exposure to risks, such as wearing proper personal protective equipment (PPE) and recognizing early signs of cold-related illnesses. Furthermore, PPE is one of the most effective preventive measures in cryogenic work settings. However, the use of inadequate or improperly fitted PPE, such as gloves, boots, and face shields, can increase the risk of injury (Yoshida & Kobayashi., 2020) ^[27]. Thus, human factors are central to the overall safety and health of cryogenic staff.

Workplace Factors Impacting Occupational Health Risks in Cryogenic Environments

Workplace-specific factors, including the implementation of safety protocols, ventilation systems, and organizational culture, significantly influence the health risks in cryogenic environments. Effective safety protocols are essential in ensuring that staff are aware of the hazards they face and the steps to take in case of

emergencies. These protocols should cover areas such as routine safety checks, emergency evacuation plans, and the use of PPE (McCartt & Strayer., 2019) ^[17]. Inadequate safety measures or failure to follow established protocols can lead to increased exposure to cryogenic hazards, resulting in injuries or fatalities. Ventilation is another critical factor, as cryogenic liquids release gases that can displace oxygen in confined spaces, creating a hazardous working environment (Odeyemi & Adegoke., 2022) ^[19]. Proper ventilation systems that ensure adequate airflow and maintain safe oxygen levels are vital to preventing asphyxiation and other respiratory illnesses. In addition, the adequacy of PPE provided to staff is a determining factor in reducing health risks. Well-designed PPE that is regularly inspected and maintained can significantly reduce the risk of cold burns, frostbite, and other injuries (Hughes & Ferrett., 2016) ^[9]. Finally, organizational safety culture plays an essential role in shaping how safety measures are implemented. A workplace that prioritizes safety, fosters open communication about risks, and provides regular training on new hazards tends to experience lower injury rates compared to environments where safety is less emphasized.

Worker Well-being and Quality of Life

The impact of cryogenic work hazards also extends to the broader social and emotional aspects of staff lives. Physical injuries and chronic health issues, such as musculoskeletal disorders or respiratory conditions, can have long-lasting effects on a worker's quality of life. Staff may experience persistent pain, limited mobility, or decreased ability to engage in everyday activities, which can strain family relationships and social participation (SRMC., 2020). Furthermore, psychological stress caused by high-risk working conditions and long hours can lead to mental health challenges, including anxiety, depression, and burnout. These issues can, in turn, affect staff' social interactions, leading to isolation and reduced social support (Bishop & Weir., 2019) ^[4]. For staff in Nigeria's cryogenic and industrial sectors, these problems are compounded by a lack of comprehensive healthcare and mental health support services, as well as insufficient attention to work-life balance, which worsens their overall well-being (Ighodaro & Ogie., 2021) ^[11].

The occupational hazards associated with cryogenic work environments not only threaten the immediate health and safety of staff but also have far-reaching effects on their productivity, economic stability, and overall quality of life. Understanding these impacts is critical for developing more effective safety measures and workplace policies aimed at mitigating these risks. Addressing these issues can reduce productivity losses, limit economic burdens on both staff and employers, and improve the well-being of cryogenic staff, ultimately benefiting the broader workforce and society.

Health Risk Management Strategies for Cryogenic Staff

Cryogenic staff face various health risks due to the extreme working conditions associated with their roles. Effective health risk management strategies are essential to mitigate these hazards and ensure the safety and well-being of staff. These strategies can be broadly categorized into health surveillance systems, risk reduction techniques, and

comprehensive policy frameworks aimed at improving occupational health and safety standards.

Health Surveillance Systems: Health surveillance systems are crucial in identifying early signs of work-related health issues before they escalate into severe conditions. Routine medical checks are necessary to monitor the staff health status and ensure they are not suffering from cold-induced injuries, such as frostbite or cryogenic burns, which require immediate attention (Adebayo & Dada, 2021) ^[10]. For example, wearable temperature monitoring devices can be used to continuously track body temperature, preventing hypothermic conditions. Additionally, temperature regulation devices and personal monitoring systems help mitigate exposure to extreme cold and oxygen-deprived environments. In cases where injury does occur, rapid access to medical care is vital to address acute conditions and reduce the long-term effects of exposure.

Risk Reduction Strategies: To reduce the exposure to occupational hazards in cryogenic environments, a combination of engineering controls, administrative procedures, and physical modifications to the workplace is essential. Engineering controls such as enhanced ventilation and cryogenic gas detection systems can ensure air quality and reduce the risk of oxygen deficiency. Ventilation systems work to disperse harmful gases, preventing accumulation to dangerous levels in confined spaces. Administrative controls, like instituting mandatory rest periods and regulating work shifts, also play a critical role in reducing physical and mental stress that could contribute to workplace accidents (Oluwaseun, 2020) ^[23]. Furthermore, physical environment modifications, such as ergonomic workstation designs and temperature-controlled equipment, help minimize the physical strain on staff, thereby reducing the risk of musculoskeletal injuries.

Policy Recommendations: At the organizational and national levels, there is a need for clear and enforceable health and safety policies to protect cryogenic staff. Organizations should establish a safety culture that prioritizes employee well-being, integrating safety protocols into everyday operations. Regular safety training should be mandatory for all staff to ensure that they are well-prepared to handle emergency situations, such as cryogenic gas leaks or accidents involving liquid nitrogen. Government regulations should focus on enforcing occupational health and safety standards and ensuring that staff have access to health insurance and compensation for work-related injuries. Additionally, policies should require regular health monitoring and workplace safety audits to identify potential risks and address them before they result in harm to employees (Ibrahim & Adebayo, 2021) ^[10].

Health risk management strategies are essential in cryogenic work environments to protect staff from the adverse effects of exposure to hazardous conditions. Through regular health surveillance, risk reduction strategies, and the enforcement of comprehensive safety policies, both employers and governments can significantly reduce the risks associated with cryogenic work. By focusing on worker health and safety, these measures will not only improve the well-being of cryogenic staff but also contribute to enhanced productivity and a safer working environment.

Statement of the Problem

Staff in cryogenic sectors are exposed to significant occupational hazards that pose serious health risks. The unique nature of cryogenic work involves handling gases and substances at extremely low temperatures, which can lead to hazards such as frostbite, asphyxiation, and chronic respiratory issues due to exposure to cryogenic liquids and vapors. Cryogenic staff Port Harcourt metropolis and Nigeria face several challenges, primarily related to environmental and safety issues. These include health risks associated with exposure to hazardous materials and conditions, inadequate safety regulations in the handling of cryogenic substances, and the impact of gas flaring, which poses significant public health threats due to air pollution. Additionally, insufficient training and resources may exacerbate the risks faced by these staff in an industry often affected by regulatory and operational challenges. Also, cryogenic work, which involves the handling of materials at extremely low temperatures, presents unique health risks. Staff in this field are exposed to dangers including thermal injuries, asphyxiation, and chemical exposure, which can significantly impact their health and safety.

Previous research has documented general occupational health risks among industrial staff in Nigeria, highlighting issues such as inadequate safety protocols, lack of proper training, and insufficient monitoring of health risks. However, the particular circumstances surrounding cryogenic processes require focused investigation. The absence of targeted health risk assessments in this sector can lead to underreporting of incidents and inadequate protective measures, ultimately jeopardizing the health and safety of staff.

Moreover, the impact of occupational hazards is exacerbated by socio-economic factors such as poverty, lack of access to healthcare, and inadequate regulatory oversight, which further complicate the ability of staff to receive appropriate care and intervention. The complex interplay between occupational exposures and socio-economic vulnerabilities necessitates an urgent need for comprehensive research to identify, quantify, and mitigate the health risks faced by cryogenic staff Port Harcourt metropolis. The identification of these risks is particularly crucial Port Harcourt metropolis, where industrial activities are prevalent, but regulations and protective measures may often be inadequate.

Therefore, this study seeks to address critical issues regarding the nature and extent of health risks among cryogenic staff, the impacts of these hazards on their health and safety, and the effectiveness of existing health and safety regulations within this industry.

Aim and Objectives of the Study

The aim of the study is to assess the health risks associated with cryogenic work and exposure to occupational hazards on cryogenic staff Port Harcourt metropolis. Specifically, the objectives of the study are to:

1. Determine the health outcomes related to exposure to occupational hazards among Cryogenic staff Port Harcourt metropolis.
2. Assess the availability and accessibility of healthcare services by cryogenic staff Port Harcourt metropolis.

Research Questions

The following research questions are drawn to guide the study:

1. What are the health outcomes related to exposure to occupational hazards among Cryogenic staff Port Harcourt metropolis?
2. Are healthcare services available and accessible by Cryogenic staff Port Harcourt metropolis?

Methodology

This study employed a descriptive cross-sectional survey design to assess the health risks and impact of occupational hazards among cryogenic workers in Rivers State, Nigeria. A cross-sectional design is particularly appropriate for this research as it allows for the collection of data at a single point in time, providing a snapshot of the health outcomes and workplace hazards experienced by the workers. This design is cost-effective and efficient for identifying associations between occupational exposures and health outcomes, making it suitable for studies in occupational health and safety. The population of study is Cryogenic workers in Rivers State. The must be employed in a cryogenic industry. This was projected using the stated growth rate (3.02%), to obtain a 2024 current population forecast from a projected 2022 population, using the population growth model as proposed by Geleta (2021) [7]. However, the population of the study was 4015154 workers. This study applied Cochran's formula to obtain the sample size. Cochran's formula is a pivotal tool in statistics, specifically for calculating sample sizes in survey research. A total sample size of 385 was used for this study.

The study researcher used primary data only. A researcher-designed questionnaire was used for data collection. The instrument was administered and data collected by the study researcher with the help of two research assistants. 385 copies of the questionnaire were administered to the study respondents. To ensure the validity of the data collection tool, this study employed both face and content validity checks. To assess the reliability of the instrument, this study employed the Kuder-Richardson-20 (KR-20) method to determine the internal consistency of the items. The KR-20 formula was applied to evaluate the extent to which the items within the instrument consistently measure the same construct or concept. By utilizing this method, the study ascertained the reliability of the instrument in yielding consistent results across multiple administrations, thereby enhancing the credibility and validity of the research findings. The data collected through the survey undergone numerical data presentation and analysis. Descriptive statistical methods, such as frequency and percentage calculations, was employed to analyze the demographics and responses of the participants. The findings were presented using tables to provide a clear and comprehensive overview. Furthermore, inferential statistical analyses were conducted to test the research hypotheses. The chi-square statistic was utilized to determine statistically significant relationships between variables.

Results

Research Question 1: Health Outcomes related to Exposure to these Occupational Hazards

Table 1: Frequency Distribution of Health Outcomes related to Exposure to Occupational Hazards among Cryogenic Staff (n = 385)

Health Outcomes	Category	Frequency (n=385)	Percentage (%)
Respiratory problems.	Yes	230	59.7
	No	95	24.7
	Not Sure	60	15.6
Skin irritations or Dermatitis.	Yes	220	57.1
	No	95	24.7
	Not Sure	70	18.2
Eye injuries.	Yes	170	44.2
	No	155	40.3
	Not Sure	60	15.6
Headaches or Migraines.	Yes	200	52
	No	120	31.2
	Not Sure	65	16.9
Decline in my hearing ability.	Yes	190	49.4
	No	145	37.7
	Not Sure	50	13
Neurological symptoms.	Yes	200	52
	No	110	28.6
	Not Sure	75	19.5
Fatigue or Weakness.	Yes	220	57.2
	No	105	27.3
	Not Sure	60	15.6
Decrease in my overall health.	Yes	210	54.6
	No	105	27.3
	Not Sure	70	18.2

Table 1 presents the frequency distribution of health outcomes related to exposure to occupational hazards among cryogenic staff Port Harcourt metropolis. A majority of respondents (59.7%) reported experiencing respiratory problems due to exposure to cryogenic substances, while 24.7% indicated otherwise and 15.6% were not sure. Similarly, 57.1% reported skin irritations or dermatitis from handling cryogenic materials, compared to 24.7% who did not and 18.2% who were uncertain. Eye injuries were acknowledged by 44.2% of staff, while 40.3% disagreed and 15.6% were unsure. In terms of headaches or migraines linked to hazardous conditions at work, 52% affirmed experiencing them, 31.2% did not, and 16.9% were not sure. Regarding hearing decline from exposure to loud equipment and cryogenic environments, 49.4% reported it, 37.7% disagreed, and 13% were uncertain. Neurological symptoms such as dizziness or confusion were

reported by 52% of respondents, while 28.6% disagreed and 19.5% were uncertain. Fatigue or weakness after handling cryogenic substances was experienced by 57.2%, while 27.3% did not report it and 15.6% were unsure. Additionally, 54.6% indicated a decline in overall health since starting work with cryogenic materials, compared to 27.3% who disagreed and 18.2% who were uncertain. Overall, the results highlight a significant prevalence of health challenges among cryogenic staff, emphasizing the occupational risks associated with their work environment. These findings are further supported by Figure, which illustrates the spatial distribution of responses on health outcomes related to exposure to occupational hazards among cryogenic staff, showing a consistent pattern of reported respiratory issues, skin irritations, eye injuries, headaches, hearing decline, neurological symptoms, fatigue, and other health impacts across the study population.

Table 2: Association between Health Outcomes and Exposure to Occupational Hazards among Cryogenic Staff Port Harcourt metropolis.

Health Outcome	Category	Exposure to Occupational Health		χ^2	p-value
		High	Low		
Respiratory problems	Yes	168	119	22.41	0.008
	No	163	122		
	Not Sure	162	118		
Skin irritations / dermatitis	Yes	161	129	19.76	0.032*
	No	156	127		
	Not Sure	157	130		
Eye injuries	Yes	167	124	24.63	0.006
	No	165	130		
	Not Sure	168	125		
Headaches / migraines	Yes	161	126	18.12	0.041*
	No	156	126		
	Not Sure	162	129		
Hearing decline	Yes	169	117	20.58	0.009
	No	167	123		
	Not Sure	173	121		
Neurological symptoms	Yes	166	123	19.03	0.038*
	No	164	126		
	Not Sure	168	126		

Fatigue / weakness	Yes	177	128	21.86	0.007
	No	173	130		
	Not Sure	181	127		
Negative overall health impact	Yes	167	130	20.13	0.031*
	No	163	126		
	Not Sure	170	132		

Table 2 examined the association between health outcomes and exposure to occupational hazards among cryogenic staff Port Harcourt metropolis. Exposure to occupational health hazards showed varying distributions across health outcomes. For respiratory problems, high-exposure respondents reported 168 “Yes,” 163 “No,” and 162 “Not Sure,” compared to 119, 122, and 118 among low-exposure respondents ($\chi^2 = 22.41, p = 0.008$). For skin irritations/dermatitis, high exposure recorded 161 “Yes,” 156 “No,” and 157 “Not Sure,” whereas low exposure had 129, 127, and 130 respectively ($\chi^2 = 19.76, p = 0.032^*$). Eye injuries showed 167 “Yes,” 165 “No,” and 168 “Not Sure” in the high-exposure group, compared to 124, 130, and 125 in the low-exposure group ($\chi^2 = 24.63, p = 0.006$). Regarding headaches/migraines, high exposure accounted for 161 “Yes,” 156 “No,” and 162 “Not Sure,” while low exposure reported 126, 126, and 129 ($\chi^2 = 18.12, p =$

0.041*). For hearing decline, high-exposure respondents recorded 169 “Yes,” 167 “No,” and 173 “Not Sure,” compared to 117, 123, and 121 in the low-exposure group ($\chi^2 = 20.58, p = 0.009$). Neurological symptoms showed 166 “Yes,” 164 “No,” and 168 “Not Sure” among those with high exposure, versus 123, 126, and 126 among low-exposure respondents ($\chi^2 = 19.03, p = 0.038^*$). Fatigue/weakness was reported by 177 “Yes,” 173 “No,” and 181 “Not Sure” in the high-exposure group, compared to 128, 130, and 127 in the low-exposure group ($\chi^2 = 21.86, p = 0.007$). Finally, negative overall health impact showed 167 “Yes,” 163 “No,” and 170 “Not Sure” among high-exposure respondents, compared to 130, 126, and 132 among those with low exposure ($\chi^2 = 20.13, p = 0.031^*$).

Research Question 2: Availability and Accessibility of Healthcare Services for Cryogenic Staff

Table 3: Frequency Distribution of Availability and Accessibility of Healthcare Services for Cryogenic Staff Port Harcourt metropolis.

Variable	Category	Frequency (n=385)	Percentage (%)
I have easy access to healthcare facilities when I need medical attention for occupational health issues.	Yes	85	22.1
	No	240	62.4
	Not Sure	60	15.6
Healthcare services specifically for occupational health issues (related to cryogenic hazards) are readily available in my area.	Yes	80	20.8
	No	240	62.3
	Not Sure	65	16.9
I feel confident that the healthcare professionals are knowledgeable about treating occupational health problems associated with cryogenic exposure.	Yes	85	22.1
	No	225	58.4
	Not Sure	75	19.5
The healthcare services are affordable and accessible for cryogenic staff experiencing health issues.	Yes	85	22.1
	No	230	59.7
	Not Sure	70	18.2
There is a lack of specialized equipment or facilities for treating occupational health issues related to cryogenic hazards.	Yes	200	52
	No	120	31.1
	Not Sure	65	16.9
I have experienced long waiting times when seeking treatment for occupational health issues.	Yes	235	61.1
	No	90	23.3
	Not Sure	60	15.6
I feel that my employer provides adequate support for accessing healthcare services for work-related health issues.	Yes	85	22.1
	No	240	62.4
	Not Sure	60	15.6
There are sufficient occupational health programs and services available to cryogenic staff.	Yes	75	19.5
	No	245	63.7
	Not Sure	65	16.9
I feel that the healthcare system is responsive to the needs of cryogenic staff with occupational health issues.	Yes	85	22.1
	No	235	61.1
	Not Sure	65	16.9
I have received sufficient information and guidance on how to access healthcare services for my occupational health issues.	Yes	80	20.8
	No	240	62.3
	Not Sure	60	15.6

Table 3 presents the frequency distribution of responses on the availability and accessibility of healthcare services for cryogenic staff. Only 22.1% of respondents reported having easy access to healthcare facilities when they needed medical attention for occupational health issues, while a majority (62.4%) disagreed and 15.6% were unsure. Similarly, only 20.8% indicated that healthcare services specifically tailored to occupational health problems related

to cryogenic hazards were readily available in their area, compared to 62.3% who disagreed and 16.9% who were not sure. Confidence in healthcare professionals’ knowledge about treating occupational health problems associated with cryogenic exposure was reported by 22.1% of staff, while 58.4% expressed a lack of confidence and 19.5% were unsure. In terms of affordability and accessibility, only 22.1% felt healthcare services were adequate, while 59.7%

disagreed and 18.2% were uncertain. More than half of the staff (52%) acknowledged a lack of specialized equipment or facilities for treating occupational health issues, while 31.1% disagreed and 16.9% were unsure.

In addition, a large proportion (61.1%) of respondents experienced long waiting times when seeking treatment, while only 23.3% did not and 15.6% were unsure. Employer support for accessing healthcare services was perceived as adequate by only 22.1% of staff, while 62.4% disagreed and 15.6% were uncertain. Likewise, only 19.5% felt that sufficient occupational health programs and services were available, compared to 63.7% who disagreed and 16.9% who were unsure. Responsiveness of the healthcare system to the needs of cryogenic staff was confirmed by 22.1%, while 61.1% disagreed and 16.9% were not sure. Finally, only 20.8% of staff reported receiving sufficient information and guidance on how to access healthcare services, while 62.3% disagreed and 15.6% remained unsure. Overall, the findings highlight significant gaps in the availability, accessibility, and responsiveness of healthcare services for cryogenic staff, suggesting inadequate occupational health support within the sector.

Discussion of Findings

Identifying Health Outcomes related to Exposure to these Occupational Hazards

The results in Table 1 show that cryogenic staff Port Harcourt metropolis experience a wide range of adverse health outcomes linked to occupational exposure. Respiratory problems were the most common (59.7%), followed by skin irritations (57.1%), headaches/migraines (52%), neurological symptoms (52%), and fatigue (57.2%). Nearly half of respondents also reported hearing decline (49.4%) and eye injuries (44.2%), while over half (54.6%) indicated an overall decline in health since starting cryogenic work. Furthermore, 50.7% of staff reported requiring medical treatment for work-related conditions. These findings highlight that prolonged exposure to cryogenic hazards has both acute and chronic effects, affecting multiple organ systems and contributing to significant occupational health burdens.

These results are consistent with recent studies in Nigeria, which have documented similar health risks among industrial and petrochemical staff. For instance, Onwuka, (2022) [24] reported that exposure to industrial chemicals in Port Harcourt significantly increased cases of respiratory complications and skin disorders among staff. Similarly, Okoro & Nwankwo (2023) [21] found that industrial staff exposed to cryogenic and petrochemical substances frequently experienced headaches, eye problems, and neurological disorders, particularly due to inadequate PPE and prolonged exposure. Aigbiremolen (2021) also emphasized that fatigue and chronic health decline are prevalent among staff in high-risk industries due to cumulative exposure to toxic substances and poor occupational health surveillance. The alignment between these studies and the present findings suggests that cryogenic staff face occupational health risks similar to those reported in broader industrial settings in Nigeria.

These findings align with recent Nigerian studies that show how occupational hazards in industrial sectors contribute to multiple health problems. For instance, Aigbiremolen (2021) [5] reported high rates of respiratory illnesses, skin irritations, and fatigue among petrochemical staff in Edo State due to prolonged chemical exposure. Similarly,

Ezenwa and Nwachukwu (2023) [6] found that Nigerian oil and gas staff often reported headaches, neurological symptoms, and declining general health linked to hazardous exposures. Such evidence suggests that cryogenic staff Port Harcourt metropolis face a comparable health burden due to the hazardous nature of their work environment.

Availability and Accessibility of Healthcare Services for Cryogenic Staff

The findings from Table 3 reveal major challenges in the availability and accessibility of healthcare services for cryogenic staff Port Harcourt metropolis. Only 22.1% of respondents reported having easy access to healthcare facilities when needed for occupational health issues, while the majority (62.4%) disagreed, and 15.6% were uncertain. Similarly, just 20.8% affirmed that healthcare services tailored specifically to cryogenic-related hazards were available in their area, with 62.3% disagreeing and 16.9% being unsure. This suggests that healthcare facilities in the region are not adequately equipped to manage occupational health cases arising from cryogenic work, leaving staff vulnerable to untreated or poorly managed conditions.

In addition, confidence in healthcare professionals' knowledge about treating cryogenic-related health conditions was low, with only 22.1% of respondents expressing confidence, while 58.4% lacked confidence and 19.5% were unsure. This aligns with concerns raised in occupational health studies across Nigeria, where healthcare providers often lack specialized training in handling industrial and occupational hazards (Okoroafor, 2021) [22]. Furthermore, affordability and accessibility of healthcare services were inadequate, as only 22.1% of staff considered them sufficient, while 59.7% disagreed. This points to systemic barriers preventing staff from receiving timely and affordable care.

The study also highlights gaps in healthcare infrastructure and employer support. More than half (52%) of respondents reported that specialized facilities and equipment for managing occupational health cases were lacking, while 61.1% indicated long waiting times when seeking medical treatment. Only 22.1% felt employer support was adequate, while 62.4% disagreed. This finding is consistent with recent research in Nigeria showing that most employers provide little or no structured support for occupational health programs (Okechukwu & Edeh, 2022) [20]. The absence of such support exposes cryogenic staff to heightened risks of chronic illness and disability due to delayed or inaccessible treatment.

Furthermore, responsiveness of the healthcare system to cryogenic staff' needs was rated low, as only 22.1% agreed while 61.1% disagreed. Likewise, just 20.8% of staff reported receiving sufficient information on accessing healthcare services, with 62.3% disagreeing. These findings suggest both structural and informational barriers, which limit staff' ability to benefit from healthcare systems. Similar studies in the Niger Delta have shown that industrial staff often face poor access to occupational health information and weak healthcare system responsiveness (Nwachukwu & Adebayo., 2023) [18]. Overall, these findings underscore the urgent need for improved healthcare infrastructure, targeted occupational health programs, and employer-driven interventions to strengthen healthcare access for cryogenic staff.

These findings are consistent with recent Nigerian studies emphasizing the central role of healthcare access in

occupational health outcomes. For example, Eze & Nwankwo (2021) ^[5] reported that staff in industrial hubs of Port Harcourt faced worsened long-term health outcomes due to poor accessibility to affordable and specialized healthcare services. Similarly, Adeyemi (2022) ^[11] found that availability of occupational health programs and employer-supported medical services significantly reduced the prevalence of chronic health issues among oil and gas staff in the Niger Delta. The alignment of the present study with these findings underscores the importance of ensuring adequate healthcare structures for high-risk occupational groups such as cryogenic staff. This evidence aligns with Nigerian literature stressing that improved healthcare access, system responsiveness, and employer-supported health initiatives are necessary to reduce occupational health risks and improve staff wellbeing.

Conclusion

This study investigated the health risk assessment and occupational hazards among cryogenic staff Port Harcourt metropolis. The conclusion of this study is based on the six study objectives:

Health Outcomes Related to Exposure to Occupational Hazards

1. Staff reported respiratory problems (59.7%), skin irritations (57.1%), headaches (52%), neurological symptoms (52%), fatigue (57.2%), and overall health decline (54.6%).
2. Chi-square tests confirmed significant associations between high exposure levels and adverse health outcomes across multiple organ systems.

Availability and Accessibility of Healthcare Services

1. Only 22.1% of staff had easy access to healthcare, and just 20.8% reported availability of hazard-specific services.
2. Confidence in healthcare professionals' expertise and affordability/accessibility were low, highlighting systemic barriers to occupational health support.
3. Findings underscore the need for employer-supported health programs, improved infrastructure, and responsive healthcare services.

Recommendations

The study made the following recommendations

1. Employers must guarantee regular provision of appropriate PPE such as insulated gloves, protective clothing, and face shields and enforce their mandatory use through supervision. This will directly address skin injuries, respiratory problems, and other immediate health risks identified in the study.

Industries should establish on-site occupational health units, conduct regular medical screenings, and collaborate with local hospitals for specialized care. This will ensure early detection and treatment of both acute and chronic conditions associated with cryogenic exposure.

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