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Occupational Health Risks and Preventive Strategies for Scientists and Engineers in Nasrda Selected Facilities

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Abstract- This study evaluates occupational health risks, individual risk awareness, and preventive strategies for scientists and engineers across five selected National Space Research and Development Agency (NASRDA) Facilities in Nigeria. Using a descriptive cross-sectional research design, a structured questionnaire was administered to fifty (N=50) technical personnel across the selected facilities including Centre for Space Innovation and Development (CSID) Abuja, Centre for Satellite Technology Development (CSTD), Abuja, Bola Ahmed Centre for Space Transport and Propulsion (BATCSTP) Epe, Ground Receiving Station Abuja, and Advanced Space Composite (ASCO) Laboratory, Ilorin. Demographic analysis reveals a highly educated, male-dominated workforce (66%, n=33) where engineers (72%, n=36) significantly outnumber scientists (28%, n=14). Key areas include Electrical/Electronic (32%, n=16), Chemical (18%, n=9), and Mechanical (14%, n=7) engineering units, with 48% (n=24) of the total population holding master's degrees. A severe generational gap was identified, with only 4% (n=2) of personnel aged between 20 and 29 years. Regarding occupational health and safety (OHS) metrics, a systemic paradox emerged: while 70% (n=35) of respondents possess strong personal awareness of their work-related hazards, institutional support is seriously Lacking. Specifically, 44% (n=22) explicitly report a deficit in hazard and risk information delivery from their centres, while 20% (n=10) function without any formal safety training. These administrative communication gaps and training deficits directly expose NASRDA's highly specialized engineering capital within Abuja to preventable physical hazards. The study recommends the integration of comprehensive occupational health and safety management systems tailored to space science facilities in Nigeria, centralized training frameworks to close the 20% training gaps, and structured graduate pipelines to address looming succession risks thereby enhancing workforce protection, productivity, and institutional sustainability.

Keywords: aerospace occupational health and safety, hazard risk awareness, preventive strategies, nasrda, engineering, workplace safety training, institutional communications

I. INTRODUCTION

Background and Context

Occupational health and safety (OHS) in specialized research institutions represents a critical yet often underexplored domain of workplace health protection. Space research facilities, in particular, present unique occupational hazards that extend beyond conventional laboratory and industrial settings, combining advanced technological operations with diverse chemical, physical, biological, and psychosocial risk factors (NASA, 2019; European Space Agency, 2021). Scientists and technicians working in these environments routinely encounter specialized hazards, including exposure to hypergolic propellants, cryogenic materials, ionizing and non-ionizing radiation, electromagnetic fields, composite material dusts, and high-noise environments, while simultaneously managing the psychological demands of mission-critical operations and stringent project timelines (Jones et al., 2020; Kumar & Singh, 2018).

The global space industry has expanded significantly over the past two decades, with an increasing number of nations establishing dedicated space research agencies to advance satellite technology, telecommunications infrastructure, earth observation capabilities, and scientific exploration (United Nations Office for Outer Space Affairs, 2022). This expansion has been particularly notable in developing nations, where space programs serve as catalysts for technological advancement, capacity building, and economic development. However, the rapid growth of space research capabilities in resource-limited settings has not been uniformly accompanied by commensurate development of occupational health infrastructure and safety management systems (Adeleke & Ogunbanwo, 2019; Moeti et al., 2021).

Nigeria's entry into the space sector through the establishment of the National Space Research and

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Development Agency (NASRDA) in 1999 marked a significant milestone in Africa's space exploration endeavors. NASRDA operates as Nigeria's apex space research institution with a mandate encompassing satellite design and development, space science research, ground station operations, and capacity building for the nation's space technology sector (NASRDA, 2020). Key centres such as the Centre for Satellite Technology Development (CSTD), Centre for Space Innovation and Development (CSID), Centre for Space Transport and Propulsion (CSTP), the Ground Receiving Station, and the Advanced Space Composite (ASCO) Laboratory represent highly specialized environments where scientists and technical officers perform precision-driven tasks under potentially hazardous conditions. The Centre for Satellite Technology Development (CSTD) in Abuja, which focuses on satellite design, integration, and testing; the Centre for Space Innovation and Science (CSID) in Abuja, focused on the commercialization of space-based solutions; the Centre for Space Transport and Propulsion (CSTP) in Epe, which researches rocket propulsion systems; and multiple ground receiving stations for satellite data acquisition and processing (Federal Ministry of Science and Technology, 2018).

Over the past two decades, NASRDA has achieved notable successes, including the development and launch of multiple satellites (NigeriaSat-1, NigeriaSat-2, NigeriaSat-X, NigComSat-1R), the establishment of robust ground infrastructure, and the training of Nigerian space scientists and engineers (Boroffice, 2017). The agency employs hundreds of scientists, engineers, and technical personnel engaged in activities ranging from precision satellite assembly in cleanroom environments to high-power radiofrequency operations at ground stations, from propulsion system testing to software development and data analysis. Each of these operational domains presents distinct occupational health challenges that require systematic identification, assessment, and management.

Occupational Health Risks in Space Research Environments

The occupational health risk profile of space research institutions is multifaceted and evolves with technological advancement. Chemical hazards constitute a primary concern, particularly in facilities engaged in satellite assembly, testing, and propulsion research. Workers may be exposed to various solvents used in cleaning and surface preparation, adhesives and epoxy resins in component bonding, thermal control fluids, battery electrolytes, and potentially toxic outgassing products from electronic components and composite materials (Chen et al., 2019; National Institute for Occupational Safety and Health, 2020). In propulsion research facilities, exposure to hydrazine-based propellants, nitrogen tetroxide, and combustion byproducts presents significant acute and chronic health risks (Williams & Peterson, 2021).

Physical hazards in space research environments are equally diverse. Electromagnetic radiation exposure is particularly relevant for personnel operating ground stations, working with radiofrequency testing equipment, or conducting electromagnetic compatibility assessments. Studies from established space agencies have documented elevated electromagnetic field exposures among ground station operators and antenna maintenance personnel, with potential health implications including thermal effects and, controversially, non-thermal biological effects (International Commission on Non-Ionizing Radiation Protection, 2020; Lambrozo et al., 2018). Noise exposure represents another significant concern, particularly in propulsion test facilities, environmental testing chambers (acoustic and vibration), and certain mechanical assembly operations, with potential consequences ranging from noise-induced hearing loss to cardiovascular effects and sleep disturbance (Basner et al., 2014; Lie et al., 2016).

Ergonomic hazards arise from the precision nature of space technology work. Satellite assembly and integration activities often require prolonged periods of standing, overhead work, fine motor tasks with awkward postures, and repetitive motions in cleanroom environments where mobility is restricted by protective garments (García et al., 2017). Microscopy work, quality inspection, and precision soldering operations impose significant visual demands and may contribute to visual fatigue and musculoskeletal complaints in the neck and shoulder regions (Roquelaure et al., 2018). The constrained working conditions within cleanrooms, combined with thermal discomfort from protective clothing, further compound ergonomic stressors (Holm & Kalliokoski, 2020).

Psychosocial and organizational factors represent an increasingly recognized dimension of occupational health in high-technology environments. Space research operations are characterized by stringent quality requirements, mission-critical timelines, high-stakes decision-making, and the potential for significant consequences from errors (Kanas & Manzey, 2008). Mission operations personnel may work extended or irregular shifts to support satellite operations, particularly during launch campaigns, early orbit phases, and anomaly resolution (Barger et al., 2014). The combination of high cognitive demands, time pressure, and shift work creates conditions conducive to fatigue, stress, and potential burnout, with implications for both worker wellbeing and operational safety (Gander et al., 2013; Van Cutsem et al., 2017).

Occupational Health Risks in Developing Nation Space Programs

While occupational health challenges in space research environments are substantial across all contexts, developing nation space agencies face additional constraints that may amplify risks and complicate preventive efforts. Resource limitations often restrict the availability of specialized safety equipment, advanced engineering controls, and comprehensive monitoring instrumentation (Adewole & Desalu, 2017). Infrastructure challenges, including unreliable power supply, inadequate climate control in tropical settings, and aging facilities, may compromise the effectiveness of existing safety measures (Okojie, 2010). Limited access to specialized occupational health expertise familiar with aerospace-specific hazards may result in generic rather than tailored risk management approaches (Occupational Safety and Health Administration, 2015).

Training and capacity building constraints represent another critical challenge. While technical training for space technology competencies receives appropriate emphasis, occupational health and safety training may be under-prioritized due to competing demands and resource constraints (Aderaw et al., 2011). The rapid expansion of space capabilities may outpace the development of safety culture and institutional safety management systems, particularly when experienced international consultants depart, and local expertise remains nascent (Hofmann & Morgeson, 2018). Furthermore, regulatory frameworks for occupational health in developing nations may not adequately address the specialized hazards of space research environments, creating gaps in legal requirements and enforcement mechanisms (International Labour Organization, 2018).

Climate and environmental factors specific to tropical and sub-Saharan African contexts introduce additional considerations. High ambient temperatures and humidity levels exacerbate heat stress risks, particularly for workers in non-climate-controlled facilities or those wearing protective equipment (Kjellstrom et al., 2016). Dust and particulate matter from the external environment may compromise cleanroom operations and air quality, while challenges in maintaining consistent environmental conditions affect both occupational comfort and precision technical operations (Schwela, 2000). Vector-borne diseases, though not directly related to space research activities, affect workforce health and productivity, while limited healthcare infrastructure may constrain access to occupational health services and emergency medical response capabilities (World Health Organization, 2019).

Understanding these risks is essential for developing institutional policies that ensure worker safety while maintaining the high precision and productivity required in space research operations.

II. LITERATURE REVIEW

The literature on occupational health and safety (OHS) reflects a growing emphasis on innovation, proactive risk management, and integrated health promotion strategies across diverse work environments.

Awad Hicham and Ercument Neset Dizdar (2025), in Innovation in Occupational Health and Safety in Africa: A Systematic Review of Technological, Organization, and Strategic Advances, review African OHS innovations, highlighting technological and organizational strategies adopted to address infrastructural and policy challenges typical of resource-constrained settings. Their work is particularly relevant to Nigerian agencies, as it underscores context-specific constraints and the need for adaptive safety frameworks that respond to local realities.

Similarly, Chun-yip Hon and Enrico Bergamaschi (2025), in their editorial Innovative Prevention Strategies for Occupational Health Hazards, synthesize research on emerging approaches to managing a wide range of occupational health risks. These include psychosocial stress, burnout, musculoskeletal disorders, chemical exposure, thermal stress, ergonomic hazards, and risks associated with nanomaterials. The authors emphasize that organizational interventions, health promotion programs, improved ergonomics, mindfulness training, and structured risk assessment frameworks can significantly enhance worker health outcomes. They also highlight the role of advanced technologies such as virtual environments, artificial intelligence, and computer vision in improving hazard identification and workplace safety performance.

Santos Baptista, Castelo Branco, Duarte, and Perestrelo (2025), in Occupational and Environmental Safety and Health: Occupational Risk Assessment, Management and Case Studies, provide comprehensive frameworks for occupational risk assessment, hazard control hierarchies, and safety management systems across technical environments. Their methodologies and case studies support the development of structured Occupational Health and Safety Management Systems (OHSMS), particularly suitable for complex facilities such as research institutions and industrial operations. The book contributes practical models for implementing systematic risk management approaches in high-risk settings.

Ebtisam Abdulqasem Abdulmejeed and colleagues (2024), in their systematic review Occupational Exposure to Hazardous Substances among Laboratory and Health Security Technicians: A Systematic Review of Health Risk and Compliance with Safety Regulation, synthesize evidence on chemical and biological hazards in laboratory settings. The study links exposure risks with compliance to safety regulatory frameworks and emphasizes the hierarchy of controls, exposure assessment, training, and medical surveillance. The authors demonstrate the importance of structured safety protocols and regulatory adherence in minimizing occupational illnesses among laboratory scientists and technicians.

Broader perspectives on the future of occupational safety are presented by Schulte et al. (2020) in Potential Scenarios and Hazards in the work of the future published in the Journal of Occupational and Environmental Medicine. The authors identify emerging risks associated with new technologies and evolving work arrangements. They advocate for proactive, rather than reactive, approaches to occupational health and safety, emphasizing surveillance, research, and early intervention to address future work-related health risks. Their work reinforces the importance of anticipating technological and organizational changes that may introduce new hazards.

Chia et al. (2019), in The Need for a New Workplace Safety and Health Strategy in the Journal of Occupational and Environmental Medicine, identify limitations in traditional safety and health strategies and advocate for a more proactive and preventive framework. The authors emphasize worker engagement, integration of technology, and data-driven decision-making as critical components of modern OHS systems. Their findings align with the growing recognition that sustainable safety improvements require organizational commitment and participatory approaches.

Finally, Nicola Magnavita (2018), in Medical Surveillance, Continuous Health Promotion and a Participatory Intervention in a Small Company, discusses the evolving role of occupational health services. The study highlights how mandatory medical examinations conducted by occupational physicians can serve not only to prevent work-related diseases but also to promote general health and healthy lifestyles. Modern occupational health practice, according to Magnavita, has shifted from a narrow focus on traditional hazards to a holistic approach that addresses psychosocial risks, stress, and overall well-being.

Effective workplace health promotion depends on collaboration between employers, workers, and

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medical staff and is most sustainable when integrated into routine health surveillance activities rather than treated as a separate initiative.

Collectively, these studies demonstrate a shift in occupational health and safety from reactive hazard control toward proactive, technology-driven, and participatory systems that integrate risk assessment, health promotion, regulatory compliance, and future-oriented planning. They provide a comprehensive foundation for developing structured, innovative, and context-sensitive occupational health and safety management systems.

III. RESEARCH GAPS AND THE UNIQUENESS OF THIS STUDY

This study focuses specifically on space research occupational hazards rather than general workplace safety, which other authors in the literature review dwell on. This study examines Nigeria's NASRDA facilities, which are rarely discussed in global OHS literature. It addresses emerging aerospace-related hazards such as propulsion materials, radiation, and mission-critical engineering environments. This work also bridges the gap between general OHS theory and practical safety management in space research institutions. This work contributes knowledge from a developing country space program, which is underrepresented in current literature.

IV. METHODOLOGY

This study employs a descriptive cross-sectional design to evaluate occupational health risks and preventive strategies among scientists and engineers in selected NASRDA facilities. The study population includes personnel engaged in laboratory work, satellite development, propulsion systems, and ground station operations.

A purposive sampling technique is used to select participants with direct exposure to technical environments. Data are collected through structured questionnaires, interviews, observations, and review of safety documents. Key hazard variables examined include physical, chemical, ergonomic, electrical, radiation, and psychosocial risks, while safety practices and health outcomes are assessed as dependent variables.

Data are analyzed using descriptive statistics to summarize findings and identify patterns. Instrument validity is ensured through expert review, and reliability is tested via a pilot study. Ethical standards, including informed consent and confidentiality, are strictly maintained, while study limitations such as restricted access and self-reported data are acknowledged.

V. RESULTS

This section presents the analysis and discussion of data collected from members of staff working at NASRDA facilities. The section focuses on examining respondents' socio-demographic characteristics, educational qualifications, field of expertise, years of experience, beliefs and perceptions concerning health risks and preventive strategies.

Table 1 examines the socio-demographic profile of the 50 respondents, including age, gender, educational qualification, employment, and years of work experience. Understanding these characteristics is essential as they can influence patients' knowledge and beliefs regarding the health risks and preventive strategies.

Table 1: Demographic Characteristics of Respondents (N = 50)

Variable	Category	Frequency	Percentage
Gender	Male	33	66%
	Female	17	34%

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Age	20 - 29	2	4%
	30 - 39	15	30%
	40 - 49	25	50%
	50 and above	8	16%
Educational Qualification	B.Sc./B.Eng	19	38%
	HND	5	10%
	M.Sc./M.Eng	24	48%
	PhD	2	4%
Primary Field of Expertise	Aerospace Engineering	1	2%
	Biotech	1	2%
	Chemical Engineering	9	18%
	civil engineering	2	4%
	Computer scientist	1	2%
	Electrical and Electronics Engineering	16	32%
	Geologist	2	4%
	Innovation and product development	1	2%
	Life sciences	2	4%
	Materials Engineering	1	2%
	Mechanical Engineering	7	14%
	Renewable energy	1	2%
	Scientists	3	6%
	Software Engineering	3	6%
Job Category	Engineer	36	72%
	Scientist	14	28%
Years of Work Experience	<5 years	5	10%
	>15 years	7	14%

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	11 - 15 years	12	24%
	5 - 10 years	26	52%
Centre/Lab	ASCO Lab, Ilorin	2	4%
	BATCSTP, Epe	2	4%
	CSID, Abuja	28	56%
	CSTD, Abuja	12	24%
	Ground Station, Abuja	6	12%

In terms of gender, males made up most of the population with 66% (n=33), and females were smaller with 34% (n=17). Also, a vast majority of the participants were between the ages of 40-49 years of age, making up about 50% (n=25), and 30% (n=15) between 30-39 years. Those 50 years and above made up 16% (n=8), and 4% (n=2) were between the ages of 20-29 years. The majority of the participants were M.Sc./M.Eng holders at 48% (n=24), closely followed by B.Sc./B.Eng holders at 38% (n=19). 10% were HND holders, and 4% were Ph.D holders. CSID, Abuja, had the largest number of respondents (56%), with CSTD, Abuja, having the second largest number of respondents (24%). Ground station had 12%, whereas ASCO Lab, Ilorin, and BATCSTP, Epe, both had 4% each of the total respondents.

The engineers working in the organization were a vast majority (72%) out of which 32% were Electrical and Electronic engineers, and chemical engineers and mechanical engineers had 18% and 14% respectively, with the scientists being the minority (28%). Also, a majority had 5-10 years of experience (52%), and those who had 11-15 years of experience (24%), less than 5 years (10%), and greater than 15 years (14%) were the constituents of the lesser 48%.

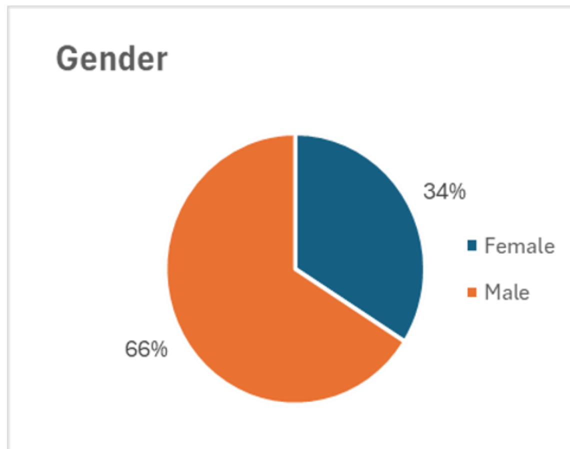

Figure 1: A pie chart showing the distribution of males and females from the survey, with 34% being females and 66% being males.

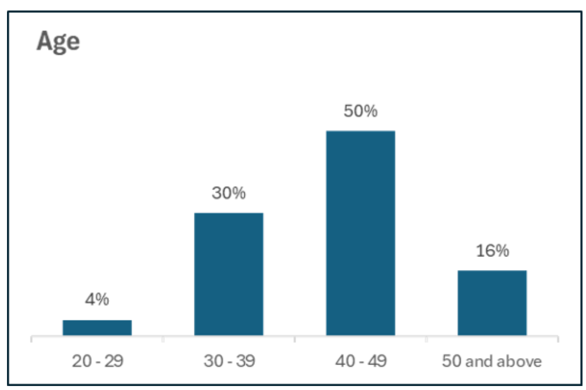

Figure 2: A bar chart showing the age distribution. From the figure, 50% are between the ages of 40-49.

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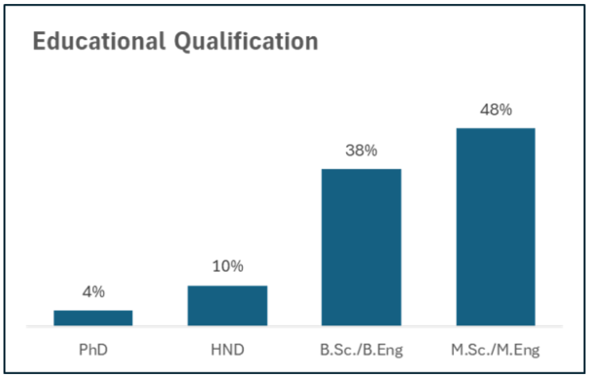

Figure 3: A bar chart showing the distribution of the highest educational qualification.

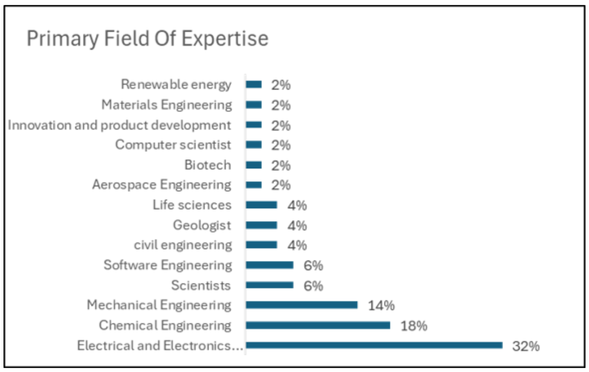

Figure 4: A column chart showing the distribution of the primary fields of expertise of the various workers.

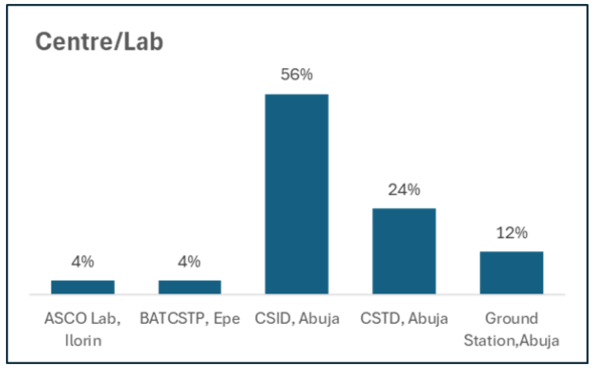

Figure 5: A bar chart showing the distribution of respondents from the various labs/centres operated by NARSDA.

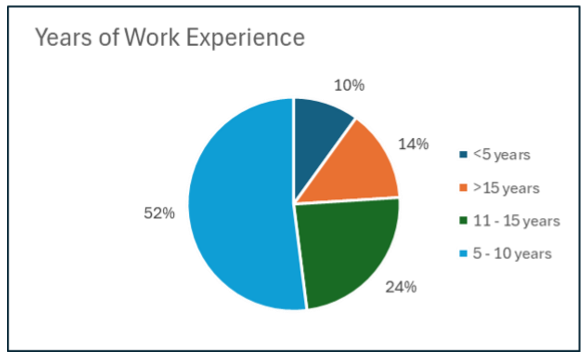

Figure 6: A pie chart showing the average years of work experience of the respondents at the NARSDA facilities.

Table 2 shows the knowledge and beliefs of respondents concerning health risks and preventive strategies

Table 2:

Variable	Category	Frequency	Percentage
I am aware of the occupational health risks associated with my work	Strongly Disagree	8	16%
	Disagree	4	8%
	Neutral	3	6%
	Agree	10	20%
	Strongly Agree	25	50%
My Centre/Lab provides adequate information on workplace hazards	Strongly Disagree	6	12%

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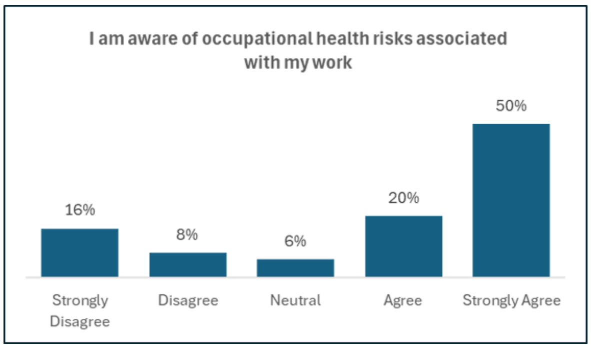
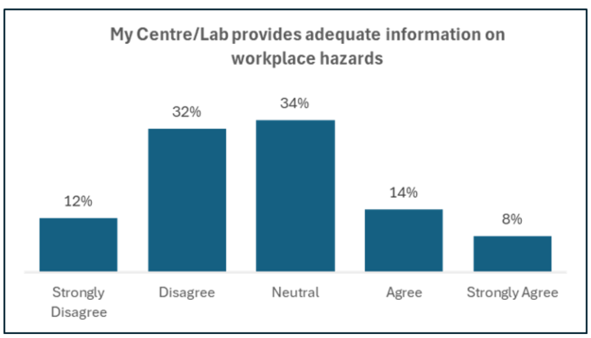
	Disagree	16	32%
	Neutral	17	34%
	Agree	7	14%
	Strongly Agree	4	8%
I have received training on occupational health and safety	Strongly Disagree	25	50%
	Disagree	6	12%
	Neutral	9	18%
	Agree	9	18%
	Strongly Agree	1	2%
I understand the risks associated with the chemicals used in my workplace	Strongly Disagree	14	28%
	Disagree	7	14%
	Neutral	2	4%
	Agree	19	38%
	Strongly Agree	8	16%
I am aware of radiation/electromagnetic exposure risks in my unit	Strongly Disagree	14	28%
	Neutral	9	18%
	Agree	17	34%
	Strongly Agree	10	20%
Personal Protective Equipment (PPE) is available in my workplace	Strongly Disagree	8	16%
	Disagree	14	28%
	Neutral	11	22%
	Agree	10	20%
	Strongly Agree	7	14%

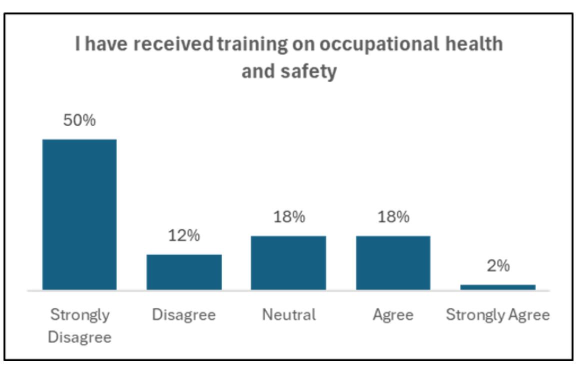
When asked "I am aware of the occupational health risks associated with my work", 50% strongly agreed (n=25), 20% agreed (n=10), 16% strongly disagreed (n=8), 8% and 6% disagreed (n=4) and were neutral (n=3), respectively.

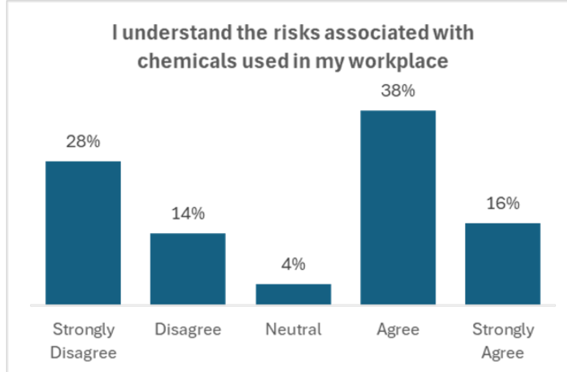
With respect to the information concerning hazards and risks being provided by the center, 17 were neutral (34%), 16 disagreed (32%), 7 agreed (14%), 6 strongly disagreed (12%), and 4 strongly agreed. (8%).

When it came to training on occupational health and safety, 25 strongly disagreed (50%) that they had not received training, 6 disagreed (12%), 1 person strongly agreed (2%), whereas 9 people each were neutral(18%) and agreed(18%) respectively.









VI. CONCLUSION

The demographic baseline of the selected National Space Research and Development Agency (NASRDA) facilities, particularly the centers in Abuja, reveals a highly educated, male-dominated, mid-career technical workforce consisting of 72% (n=36) engineers specializing heavily in high-risk domains like Electrical, Chemical, and Mechanical Engineering and 28% (n=14) scientific minority. While a robust majority of these professional 70% (n=35) exhibit individual awareness of the occupational health and safety (OHS) risks linked to their specific roles, a severe breakdown occurs at the institutional level. A substantial 44% (n=22) of the personnel explicitly report a deficit in the provision of structured hazard and risk information by their centres further compounded by a 32%(n=16) neutrality rate that projects poor visibility of safety protocols. Furthermore, 20% (n=10) of the technical workforce remains entirely untrained in OHS protocols, exposing core institutional assets to significant operational vulnerabilities. Ultimately, individual baseline safety awareness is insufficient without proactive, system-wide institutional deployment. The concentration of these communication and training gaps within NASRDA's selected facilities exposes the agency's most specialized human capital to preventable operational hazards, threatening overall institutional sustainability and technical capacity.

VII. RECOMMENDATIONS

To address and mitigate the identified occupational hazards and safeguard the highly specialized workforce across the selected NASRDA facilities, several strategic preventive measures must transition from passive data availability to active communication by establishing prominent digital safety dashboards and mandatory hazard briefing channels across all departments to eliminate the 44% (n=22) information gap. Secondly, the agency must mandate discipline-specific safety certifications tailored directly to high –risk engineering divisions to ensure a 100% safety compliant operational environment and eliminate the 20% (n=10) untrained gap. Third, geographic disparities must be addressed by appointing dedicated Safety and Health officers to centres outside Abuja, comprising of ASCO Lab in Ilorin, and BATCSTP in Epe, ensuring that safety protocols match the standards maintained at the Abuja Headquarters. Fourth, immediate, targeted risk audits must be executed within the dominant Electrical, Chemical, and Mechanical Engineering units to engineer out physical and environmental hazards, Finally, to ensure long term institutional sustainability, NASRDA must bridge its generational gap where only 4% (n=2) of the workforce is aged 20-29 by launching structured graduate engineering trainee programs to secure institutional knowledge transfer before senior staff members retire, while simultaneously providing target funding for the large cohort of master's degree holders 48% (n=24) to transition into doctoral research programs.

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