MEDICAL SCIENCES

PATTERNS OF OCCUPATIONAL INJURIES BY BODY REGION IN INDONESIA'S UPSTREAM OIL AND GAS INDUSTRY

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ABSTRACT

Introduction The oil and gas sectors are inherently high-risk due to complex processes, high-pressure systems, and hazardous physical & chemical exposure. Yet evidence on injury patterns remains limited, hindering effective safety interventions. This study aimed to categorize body part injuries by event type, severity, and work activity to address this gap.

Materials and methods This descriptive cross-sectional study used secondary data from five oil and gas companies in Indonesia (2013–2023), including 948 injury cases, of which 621 were limb injuries, which were analyzed. Data were categorized by injured body part (BPI), event type (TOE), work activity, and severity. The Phi coefficient was used to assess relationships between TOE, work activity, and BPI.

Results This study found that hand, finger, or forearm injuries (BP5) were the most frequent (294 cases; 49.34%) and predominated in all companies, especially Company X1 (>70%). Being caught in, on, between, or under objects was the most common cause, usually involving pinch mechanisms. A strong association was observed between TOE5 and hand/finger injuries (Phi = 0.563), suggesting frequent upper limb pinch and crushing injuries. These incidents, totaling 134 cases, often occurred during nonspecific work activities.

Conclusions This study highlights the high burden of hand and finger injuries in the oil and gas industry, revealing gaps in safety practices. Targeted prevention focusing on pinch hazards and task-specific risks is needed. Future research should assess the effectiveness of interventions and ergonomic improvements to reduce limb injuries.

Keywords Occupational injury, body part injured, oil and gas industry, accident mechanism, prevention, hand injury, Indonesia.

RISCURI DE LEZIUNI ALE DIFERITELOR PĂRȚI ALE CORPULUI ȘI PROVOCĂRILE PRIVIND SIGURANȚA ÎN RÂNDUL LUCRĂTORILOR DIN INDUSTRIA PETROLIERĂ ȘI A GAZELOR DIN INDONEZIA

Introducere Industria petrolieră și a gazelor naturale este considerată una dintre cele mai periculoase ramuri economice, din cauza proceselor tehnologice complexe, a sistemelor care funcționează la presiuni înalte și a expunerii la numeroși factori fizici și chimici periculoși. Cu toate acestea, informațiile privind tipurile leziunilor ocupaționale rămân limitate, ceea ce îngreunează elaborarea unor măsuri eficiente de prevenire. Acest studiu și-a propus să clasifice leziunile în funcție de partea corpului afectată, tipul activității, gravitatea și intensitatea muncii desfășurate.

Materiale și metode Studiul descriptiv transversal a utilizat date secundare provenite de la cinci companii din sectorul petrolier și al gazelor din Indonezia, colectate în perioada 2013–2023. Au fost analizate 948 de cazuri de accidentare, dintre care 621 au reprezentat leziuni ale membrelor. Datele au fost clasificate în funcție de partea corpului lezată, tipul activității, activitatea desfăşurată și severitatea leziunii. Relațiile dintre tipul activității, și partea corpului afectată au fost evaluate utilizând coeficientul Phi.

Rezultate Leziunile mâinii, degetelor sau ale antebrațului au fost cele mai frecvente, fiind înregistrate în 294 dintre cazuri (49,34%) și predominând în toate companiile analizate, în special în Compania X1 (peste 70% din cazuri). Cea mai comună cauză a fost prinderea între, sub sau de obiecte, de regulă prin mecanisme de strivire sau ciupire. S-a observat o asociere puternică între TOE5 și leziunile mâinilor/degetelor (Phi = 0,563), sugerând o frecvență ridicată a traumatismelor membrelor superioare cauzate prin strivire și prindere. Aceste incidente, însumând 134 de cazuri, au avut loc, frecvent, în timpul unor activități de muncă nespecificate.

Concluzii Studiul evidențiază povara semnificativă a leziunilor mâinilor și degetelor în industria petrolieră și a gazelor naturale, indicând existența unor lacune în practicile de securitate ocupațională. Sunt necesare măsuri de prevenire, orientate spre reducerea riscurilor de prindere și strivire, precum și spre gestionarea pericolelor specifice anumitor sarcini de lucru. Cercetările viitoare ar trebui să evalueze eficiența intervențiilor preventive și a îmbunătățirilor ergonomice în reducerea leziunilor membrelor.

Cuvinte-cheie Accidentare ocupațională, parte a corpului lezată, industria petrolieră și a gazelor, mecanism de accidentare, prevenire, leziuni ale mâinii, Indonezia.

INTRODUCTION

The oil and gas industry in Indonesia plays a crucial role in supporting national economic growth by supplying a significant portion of the country's energy resources. However, this sector is also characterized by hazardous working environments, including high-pressure systems, toxic chemicals, and extreme field conditions, all of which increase the risk of occupational injuries and illnesses (1,2). In the United States, the rate of non-fatal injuries in the oil and gas sector reached 1.8 per 100 full-time workers by 2022, signaling similar concerns globally (3). Moreover, OSHA data indicate a substantial burden of severe workplace injuries, with upper extremities, particularly fingers, being the most affected body parts. Injuries to the fingers and fingertips consistently rank as the most affected body parts, accounting for approximately 24.7% of all severe injury cases, underscoring that the hands remain the most vulnerable body parts in high-risk occupational settings (4). Arifuddin et al. (2020), in their study, reported data from PT Jamsostek on occupational accidents in Indonesia from 2010 to 2017(5). Subsequently, data from BPJS Ketenagakerjaan (2022), covering the period from 2017 to 2022, indicate a continuous year-on-year increase in the number of occupational accidents (6).

The oil and gas industry is characterized by high-risk environments that expose workers to significant injury hazards (7,8). In this context, analyzing injury patterns linked to specific body parts is crucial for formulating effective safety intervention strategies. Workers often operate under physically and mentally demanding conditions, on rotating shifts, and in various hazardous environments. These conditions increase the risk of musculoskeletal disorders and limb injuries (9–11).

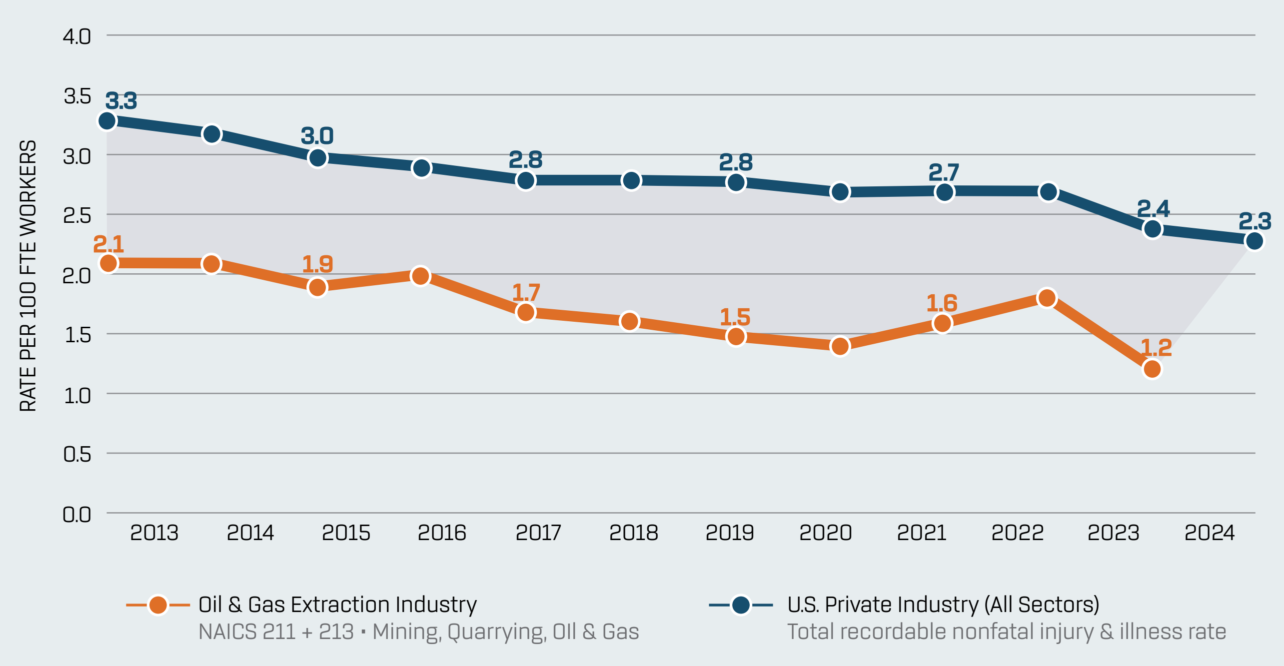


Figure 1. Prevalence of Oil and gas Sector vs Private Sector Non-Fatal Injuries in the United States in 2013-2024 (12)

Despite an overall downward trend in non-fatal injury and illness incidence rates over the past decade, the oil and gas sector continues to present notable occupational safety concerns. As shown in Figure 1, injury rates in the Oil and Gas Extraction Industry decreased substantially, yet remained consistently below the U.S. private industry average. However, the persistence of injuries, particularly those with severe outcomes, highlights ongoing challenges in occupational safety within this high-risk sector.

Recent evidence indicates that upper-extremity injuries are highly prevalent in the oil and gas sectors. A CDC/MMWR study published in 2024 found that 42.6% of severe injuries in the oil and gas industry from January 2015 to July 2022 involved upper extremities, with contract workers in service and drilling subindustries bearing a disproportionately higher burden of these injuries (13). Hand and finger injuries are among the most prevalent types of injuries in the oil and gas sector, often associated with machine tool usage, chemical exposure, unsafe behaviors, inadequate machine maintenance, time pressures, and insufficient training (14,15). Consistent with this, NIOSH data (2015–2022) indicate a substantial burden of injuries to the fingers, hands, and wrists, while national statistics further confirm that upper extremities remain the most commonly affected body region in occupational injuries (16,17).

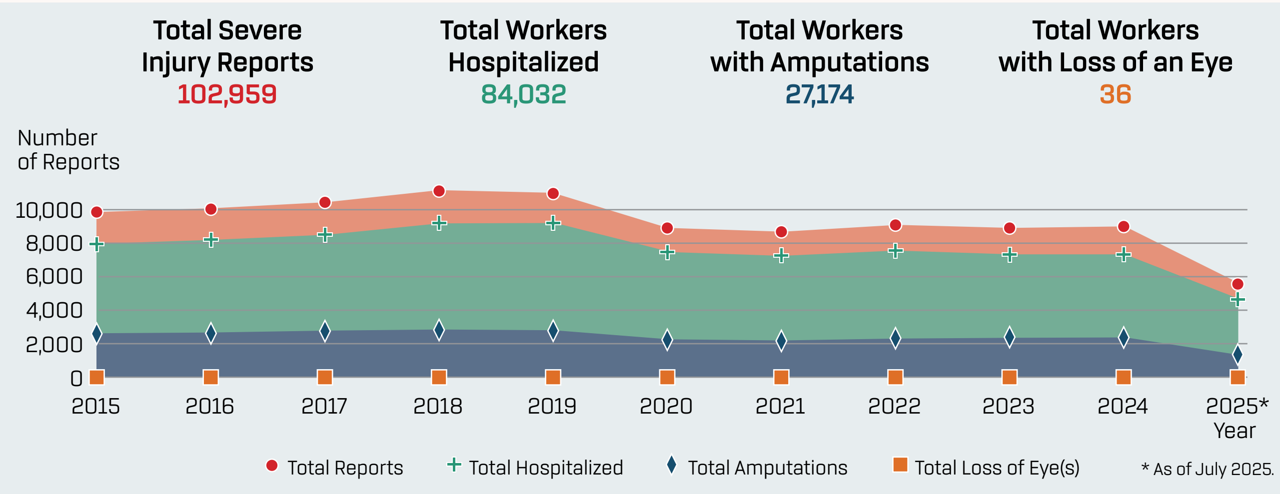


Figure 2. Annual Trends in Severe Workplace Injury Outcomes Reported to OSHA, United States, 2015–2025 (4)

Workplace injuries in the United States continue to pose a significant threat to worker safety (18). OSHA data from 2015 to July 2025 report over 102,000 severe injury cases, with a substantial proportion resulting in hospitalization and a considerable number involving amputations. As shown in Figure 2, although the annual number of reported cases has generally declined since its peak in 2017–2019, the severity of injuries has remained relatively unchanged, as reflected by the persistently high proportion of cases requiring hospitalization. Amputation cases also remained consistently reported over time, indicating ongoing exposure to high-risk hazards. These patterns highlight persistent challenges in workplace safety and underscore the need for more targeted and effective preventive interventions, particularly in high-risk sectors such as oil and gas.

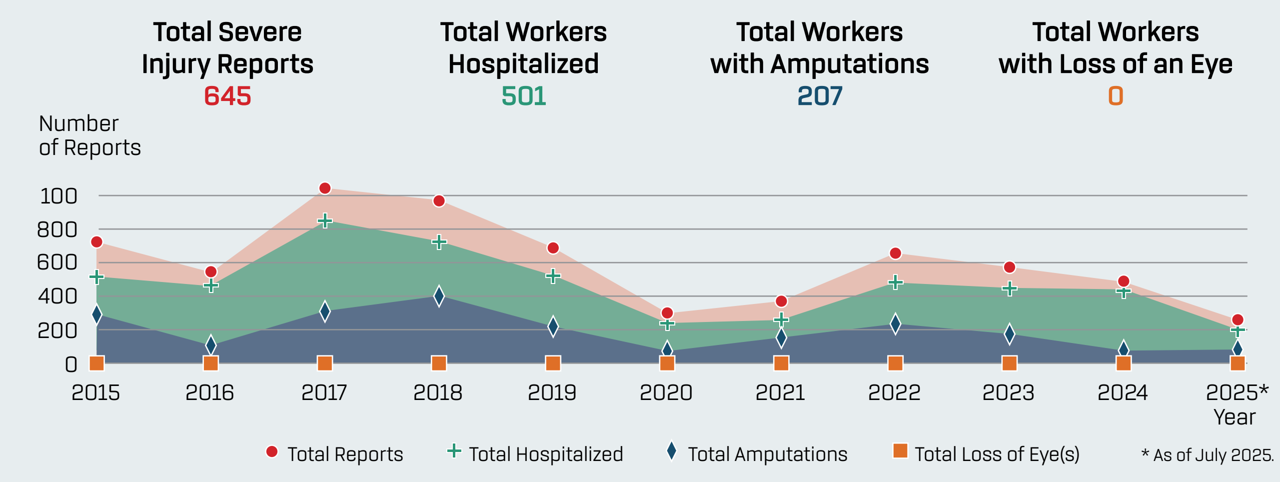


Figure 3. OSHA – 213111: Drilling oil and Gas wells injury reports data (4)

Focusing on the oil and gas sector, OSHA data from 2015 to 2025 recorded 645 severe injury cases, with a substantial proportion resulting in hospitalization and a notable number involving amputations. As shown in Figure 3, injury reports peaked around 2017–2018, declined sharply in 2020, and then fluctuated in subsequent years. Despite the overall decline, the consistently high proportion of hospitalizations indicates that injuries in this sector are often severe. These patterns highlight the persistent risk associated with oil and gas operations and underscore the need for strengthened safety interventions, particularly in settings where safety systems are still developing, such as Indonesia.

Occupational health risks in the oil and gas sector arise from complex operational processes and hazardous workplace exposures, increasing the likelihood of injuries and adverse health outcomes (17,19). Evidence shows that safety management practices—including training, clear procedures, communication, and safety promotion—play a critical role in reducing accident rates, particularly when supported by worker compliance (20–23). In addition, the role of safety culture in preventing injuries cannot be ignored; safety culture is a predictor of safety behavior and safety performance (24). This is especially pertinent in the oil and gas sector, where the inherently high-risk nature of operations requires a robust safety culture characterized by strong safety practices and effective communication to mitigate accident and injury rates (25–27). A study of workers in Nigeria's oil and gas industry found that safety culture significantly influences worker performance (28).

However, challenges remain in ensuring consistent implementation and compliance. Additionally, demographic factors such as age, marital status, and level of experience are associated with injury vulnerability, with newer workers facing higher risks (29,30). Considering these injury patterns and risk factors, stakeholders must implement effective health and safety measures to address both immediate hazards and long-term health impacts. Despite growing research on safety management, evidence on detailed limb injury patterns by event type, severity, and work activity remains limited, particularly in the Indonesian oil and gas context.

Therefore, this study aimed to analyze the incidence and characteristics of body part injuries in Indonesia's oil and gas industry based on type of event, severity, and work activity. It was hypothesized that specific event types are significantly associated with body part injuries in this industry. The findings are expected to inform targeted interventions for improving occupational safety and preventing limb-related injuries in this high-risk sector.

MATERIAL AND METHODS

RESEARCH TYPE

This study employed a quantitative descriptive approach to analyze occupational injury data in the oil and gas industry. The research aimed to provide a comprehensive overview of injury patterns affecting limbs, categorized by the type of incident, severity level, and work activity associated with each case.

POPULATION AND SAMPLE

The study population comprised all reported occupational injury cases from five oil and gas companies in Indonesia, identified by the anonymized codes X1, X2, X3, X4, and X5. Of the 948 total recorded cases, 621 cases of limb injuries reported between 2013 and 2023 were included using total population sampling, ensuring complete representation of injury records across the selected companies.

RESEARCH LOCATION

The study was conducted using occupational injury records obtained from five companies in Indonesia, representing diverse operational environments within the national oil and gas sector.

INSTRUMENTATION OR TOOLS

Secondary data were obtained from official company safety reports, government regulatory records, and industry safety databases. Data variables included the injured body part, type of incident, severity level, and type of work activity involved. To ensure consistency in classification, injury-related variables were standardized using coding systems adapted from industrial safety protocols.

DATA COLLECTION PROCEDURES

Data were extracted retrospectively and compiled into a structured database. Injuries were categorized into five body part groups using a Body Part (BP) code: BP1 – body, back, waist, or shoulders; BP2 – feet, toes, or knees; BP3 – head, face, eyes, neck, or ears; BP4 – internal organs (respiratory, digestive, or other); and BP5 – hands, fingers, or forearms.

The causes of injury were categorized into 31 event types, each assigned a Type of Event (TOE) code, including events such as pinch mechanisms (TOE5), contact with hazardous materials (TOE13), falls (TOE3–TOE4), equipment failure (TOE18), fire and explosion (TOE16–TOE17), and others. Severity was classified into six levels: First Aid (Level 1), Medical Treatment (Level 2), Restricted Workday (Level 3), Day Away from Work (Level 4), and Fatality (Level 5). Work activity types were coded into 12 categories (A1–A12), including construction (A1), maintenance (A5), production operations (A7), land and marine transport (A10–A11), and unspecified activities (A12).

DATA ANALYSIS

Descriptive statistical analysis was conducted to identify the distribution of limb injuries by body part, incident type, severity level, and work activity. Results were tabulated and visualized to determine patterns and high-risk combinations, particularly focusing on the most common injury mechanisms and body regions affected. In addition to descriptive analysis, the strength of association between categorical variables was examined using the Phi coefficient (φ). Phi correlation analysis was applied to assess the relationship between Type of Event (TOE) and Body Part Injury (BP), as well as between work activity categories (A1–A12) and injured body parts.

Given that the Phi coefficient is appropriate for 2×2 contingency tables, categorical variables were dichotomized prior to analysis. Correlation strength was interpreted as weak ($\varphi < 0.20$), moderate ($\varphi = 0.20–0.39$), strong ($\varphi = 0.40–0.59$), and very strong ($\varphi \geq 0.60$). Statistical significance was determined using chi-square p-values, with $p < 0.05$ considered statistically significant. This combined descriptive and associative approach allowed identification not only of the most frequent injury categories but also of the most strongly concentrated body part–event and body part–activity combinations within the oil and gas occupational context.

RESULTS

A total of 621 cases of body-part injury were recorded in five oil and gas companies in Indonesia from 2010 to 2023 in Figure 4. (31)

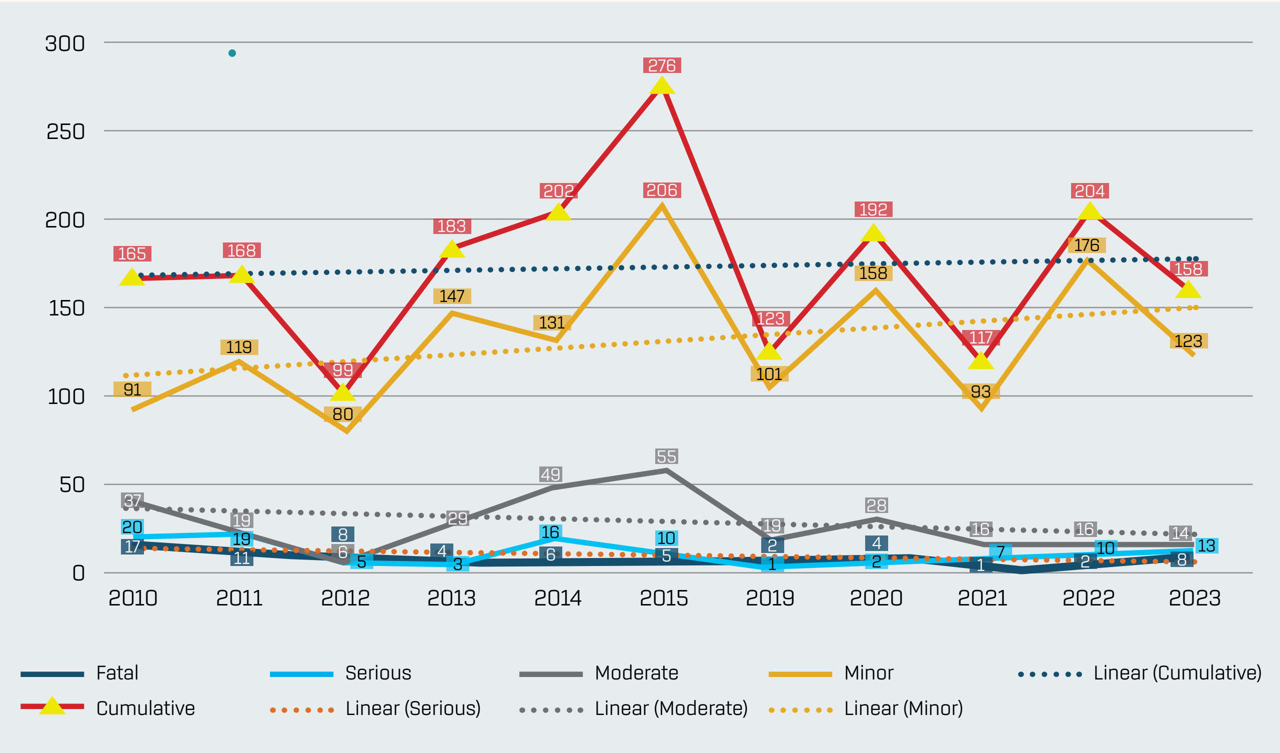


Figure 4. Indonesia's Upstream Oil and gas Work Accident (2010-2023)

The descriptive analysis revealed that the most frequently injured body part was the hands, fingers, or forearms (BP5), accounting for 294 cases (47,34%). This was followed by injuries to the head, face, eyes, neck, or ears (BP3) with 125 cases (20.13%), feet, toes, or knees (BP2) with 119 cases (19.16%), respiratory, digestive, or other internal organs (BP4) with 43 cases (6.92%), and body, back, waist, or shoulders (BP1) with 40 cases (6.44%) in Table 1.

Table 1. Number of Personal Body Injury Incidents among Workers in Oil and gas Companies

No	Body Part Injury (BP)	Frequency	%
1	BP1	40	6,44
2	BP2	119	19,16
3	BP3	125	20,13
4	BP4	43	6,92
5	BP5	294	47,34
	Total	**621**	**100**

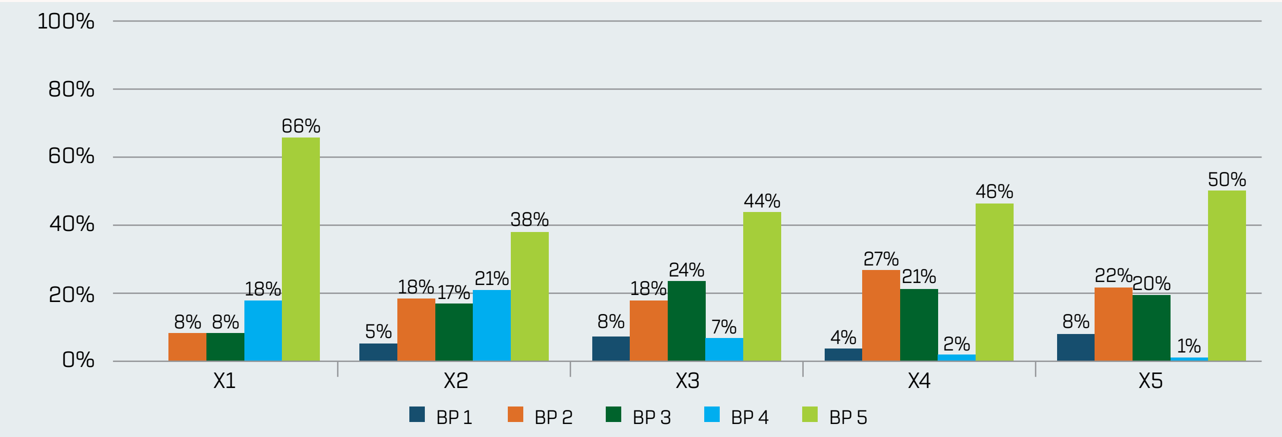
Source: Secondary Data

When examined by company, BP5 remained the most common injury type across all five organizations. In Company X1, about 66% of injuries involved BP5. Company X5 and X3 also reported a high number of BP5 cases (236 and 203 cases, respectively), whereas injuries involving body, back, waist, or shoulders (BP1) were relatively rare but most common in Company X3 (Table 2, Figure 5).

Table 2. Number of Personal Body Injury Incidents among Workers in Each Oil and gas Company

No	Company	BP1	BP2	BP3	BP4	BP5	Total
1	X1	0	4	4	9	33	50
2	X2	4	14	13	16	29	76
3	X3	18	42	56	16	104	236
4	X4	2	15	12	1	26	56
5	X5	16	44	40	1	102	203
	Total	**40**	**119**	**125**	**43**	**294**	**621**

Source: Secondary Data



Source: Secondary Data

Figure 5. Percentage Chart of Personal Body Injury Incidents in Workers in Each Company

A comparison with OSHA data based on NAICS codes 213111 (Drilling Oil and Gas Wells) and 213112 (Support Activities for Oil and Gas Operations) confirmed that hand and finger injuries are consistently the most prevalent type of injury in the oil and gas drilling sector across jurisdictions in Figure 6.

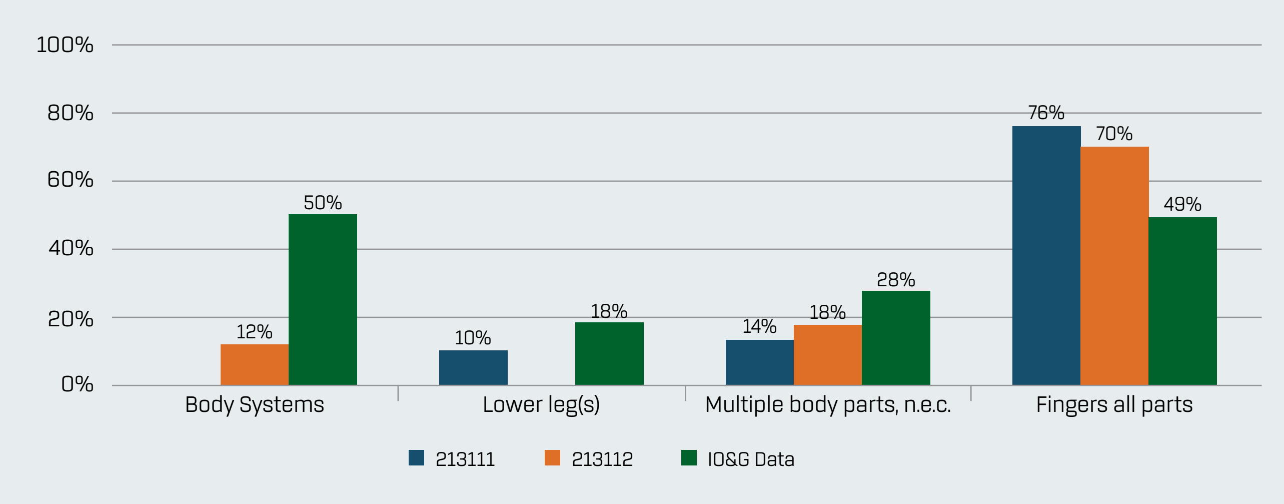


Figure 6. Percentage Chart of Personal Body Injury OI&G Data Compared to NAICS Codes 213111 and 213112

Type of Event (TOE) refers to the classification of incidents involving workers that are formally reported and recorded. This classification is compiled using the PHE SCAT (Systematic Cause Analysis Technique) Table. Analysis of event types in the accident investigation process allows for more effective identification of risk factors and prevention. Table 3 highlights that being struck (TOE2) was the most prevalent type of event, recording 142 cases, with Company X3 accounting for the highest incidence at 60 cases. This was closely followed by being caught in or between objects, or under/being crushed (TOE5), accounting for 140 cases. Other unspecified causes (TOE30) contributed 95 cases, while falling from a height (TOE3) and falling from the same height (TOE4) were less common, with 67 and 56 cases, respectively in Table 3.

Table 3. Number of Type of Event (TOE) among Workers in Oil and gas Companies

Type of Event	Description	X1	X2	X3	X4	X5	Total
TOE2	Being struck (hitting a moving object)	9	15	60	20	38	142
TOE3	Falling from a height (person/equipment/material)	5	9	44	14	12	67
TOE4	Falling from the same height (slipping/tripping)	6	8	17	4	25	56
TOE5	Being trapped in, on, between, or under/being crushed	13	12	55	17	43	140
TOE30	Others	15	6	30	6	50	95

Source: Secondary Data

Activities are characterized as the specific area or tasks in which workers are engaged directly before or at the precise moment an incident takes place. Table 4 illustrates the distribution of various activities among workers across five oil and gas companies. The most frequently observed activity was non-specific activities (A12), accounting for 214 cases, with Company X3 accounting for the highest incidence at 86 cases. This was closely followed by Drilling, Workover, Well Services (A3) with 150 cases, and Maintenance, Inspection, Testing (A5) with 113 cases. Notably, Company X3 consistently exhibited the highest overall activity, particularly dominating in A3 (74 cases) and A5 (49 cases), while Company X5 also showed a high volume of A5 activities (48 cases).

Table 4. Number of Activity among Workers in Oil and gas Companies

Activity	Description	X1	X2	X3	X4	X5	Total
A3	Drilling, Workover, Well Services	11	16	74	16	33	150
A4	Lifting, Crane, Rigging, Deck Operations	1	6	20	12	13	52
A5	Maintenance, Inspection, Testing	4	10	49	2	48	113
A6	Office, Warehouse, Accommodation, Catering	5	9	10	4	22	50
A12	Non-specific activities	19	21	86	47	41	214

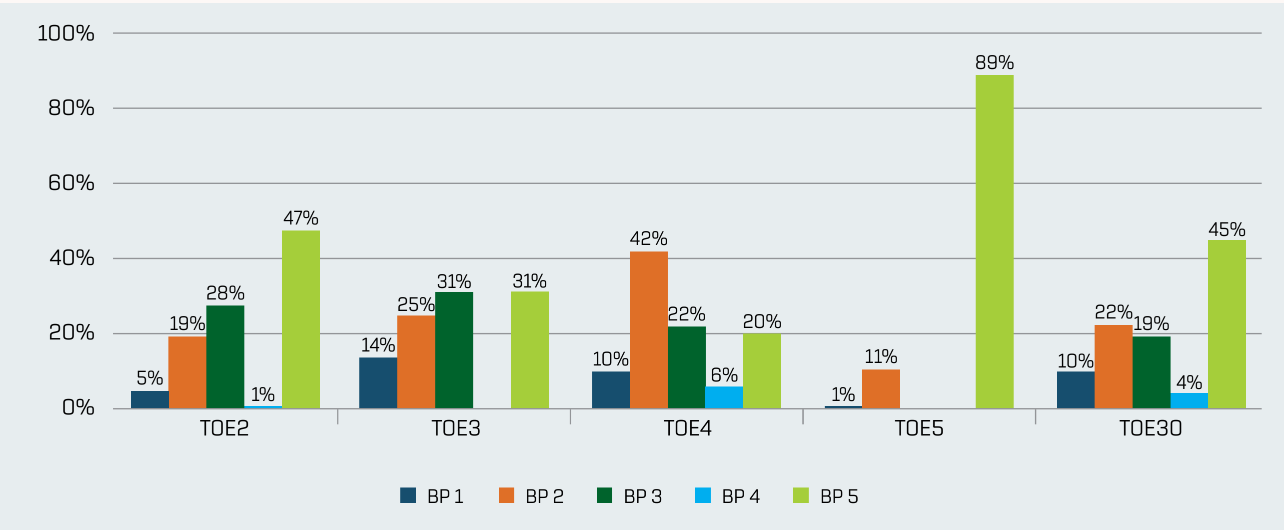
Source: Secondary Data

Injury trends by type of event indicated that BP5 injuries were most frequently caused by being caught in, on, between, or under equipment or objects (TOE5), accounting for 132 cases. This was followed by being struck by moving objects (TOE2) and other unspecified causes (TOE30). Injuries to the head, face, eyes, neck, or ears (BP3) and injuries to the feet, toes, or knees (BP2) were mostly linked to being struck by moving objects (TOE2), while body, back, waist, or shoulders (BP1) were primarily caused by falls from height (TOE3) in Table 5, Figure 7.

Table 5. Body Part Injury by Type of Event

Type of Event	Description	BP1	BP2	BP3	BP4	BP5	Total	Highest BP (φ)
TOE2	Being struck (hitting a moving object)	8	30	43	1	74	156	BP3 = 0.293
TOE3	Falling from a height (person/equipment/ material)	11	20	25	0	25	81	BP1 = 0.232
TOE4	Falling from the same height (slipping/tripping)	5	21	11	3	10	50	BP2 = 0.237
TOE5	Being trapped inside, on, between, or under/ being crushed	1	16	0	0	132	149	BP5 = 0.563
TOE30	Others	10	23	20	4	46	103	BP5 = 0.199

Source: Secondary Data



Source: Secondary Data

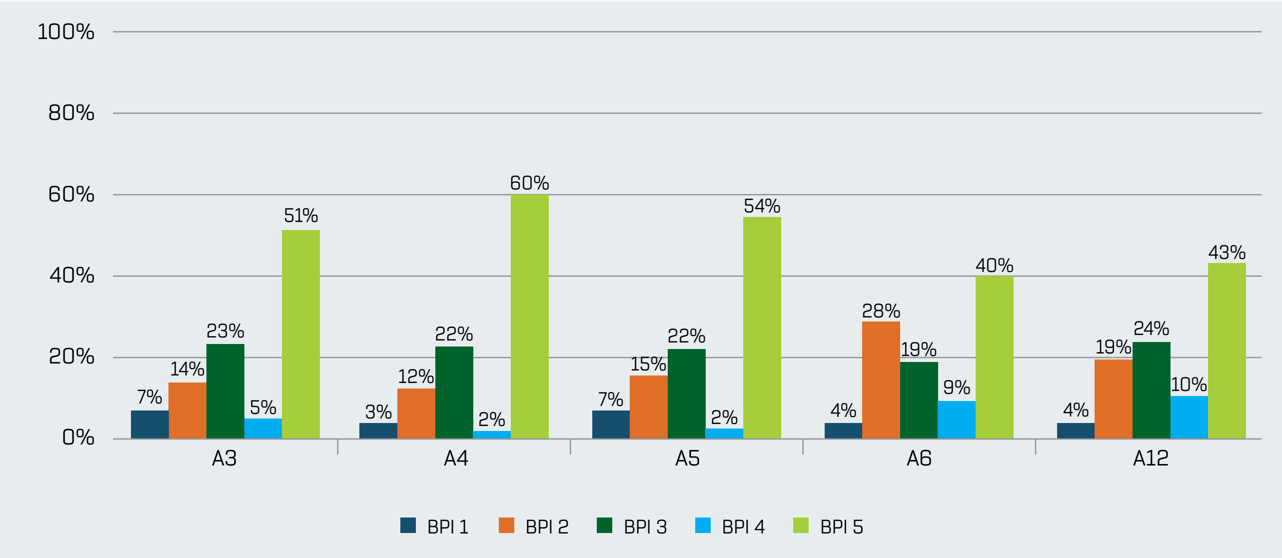
Figure 7. Percentage Chart of Personal Body Injury in Type of Event

In terms of work activity, most BP5 injuries occurred during non-specific activities (A12), with 79 cases, followed by drilling, workover, and well services (A3) with 75 cases, and maintenance, inspection, and testing (A5) with 74 cases. A similar pattern was observed for other body part injuries, with most incidents occurring during A12, A3, and A5 activities in Table 6, Figure 8.

Table 6. Body Part Injury in Each Activity

Activity	Description	BP1	BP2	BP3	BP4	BP5	Total
A3	Drilling, Workover, Well Services	10	20	34	7	75	146
A4	Lifting, Crane, Rigging, Deck Operations	2	7	13	1	35	58
A5	Maintenance, Inspection, Testing	9	21	30	3	74	137
A6	Office, Warehouse, Accommodation, Catering	2	15	10	5	21	53
A12	Non-specific activities	7	36	44	19	79	185

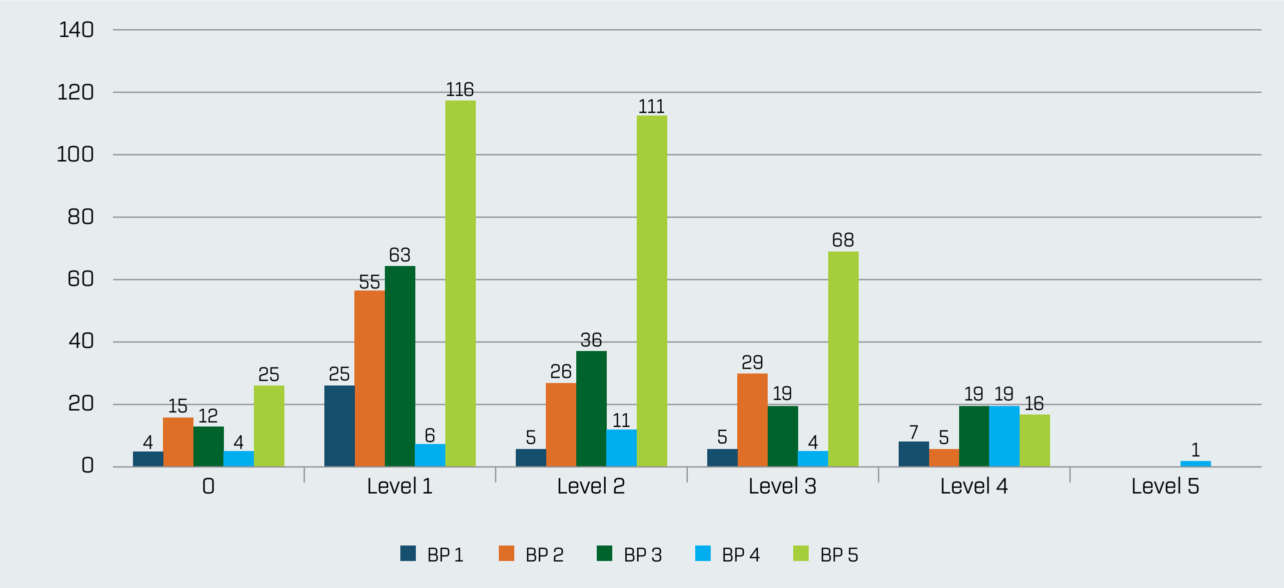
Source: Secondary Data



Source: Secondary Data

Figure 8. Distribution of Occupational Injuries by Body Region in Each Activity

Analysis of injury severity demonstrated that injuries categorized as BP5, BP3, BP2, and BP1 were primarily of Level 1 (First Aid) severity. In contrast, BP4, despite representing the lowest number of cases, exhibited the highest proportion of Level 4 (Day Away from Work) severity ratings in Figure 9.



Source: Secondary Data

Figure 9. Graph of the Number of Personal Body Injury Incidents by Severity Level

These results underscore the high prevalence of upper limb injuries in oil and gas operations, particularly during high-risk and undefined work activities. The findings also highlight key injury mechanisms such as pinch points and contact with moving machinery, providing critical insights for targeted prevention strategies.

Table 7. Correlation between type of event and body part injury

Correlation (Phi Coefficient)	BP0	BP1	BP2	BP3	BP4	BP5
TOE2	-0.026959	0.066379	0.138906	0.293314	-0.028275	0.182433
TOE3	0.232156	0.161474	0.131430	0.163508	0.001415	0.045475
TOE4	0.124480	0.054237	0.237119	0.061236	0.021219	-0.008887
TOE5	-0.007099	-0.024466	0.057367	-0.076820	-0.025792	0.563432
TOE30	0.090708	0.063539	0.093961	0.067391	0.044668	0.198715

The correlation analysis indicates generally weak associations between event types and injured body parts, suggesting that no single event strongly predicts specific injury locations (Table 7). Nevertheless, distinct patterns highlight differentiated risk profiles across activities. Some event types exhibit more specific injury tendencies, reflecting task-related exposure mechanisms, while others show a more distributed pattern, indicating broader hazard exposure. A particularly notable finding is one event type demonstrating a concentrated association with a single body part, suggesting a localized and specific injury mechanism. The presence of both positive and negative correlations further reflects heterogeneity in injury pathways, where risks vary depending on task interactions and work conditions. Overall, these findings suggest that injury risks are shaped by activity-specific processes and exposure dynamics, emphasizing the importance of targeted, rather than generalized, safety interventions.

Table 8. Correlation between work activity and body part injury

Correlation (Phi Coefficient)	BP0	BP1	BP2	BP3	BP4	BP5
A3	0.091129	0.079062	0.090015	0.168713	0.027909	0.248822
A4	0.087951	0.024665	0.062901	0.090782	-0.015194	0.181037
A5	0.025720	0.079504	0.095125	0.162155	0.010411	0.242920
A6	0.034763	0.020480	0.119190	0.058384	0.059017	0.090007
A12	0.226310	0.055004	0.137772	0.164707	0.138715	0.211786

The correlations are generally weak, indicating that no single work activity strongly determines the location of injuries. However, some activities (e.g., A3, A5, and A12) show more specific associations with particular body parts, suggesting focused exposure to hazards. In contrast, other activities display more diffuse patterns, indicating broader exposure (Table 8). Overall, the variation reflects task-specific risk mechanisms, highlighting the need for activity-based targeted safety interventions.

DISCUSSION

Workplace accident data from 2010 to 2023 in Indonesia's oil and gas sector indicate a fluctuating trend across injury-severity categories (31). Despite the growing attention to occupational safety, hand and finger injuries continue to be among the most prevalent, with studies estimating that these account for approximately 15% of all lost-time injuries, often caused by pinch mechanisms, contact with machinery, and insufficient training (14,16). This study found that injuries to the hands, fingers, and forearms (BP5) were the most common among workers in five oil and gas companies in Indonesia between 2013 and 2023. These upper-limb injuries accounted for nearly half of all reported injuries.

This finding is consistent with a report from PT XYZ in 2021–2022, where hand injuries led to medical treatment and work restrictions (32). Similar trends are also seen in the United States, where OSHA records for drilling and well operations (NAICS 213111 and 213112) show upper limb injuries as the most frequently reported. These results suggest that BP5 injuries are a major concern in both national and international oil and gas operations. This pattern is consistent with findings from other industrial sectors, where upper-limb injuries are the most frequent (33). Studies in manufacturing and construction indicate that workers' hands and fingers are particularly vulnerable due to their direct involvement in operating tools and machinery (34). The high prevalence of BP5 injuries observed in this study aligns with previous research, which identifies inadequate training and poor hazard control as key contributing factors (35,36).

Like our findings, Dang et al. (2019) reported that blunt trauma was the primary cause of head and neck injuries in Oil and gas sites in Alberta, Canada, accounting for nearly half of all injuries (37). Head and neck injuries are also common in other industrial sectors, particularly in manufacturing and construction (38). Our data also revealed a notable percentage (28%) of injuries to the head, face, neck, and eyes (BP3), often due to impacts with moving objects (TOE2). This supports earlier studies that found head trauma to be a key cause of workplace deaths (39,40). Likewise, lower limb injuries (BP2) were often associated with slips, trips, and falls, which are common across industrial sectors and often lead to lost workdays (41–44). Injuries to the back, waist, and shoulders (BP1), though less frequent, were tied to high-risk ergonomics and falls from height (45,46). Internal organ injuries (BP4), though rare, often stem from chemical exposure or body function failure, reinforcing previous findings on respiratory and digestive risks from exposure to hydrocarbons and pollutants (47–49).

Analysis of incident data by type of event (TOE), as presented in Table 3, identified TOE2 (being struck) and TOE5 (being trapped inside, on, between, or under/being crushed) as the most dominant causes of incidents. These two types of events contributed 142 and 140 incidents, respectively, collectively accounting for approximately 45% of the total recorded incidents. This significant proportion indicates that workers in oil and gas environments are at high risk of impact and crushing hazards. Further observation revealed variations in the distribution of incidents per TOE across companies. Companies X3 and X5, for example, recorded relatively high numbers of incidents across most TOE categories, which implies the urgency of a comprehensive evaluation of standard operating procedures and hazard controls at these facilities.

As presented in Table 5 and Figure 7, TOE5 within BP5 exhibited the highest event frequency, contributing 132 cases (24%) and representing the largest proportion of the 539 recorded events, indicating a concentration of incidents in this category rather than a correlational relationship. This finding suggests that injuries in BP5 are mostly a direct consequence of being caught or crushed. From an occupational ergonomics perspective, the oil and gas industry involves numerous physical and ergonomic demands, as both upstream and downstream operations rely on complex technologies that require substantial human involvement during operational and maintenance activities (50,51). Ergonomic hazards are recognized as significant contributors to debilitating injuries and long-term disabilities among oil and gas drilling workers (52). Workers in the oil and gas industry frequently perform lifting, operate heavy machinery, perform repetitive tasks, and work in confined spaces, all of which may increase ergonomic strain, particularly during maintenance and operational activities (53).

The predominance of TOE5-related BP5 injuries may also reflect insufficient implementation of engineering and technical risk control measures, particularly during non-routine activities such as startup, shutdown, maintenance, and commissioning processes, which generally require greater levels of human involvement in system operations and are associated with elevated accident risks due to the potential for operator errors and deviations from established procedures (54). In addition, TOE2 showed a substantial contribution to injuries in BP5 and BP3. Meanwhile, TOE3 (falling from a height) was more frequently associated with injuries in BP3 and BP5. In contrast, TOE4 (falling from the same height/slipping/tripping) predominantly caused injuries in BP2.

Analysis of incidents by work activity category reveals distinct patterns in their contribution to total injuries. A12 (non-specific activities) recorded the highest number of incidents, suggesting gaps in task classification or risk identification for non-routine or poorly defined activities. In addition, core operational activities such as A3 (Drilling, Workover, Well Services) and A5 (Maintenance, Inspection, Testing) also contributed substantially to the occurrence of injuries. This indicates that significant risks are not limited to non-specific tasks but are also inherent in essential operational processes. These activities typically involve close interaction with heavy equipment and hazardous energy sources, making them particularly high-risk (55,56). Variations in incident distribution by activity type across companies (e.g., X3 and X4) further suggest differences in work-process characteristics, safety-procedure implementation, or exposure to specific risks (57). The relationship between work activity type and injured body part consistently confirms BP5 (hand, finger, or forearm) as the most frequently injured body part across nearly all activity categories. The consistent presence of BP5 injuries across companies and activities shows a shared vulnerability. These findings support the need for targeted safety programs focusing on hand protection and machine safety.

These findings indicate common, widespread risk factors contributing to hand and forearm injuries across various task types. While BP5's dominance is clear, variations, such as the more even injury distribution between BP2 (foot, toe, or knee) and BP5 in A6 (Office, Warehouse, Accommodation, Catering), suggest differences in injury mechanisms depending on the nature of the work. Pinch-point injuries (TOE5) in which workers' limbs are trapped between, under, or inside objects emerged as the leading mechanism of harm, particularly during nonspecific (A12) and lifting-related activities (A4). These patterns reinforce previous studies indicating that pinch injuries commonly arise from unsafe behaviors, poor hazard recognition, and inadequate safety measures (58).

Detailed incident data show that injuries to BP5 (hands, fingers, forearms) are the most frequent and severe. This was particularly linked to TOE5 (being caught, crushed, or pinched), showing a clear connection between hand use in operations and injury mechanisms. TOE2 (struck by moving objects) was also a major cause of upper-limb injuries, underscoring the dangers of uncontrolled machine movement. These incidents are often associated with insufficient implementation of engineering controls such as machine guarding or lockout/tagout procedures (59). The high frequency of such incidents highlights gaps in mechanical safety systems, supervision, and worker protection measures. Variations across companies further suggest differences in safety culture and the effectiveness of occupational safety and health systems.

The findings underscore the urgent need to strengthen workplace safety in the Indonesian Oil and gas sector. Given the high burden of hand and finger injuries, implementing standardized use of protective gloves and other personal protective equipment (PPE) is critical. Studies show gloves can significantly reduce the severity of impact-related injuries (60). Furthermore, investing in regular training, hazard awareness, and the Permit-to-Work (SIKA) system has been shown to improve safety knowledge and reduce workplace incidents (31,61). Addressing root causes of unsafe behavior, such as lack of competence, poor supervision, and weak enforcement, is essential. Strengthening safety culture through leadership commitment and effective communication can further improve compliance and reduce injury risk. Safety culture plays a pivotal role in driving worker behavior; promoting this through clear communication and leadership accountability can lead to measurable improvements in safety performance (31,61).

This study has several limitations. First, it is based on secondary data collected from company reports and industry databases, which may vary in quality, completeness, and consistency across companies and reporting periods. In addition, the use of company-reported injury records may introduce reporting bias, including underreporting, inconsistent incident classification, or differences in reporting practices across organizations. Second, the available datasets lacked detailed socio-demographic and occupational variables such as age, tenure, gender, job position, employment status, work experience, shift pattern and educational background. The absence of these variables limited the ability to examine individual- and occupational-level risk factors associated with body-part injuries. Moreover, the descriptive design does not allow causal inferences or statistical modeling to control confounding variables. Nevertheless, the study provides an essential overview of injury patterns and mechanisms that can inform safety management practices.

Future research should incorporate qualitative and longitudinal methods to examine root causes, behavioral factors, and organizational safety practices, thereby enhancing our understanding of workplace safety and informing more effective safety management systems and policy frameworks in high-risk industries.

CONCLUSIONS

1. Limb injuries in Indonesia's oil and gas industry are predominantly concentrated in the upper extremities, particularly the hands, fingers, and arms (BP5), making them the most affected body region among reported cases.
2. The most common mechanisms of injury include pinch points, being struck by moving objects, and slips or falls, indicating consistent exposure to mechanical and operational hazards.
3. Injuries occurred most frequently during drilling, lifting, and routine operational tasks.
4. The distribution of injuries across body parts, event types, and work activities highlights specific high-risk combinations that require focused attention.
5. These findings support the need for targeted, activity-based occupational safety strategies, particularly addressing upper limb protection and high-risk operational tasks.

CONFLICT OF INTEREST The authors declare no conflicts of interest.

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REFERENCES

1. Alahjil RAA, Jaafar MH, Zuknik MH, Firdaus RBR, Ibrahim AM. The Impact of Physical, chemical and Biological Hazards on Occupational Accidents and Illnesses in the oil and gas industry – A Review. *J Sustain Sci Manag*. 2025;20(6):1344-1363.
2. Mahalkar V, Kumar S, Singhal S. Long-term and short-term occupational health risks associated with the petroleum industry in India. *World Journal of Advanced Engineering Technology and Sciences*. 2022;5(2):054-061. https://doi.org/10.30574/wjaets.2022.5.2.0044
3. American Petroleum Institute. *Workplace Safety Report 2013-2022*. 2023. https://www.api.org/-/media/files/misc/2023/12/2023-12-api-workplace-safety-report.pdf
4. Occupational Safety and Health Administration. *Severe Injury Reports*. 2024. https://www.osha.gov/severe-injury-reports
5. Arifuddin R, Latief RU, Suraji A. An investigation of fall accident in a high-rise building project. *IOP Conf Ser Earth Environ Sci*. 2020;419(1):012144. https://doi.org/10.1088/1755-1315/419/1/012144
6. Ministry of Manpower of the Republic of Indonesia. Indonesian National Occupational Safety and Health Profile 2022
7. Wardana H, Mexiwel R, Zulfikar AJ. The impact of occupational health and safety system implementation on work-related illnesses among drilling rig workers: A review article. *TEKNOSAINS: Jurnal Sains, Teknologi and Informatics* 2025;12(2):309-314. https://doi.org/10.37373/tekno.v12i2
8. Okon OS, Chukwu-Okeah DrG, Osazuwa CM. Prevalence and Patterns of Workplace Accidents in Selected Oil Servicing Companies in Port Harcourt, Nigeria. *The American Journal of Social Science and Education Innovations*. 2025;7(10):23-47. https://doi.org/10.37547/tajssei/Volume07Issue10-02
9. Ge H, Sun X, Liu J, Zhang C. The Status of Musculoskeletal Disorders and Its Influence on the Working Ability of Oil Workers in Xinjiang, China. *Int J Environ Res Public Health*. 2018;15(5):842. https://doi.org/10.3390/ijerph15050842
10. Hagan-Haynes K, Pratt S, Lerman S, et al. US research needs related to fatigue, sleep, and working hours among oil and gas extraction workers. *Am J Ind Med*. 2022;65(11):840-856. https://doi.org/10.1002/ajim.23310
11. Wingate KC, Scott KA, Pratt S, et al. Self-reported exposure to hazards and mitigation strategies among oil and gas extraction workers in three U.S. states. *J Occup Environ Hyg*. 2022;19(10-11):676-689. https://doi.org/10.1080/15459624.2022.2123496
12. U.S. Bureau of Labor Statistics (BLS). Survey of Occupational Injuries and Illnesses (SOII), 2013–2024. January 2026. https://www.bls.gov/iif/
13. Parasram V, Socias-Morales C, Reichard A. Severe Work-Related Injuries in the Oil and Gas Extraction Industry — 32 Federal Occupational Safety and Health Administration Jurisdictions, United States, January 2015–July 2022. *MMWR Morb Mortal Wkly Rep*. 2024;73(5):104-109. https://doi.org/10.15585/mmwr.mm7305a3
14. Bhatti DS, Ain NU, Fatima M. Occupational Hand-Related Injuries at a Major Tertiary Care Burn and Reconstructive Center in Pakistan. *Cureus*. Published online September 14, 2020. https://doi.org/10.7759/cureus.10444
15. Kusumawati D, Erwandi D, Puspa W. Fingers of Fire: Understanding Hand and Fingers Injuries in Oil and Gas Industry. In: *ADIPEC*. SPE; 2023. https://doi.org/10.2118/216463-MS
16. U.S. Bureau of Labor Statistics. *Number of Nonfatal Occupational Injuries and Illnesses Involving Days Away from Work by Industry and Selected Parts of Body Affected by Injury or Illness,* Private Industry, 2020.
17. Fox JL, Gurney T, Kondalsamy-Chennakesavan S, et al. A Narrative Review of Health Status and Healthcare Delivery in the Oil and Gas Industry: Impacts on Employees, Employers, and Local Communities. *Healthcare*. 2023;11(21):2888. https://doi.org/10.3390/healthcare11212888
18. Sorensen JA, Milkovich PJ, Dorfman L, Mejia P, Perez-Sanz SB. ROPS commentary—Addressing our fatal blind spot: Applying evidence-based solutions to reduce the most frequent cause of death on U.S. farms. *Am J Ind Med*. 2023;66(7):554-557. https://doi.org/10.1002/ajim.23484
19. Saptarini DA, Nainggolan YA. Risk Management in Oil and Gas Field Development Project with Marginal Resources: A Case in Mature Field in East Kalimantan. *European Journal of Business and Management Research*. 2022;7(5):45-53. https://doi.org/10.24018/ejbmr.2022.7.5.1629
20. Ajmal M, Isha ASN, Nordin SMD, et al. Safety management paradigms: COVID-19 employee well-being impact on occupational health and safety performance. *Journal of Hunan University Natural Sciences*. 2021;48(3). https://www.jonuns.com/index.php/journal/article/view/556/553
21. Ajmal M, Isha ASN, Nordin SM, Rasheed S, Al-Mekhlafi AA, Naji GMA. Safety management and safety outcomes in oil and gas industry in Malaysia: Safety compliance as a mediator. *Process Safety Progress*. 2022;41(S1). https://doi.org/10.1002/prs.12345
22. Ajmal M, Isha ASN Bin, Nordin SM, Kanwal N, Al-Mekhlafi ABA, Naji GMA. A Conceptual Framework for the Determinants of Organizational Agility: Does Safety Commitment Matters? *Solid State Technology*. 2020;63(6):4112-4119.
23. Bautista-Bernal I, Quintana-García C, Marchante-Lara M. Safety culture, safety performance and financial performance. A longitudinal study. *Saf Sci*. 2024;172:106409. https://doi.org/10.1016/j.ssci.2023.106409

24. Asamani L. Promote Safety Culture and Enhance Safety Performance through Safety Behaviour. *European Journal of Business and Management Research*. 2020;5(4). https://doi.org/10.24018/ejbmr.2020.5.4.405
25. Zara J, Nordin SM, Isha ASN. Influence of communication determinants on safety commitment in a high-risk workplace: a systematic literature review of four communication dimensions. *Front Public Health*. 2023;11. https://doi.org/10.3389/fpubh.2023.1225995
26. Naji GMA, Isha ASN, Mohyaldinn ME, et al. Impact of Safety Culture on Safety Performance; Mediating Role of Psychosocial Hazard: An Integrated Modelling Approach. *Int J Environ Res Public Health*. 2021;18(16):8568. https://doi.org/10.3390/ijerph18168568
27. Jamil Z, Nordin S, Miraj M, et al. Sustainable safety practices and hazard management in the oil and gas industry: an HSE perspective. *Front Public Health*. 2025;13. https://doi.org/10.3389/fpubh.2025.1611106
28. Benson C, Obasi IC, Akinwande DV, Ile C. The impact of interventions on health, safety and environment in the process industry. *Heliyon*. 2024;10(1). https://doi.org/10.1016/j.heliyon.2023.e23604
29. Guzman J, Recoco GA, Pandi AW, Padrones JM, Ignacio JJ. Evaluating workplace safety in the oil and gas industry during the COVID-19 pandemic using occupational health and safety Vulnerability Measure and partial least square Structural Equation Modelling. *Clean Eng Technol*. 2022;6:100378. https://doi.org/10.1016/j.clet.2021.100378
30. Bilim A. Demographic Analysis of Occupational Safety in the Construction Sector: Strategies and Insights for Risk Reduction. *Buildings*. 2025;15(4):528. https://doi.org/10.3390/buildings15040528
31. Martarinza, Djunaidi Z, Susilowati I, Ajizar I. The Effectiveness of Safe Work Permit System Training In Improving Workplace Safety Understanding: Pre-Post Test Intervention Study. In: 2025. https://doi.org/10.17501/24246735.2024.9109
32. Masiha AF, Susilowati IH. Incidents and Severity of Hand and Finger Injuries at PT. XYZ in 2021-2022. *Cahaya Mandalika Journal*. 2023;3(2):783-796. https://www.ojs.cahayamandalika.com/index.php/JCM/article/view/1813
33. Alessa FM, Nimbarte AD, Sosa EM. Incidence and severity of wrist, hand, and finger injuries in the U.S. mining industry. *Saf Sci*. 2020;129:104792. https://doi.org/10.1016/j.ssci.2020.104792
34. Kim LS, Yoon C, Lee D, Shin G, Jung S. A Study on the Sustainability of Petrochemical Industrial Complexes Through Accident Data Analysis. *Processes*. 2024;12(12):2637. https://doi.org/10.3390/pr12122637
35. Gupta A, Gupta AK, Uppal SK, Mittal RK, Garg R, Aggarwal N. Demographic Profile of Hand Injuries in an Industrial Town of North India: A Review of 436 Patients. *Indian Journal of Surgery*. 2013;75(6):454-461. https://doi.org/10.1007/s12262-012-0536-2
36. Kusumawati D. *Analysis of Human Factors in Hand and Finger Injury Cases Using the HFACS Framework at PT X*. Universitas Indonesia; 2021.
37. Dang JT, Lester E, Sun W, Fawcett V, Widder S, Tsang B. The impact of traumatic injury in the oil and gas industry. *Trauma*. 2019;21(1):61-67. https://doi.org/10.1177/1460408617744817
38. Heimonen A, Nousiainen K, Lassila H, Kaukiainen A. Work-related head injury and industry sectors in Finland: causes and circumstances. *Int Arch Occup Environ Health*. 2023;96(4):577-586. https://doi.org/10.1007/s00420-022-01950-9
39. NIOSH. Hierarchy of Controls. 2023. https://www.cdc.gov/niosh/topics/hierarchy/default.html
40. Yeoman K, O'Connor MB, Sochor S, Poplin G. Characterization of fatal injuries in oil and gas industry-related helicopter accidents in the Gulf of Mexico, 2004–2014. *Inj Epidemiol*. 2020;7(1):64. https://doi.org/10.1186/s40621-020-00288-5
41. Kim IJ. Editorial: Research challenge on slip prevention measures in the workplace. *Front Public Health*. 2022;10. https://doi.org/10.3389/fpubh.2022.1105047
42. Liddle M, Nicholls G, Leigh D, Kinder J, Curran A, Zand M. Work-related slip, trip and fall injuries reported by National Health Service staff in Great Britain: how many are due to slipping? *Injury Prevention*. 2024:ip-2023-045210. https://doi.org/10.1136/ip-2023-045210
43. Lim J, Cho J, Kim J, Kang S. Workers' Injury Risks Focusing on Body Parts in Reinforced Concrete Construction Projects. *Int J Environ Res Public Health*. 2024;21(12):1655. https://doi.org/10.3390/ijerph21121655
44. Galasso A, Caughman AM, Griffith A, et al. A Detailed Analysis of Workplace Foot and Ankle Injuries. *Foot Ankle Spec*. 2026;19(1):44-52. https://doi.org/10.1177/19386400241233844
45. Alshuweihi HH, Zadeh SAM, Al-Sharman A, et al. Prevalence and risk factors associated with work-related musculoskeletal disorders among physiotherapists in United Arab Emirates. *Sci Rep*. 2025;15(1):38878. https://doi.org/10.1038/s41598-025-22619-6
46. Nygaard NPB, Thomsen GF, Rasmussen J, Skadhauge LR, Gram B. Ergonomic and individual risk factors for musculoskeletal pain in the aging workforce. *BMC Public Health*. 2022;22(1):1975. https://doi.org/10.1186/s12889-022-14386-0
47. Betancur S, Leak Bryant A, Conklin J, Walton A. Occupational exposure to chemical substances and health outcomes among hospital environmental services workers: A scoping review of international studies. *J Occup Environ Hyg*. 2024;21(4):287-309. https://doi.org/10.1080/15459624.2024.2311870
48. Barth H, Worek F, Steinritz D, Papatheodorou P, Huber-Lang M. Trauma-toxicology: concepts, causes, complications. *Naunyn Schmiedebergs*

Arch Pharmacol. 2024;397(5):2935-2948. https://doi.org/10.1007/s00210-023-02845-3

49. Nwankwo CD, Arewa AO, Theophilus SC, Esenowo VN. 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*. 2022;28(3):1642-1654. https://doi.org/10.1080/10803548.2021.1916238
50. Nolan DP. *Handbook of Fire and Explosion Protection Engineering Principles: For Oil, Gas, Chemical and Related Facilities*. 4th ed. Gulf Professional Publishing; 2018.
51. Noor MHH, Raja Ghazilla RA. Physical ergonomics awareness in an offshore processing platform among Malaysian oil and gas workers. *International Journal of Occupational Safety and Ergonomics*. 2020;26(3):521-537. https://doi.org/10.1080/10803548.2018.1480341
52. Asad MM, Hassan R, Latif K, Sherwani F. Identification of Potential Ergonomic Risk Factors and Mitigating Measures for Malaysian Oil and Gas Drilling Industries: A Conceptual Research Proposition. *IOP Conf Ser Mater Sci Eng*. 2019;530(1):012052. https://doi.org/10.1088/1757-899X/530/1/012052
53. Wahono T, Purniawan A, Mukhlash I, Putri ERM. Risk-based asset integrity management in the oil and gas industry from traditional to machine learning approaches: A systematic review. *Results in Engineering*. 2025;28:107287. https://doi.org/10.1016/j.rineng.2025.107287
54. Kwon SJ, Choi SW, Lee EB. Hazard Identification and Risk Assessment During Simultaneous Operations in Industrial Plant Maintenance Based on Job Safety Analysis. *Sustainability*. 2024;16(21):9277. https://doi.org/10.3390/su16219277
55. Wang Y, Chen H, Long R, Jiang S, Liu B. Evaluation of Occupational Health and Safety Management of Listed Companies in China's Energy Industry Based on the Combined Weight-Cloud Model: From the Perspective of FPE Information Disclosure. *Int J Environ Res Public Health*. 2022;19(14):8313. https://doi.org/10.3390/ijerph19148313
56. Dwi Septalita E. Workplace Accidents In The Oil and Gas Drilling Areas In 2012 - 2016. *The Indonesian Journal of Occupational Safety and Health*. 2018;7(1):52. https://doi.org/10.20473/ijosh.v7i1.2018.52-62.
57. OSHA. *Machine Guarding*. U.S. Department of Labor; 2021.
58. Sosa EM, Alessa FM. Experimental evaluation of protected and unprotected hands under impact loading. *J Biomech*. 2021;118:110326. https://doi.org/10.1016/j.jbiomech.2021.110326
59. Liu S, Nkrumah ENK, Akoto LS, Gyabeng E, Nkrumah E. The State of Occupational Health and Safety Management Frameworks (OHSMF) and Occupational Injuries and Accidents in the Ghanaian Oil and Gas Industry: Assessing the Mediating Role of Safety Knowledge. *Biomed Res Int*. 2020;2020(1). https://doi.org/10.1155/2020/6354895

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