The scale **Journal Website:** https://thescalejournal.com.ng/
An Interdisciplinary Journal of **https://doi.org/10.5281/zenodo.20313453**
The ACADEMIC STAFF UNION OF POLYTECHNICS - ZONE D
ISSN: 2992-3727 Published 30th May, 2026

SOCIO-ECONOMIC AND OPERATIONAL FACTORS CONTRIBUTING TO ACCIDENTS IN PETROLEUM GEOPHYSICAL EXPLORATION

Oviawe, C. I. [1]; Ikheloa, S. O. [2]; Osemwengie, D.N. [3]
[1,3] Department of Mechanical Engineering, Edo State, Polytechnic, Usen, Edo State, Nigeria.
[2] Department of Electrical/Electronic Engineering, National Institute of Construction and Management, Uromi, Edo State, Nigeria
*Corresponding Author: iyekowa@yahoo.co.uk , 08055805619

Abstract
Petroleum geophysical exploration, a critical phase in the oil and gas industry, involves high-risk activities such as seismic surveys and drilling that are prone to accidents due to intertwined socio-economic and operational factors. This study examines these contributors through a comprehensive analysis, drawing on primary data collected from field surveys and integrating insights from both historical and contemporary literature. Socio-economic elements, including workforce demographics, economic pressures on contractors, and inadequate training linked to cost-cutting measures, exacerbate risk, while operational factors like equipment failure, poor maintenance, and procedural lapses directly precipitate incidents. The research employs a mixed-methods approach, with quantitative surveys of 250 participants from exploration sites in Nigeria and qualitative interviews to capture nuanced experiences. Demographically, the sample revealed a predominantly male workforce (85%), with ages ranging from 25-45years, and varying educational levels from high school to advanced degrees in geophysics. Theoretical frameworks such as the Human Factors Analysis and Classification system for Oil and Gas (HFACS-OG) and Heinrich's Domino Theory guide the analysis, highlighting how organizational influences cascade into unsafe acts. Findings indicate that socio-economic disparities, such as low wages leading to fatigue among entry-level workers, contribute to 40% of reported near-misses, while operational shortcomings like outdated seismic equipment account for 35% of accidents. The study underscores the need for integrated safety protocols that address both human and systemic vulnerabilities. Recommendations include enhanced regulatory oversight, investment in worker training, and adoption of resilient engineering practices to mitigate future risks. This article contributes to humanities-oriented scholarship by framing accidents not merely as socio-cultural phenomena embedded in global economic structures.

Keywords: Petroleum, geophysical, accident causation, demographics, workforce.

Introduction

The petroleum industry has long been synonymous with innovation and economic prosperity, yet its geophysical exploration segment remains fraught with hazards that underscore the precarious balance between resource extraction and human safety. Geophysical exploration, encompassing seismic surveying, gravity and magnetic measurements, and preliminary drilling, serves as the foundational step in identifying viable hydrocarbon reserves. However, this phase is inherently risky, involving remote operations in challenging terrains, heavy machinery, and exposure to volatile substances. Accidents in this domain not only result in loss of life and environmental degradation but also impose substantial economic burdens on stakeholders. Historically, the industry has witnessed catastrophic events that highlight these vulnerabilities, such as the Exxon Valdez oil spill in 1989, which primarily

a transportation incident, stemmed from broader operational lapses in exploration-related activities [1]. More recently, analyses of pipeline and drilling accidents in the 2020s reveal persistent issues, including human error amplified by socio-economic pressures [2].

The background of this study is rooted in the evolving landscape of the oil and gas sector, where globalization and market fluctuations have intensified socio-economic dynamics. In regions like Africa, crude oil exploration has brought economic boons but at the cost of community displacement and environmental harm, as evidenced in studies from the Niger Delta.[3] Economic imperatives often drive cost reductions, leading to subcontracting practices workers [4]. Operational factors, such as equipment malfunction and inadequate risk assessments, compound these issues, as seen in the Deepwater Horizon disaster of 2010, which, though post-exploration, illustrated cascading failures from initial geophysical misjudgments [5]. Current literature emphasizes the interplay between these elements; for instance, recent frameworks like HFACS-OGI adapt human factors models to the oil and gas context, identifying contractor environments as predominant in 90% of accidents between 2013 and 2017 [6].

The statement of the problem lies in the persistent high incidence of accidents despite advancements in technology and regulations. Global statistics indicate that the exploration sector records the highest fatal accident rates in the industry, with Europe reporting 5 fatalities per 100 million hours worked in 2016 [7]. In developing nation, socio-economic factors such as poverty-driven labor migration and insufficient regulatory enforcement exacerbate risks, leading to underreported incidents and inadequate compensation [8]. Operational challenges, including seismic cutline creation in ecologically sensitive areas, further contribute, as demonstrated in British Columbia where high-impact geophysical paths exceed safe widths due to poor planning [9]. This study addresses the gap in integrated analyses that merge socio-economic demographics with operational data, using primary methods to provide empirical evidence.

Relevant literature spans decade, blending old and new perspectives. Early works from the 1980s and 1990s focused on basic causation models; Heinrich's Domino Theory (1931, revisited in 1980s studies) posited accidents as sequences of unsafe acts triggered by social environments, influencing later oil-specific adaptations [10]. Pipeline accidents in the 1980s, such as the Berwick, Louisiana spill in 1980, highlighted weld failures and monitoring deficiencies [11]. In the 1990s, studies on international drilling workers revealed elevated injury risks, five times higher than other sectors, linked to demographic factors like youth and inexperience [12]. Contemporary research builds on this, incorporating complex systems theory; for example, chaos theory and resilience engineering offer alternatives to linear models, advocating for adaptive safety in offshore operations [13]. Recent analyses of the 2020s emphasize climate-induced hazards with rainfall-triggered geohazards in oil fields rising due to extreme weather [14]. Socio-economic reviews note that host communities suffer from infrastructure deficits, violating human capabilities without adequate remediation [8]. Operational literature points to human factors in 80% of incidents, with HFACS frameworks revealing organizational flaws [6]. This merged introduction sets the stage for a humanities-inflected examination, viewing accidents as narratives of power, labor, and technology.

Methodology

The research designs to investigate socio-economic and operational factors in petroleum geophysical exploration accidents, emphasizing primary data collection to ensure authenticity and relevance. The approach is grounded in interpretive paradigms common inhumanities scholarship, where accidents

are seen as socio-cultural constructs rather than isolated events. Primary data were gathered through structured surveys and semi-structured interviews, allowing for quantitative measurement of factors and qualitative depth in participant experiences. The study targeted workers in Nigeria's Niger Delta, a hotspot for exploration activities to capture context specific insights while drawing parallels to global patterns.

The research design is cross-sectional, capturing data at a single point in time from August to February, 2026 to assess current conditions amid ongoing industry challenges. A purposive sampling strategy was employed, selecting participants from active geophysical sites operated by major firms like shell and ExxonMobil affiliates. The samples size comprised 250 respondents for surveys and 50 for interviews ensuring statistical robustness and thematic saturation. Surveys included likert-scale questions on socio-economic pressures (e.g., wage adequacy, Job security) and operational risks (e.g., equipment reliability, procedural adherence), validated through pilot testing with cronbach's alpha exceeding 0.8 for reliability. Interviews explored personal narratives, probing how economic hardships influence safety behaviors.

Demography of participants reflects industry norms: 85% male, 15% female, aligning with global trends where women constitute about 16-23% of the workforce [15], Ages ranged from 20-55 years, with a mean of 35, and 40% aged 25-34, indicating a youthful demographic prone to risk-taking. Ethnically, 60% were indigenous to the Niger Delta (e.g. Ijaw, Urhobo), 25% migrant workers from other Nigerian regions, and 15% expatriates, highlighting socio-economic migration. Educationally, 45% held bachelor's degrees in geophysics or engineering, 30% diplomas in technical fields, and 25% high school equivalents, underscoring skill disparities. Experience averaged 8years, with 35% having less than 5 years, correlating with higher accident involvement.

The theoretical framework integrates HFACS-OGI [6] with socio-technical systems theory [16], updated in 2020s contexts. HFACS-OGI categorizes causes into unsafe acts, preconditions, supervision failures organizational influences, and external factors like sabotage or legislation gaps, adapted here to include socio-economic elements such as contractor exploitation. Socio-technical theory views accidents as mismatches between human capabilities and technical demands, influenced by economic structures. This dual frame allows for holistic analysis, linking individual behaviour to broader systemic issues.

Data analysis involved descriptive statistics for survey responses, thematic coding for interviews using NVivo software, and regression modeling to test relationship between variables. Ethical consideration included informed consent, anonymity and institutional review board approval from a Nigerian university. Limitations include potential re call bias in self- reported data and geographic focus, mitigated by triangulation with secondary sources.

Results and Analysis

Primary data revealed stark patterns in accident causation, with socio-economic factors emerging as pivotal survey results indicated that 65% of respondents cited economic pressures, such as low wages (average monthly income NGN150,000 or ~USD 300), as leading to extended shifts and fatigue, contributing to 40% of near-misses. Demographically, younger workers (20-34 years) reported higher incidents (55%), attributing this to inexperience and economic desperation driving risk acceptance. Table 1 presents demographic breakdowns and associated risk perceptions. While table 2 presents frequency of accident courses (form surveys).

Table1: Demographic profile and risk perception scores (N=250)

Demographic variable	Percentage (%)	Mean risk perception score (1-5 scale)
Gender: Male	85	3.8
Gender: Female	15	4.1
Age: 20-24	15	4.2
Age: 25-34	40	3.9
Age: 35-44	30	3.5
Age: 45+	15	3.2
Ethnicity: indigenous	60	4.0
Ethnicity: migrant	25	3.7
Ethnicity: Expatriate	15	3.4
Education: high school	25	4.3
Education: diploma	30	3.8
Education: Degree+	45	3.3

Higher scores indicate greater perceived risk. Females and less-educated workers perceived higher risks, possibly due to marginalization.

Operational factors dominated accident reports, with 50% involving equipment failure, such as seismic vibrators malfunctioning in rugged terrain. Interviews described instances where poor maintenance, driven by budget cuts, led to explosions during surveys. Regression analysis showed operational lapses $(\beta = 0.45, p < 0.01)$ strongly predicting accidents, moderated by socio-economic variables like training access $(\beta = 0.32, p < 0.05)$

Applying HFACS-OGI, 70% of incidents traced to organizational influences, including contractor unfamiliarity [6]. Old literature corroborates this, 1980s studies noted fivefold injury risks in geophysical sectors [17]. Recent data from 2020s, like geohazard increases [14], link climate factors to operational disruptions.

Table 2: Frequency of Accident Courses (form surveys)

Cause category	Frequency (%)	Examples
Socio-economic	40	Fatigue from low pay, migration stress
Operational	35	Equipment failure, procedural errors
Human factors	15	Inadequate training
Environmental	10	Terrain, weather

These findings illustrate how socio-economic vulnerabilities amplify operational risks, forming a vicious cycle

Discussion

The results align with literature where socio-economic factors like contractor reliance foster unsafe environments [4]. Demographically, the male-dominated, youthful workforce mirrors global patterns. [15]. Increasing susceptibility to accidents due to bravado and inexperience. Operational issues, such as in seismic outlines [9]. Echo 1980s pipeline failures [11], suggesting persistent systemic flaws.

Theoretical integration reveals HFACS-OGI's utility in dissecting layers; for instance, legislation gaps in Nigeria allow unchecked subcontracting cascading into unsafe acts. Socio-technical mismatches, as in poor equipment for diverse terrains, exacerbate this [16]. Compared to old models like Domino Theory [10], modern approaches incorporate chaos elements, explaining unpredictable weather – induced incidents [13].

Humanities lens frames these as narratives of inequality, indigenous workers' higher risk perceptions reflect colonial legacies in resource extraction [3]. Global comparisons show similar patterns in Africa and the Gulf, where economic booms mask safety deficits [8].

Conclusion and Recommendations

In conclusion, socio-economic and operational factors interweave to perpetuate accidents in petroleum geophysical exploration, as evidenced by primary data and literature. The study's findings underscore the need for holistic interventions.

Recommendations include mandating comprehensive training programs tailored to demographics, enhancing regulatory frameworks to address contractor risks, and investing in resilient technologies for operational safety. Firms show adopt proactive monitoring, integrating socio-economic audits into risk assessments. Policy makers must prioritize community compensation and environmental safeguards to break the cycle of exploitation. Future research could expand to longitudinal studies for deeper causal insights.

References

[1] Davidson, A. (1990), in the wake of the exxon valdez: The devastating impact of the Alaska oil spill. Sierra Club Books

[2] Gong Y., & Xiong, Y. (2025) HFACS-OGP. : An analysis framework for oil and gas pipeline accident causation. Safety Science, 182.106682

[3] Aghobidi, O.M., Okonta, B.C., & Dolor, D.E. (2005), Socio-economic and environmental impact of crude oil exploration and production on agricultural production. A case study of Edjeba and Kokori communities in Delta State of Nigeria. Global Journal of Environmental Science, 4(2), 171-176.

[4] Norazahar, N. Khan, F., Veitch, B., & Mackinnon, S. (2014). Human and organizational factors assessment of the evacuation of BP Deepwater Horizon: A dynamic simulation approach Process Safety and Environmental Protection, 92(6), 500-511

[5] Theophilus, S.C., Nwankwo, C.D., Acquah, E., Bassey, E.U. & Umoren, U.J. (2021). Analysis of accidents caused by human factors in the oil and gas industry using the HFACS-OGI framework. International Journal of Occupational Safety and Ergonomics, 27(3), 807-824

[6] IOGP (2017). Safety performance indicators – 2016 data. International Association of Oil & Gas Producers

[7] Kalu, V.E., & Ott, U.F. (2019). Crude oil exploration in Africa: Socio-economic implications, environmental impacts, and mitigation strategies. Environment, Development and Sustainability, 21(5), 2075-2099

[8] Strouth, A., McDougall, S., & Jakob, M. (2024). Factors influencing the creation of high-impact oil and gas geophysical seismic cutlines in an ecologically-sensitive landscape in northeastern British Columbia, Canada. Journal of Environmental Management, 351, 119782

[9] Heinrich, H.W. (1980).Industrial accident prevention: A safety management approach (5th ed). McGraw-Hill

[10] NTSB. (1981). Pipeline accident report: Texas Eastern Gas Pipeline company rupture and fire, Berwick, Louisiana, January 2, 1980. National Transportation Safety Board

[11] CDC (1993). Injuries to international petroleum drilling workers, 1988-1990. Morbidity and mortality weekly Report, 42(4), 65-68

[12] Sonier, B., Johnson, P., & Dahien, P. (2020). Examining alternative to traditional accident causation models in the offshore oil and gas industry. Journal of Risk research, 23(11), 1409-1424

[13] Chen, C., Xie, M., Du, Y., & Zhang, X. (2025). Dual-indicator micro-electro-mechanical system monitoring method for rock instability early warning. Applied Sciences, 15, 4210

[14] BLS (2025). Describing the U.S. oil and gas extraction workforce with public data. Monthly Labor Review. https://www.bls.gov/opub/mir/2025/article/describing-th-us-oil-and-gas-extraction-workforce-with-public-ata.htm

[15] Trist, E.L., & Bamforth, K. W. (1951). Some social and psychological consequences of the longwall method of coal-getting Human Relations, 4(1), 3-38.

[16] Flin, R., & Mearns, K. (1995). Risk perception and attitudes to safety by personnel in the offshore oil and gas industry: A review Journal of Loss Prevention in the Process Industries, 8(5), 299-305