JOURNAL OF ENVIRONMENTAL SCIENCES AND BUILT ENVIRONMENT RESEARCH (JESBER)
2026, Vol. 1, No. 2, pp. 41-56
Published by Faculty of Environmental Sciences, University of Calabar, Nigeria
Print ISSN: 3141-5547 | OPEN ACCESS

Research article

OCCUPATIONAL HEALTH AND SAFETY COMPLIANCE AND ITS IMPLICATIONS FOR WORKFORCE PRODUCTIVITY AND PATIENT SAFETY IN TERTIARY HEALTHCARE FACILITIES IN CROSS RIVER STATE, NIGERIA

Atu, Alfred Atu[1]* & Elizabeth E. Andrew-Essien[1]

[1]Department of Environmental Management, University of Calabar, Calabar
*Corresponding author: atualfred23@gmail.com

ABSTRACT

Occupational health and safety (OHS) failures in hospitals expose workers to biological, chemical, physical, ergonomic and psychosocial hazards, undermining productivity and patient safety. This study assessed OHS compliance, hazard exposure, occupational incidents, and the relationships of compliance with workforce productivity and patient safety in hospitals in Cross River State, Nigeria. A descriptive mixed-method survey combined questionnaires from 400 healthcare workers, key-informant interviews and hospital records for 2020-2025. Sampling was stratified and random. Data were analysed with percentages, Pearson correlation and a risk-priority matrix derived from cadre-level compliance and hazard-exposure scores. Compliance was below 60% in every cadre and lowest among cleaners (34%) and orderlies (39%). Biological exposure was highest among laboratory scientists (88%) and nurses (85%), while psychological stress peaked among nurses (88%). Records documented 353 COVID-19 infections, 348 needle-stick injuries and 241 slips/falls. OHS compliance correlated positively with workforce productivity (r = .72) and patient safety (r = .76). Cleaners and orderlies occupied the highest-priority risk quadrant. PPE provision, recurrent training, incident surveillance, ergonomic controls, protected safety budgets and enforceable audits are required. The study integrates worker, institutional and longitudinal evidence to identify cadre-specific intervention priorities.

KEYWORDS

occupational health and safety compliance; healthcare workforce productivity; patient safety culture; occupational hazard burden; personal protective equipment; healthcare risk governance; tertiary healthcare facilities; Cross River State

Introduction

Occupational health and safety (OHS) is a central component of healthcare quality because the conditions under which health workers perform their duties influence both worker wellbeing and the safety, continuity and effectiveness of patient care. In hospitals, OHS extends beyond the prevention of accidents. It encompasses the systematic identification, assessment and control of biological, chemical, physical, ergonomic and psychosocial hazards; the provision and correct use of personal protective equipment (PPE); safe handling of sharps, pharmaceuticals and healthcare waste; infection prevention and control; occupational health surveillance; incident reporting; emergency preparedness; and the creation of a work environment in which staff can raise safety concerns without fear of blame or retaliation. A safe workplace therefore functions as an enabling infrastructure for reliable clinical performance rather than as a peripheral administrative obligation. The World Health Organization (WHO, 2020) explicitly linked health-worker safety to patient safety, while the Global Patient Safety Action Plan 2021-2030 positioned a competent, protected and supported workforce as a prerequisite for eliminating avoidable harm in healthcare (WHO, 2021).

Healthcare facilities are intrinsically complex work systems. Clinical staff interact continuously with patients, biological materials, pharmaceuticals, disinfectants, radiation sources, diagnostic equipment and time-sensitive decision processes. At the same time, cleaners, sanitation personnel, orderlies, porters and other support workers handle contaminated

surfaces, waste streams, soiled linen and patient movement, often with less access to professional training and institutional protection. Consequently, occupational exposure is neither uniform nor confined to a single professional group. The pattern of risk is shaped by task allocation, staffing levels, equipment availability, facility design, workload, organisational culture and the strength of safety-management systems. Human-factors scholarship accordingly treats safety as an emergent property of interactions among people, tasks, technologies, organisational arrangements and the physical environment (Carayon et al., 2014). This systems perspective is especially relevant to tertiary hospitals, where high patient volumes, specialised procedures and multiple interdependent departments can amplify the consequences of weak controls.

The productivity implications of unsafe work are substantial. Occupational injuries and illnesses may increase absenteeism, presenteeism, staff turnover, fatigue and the time required to complete routine tasks. They may also weaken morale and organisational commitment when workers perceive that management does not prioritise their protection. Evidence from occupational safety research indicates that a positive safety climate is associated with stronger safety knowledge, safer behaviour and reduced accidents (Clarke, 2006), while psychosocial safety climate influences work demands, psychological health and engagement (Dollard & Bakker, 2010). In healthcare, these mechanisms have direct operational consequences: an injured, exhausted or psychologically distressed worker may have reduced concentration, slower response time and diminished capacity to sustain accurate, compassionate care. Studies linking staff wellbeing and burnout with patient safety have reported associations with medical errors, reduced quality of care and adverse safety outcomes (Hall et al., 2016; Panagioti et al., 2018; Salyers et al., 2017). OHS compliance should therefore be understood simultaneously as a workforce-protection strategy, a productivity intervention and a patient-safety requirement.

The hazard burden in healthcare remains pronounced in low- and middle-income countries, where resource limitations can weaken even well-designed safety policies. Blood and body-fluid exposure, needle-stick injuries, infectious diseases, chemical contact, musculoskeletal strain, violence, long working hours and psychosocial stress frequently coexist. A global systematic review identified needle-stick injuries as a persistent occupational problem among health workers and highlighted the influence of unsafe devices, recapping practices, inadequate training and deficient reporting systems (Bouya et al., 2020). In Nigeria, Aluko et al. (2016) found a notable gap between health workers' knowledge of occupational hazards and consistent adherence to safety practices, with inadequate safety equipment among the reasons for non-compliance. More recent studies supplied for the present manuscript similarly emphasise the roles of psychosocial safety climate, workplace conditions, occupational injury, mental workload, infection-control compliance and institutional safety practices in shaping staff outcomes (Amoadu et al., 2025; Baidoo et al., 2025; Park et al., 2025; Poku et al., 2025).

The COVID-19 pandemic exposed and intensified longstanding weaknesses in occupational protection. During the acute phase, health workers faced elevated infection risks, rapidly changing protocols, constrained PPE supplies, extended shifts and psychological distress. However, pandemic preparedness cannot be reduced to episodic emergency response. The persistence of needle-stick injuries, slips, falls, chemical exposures and musculoskeletal disorders after the decline of COVID-19 cases indicates that routine hazards may be more institutionally entrenched than crisis-specific risks. Studies of post-pandemic health-system resilience in Nigeria have stressed the need to convert emergency lessons into durable governance, surveillance, technology and workforce reforms (Familusi et al., 2025; Okeke et al., 2025). Similarly, layered exposure-control approaches emphasise that PPE is the final barrier in a wider hierarchy that should also include elimination, substitution, engineering controls, administrative controls, training and monitoring (Andrei et al., 2025).

Within environmental management, the hospital is a socio-technical environment in which air quality, water and sanitation services, waste flows, spatial layout, equipment, work organisation and human behaviour interact. This framing connects healthcare OHS with the broader environmental-systems orientation of JESBER. Environmental research in Nigeria has increasingly applied systems, spatial and governance perspectives to infrastructure, urban services, occupational exposure, resource-dependent livelihoods and sustainable development. Related governance scholarship also demonstrates the importance of distinguishing formal policy ambition from operational strategy and implementation capacity (Eneyo et al., 2021), a distinction that is directly pertinent to hospital safety policies that exist on paper but are weakly resourced in practice. Examples include studies of petrol-station distribution and urban risk, tourism-support services and environmental management, urban service clustering, housing affordability and displacement, confined-space operations, surface-water contamination, healthcare-worker hazards and environmental-resource transitions (Eneyo & Ekpenyong, 2018; Eneyo, 2026a, 2026b; Eneyo et al., 2026; Ikeka et al., 2026; Ofem et al., 2026; Uquetan et al., 2026; Uttah et al., 2026). Broader environmental scholarship on tourism systems, ecosystem-linked livelihoods, soil and biological resource management also illustrates the value of integrated approaches that connect environmental conditions, institutions and human outcomes

(Eneyo, 2025a, 2025b, 2025c; Eneyo & Archibong, 2024; Eneyo et al., 2023; Itu, 2026a, 2026b). The present study extends this environmental-systems logic to the occupational ecology of tertiary healthcare facilities. Recent studies of waste-to-resource innovation, biological-resource utilisation, spatial environmental planning, ecotourism resources and environmental-risk mapping further demonstrate the value of integrated environmental assessment and context-sensitive management (Chinedu et al., 2026; Essien et al., 2026; Ibanga et al., 2025; Oba, Itu, & Ntuyang, 2019; Okpiliya et al., 2017; Utip et al., 2025).

Cross River State contains major referral and specialist institutions that serve diverse populations within and beyond the state. The University of Calabar Teaching Hospital, General Hospital Calabar and Federal Neuro-Psychiatric Hospital Calabar are important nodes in the regional healthcare system, yet they operate within the wider constraints affecting public health institutions in Nigeria, including resource pressure, ageing infrastructure, high service demand, staffing shortages and uneven implementation of safety standards. These conditions can generate an implementation gap in which policies exist formally but are not translated into reliable supplies, routine training, consistent supervision, ergonomic work design or effective incident-learning systems. The burden may be greatest among cadres that occupy the lowest organisational positions while performing tasks with substantial environmental exposure. This raises an equity issue: safety resources and institutional attention may not be distributed in proportion to occupational risk.

Existing studies have examined occupational hazards, safety knowledge, infection prevention, worker wellbeing or organisational performance, but fewer have integrated four evidence domains within the same local investigation: cadre-specific OHS compliance, multidimensional hazard exposure, longitudinal hospital incident records, and the relationships of OHS compliance with both workforce productivity and patient safety. The available Cross River literature is also fragmented across occupations and sectors. For example, local research has considered hazard stratification in quarry operations, confined-space petroleum work and rural healthcare settings (Ereh et al., 2025; Ikeka et al., 2026; Ofem et al., 2026), while emerging work has examined toxicological risk assessment and technology-enabled safety applications (Essien et al., 2025; Oseghale et al., 2025). These studies reinforce the relevance of risk-based analysis but do not replace a tertiary-hospital assessment that compares clinical and non-clinical cadres and links worker protection to patient outcomes.

This study therefore assessed occupational health and safety compliance and its implications for workforce productivity and patient safety in selected tertiary healthcare facilities in Cross River State, Nigeria. Specifically, it sought to: (1) assess OHS compliance across categories of healthcare workers; (2) examine exposure to biological, chemical, physical, ergonomic and psychological hazards; (3) analyse recorded occupational hazards and injuries between 2020 and 2025; and (4) determine the relationships between OHS compliance, workforce productivity and patient safety. In addition to the original descriptive and correlation analyses, the study develops a transparent cadre-level risk-priority matrix from the reported compliance and exposure data. The contribution is therefore empirical and policy-oriented: it identifies where compliance deficits and hazard burdens intersect, clarifies why worker safety and patient safety should be governed as a single system, and provides an evidence base for targeted institutional action rather than undifferentiated safety programmes.

Literature review

Occupational health and safety compliance as a systems construct

OHS compliance is often described as adherence to rules, but this behavioural definition is incomplete. Compliance is produced through an institutional system that must make safe action possible, understandable, expected and routinely reinforced. Workers require appropriate equipment, accessible procedures, relevant training, adequate staffing, supervision, feedback and a credible reporting structure. Where these conditions are absent, apparent non-compliance may represent constrained adaptation rather than simple negligence. For example, workers who purchase their own gloves or improvise protective materials may be attempting to sustain service delivery in an under-resourced environment, yet such coping strategies create variability in protection and transfer institutional responsibility to individuals. The distinction between work-as-imagined in policies and work-as-done under operational pressure is therefore crucial. Compliance management research in other sectors similarly shows that formal rules do not guarantee implementation when monitoring, resources, incentives and organisational commitment are weak (Uddin et al., 2025). In healthcare, the safety system must be designed around actual workflow and exposure conditions rather than assuming that information alone will produce safe practice.

Safety climate, leadership and organisational responsibility

Safety climate refers to workers' shared perceptions of the priority that an organisation gives to safety through its policies, procedures and daily practices. It is communicated not only through official statements but also through budget decisions, staffing, procurement, managerial responses to incidents and the consistency with which standards are enforced. A positive climate is likely when workers observe that safety concerns receive timely attention, PPE is reliably available, incidents are investigated fairly and corrective actions are visible. Conversely, a weak climate emerges when production or service pressure routinely overrides safety requirements. Meta-analytic evidence has linked safety climate with safety knowledge, motivation, compliance and accident reduction (Clarke, 2006). Psychosocial safety climate also influences whether work demands are managed in ways that protect psychological health (Dollard & Bakker, 2010). In healthcare, this is important because burnout, stress and emotional exhaustion can compromise communication, teamwork and vigilance. Amoadu et al. (2025) similarly place psychosocial safety climate at the centre of the relationship between working conditions, provider wellbeing and safety.

The multidimensional occupational hazard environment in hospitals

Hospital hazards operate through multiple pathways. Biological hazards include exposure to blood-borne viruses, respiratory pathogens, contaminated sharps, body fluids and infectious waste. Chemical hazards arise from disinfectants, sterilants, laboratory reagents, cytotoxic drugs, anaesthetic gases and cleaning agents. Physical hazards include slips, falls, radiation, electrical risks, noise, heat and violence. Ergonomic hazards result from patient lifting, repetitive movement, prolonged standing, awkward posture and poorly designed workstations. Psychosocial hazards include excessive workload, long shifts, role conflict, traumatic events, workplace violence, job insecurity and insufficient organisational support. These categories are analytically distinct but practically interdependent. A staff shortage, for example, can increase fatigue, reduce time for proper infection-control procedures, intensify psychological stress and increase musculoskeletal strain. Thus, a single organisational weakness can elevate several exposure domains simultaneously.

Biological exposure, sharps injuries and infection prevention

Biological exposure has received sustained attention because infection can affect workers, families, patients and the wider community. Standard precautions, hand hygiene, vaccination, safe injection practices, appropriate waste segregation and prompt post-exposure management are essential controls. Nevertheless, exposure persists when sharps containers are unavailable, recapping occurs, staffing is inadequate or PPE supply is irregular. Aluko et al. (2016) showed that high awareness among Nigerian health workers did not translate into universal compliance, illustrating the knowledge-practice gap. Bouya et al. (2020) identified needle-stick injury as a global problem and emphasised safer devices, training and reporting. Park et al. (2025) likewise linked prevention-guideline compliance with blood-borne infection exposure in a tertiary hospital. The implication is that infection prevention should be evaluated as a system of mutually reinforcing controls, not as an isolated obligation placed on individual workers.

Chemical, physical and ergonomic risks

Chemical and physical hazards are sometimes under-recognised because their effects may be less immediate than infectious exposure. Laboratory personnel may experience frequent contact with reagents and solvents, while pharmacists may handle hazardous drugs and cleaners may use concentrated chemicals without adequate information on dilution, ventilation or compatibility. Slips and falls can be produced by wet floors, congestion, poor lighting, damaged surfaces and delayed maintenance. Ergonomic stress is similarly distributed across clinical and support work: nurses and orderlies lift or reposition patients; laboratory workers perform repetitive tasks; clinicians stand for prolonged periods; and cleaners bend, push, lift and transport loads. Cumulative musculoskeletal injury can reduce functional capacity and productivity even when it does not produce a dramatic reportable event. The persistence of these hazards supports the use of engineering and ergonomic controls rather than reliance on PPE alone. Emerging toxicological and predictive-risk research also underscores the need to anticipate complex exposures before they produce disease (Essien et al., 2025).

Psychological health, workload and workforce productivity

Workforce productivity in healthcare cannot be reduced to the volume of tasks completed. It includes attendance, timeliness, concentration, teamwork, service continuity, decision quality and the capacity to deliver care without avoidable delay or error. Unsafe work environments reduce productivity through injury-related absence, fatigue, anxiety, burnout and reduced motivation. Baidoo et al. (2025) reported a positive relationship between OHS practices and productivity in private

health facilities in Ghana, while Jibril (2022) found that occupational safety compliance was associated with organisational productivity in a Nigerian pharmaceutical setting. Shabani et al. (2023) similarly linked structured OHS programmes with fewer accidents and stronger organisational performance in Zimbabwe. These findings are consistent with the proposition that safety investment is productive capital rather than an avoidable overhead. Workplace wellbeing also supports retention and sustained performance, particularly in labour-intensive service organisations (Muppidi & Manoharan, 2025).

Patient safety as an outcome of worker safety

The relationship between worker safety and patient safety is both direct and indirect. Direct pathways include cross-infection, contamination, unsafe handling of equipment and errors that occur when protective procedures are bypassed. Indirect pathways operate through fatigue, burnout, understaffing, communication failures and reduced psychological safety. Systematic reviews have linked poor staff wellbeing and burnout with patient-safety incidents and lower perceived quality of care (Hall et al., 2016; Panagioti et al., 2018; Salyers et al., 2017). Nurse staffing and work-environment research has also shown that excessive workloads can compromise outcomes and increase mortality risk (Aiken et al., 2014). Cimiotti et al. (2012) reported an association between nurse burnout and healthcare-associated infection. These findings support the WHO formulation that safe health workers are foundational to safe patients. A hospital cannot sustainably improve patient safety while normalising hazardous work for the people who deliver care.

Safety culture, reporting and organisational learning

Incident reporting converts adverse events and near misses into organisational learning only when workers trust the system, reports are analysed and corrective actions follow. Under-reporting may occur because workers perceive incidents as routine, fear blame, doubt that management will respond or lack simple reporting channels. A weak reporting culture creates a false appearance of safety and prevents the organisation from detecting recurrent patterns. Safety-culture research has linked stronger organisational safety climates with better safety performance and lower adverse-event rates (Mardon et al., 2010; Singer et al., 2009). Digital reporting platforms may improve timeliness and data aggregation, but technology must be usable, trusted and integrated into work processes. Lessons from digital public-service research suggest that user satisfaction and confidence are important to adoption (Mwendwa & Kandiri, 2025). Similarly, artificial-intelligence applications may support diagnostic and risk-identification functions, but they cannot substitute for basic staffing, training, PPE, accountability and a learning culture (Oseghale et al., 2025).

Equity and the unequal distribution of occupational risk

An equitable OHS system allocates protection according to exposure and vulnerability rather than occupational prestige. Support workers often experience a paradox of high exposure and low institutional visibility. Cleaners may handle infectious waste and contaminated surfaces, while orderlies move patients and equipment and perform physically demanding tasks. Yet these cadres may have less access to formal professional development, vaccination, fit-tested PPE, ergonomic equipment and decision-making forums. The result is a stratified safety environment in which the workers most exposed to environmental hazards receive the least protection. Research on environmental injustice demonstrates that unequal recognition and resource distribution can intensify psychological as well as material burdens (Couto et al., 2025). Gender also intersects with occupational hierarchy because many nursing and cleaning roles are female-dominated, and crisis-response policies may distribute resources unevenly across social groups (Onyimadu & Adetutu, 2025). Safety policy should therefore be assessed for distributive equity, procedural inclusion and outcome equity. Related Nigerian evidence on health risk, privacy and gender-sensitive wellbeing further supports confidential, non-stigmatising and inclusive risk governance (Itu et al., 2026).

Institutional constraints in African and Nigerian healthcare

Across many African health systems, OHS implementation is constrained by limited funding, infrastructure deficits, supply interruptions, staff shortages and weak regulatory enforcement. Opoku et al. (2025) documented continuing OHS challenges among healthcare professionals in Ghana, while Poku et al. (2025) highlighted occupational injuries, mental workload and coping among nurses. In Nigeria, health-system weaknesses exposed during COVID-19 continue to affect preparedness and routine service delivery (Familusi et al., 2025; Okeke et al., 2025). Resource constraints can also propagate across clinical outcomes; integrated health-systems research has linked structural limitations with adverse maternal and fetal outcomes (Omwenke et al., 2026). At the same time, environmental service deficits, including unreliable water, sanitation and waste systems, can undermine infection prevention. Research on water demand and infrastructure conditions in tropical

settings illustrates the importance of matching service capacity with actual demand (Ogunbode et al., 2025). OHS improvement therefore requires institution-wide investment and cannot be achieved through training alone.

Conceptual framework and empirical gap

The study is guided by an integrated human-factors and safety-climate framework. The human-factors perspective explains how worker characteristics, tasks, technologies, organisational conditions and the physical environment interact to produce safety and performance outcomes (Carayon et al., 2014). Safety-climate theory explains how management priorities and organisational practices shape workers' safety motivation and compliance (Clarke, 2006; Dollard & Bakker, 2010). Within this framework, PPE availability, training and safe waste handling are proximal indicators of compliance; biological, chemical, physical, ergonomic and psychological exposures represent the hazard environment; and workforce productivity and patient safety are downstream outcomes. The framework predicts that stronger compliance should be associated with better productivity and patient-safety outcomes, while cadres experiencing high hazard exposure and low compliance should receive priority intervention. The present study fills a local evidence gap by testing these relationships across multiple tertiary facilities, combining survey, interview and administrative-record evidence, and identifying cadre-specific risk priorities.

Methodology

Study area and institutional setting

The study was conducted in Cross River State, Nigeria, located between approximately latitudes 4°28′N and 6°55′N and longitudes 7°50′E and 9°28′E. The state has a humid tropical climate and a population distributed across coastal, metropolitan, rainforest and inland environments. The investigation focused on three major healthcare facilities in Calabar: the University of Calabar Teaching Hospital, General Hospital Calabar and Federal Neuro-Psychiatric Hospital Calabar. The University of Calabar Teaching Hospital serves as a major referral, teaching and specialist-care institution; the Federal Neuro-Psychiatric Hospital provides specialised mental-health and psychiatric services; and General Hospital Calabar supports high-volume general, emergency and referral care. These institutions were selected because their varied mandates, workforce structures and service demands provide a useful setting for examining OHS compliance across clinical and support occupations. The temporal scope of the hospital-record component was 2020-2025, permitting comparison of pandemic-period incidents with continuing routine occupational hazards.

Research design and sources of data

A descriptive cross-sectional survey design was adopted and complemented by qualitative key-informant interviews and a retrospective review of hospital occupational-incident records. The mixed-source design was appropriate because OHS is expressed through both measurable practices and organisational experiences. Questionnaire data provided standardised information on PPE use, safety training, waste-disposal compliance, exposure to major hazard categories and perceived performance outcomes. Key-informant interviews with hospital administrators, safety personnel and senior workers provided contextual explanations concerning procurement, funding, staffing, training and reporting. Secondary records supplied annual counts of selected occupational hazards and injuries from 2020 to 2025. Triangulating these sources reduced dependence on a single type of evidence and enabled the results to be interpreted in relation to institutional conditions.

Population, sample size and sampling procedure

The study population comprised healthcare workers employed in the selected facilities, including doctors, nurses, laboratory scientists, pharmacists, cleaners/sanitation staff and health attendants/orderlies. A total of 400 respondents participated in the questionnaire survey. The sample was distributed through a stratified sampling approach so that major professional and support-worker categories were represented. Within the relevant strata and departments, simple random sampling was used to select eligible respondents. Key informants were selected purposively on the basis of their administrative, supervisory or occupational-safety responsibilities and their ability to explain institutional processes. The combination of stratified and simple random sampling strengthened occupational coverage, while purposive selection was appropriate for the qualitative component because the required information was role-specific.

Data-collection instruments and operational measures

The principal quantitative instrument was a structured questionnaire organised around four domains: OHS compliance, occupational hazard exposure, workforce productivity and patient safety. OHS compliance was represented by adequate PPE use, receipt of safety training and compliance with waste-disposal procedures; the source manuscript reported an overall

compliance percentage for each worker category. Hazard exposure was assessed across biological, chemical, physical-injury, ergonomic-stress and psychological-stress domains. Workforce outcomes included productivity, attendance and job satisfaction, while patient safety was represented by error reduction. The interview guide elicited information on safety financing, PPE supply, workload, staffing, training, monitoring and incident reporting. An observation/checklist component was used in a limited supportive role, and hospital records were reviewed for COVID-19 infection, needle-stick injury, chemical exposure, slips/falls and musculoskeletal injury. The measures retained the substantive content and numerical results of the original manuscript.

Data collection and quality management

Questionnaires were administered to eligible workers in the selected facilities, while interviews were conducted with key institutional actors. Completed questionnaires were checked for completeness and consistency before coding. Hospital records were compiled by year and incident category. Qualitative responses were organised thematically and used to explain patterns observed in the quantitative results. Particular attention was given to recurring explanations involving inadequate budgetary allocation, irregular PPE supply, staff self-provision, high workload, temporary pandemic-era interventions and weak incident reporting. Because the original study materials did not report a psychometric coefficient or detailed validation protocol, no reliability statistic has been introduced retrospectively. The authors should add the instrument-validation procedure and reliability results, if available, before final submission.

Data analysis

Quantitative data were analysed using descriptive statistics, including frequencies, percentages, means and standard deviations. Pearson's product-moment correlation was used to examine the relationships between OHS compliance and workforce productivity, patient safety, staff attendance and job satisfaction. The reported correlation coefficients were retained. For publication completeness, two-tailed p-values and 95% confidence intervals were recomputed from the reported coefficients on the assumption of 400 complete observations; this assumption should be verified against the original SPSS output. The strength of association was interpreted using effect size rather than statistical significance alone. Qualitative evidence was analysed thematically and integrated into the discussion to explain why observed compliance and exposure patterns occurred.

Derived risk-priority analysis

A descriptive risk-priority matrix was developed from the original cadre-level data without introducing new observations. First, a mean hazard-burden percentage was calculated for each cadre by averaging the five reported exposure domains. Second, the compliance gap was calculated as 100 minus the reported overall compliance percentage. Third, a risk-pressure score was computed as mean hazard burden multiplied by the compliance gap and divided by 100. The score is not presented as a validated clinical or epidemiological index; it is a transparent prioritisation device that identifies cadres in which high exposure coincides with low compliance. Cadres were ranked from highest to lowest risk pressure. A scatter plot of overall compliance against mean hazard burden was used to visualise the intervention quadrants. This additional analysis strengthens policy targeting while preserving all original data values.

Ethical considerations

The study involved human participants and institutional records. Before submission, the authors must insert the name of the approving research-ethics committee, approval number and approval date. The manuscript should also confirm the form of informed consent obtained from questionnaire and interview participants, the procedures used to protect anonymity, and the permissions obtained for access to hospital records. No personally identifying information is reported in the present manuscript, and qualitative quotations are attributed only to professional roles. The data-collection and reporting procedures should comply with applicable Nigerian ethical requirements and the principles of voluntary participation, confidentiality and responsible data management.

Methodological limitations

The study has limitations that should guide interpretation. The cross-sectional questionnaire component identifies associations but cannot establish temporal causality between OHS compliance, productivity and patient safety. Several measures are self-reported and may be affected by recall or social-desirability bias. The incident records may underestimate the true burden where reporting systems are incomplete, and the aggregated record data do not provide facility-specific denominators or exposure-adjusted rates. The correlation analysis uses composite institutional measures and should not be

interpreted as proof that a single compliance intervention will produce a specified change in outcomes. Finally, the derived risk-pressure score is a descriptive planning tool rather than a validated risk scale. These limitations do not negate the observed patterns, but they reinforce the need for prospective surveillance, facility-level analysis and multivariable modelling in future research.

Results and Discussion

OHS compliance across healthcare-worker categories

Table 1 presents compliance with PPE use, safety training and waste-disposal procedures across six worker categories. Overall compliance was below 60% in every group. Pharmacists recorded the highest overall value (59%), followed by doctors (57%) and laboratory scientists (54%). Nurses recorded 49%, while health attendants/orderlies and cleaners/sanitation staff recorded markedly lower levels of 39% and 34%, respectively. The consistency of the pattern across the three component indicators is important: the low overall scores among support workers were not driven by a single measure. Cleaners recorded only 35% adequate PPE use, 30% receipt of safety training and 38% compliance with waste-disposal procedures. Orderlies also remained below 42% on all three indicators. These results indicate an institutional protection gradient in which workers with substantial environmental contact receive less training and protection than professional cadres.

Table 1. Occupational Health and Safety Compliance by Category of Healthcare Workers in Selected Tertiary Hospitals

Healthcare-worker category	Adequate PPE use (%)	Safety training received (%)	Waste-disposal compliance (%)	Overall compliance (%)
Doctors	58	52	60	57
Nurses	49	45	52	49
Laboratory scientists	55	50	58	54
Pharmacists	60	56	62	59
Cleaners/sanitation staff	35	30	38	34
Health attendants/orderlies	40	36	42	39

Note. Source: Field Survey (2025) and Key Informant Interviews (2025). PPE = personal protective equipment.

Discussion of compliance findings

The findings support the original observation that OHS implementation is structurally weak and unevenly distributed across the selected facilities. The key-informant evidence suggests that low compliance is not solely a matter of worker attitude. A hospital administrator reported that budgetary allocation for occupational safety was grossly inadequate and that many departments operated without dedicated safety funds. A senior nurse similarly observed that workers sometimes purchased gloves, masks and disinfectants because institutional supplies were irregular. These accounts indicate a system in which safe behaviour is constrained by procurement and financing. Aluko et al. (2016) likewise found that lack of basic safety equipment contributed to inconsistent practice among Nigerian healthcare workers. The result also aligns with Baidoo et al. (2025), Shabani et al. (2023) and Simarmata et al. (2025), who emphasised the relationship between organisational safety practices and workforce performance. The particularly low values among cleaners and orderlies show why OHS programmes must include non-clinical workers explicitly rather than assuming that hospital-wide policies are equitably implemented.

Multidimensional occupational hazard exposure

Table 2 shows a high and differentiated hazard burden. Laboratory scientists recorded the highest biological exposure (88%) and chemical exposure (80%), which is consistent with frequent handling of specimens, reagents and potentially infectious materials. Nurses recorded 85% biological exposure, 75% ergonomic stress and the highest psychological stress (88%). Doctors also reported substantial psychological stress (78%) and biological exposure (72%). Cleaners recorded 82% biological exposure, 70% physical injury and 72% ergonomic stress, while orderlies recorded the highest physical injury (75%) and ergonomic stress (78%). Pharmacists had the lowest mean exposure profile among the six cadres, although chemical exposure remained high at 68%. The results demonstrate that hazard control must be task-specific: infection prevention is central for laboratory staff and nurses; chemical controls are especially important for laboratory staff, pharmacists and cleaners; ergonomic interventions are urgent for nurses, cleaners and orderlies; and psychosocial interventions should prioritise nurses, doctors and orderlies.

Table 2. Exposure to Occupational Hazards by Healthcare-Worker Category

Worker category	Biological exposure (%)	Chemical exposure (%)	Physical injury (%)	Ergonomic stress (%)	Psychological stress (%)
Doctors	72	48	40	65	78
Nurses	85	52	60	75	88
Laboratory scientists	88	80	35	55	70
Pharmacists	60	68	28	50	60
Cleaners	82	62	70	72	65
Orderlies	78	50	75	78	72

Note. Source: Field Survey (2025), authors' computation and Key Informant Interviews (2025).

Discussion of hazard exposure

The co-occurrence of high exposure and low compliance creates a compounded risk environment. A laboratory officer stated that protective equipment was often rationed during periods of high demand, while another respondent linked overcrowding and staff shortages with difficulty following protocols consistently. These observations reflect the systems principle that workload and resource pressure can increase several hazard domains at once. Poku et al. (2025) reported the combined importance of occupational injury and mental workload among nurses, while Oshodi and Sookhoo (2025) highlighted the consequences of inadequate staffing in clinical environments. The high psychological-stress values are also consistent with evidence that psychosocial safety climate influences wellbeing and safe performance (Amoadu et al., 2025; Dollard & Bakker, 2010). Moreover, high physical and ergonomic exposure among cleaners and orderlies challenges the tendency to focus OHS programmes primarily on infection control. Safe patient handling, mechanical aids, floor maintenance, load management, work-rest scheduling and participatory ergonomic assessment are required alongside PPE.

Recorded occupational incidents, 2020-2025

Hospital records in Table 3 document 1,349 selected occupational incidents across the six-year period. COVID-19 infection accounted for 353 cases (26.2% of the recorded total), closely followed by needle-stick injuries with 348 cases (25.8%). Slips and falls contributed 241 cases (17.9%), musculoskeletal injuries 220 cases (16.3%) and chemical exposures 187 cases (13.9%). Annual totals rose from 253 incidents in 2020 to a peak of 300 in 2021, then declined to 242 in 2022, 209 in 2023, 184 in 2024 and 161 in 2025. The overall decline was driven mainly by the reduction in reported COVID-19 infections from 125 cases in 2021 to eight in 2025. Routine hazards, however, showed much less improvement. When COVID-19 cases are excluded, the annual total was 158 in 2020, 175 in 2021, 162 in 2022, 179 in 2023, 169 in 2024 and 153 in 2025. This relative persistence indicates that baseline safety problems remained after the acute pandemic response subsided.

Table 3. Recorded Occupational Hazards and Injuries among Healthcare Workers, 2020-2025

Hazard/injury	2020	2021	2022	2023	2024	2025	Total
COVID-19 infection	95	125	80	30	15	8	353
Needle-stick injury	55	60	58	62	59	54	348
Chemical exposure	28	32	30	35	33	29	187
Slips/falls	40	45	38	42	40	36	241
Musculoskeletal injury	35	38	36	40	37	34	220
Annual total	253	300	242	209	184	161	1349

Note. Source: Hospital records from the University of Calabar Teaching Hospital, General Hospital Calabar and Federal Neuro-Psychiatric Hospital Calabar (2020-2025); authors' compilation. The annual-total row is derived from the reported incident counts.

Discussion of incident trends

The incident record supports two interpretations. First, emergency mobilisation can reduce a specific threat when attention, resources and surveillance are concentrated, as reflected in the post-2021 decline in COVID-19 cases. Second, temporary emergency measures do not necessarily strengthen the routine safety system. Needle-stick injuries remained between 54 and 62 cases annually, slips and falls between 36 and 45, and musculoskeletal injuries between 34 and 40. A hospital safety officer observed that many safety interventions were temporary during COVID-19 and were not sustained, while another respondent described incident reporting as weak. The actual burden may therefore exceed the documented counts. This pattern is consistent with post-pandemic analyses calling for durable preparedness and institutional learning

rather than short-term crisis measures (Familusi et al., 2025; Okeke et al., 2025). It also reinforces the need for a unified incident-surveillance system that captures exposure, near misses, treatment, lost work time, corrective action and recurrence.

Relationships with workforce productivity and patient safety

Table 4 presents the relationships between OHS compliance and four performance outcomes. OHS compliance showed a strong positive relationship with patient safety/error reduction (r = .76, 95% CI [.72, .80], p < .001) and workforce productivity (r = .72, 95% CI [.67, .76], p < .001). It was also positively related to staff attendance (r = .69, 95% CI [.64, .74], p < .001) and job satisfaction (r = .65, 95% CI [.59, .70], p < .001). The correlation magnitudes are substantively important. They suggest that OHS is embedded in the operational performance of the facilities rather than functioning as an isolated compliance domain. Nevertheless, the cross-sectional design means that the direction of influence cannot be established conclusively. Safer systems may improve productivity and patient safety, but better-managed facilities may also be more capable of implementing OHS standards. The findings should therefore be interpreted as evidence of strong interdependence rather than a simple one-way causal effect.

Table 4. Relationship between OHS Compliance, Workforce Productivity and Patient Safety

Outcome variable	Mean score	SD	Pearson r with OHS compliance	95% CI for r	p value
Workforce productivity	2.95	0.75	.72	[.67, .76]	< .001
Patient safety (error reduction)	2.80	0.70	.76	[.72, .80]	< .001
Staff attendance	3.00	0.68	.69	[.64, .74]	< .001
Job satisfaction	2.70	0.80	.65	[.59, .70]	< .001

Note. Source: Field Survey (2025), authors' SPSS analysis and Key Informant Interviews (2025). Confidence intervals and p values were recomputed from the reported r values assuming n = 400 complete cases; the authors should verify this assumption against the original SPSS output.

Discussion of productivity and patient-safety relationships

The positive relationships are consistent with a broad body of evidence. Hall et al. (2016), Panagioti et al. (2018) and Salyers et al. (2017) linked staff wellbeing and burnout with patient-safety outcomes, while Cimiotti et al. (2012) associated nurse burnout with healthcare-associated infection. Stronger OHS compliance can support productivity through several pathways: preventing injury and illness, reducing absence, preserving physical capacity, improving morale, lowering cognitive overload and signalling organisational support. It can support patient safety by reducing cross-infection, maintaining adequate staffing, improving attention and enabling consistent adherence to clinical protocols. The finding that the correlation with patient safety (r = .76) slightly exceeded that with productivity (r = .72) underscores the clinical importance of worker protection. Safety investment should therefore be assessed not only against accident reduction but also against service continuity, error prevention, patient experience and quality-of-care indicators.

Integrated risk-priority analysis

Table 5 combines the original compliance and hazard data to identify priority groups. Cleaners recorded the highest mean hazard burden (70.2%) and the largest compliance gap (66 percentage points), producing the highest descriptive risk-pressure score (46.3). Orderlies followed with a mean hazard burden of 70.6%, a 61-point compliance gap and a risk-pressure score of 43.1. Nurses ranked third because their high mean hazard burden (72.0%) coincided with compliance of only 49%. Laboratory scientists ranked fourth, doctors fifth and pharmacists sixth. The ranking should not be interpreted as a clinical risk estimate; rather, it identifies where high reported exposure and low reported compliance overlap most strongly. The result provides a practical basis for sequencing interventions when resources are limited.

Table 5. Derived Cadre-Level OHS Risk-Priority Matrix

Cadre	Overall compliance (%)	Mean hazard burden (%)	Compliance gap (points)	Risk-pressure score	Priority rank
Doctors	57	60.6	43	26.1	5
Nurses	49	72.0	51	36.7	3
Laboratory scientists	54	65.6	46	30.2	4
Pharmacists	59	53.2	41	21.8	6
Cleaners	34	70.2	66	46.3	1
Orderlies	39	70.6	61	43.1	2

Note. Mean hazard burden is the average of the five exposure percentages in Table 2. Compliance gap = 100 - overall compliance. Risk-pressure score = mean hazard burden × compliance gap / 100. The score is a descriptive prioritisation tool, not a validated clinical risk index.

Interpretation of the risk quadrant and Figure 1

Figure 1 visualises overall compliance on the horizontal axis and mean hazard burden on the vertical axis. The upper-left area represents the most concerning combination: high hazard and low compliance. Cleaners, orderlies and nurses occupy this area, although for different reasons. Cleaners and orderlies combine weak compliance with high physical and ergonomic burden, whereas nurses combine moderate-to-low compliance with the highest overall exposure average, driven by biological, ergonomic and psychological hazards. Laboratory scientists occupy a high-hazard but relatively higher-compliance position, suggesting that exposure intensity remains substantial despite somewhat better controls. Pharmacists occupy the comparatively lower-risk area because they combine the highest compliance with the lowest mean hazard burden, although their chemical exposure still requires targeted management. The figure demonstrates why uniform hospital-wide interventions are insufficient. Each cadre requires a tailored control package and measurable improvement target.

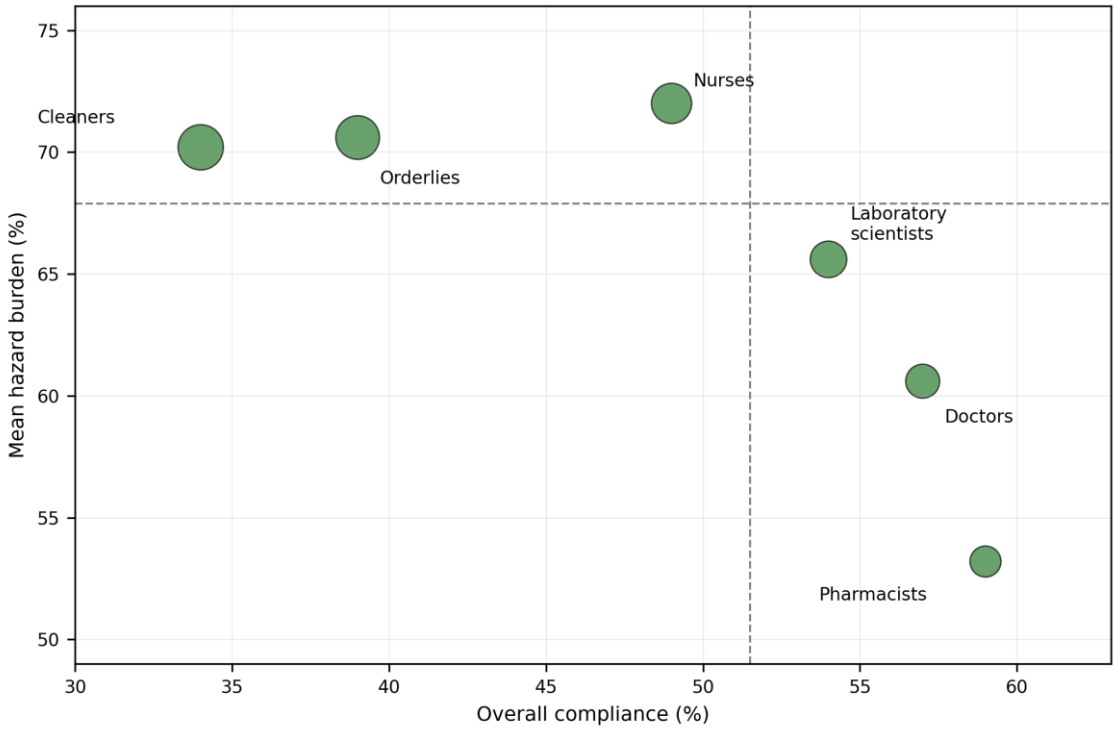

Figure 1. Cadre-specific OHS compliance and multidimensional hazard burden

Note. Bubble size reflects the derived risk-pressure score. Dashed lines show the median compliance and median hazard-burden values across the six cadres. Source: Derived from Tables 1 and 2.

Overall synthesis

Taken together, the findings reveal an OHS system characterised by three interacting problems: inadequate and unequal compliance, persistent multidimensional hazard exposure, and weak conversion of incident data into sustained prevention. The key-informant evidence points repeatedly to financing, procurement, staffing and institutional commitment as underlying mechanisms. The results therefore challenge explanations that attribute unsafe practice primarily to worker carelessness. Behaviour matters, but behaviour occurs within a resource and governance environment. The strong correlations with productivity and patient safety further show that the consequences extend beyond worker health to the core mandate of healthcare delivery. A credible response must combine environmental controls, occupational-health services, human-resource planning, safety culture, data systems and accountability. This is consistent with the WHO and ILO position that OHS programmes for health workers should be integrated into health-service planning and quality improvement rather than implemented as stand-alone activities (WHO & ILO, 2022).

Policy Implications

The findings have direct implications for state health authorities, hospital governing boards, facility managers, occupational-health units and professional bodies. First, OHS financing should be protected through a dedicated budget line in each facility. A ring-fenced allocation would make expenditure on PPE, vaccination, training, ergonomic equipment, surveillance, maintenance and emergency preparedness visible and auditable. Budgeting should be risk-based rather than distributed equally across departments: laboratory services, nursing units, sanitation services and patient-transport functions require differentiated resource packages. Procurement systems should maintain minimum stock levels, quality standards and transparent distribution records so that staff self-provision becomes exceptional rather than routine.

Second, recurrent training should be mandatory, role-specific and competency-based. General lectures are insufficient for the exposure profiles identified. Laboratory personnel require reinforced biosafety, chemical handling, spill response and exposure management. Nurses require infection-control refreshers, safe patient handling, fatigue-risk management and psychosocial support. Cleaners require practical instruction on waste segregation, sharps recognition, chemical dilution, PPE donning and doffing, and reporting. Orderlies require patient-transfer ergonomics, violence prevention and physical-hazard control. Training completion should be linked to competency checks, induction, annual appraisal and departmental safety indicators. Contractors and temporary workers should be included because excluding them creates unprotected gaps in the work system. Related evidence from park-ranger capacity building and adaptive, technology-supported learning further supports practical, role-specific and inclusive training approaches (Oba, Itu, & Eteng, 2019; Itu et al., 2025; Majebi et al., 2025a, 2025b).

Third, the facilities should establish integrated occupational-incident surveillance. A standard electronic or hybrid reporting form should capture injuries, exposures, near misses, contributing factors, treatment, time lost, corrective action and closure status. Reporting should be simple, non-punitive and accessible to all cadres. Each facility should review data monthly, while the state health authority should produce quarterly dashboards comparing departments and facilities. Digital systems should be designed around user trust, ease of use and feedback rather than data collection alone. Every report should generate acknowledgement, risk assessment and visible follow-up. The persistence of routine hazards after COVID-19 demonstrates that surveillance must continue outside emergency periods.

Fourth, hospitals should implement the hierarchy of controls. PPE remains necessary, but it should not substitute for safer design. Engineering measures should include puncture-resistant sharps containers at the point of use, safer needle devices where feasible, adequate ventilation, spill-control facilities, non-slip flooring, functional lighting, segregated waste-storage areas, mechanical patient-lifting aids and ergonomically designed workstations. Administrative controls should include staffing norms, safe shift schedules, job rotation for high-strain tasks, preventive maintenance, exposure-response protocols and routine environmental inspections. Occupational-health services should provide vaccination, post-exposure prophylaxis, confidential counselling, periodic health surveillance and return-to-work support. The importance of spatially planned and operationally accessible emergency infrastructure is also reflected in research on fire-hydrant location and disaster management in Calabar (Inah et al., 2016).

Fifth, safety governance should be strengthened through accountable leadership. Each facility should maintain a multidisciplinary OHS committee with representation from doctors, nurses, laboratory staff, pharmacists, cleaners, orderlies, environmental-health personnel and management. The committee should have authority to review incidents, inspect high-risk areas, track corrective actions and report directly to senior leadership. Annual external audits should assess compliance, resource equity and outcome trends. Performance agreements for hospital leaders should include measurable OHS and patient-safety indicators. Regulatory agencies should move beyond document inspection to verification of actual practice, supplies, training records, incident closure and worker participation.

Finally, policy should explicitly address equity. The risk-priority analysis shows that cleaners and orderlies require immediate attention, not because other cadres are safe, but because their combination of exposure and low compliance is most severe. State and facility policies should guarantee equal access to appropriate PPE, vaccination, training, reporting systems and occupational-health services regardless of employment status or professional rank. Worker consultation should include lower-cadre and outsourced personnel. A phased implementation plan could begin within three months with PPE-gap assessment, incident-system redesign and high-risk training; proceed within six to twelve months to engineering and ergonomic controls; and institutionalise annual audits, budget review and public reporting thereafter.

Conclusion

This study assessed OHS compliance, occupational hazard exposure, recorded incidents and the relationships of compliance with workforce productivity and patient safety in three major healthcare facilities in Cross River State. The evidence consistently indicates that the existing safety system is inadequate. Overall compliance remained below 60% in all worker categories, with cleaners and orderlies experiencing the largest deficits. Hazard exposure was multidimensional and occupationally differentiated: laboratory scientists and nurses experienced particularly high biological exposure; laboratory scientists and pharmacists faced substantial chemical exposure; cleaners and orderlies experienced high physical and ergonomic burdens; and nurses recorded the highest psychological stress. Hospital records showed that COVID-19 infections declined substantially after 2021, but needle-stick injuries, slips/falls, chemical exposures and musculoskeletal injuries persisted, indicating that routine safety weaknesses outlived the emergency phase of the pandemic.

OHS compliance was strongly and positively associated with workforce productivity, patient safety, attendance and job satisfaction. Although the cross-sectional design does not establish causality, the magnitude and consistency of the relationships demonstrate that worker safety is inseparable from healthcare performance. The derived risk-priority analysis further showed that cleaners, orderlies and nurses should receive urgent, cadre-specific interventions. The study therefore concludes that healthcare OHS should be governed as an integrated environmental, organisational and clinical system. Sustainable improvement requires protected financing, equitable PPE supply, recurrent competency-based training, engineering and ergonomic controls, reliable incident surveillance, occupational-health services, worker participation and enforceable leadership accountability. By integrating cadre-level compliance, multidimensional exposure, longitudinal incident data and performance relationships, the study provides a locally grounded framework for prioritising action and strengthening both workforce resilience and patient safety in resource-constrained tertiary healthcare settings.

Declarations

Funding: The study received no specific grant from any public, commercial or not-for-profit funding agency and was supported by the authors.

Ethics approval and consent to participate: All participants received study information, participated voluntarily and provided informed consent, and that permission was obtained to use institutional records.

Conflict of interest: The authors declare that they have no financial or non-financial conflicts of interest related to this manuscript

Data availability: The de-identified data supporting the findings are available from the corresponding author on reasonable request, subject to institutional approval, confidentiality requirements and applicable data-protection obligations.

Author contributions: Atu, Alfred Atu contributed to conceptualisation, methodology, investigation, data curation, formal analysis, visualisation and preparation of the original draft. Elizabeth E. Andrew-Essien contributed to supervision, validation, interpretation, resources and critical review and editing of the manuscript. Both authors approved the final manuscript and accept accountability for the work.

Related-publication disclosure: Regionally relevant publications cited in this manuscript address environmental management, spatial risk, occupational hazards, health systems, tourism, infrastructure or sustainability.

Acknowledgements: The authors acknowledge the healthcare workers, hospital administrators, safety personnel and records officers who supported data collection.

References

Aiken, L. H., Sloane, D. M., Bruyneel, L., Van den Heede, K., Griffiths, P., Busse, R., Diomidous, M., Kinnunen, J., Kózka, M., Lesaffre, E., McHugh, M. D., Moreno-Casbas, M. T., Rafferty, A. M., Schwendimann, R., Scott, P. A., Tishelman, C., van Achterberg, T., & Sermeus, W. (2014). Nurse staffing and education and hospital mortality in nine European countries: A retrospective observational study. The Lancet, 383(9931), 1824-1830. https://doi.org/10.1016/S0140-6736(13)62631-8

Almutairi, H. A. S., Alzahrani, A. A. G., Al Sillah, H. N., Harbi, A. K. A., Alotaibi, A. G. H., Alharthi, A. O. M., & Alasmari, S. A. S. (2025). Infection control protocols for patient safety: Collaboration of dentist, medical nurse, medical doctor, radiology, laboratory, nutrition, anesthesia, pharmacy, and medical information department. The Review of Diabetic Studies, 243-278.

Aluko, O. O., Adebayo, A. E., Adebisi, T. F., Ewegbemi, M. K., Abidoye, A. T., & Popoola, B. F. (2016). Knowledge, attitudes and perceptions of occupational hazards and safety practices in Nigerian healthcare workers. BMC Research Notes, 9, Article 71. https://doi.org/10.1186/s13104-016-1880-2

Amoadu, M., Agyare, D. F., Doe, P. F., & Abraham, S. A. (2025). Examining the impact of psychosocial safety climate on working conditions, well-being and safety of healthcare providers: A scoping review. BMC Health Services Research, 25(1), 90.

Andrei, N. Ș., Elena-Sabina, T., Silviu-Mihail, T., Ana-Iolanda, V., & Vladimir, P. (2025). Layers of exposure risk management measures for the prevention and control of infections of healthcare workers treating COVID-19 patients. PLOS ONE, 20(9), e0332804.

Asiedu, E. A., Appiagyei, J. N., Amfo-Otu, R., Parku, K., & Obuobisa-Darko, T. (2025). Occupational health and safety, cost reduction in accident and employee task performance: Perspectives of selected service organizations. Journal of Public Health, 33(9), 2011-2022.

Baidoo, M. A., Kumah, E., Ahmed, S. O. A., & Fafali, J. A. (2025). Examining the relationship between occupational health and safety practices and productivity levels in private health facilities in the Central Region of Ghana. BMC Public Health, 25(1), 1747.

Bouya, S., Balouchi, A., Rafiemanesh, H., Amirshahi, M., Dastres, M., Moghadam, M. P., Behnamfar, N., Shyeback, M., Badakhsh, M., Allahyari, J., Al Mawali, A., Ebadi, A., Dezhkam, A., & Daley, K. A. (2020). Global prevalence and device related causes of needle stick injuries among health care workers: A systematic review and meta-analysis. Annals of Global Health, 86(1), Article 35. https://doi.org/10.5334/aogh.2698

Braithwaite, J., Herkes, J., Ludlow, K., Testa, L., & Lamprell, G. (2017). Association between organisational and workplace cultures, and patient outcomes: Systematic review. BMJ Open, 7(11), e017708. https://doi.org/10.1136/bmjopen-2017-017708

Chinedu, N. B., Orhuebor, E. N., Nnanna, A. C., Austine, U., Effanga, B. O., Aveena, A., Itu, P.-C. O., & Bassey, B. O. (2026). Comparative evaluation and process performance analysis of bioethanol production from Carica papaya and Citrullus lanatus peels. European Journal of Innovative Studies and Sustainability, 2(2), 182-199. https://doi.org/10.59324/ejiss.2026.2(2).12

Carayon, P., Wetterneck, T. B., Rivera-Rodriguez, A. J., Hundt, A. S., Hoonakker, P., Holden, R., & Gurses, A. P. (2014). Human factors systems approach to healthcare quality and patient safety. Applied Ergonomics, 45(1), 14-25. https://doi.org/10.1016/j.apergo.2013.04.023

Cimiotti, J. P., Aiken, L. H., Sloane, D. M., & Wu, E. S. (2012). Nurse staffing, burnout, and health care-associated infection. American Journal of Infection Control, 40(6), 486-490. https://doi.org/10.1016/j.ajic.2012.02.029

Clarke, S. (2006). The relationship between safety climate and safety performance: A meta-analytic review. Journal of Occupational Health Psychology, 11(4), 315-327. https://doi.org/10.1037/1076-8998.11.4.315

Couto, M. T., Senent-Valero, M., Alves dos Santos, L., Mateuzi Carmo, M., Matijasevich, A., & Pastor-Valero, M. (2025). 'No forest, no future, but they don't see us': Eco-anxiety, inequality, and environmental injustice in São Paulo. Frontiers in Public Health, 13, 1555386.

Deo, R. C., Noor, U., Prasad, D., Kumbhar, S. M., & Shavali, T. S. (2023). The significance of occupational safety in promoting healthcare workforce satisfaction and operational efficiency. Health Leadership and Quality of Life, 2, 220.

Dollard, M. F., & Bakker, A. B. (2010). Psychosocial safety climate as a precursor to conducive work environments, psychological health problems, and employee engagement. Journal of Occupational and Organizational Psychology, 83(3), 579-599. https://doi.org/10.1348/096317909X470690

Eneyo, D. A., Atemgweye, G. I., Imanyi, V. U., & Essien. (2023). Tourism as a catalyst for entrepreneurial development: Insights from Cross River State, Nigeria. World Tourism Journal, 1, 1-19.

Eneyo, V. B. (2025a). Environment: An introduction to environmental science-A monograph. IDbeyond Printing Press.

Eneyo, V. B. (2025b). Essential of tourism for beginners. [Publisher not supplied].

Eneyo, V. B. (2025c). Tourism for beginners II. [Publisher not supplied].

Eneyo, V. B. (2026a). Tourism support services, environmental management and sustainable destination development in Uyo, Nigeria: Spatial and socio-economic evidence. Journal of Environmental Sciences and Built Environment Research, 1(1), 227-240.

Eneyo, V. B. (2026b). Where the city eats: Spatial clustering, distance-decay and patronage rhythms of eateries in Calabar, Nigeria. Journal of Environmental Sciences and Built Environment Research, 1(1), 1-13.

Eneyo, V. B., & Archibong, A. A. (2024). Examining socio-economic implications of tourism development in Nigeria. World Tourism Journal, 2(2), 61-82.

Eneyo, V. B., & Ekpenyong, E. J. (2018). Spatial distribution of petrol filling stations in Calabar South Local Government Area, Cross River State. Multi-Disciplinary Journal of Research and Development Perspectives, 7(1), 66-83.

Eneyo, V. B., Onnoghen, U. N., Apeh, C. A., Ajom, S. K. O., Ugbaka, M. A., Odey, F. I., et al. (2026). Conservation constraints and aquatic livelihood transitions among riverine women in the Cross-River Basin, Nigeria. Egyptian Journal of Aquatic Biology and Fisheries, 30(3), 3845-3869.

Eneyo, V. B., Talib, J., Attah, F. M., & Offiong, E. E. (2021). Iran's nuclear policy: Nature, ambition, and strategy. Journal of Liberty and International Affairs, 8(2), 202-222.

Ereh, O., Omin, I., Jonah, U., Koko, E., & Osy, M. (2025). Occupational exposure and health risk stratification across quarry operations in Akamkpa, Nigeria. Journal of Occupational Health, Risk Management, and Safety, 1(1), 11-20.

Essien, E. A., Okon, A. O., Udoinyang, E. P., Itu, P.-C. O., Bassey, B. O., Ekpo, N. D., & Effanga, B. O. (2026). Effects of graded inclusion of Jatropha tanjorensis leaf meal on growth and feed utilisation in Clarias gariepinus. Acta Biologica Slovenica, 69(2), 59-70. https://doi.org/10.14720/abs.69.2.23614

Essien, U. B., Akpan, A. U., Ibanga, F. I., Itu, P. C. O., Micheal, P. U., Daniel, B. A., & Ozohili, L. I. (2025). Machine learning in nanoparticles toxicology: Mechanisms, predictive modelling, and risk assessment strategies. Journal of Science Innovation and Technology Research.

Familusi, O. J., Atanda, D. O., Bakenne, H. A., & Ahmed, M. A. (2025). Highlighting the current state of the Nigeria health system post COVID-19: Positive impacts, current challenges and recommendations. Discover Public Health, 22(1), 420.

Hall, L. H., Johnson, J., Watt, I., Tsipa, A., & O'Connor, D. B. (2016). Healthcare staff wellbeing, burnout, and patient safety: A systematic review. PLOS ONE, 11(7), e0159015. https://doi.org/10.1371/journal.pone.0159015

Ibanga, F. I., Itu, P.-C. O., Udoh, U. I., & Odeleye, S. (2025). Assessment of the spatial distribution of sawmills in Akwa Ibom State, Nigeria: Implications for urban planning and environmental management. Journal of Scientific Research and Reports, 31(5), 864-872. https://doi.org/10.9734/jsrr/2025/v31i53082

Ikeka, E., Uttah, C., Uquetan, A., & Itu, P.-C. O. (2026). Occupational health and safety risks associated with confined space operations in petroleum storage facilities: Empirical evidence from the Calabar Free Trade Zone, Nigeria. Gombe Journal of Geography and Environmental Studies, 4(3), 153-161.

Inah, P. C., Okpiliya, F. I., Njoku, C. G., & Itu, P. O. (2016). Location of fire hydrants and implications for fire disaster management in Calabar, Cross River State, Nigeria. In Proceedings of the 1st Regional Conference on Disaster Risk Reduction (Vol. 1, No. 1, pp. 11-26).

Itu, P.-C. O. (2026a). Integrated tourism and environmental management systems. In Sustainable tourism and environmental systems (Vol. 1, pp. 371-408).

Itu, P.-C. O. (2026b). Sustainable tourism-environment innovation and future systems. In Sustainable tourism and environmental systems (Vol. 1, pp. 409-447).

Itu, P.-C. O., Ibanga, E. S., & Majebi, E. C. (2025, May 14-16). Adaptive learning designs for enhancing education and employability of persons with disabilities in the tourism sector: Finding the balance [Conference presentation]. 3rd ODeLAN International Conference, National Open University of Nigeria, Abuja, Nigeria.

Itu, P.-C. O., Udousoro, I. L., Bassey, B. O., Ekanem, U. L., Akam, S. N., & Ochang, M. O. (2026). Between privacy and risk: Health implications linked to the use of sexual wellness devices among female students in Nigerian universities. Journal of Occupational Health, Risk Management, and Safety, 1(2), 77-87. https://doi.org/10.60787/johrms.vol1no2.42

Jibril, Y. L. (2022). Assessment of occupational health and safety practice compliance and its impact on organisation productivity: A case study of XYZ Pharmaceutical Company, Ilorin [Master's thesis, Kwara State University].

Khuzaiyah, S., Yildiz, M., & Hashim, S. H. (2025). Transformation of the health technology system in developing countries post-pandemic crisis and the recommendation to maintain sustainability: Lesson learned from COVID-19 pandemic. In Post-pandemic crisis turning point towards health resilience (pp. 133-157). Springer Nature.

Majebi, E. C., Itu, P.-C. O., & Ailakhu, U. V. (2025a, May 14-16). Enhancing tourism and hospitality education at Nigerian universities with gamification and VR/AR technologies [Conference presentation]. 3rd ODeLAN International Conference, National Open University of Nigeria, Abuja, Nigeria.

Majebi, E. C., Itu, P.-C. O., & Ailakhu, U. V. (2025b). Enhancing tourism and hospitality education at Nigerian universities with gamification and VR/AR technologies. Journal of Hospitality & Tourism, 23(2), 72-87.

Mardon, R. E., Khanna, K., Sorra, J., Dyer, N., & Famolaro, T. (2010). Exploring relationships between hospital patient safety culture and adverse events. Journal of Patient Safety, 6(4), 226-232. https://doi.org/10.1097/PTS.0b013e3181fd1a00

Muppidi, S., & Manoharan, G. (2025). Fostering workplace well-being: The key to happiness, productivity, and retention. In Development of self-awareness and wellbeing: Global learning challenges in a shifting society (pp. 479-504). IGI Global Scientific Publishing.

Mwendwa, G. F., & Kandiri, J. M. (2025). Citizen satisfaction with electronic-government services: A case study of Huduma Centre Mombasa. International Journal of Innovative Science and Research Technology, 10(4), 937-949.

Oba, D. O., Itu, P.-C. O., & Eteng, E. E. (2019). On-the-job training of park rangers: A machinery for sustainable ecotourism in Nigeria: Empirics of Cross River National Park. International Journal of Scientific & Engineering Research, 10(8), 122-139.

Oba, D. O., Itu, P. O., & Ntuyang, E. I. (2019). Assessment of lakes as ecotourism potentials in Cross River State, South-South Nigeria. International Journal of Scientific & Engineering Research, 10(7), 1750-1757.

Ofem, E., Uquetan, A., Itu, P.-C. O., Ekpo, E. B., Udousoro, I. L., & Bassey, B. O. (2026). Prevalence and multidimensional risk assessment of occupational hazards among healthcare workers in rural health facilities: Evidence from Yakurr Local Government Area, Cross River State, Nigeria. Gombe Journal of Geography and Environmental Studies, 4(3), 162-172.

Ogunbode, T. O., Victor, Oyebamiji, O., Oyelami, A. A., & Akinkuolie, T. A. (2025). Evaluating basic household characteristics influencing domestic water demand in tropical environments: A comprehensive case study. Applied Water Science, 15(1), 9.

Okeke, C. C., Uguru, N. P., Uzochukwu, B., & Onwujekwe, O. (2025). How can health systems better prepare for the next pandemic? A qualitative study of lessons learned from the COVID-19 response in Nigeria. SSM-Health Systems, 4, 100052.

Okpiliya, F. I., Itu, P. O., Njoku, C. G., & Erhabor, F. (2017). Spatial assessment of gully erosion in Calabar Metropolis, Cross River State, Nigeria. Researchjournali's Journal of Geography, 4(4), 1-14.

Omwenke, I. W., Itu, P. C. O., Bassey, B. O., Effanga, B. O., Petters, E. S., Isangadighi, G. E., & Alhassan, A. (2026). Multilevel determinants of adverse maternal-fetal outcomes in resource-constrained settings: An integrated obstetric and health systems analysis from Nigeria. European Journal of Medical and Health Research, 4(1), 75-85.

Onyimadu, C. O., & Adetutu, O. B. (2025). Evaluating gendered fault lines: Nigeria's COVID-19 stimulus through a feminist political economy and OECD-DAC lens. Evaluation and Program Planning, 102694.

Opoku, F., Boakye-Yiadom, J., Oppong, F., Agyekum, T. P., & Dassah, E. (2025). Occupational health and safety among healthcare professionals at the Ashanti Regional Hospital, Ghana. medRxiv, 2025-06.

Oseghale, E. A., Ogheneochuko, I., Francis, E., Oshiokhayamhe, I. K., & Oberhiri, O. K. (2025). The role of artificial intelligence in identifying abuse-related fractures in children: A systematic review. Applied Medical Research, AMR-1087.

Oshodi, T. O., & Sookhoo, D. (2025). Nursing students' perceptions of inadequate nurse staffing in the clinical learning environment: A systematic narrative review. Nurse Education in Practice, 82, 104221.

Panagioti, M., Geraghty, K., Johnson, J., Zhou, A., Panagopoulou, E., Chew-Graham, C., Peters, D., Hodkinson, A., Riley, R., & Esmail, A. (2018). Association between physician burnout and patient safety, professionalism, and patient satisfaction: A systematic review and meta-analysis. JAMA Internal Medicine, 178(10), 1317-1331. https://doi.org/10.1001/jamainternmed.2018.3713

Park, J. J., Lee, S. G., Jang, S. Y., & Kim, T. H. (2025). Compliance with prevention guidelines and bloodborne infection exposure among healthcare workers in a tertiary hospital. Health Insurance Review & Assessment Service Research, 5(2), 130-147.

Poku, C. A., Ahulu, A. A., Otomo, J., Hagan, D., Dwumfour, C. K., Issifu, J. S., & Dzomeku, V. (2025). Occupational injuries, mental workload and coping strategies among the nursing workforce in the Eastern Region of Ghana: A multi-centre study. BMC Nursing, 24(1), 78.

Salyers, M. P., Bonfils, K. A., Luther, L., Firmin, R. L., White, D. A., Adams, E. L., & Rollins, A. L. (2017). The relationship between professional burnout and quality and safety in healthcare: A meta-analysis. Journal of General Internal Medicine, 32, 475-482. https://doi.org/10.1007/s11606-016-3886-9

Shabani, T., Jerie, S., & Shabani, T. (2023). The impact of occupational safety and health programs on employee productivity and organisational performance in Zimbabwe. Safety in Extreme Environments, 5(4), 293-304.

Simarmata, V. P. A., Marantuan, R. S., & Hutagalung, P. (2025). The relationship between work environment, occupational safety and health implementation, and employee performance: A cross-sectional study. Journal of Applied Nursing and Health, 7(3), 762-774.

Singer, S., Lin, S., Falwell, A., Gaba, D., & Baker, L. (2009). Relationship of safety climate and safety performance in hospitals. Health Services Research, 44(2p1), 399-421. https://doi.org/10.1111/j.1475-6773.2008.00918.x

Uddin, M., Arif, M. I., Hoque, N., & Ahmad, A. (2025). Understanding compliance management practices of ready-made garment industries in Bangladesh: Revisiting the challenges and pathways. International Journal of Critical Accounting, 14(2), 187-202.

Ugwu, E. N. (2025). Mental health consequences of public health emergencies among workers in Nigeria. International Journal of Education Research and Scientific Development, 8(1), 421-440.

Uquetan, A., Etuk, Anim, Itu, Ese, Okpara, & Ekpo. (2026). Hydrological and microbial characterization of surface water systems impacted by dumpsite leachate in Uyo Capital City, Akwa Ibom State, Nigeria. Gombe Journal of Geography and Environmental Studies, 2(3), 185-198.

Utip, I. U., Uduak, L. U., Itu, P. O., Ekpe, E. B., & Adegoke, O. O. (2025). The effect of graded levels of dietary atama (Heinsia crinita) leaf meal on the growth performance and cost benefits of starter broiler chickens. South Asian Research Journal of Biology and Applied Biosciences, 7(3), 183-189. https://doi.org/10.36346/sarjbab.2025.v07i03.004

Uttah, C., Itu, P.-C. O., Uloh, A. E., Michael, O. O., Bassey, B. O., & Nyong, D. M. (2026). Mapping housing affordability stress and residential displacement in Calabar Metropolis, Nigeria: A GIS-based assessment of migration flows to low-cost peri-urban settlements. Journal of Environmental Sciences and Built Environment Research, 1(1), 157-171. https://doi.org/10.83374/jesber.vol1no1.17

World Health Organization. (2020). Health worker safety: A priority for patient safety. WHO.

World Health Organization. (2021). Global patient safety action plan 2021-2030: Towards eliminating avoidable harm in health care. WHO.

World Health Organization, & International Labour Organization. (2022). Caring for those who care: Guide for the development and implementation of occupational health and safety programmes for health workers. WHO.