

Occupational Injuries Presenting to an Emergency Department Adjacent to a Large Organized Industrial Zone: Epidemiological Characteristics and Fracture-Related Factors

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Abstract

Objective: Emergency departments near industrial zones can support occupational-injury surveillance. We described presentations to the hospital closest to a large organized industrial zone and evaluated fracture-related factors. **Methods:** This retrospective cross-sectional study included all occupational-injury presentations, regardless of injury type or anatomical region, recorded from 1 January to 28 February 2024. Detailed occupational-accident examination forms and emergency department records were reviewed, and radiological images underwent blinded orthopaedic assessment with specialist verification. Demographic, temporal, mechanistic, anatomical, fracture, and surgical-treatment variables were analyzed using exact or Monte Carlo tests, the Mann-Whitney U test, and logistic regression. **Results:** Of 871 records screened, 860 were included. Mean age was 32.8±11.2 years, and 84.2% of patients were male. Most presentations occurred at 08:00–15:59 (58.6%). Falling object/impact (30.5%), cutting/penetrating injury (20.6%), caught-in/crush injury (16.2%), and falls (13.7%) predominated; the hand/wrist/fingers were affected in 41.4%. Sixty-three patients had a validated fracture (7.3%; 95% CI, 5.8–9.3%), and 9 (1.0%) underwent surgery. Fracture prevalence differed by mechanism ($p<0.001$) and body region ($p=0.005$). Patients with fracture were older (median, 39 vs 31 years; $p<0.001$). Each 10-year age increase was independently associated with fracture (aOR, 1.66; 95% CI, 1.33–2.07), whereas sex was not. **Conclusion:** Occupational injuries predominantly involved young and middle-aged men, daytime presentations, and distal extremities. Impact, crush, and fall mechanisms accounted for nearly all fractures. Prevention should prioritize engineering controls, task-specific extremity protection, and age-sensitive fall prevention.

Keywords: occupational injuries; workplace accidents; emergency department; industrial zone; hand injuries; fractures; injury surveillance

1. Introduction

Occupational injuries remain a major and largely preventable source of mortality, disability, lost productivity, and health-care use. The International Labour Organization estimates that approximately 395 million workers sustain non-fatal work injuries annually and that work accidents account for about 330,000 deaths worldwide¹. Emergency departments (EDs) are central to the initial management of these events and are also important surveillance sites because they capture a broad spectrum of severity, including patients who arrive without ambulance transport. In Türkiye, occupational injuries additionally have a medicolegal dimension: health-care providers have statutory reporting duties, and clinical documentation may inform both social-security and judicial processes^{2,3}.

Turkish ED studies consistently describe a predominantly male population in the third and fourth decades of life, with injuries clustering during daytime working hours^{4,9}. However, the relative frequency of cutting, crush, impact, fall, and ocular mechanisms varies substantially across centers. This variation reflects differences in nearby economic activity, referral pathways, case definitions, and the level of the treating hospital. Recent studies have therefore emphasized that prevention priorities should be based on local injury patterns rather than on national averages alone^{5,6}.

The study hospital is the closest acute-care facility to a large organized industrial zone that hosts approximately 350 factories. These workplaces span heavy machinery, food production, plastics, white goods, and related manufacturing sectors. The hospital functions as an initial point of care for both ambulance-transported and walk-in occupational injuries. In addition, structured occupational-accident examination forms and routinely obtained radiological images provide information on how an injury occurred, the affected body region, and the presence and site of fracture. This combination makes the ED a pragmatic sentinel site for identifying locally actionable hazards.

The primary aim of this study was to describe the demographic, temporal, mechanistic, anatomical, and clinical characteristics of occupational injuries presenting to this industrial-zone-adjacent ED during a two-month period. The secondary aim was to determine whether age, sex, injury mechanism, or injured body region was associated with fracture.

2. Materials and Methods

The study was conducted following approval by the local ethics committee (approval code: BAEK-2026-161; date: 4 January 2026). The requirement for individual informed consent was waived because the study involved retrospective review of existing records. Data were analyzed in de-identified form and in accordance with the Declaration of Helsinki and applicable national regulations. This single-center retrospective cross-sectional study was conducted at Sincan Training and Research Hospital, a tertiary-care institution and the closest acute-care facility to a large organized industrial zone containing approximately 350 factories from diverse manufacturing branches. The hospital has a level III intensive care unit capable of managing patients requiring invasive mechanical ventilation, all major trauma-related specialist services are available on-site, and its operating theatres actively provide emergency surgical care. Owing to its proximity to the industrial zone and ease of access, its emergency department is among the highest-volume emergency centers in the region.

The source population comprised all eligible occupational-injury presentations registered from 1 January through 28 February 2024. All occupational injuries were eligible irrespective of injury mechanism, anatomical region, injury type, specialty consultation, or radiological finding. The cohort was therefore not restricted to orthopaedic or extremity injuries; the predominance of extremity injuries emerged from the observed injury

distribution. Case identification used the institution's occupational-accident administrative/diagnostic flag together with the occupational-accident examination form. In our institution, occupational-accident presentations were recorded in the hospital information system using the Z04.2 code; therefore, this code was used for initial case identification. All age groups were eligible. Records with an affirmative 'non-work injury' indicator were excluded. Hospital-employee injuries recorded as occupational accidents were retained. Duplicate patient records were assessed using the available identifiers; none were identified.

Approximately 6,700 occupational-injury presentations were registered in the hospital information system during 2024. Because the study protocol required manual case-level review of detailed occupational-accident examination forms, complete emergency department clinical documentation, and all available radiological images rather than reliance on administrative codes alone, review of the entire annual archive was not feasible within the available research resources. A fixed, consecutive two-month sampling window from 1 January through 28 February 2024 was therefore prespecified before data analysis. The study period was not selected according to injury frequency or outcome patterns. Data abstraction for the defined period was completed before analysis, after which the dataset was locked.

Investigators reviewed the detailed occupational-accident examination forms and emergency department documentation. All available radiological images were initially evaluated for fracture presence and anatomical site by an orthopaedic surgeon who was blinded to the original radiology reports. A second orthopaedic specialist subsequently verified concordance between the blinded image-based assessment and the corresponding radiology report. When a radiology report indicated a fracture that had not been identified during the blinded review, both specialists jointly re-evaluated the images, and final fracture status was determined by consensus. Thus, radiological evaluation involved sequential blinded assessment and verification rather than two independent readings of every examination.

Age was calculated from the date of birth and admission date. Age categories were defined a priori for descriptive purposes and were not derived from the observed outcomes. Patients younger than 18 years were considered separately because they were minors, while those aged 18–24 years represented young adults in the early working-life period. Ages 25–54 years were divided into 10-year intervals to provide interpretable comparisons across working-age adulthood while preserving adequate cell sizes, and patients aged ≥55 years were combined because of their relatively small number. These categories were used only for descriptive reporting; age was analyzed as a continuous variable per 10-year increase in the logistic regression model. Emergency department arrival time was classified as 00:00–07:59, 08:00–15:59, or 16:00–23:59. The documented time of injury, when present, was grouped into the same shifts. Weekend was defined as Saturday or Sunday.

Free-text injury descriptions were recoded into eight mutually exclusive mechanism groups: falling object/impact, cutting/penetrating injury, caught-in/crush injury, fall, strain/sprain, ocular foreign body, thermal/chemical/electrical injury, and other/unclear. Injured body region was grouped as hand/wrist/fingers, foot/ankle/toes, other lower extremity, head/face/eye, other upper extremity, spine/back, trunk, multiple regions, or other/unclear. Because distal extremity injuries were common and highly relevant to manufacturing prevention, hand and foot categories were retained separately.

All statistical analyses were performed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean±standard deviation (SD), median and interquartile range (IQR), and range. Categorical variables are reported as counts and percentages. Wilson 95% confidence intervals (CIs) were calculated for key proportions. Age distributions were compared with the Mann–Whitney U test. Fisher's exact test was

used for 2×2 comparisons. For larger contingency tables with sparse expected counts, Pearson chi-square statistics were accompanied by Monte Carlo p values based on 50,000 simulated tables; effect size was summarized with Cramér V. A binary logistic regression model included age per 10-year increase and male sex to estimate adjusted odds ratios (aORs) for fracture. Two-sided $p < 0.05$ was considered statistically significant.

3. Results

Of 871 records screened, 11 with an affirmative non-work injury indicator were excluded, leaving 860 patients for analysis. The mean age was 32.8 ± 11.2 years (95% CI for the mean, 32.1–33.6), the median age was 32 years (IQR, 23–41), and the range was 14.4–64.0 years. There were 724 male (84.2%) and 136 female (15.8%) patients, corresponding to a male-to-female ratio of 5.3:1. Age did not differ by sex (median, 31 years in men and 33.5 years in women; $p = 0.933$). Thirty-three patients (3.8%) were younger than 18 years (Table 1).

ED arrival time was available for all patients. The median arrival time was 13:44 (IQR, 10:21–17:05). Most presentations occurred between 08:00 and 15:59 ($n = 504$, 58.6%), followed by 16:00–23:59 ($n = 270$, 31.4%) and 00:00–07:59 ($n = 86$, 10.0%). In four-hour intervals, admissions were most frequent between 12:00 and 15:59 ($n = 264$, 30.7%), followed by 08:00–11:59 ($n = 240$, 27.9%) and 16:00–19:59 ($n = 183$, 21.3%). The single-hour peak occurred between 14:00 and 14:59, accounting for 76 presentations (8.8%). Overall, 607 patients (70.6%) presented between 08:00 and 17:59. Fracture prevalence was 8.5% during 08:00–15:59, 6.3% during 16:00–23:59, and 3.5% during 00:00–07:59; however, the difference across admission-time groups was not statistically significant (Monte Carlo $p = 0.194$; Cramér's $V = 0.063$). Twenty patients (2.3%) arrived by ambulance, and 10 injuries (1.2%) occurred among hospital employees.

Table 1. Demographic, temporal, and clinical characteristics of the cohort ($n = 860$).

Variable	Category/summary	Value
Age, years	Mean±SD	32.8±11.2
	Median (IQR)	32 (23–41)
	Range	14.4–64.0
Sex	Male	724 (84.2)
	Female	136 (15.8)
Age group	<18 years	33 (3.8)
	18–24 years	226 (26.3)
	25–34 years	239 (27.8)
	35–44 years	218 (25.3)
	45–54 years	110 (12.8)
	≥55 years	34 (4.0)
Month	January	466 (54.2)
	February	394 (45.8)
ED arrival shift	00:00–07:59	86 (10.0)
	08:00–15:59	504 (58.6)
	16:00–23:59	270 (31.4)
Weekend presentation	Yes	108 (12.6)
Ambulance transport	Yes	20 (2.3)

Variable	Category/summary	Value
Hospital-employee injury	Yes	10 (1.2)
Validated fracture	Yes	63 (7.3)
Surgical treatment	Yes	9 (1.0)
Additional organ injury	Yes	2 (0.2)

Values are n (%) unless otherwise stated. ED, emergency department; IQR, interquartile range; SD, standard deviation.

The leading mechanisms were falling object/impact (n=262, 30.5%), cutting/penetrating injury (n=177, 20.6%), caught-in/crush injury (n=139, 16.2%), and falls (n=118, 13.7%). Together, these four mechanisms accounted for 80.9% of the cohort. Mechanism distributions differed modestly by sex (Monte Carlo p=0.007; Cramér V=0.151): falls represented 22.1% of injuries among women and 12.2% among men, whereas ocular foreign bodies represented 0.7% and 5.8%, respectively. These comparisons describe presentation patterns and do not estimate sex-specific occupational risk because workforce denominators were unavailable.

The hand/wrist/fingers were the most frequently injured region (n=356, 41.4%), followed by the foot/ankle/toes (n=146, 17.0%), head/face/eye (n=128, 14.9%), other lower extremity (n=80, 9.3%), and other upper extremity (n=77, 9.0%) (Figure 1). The overall region distribution did not differ significantly by sex (Monte Carlo p=0.186; Cramér V=0.114).

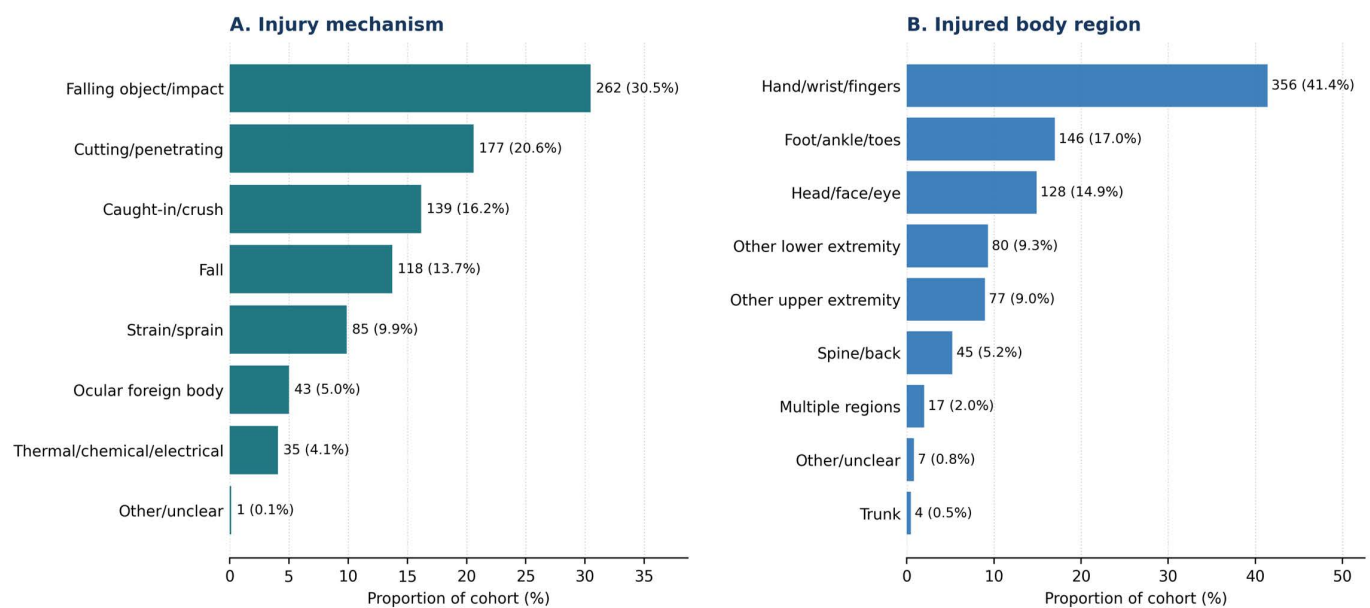


Figure 1. Distribution of injury mechanisms and injured body regions in the cohort (n=860). Bars show the proportion of the total cohort; labels show n (%). Categories were derived from structured fields and standardized recoding of free-text occupational-accident forms.

Sixty-three patients had a validated fracture, corresponding to a prevalence of 7.3% (95% CI, 5.8–9.3%). Among patients with fracture, the primary injured region was the hand/wrist/fingers in 31 (49.2%), foot/ankle/toes in 17 (27.0%), other lower extremity in 5 (7.9%), multiple regions in 4 (6.3%), and other upper extremity in 3 (4.8%); head/face/eye, spine/back, and trunk accounted for one case each (1.6%). Nine patients (1.0%; 95% CI, 0.6–2.0%) underwent surgery. Of these, six had fractures and three had tendon injuries; 9.5% of patients with fracture underwent surgery. Additional organ injury was documented in two patients (0.2%).

Fracture prevalence differed across mechanism groups ($\chi^2=39.11$, $df=7$; Monte Carlo $p<0.001$; Cramér $V=0.213$). Falls had the highest fracture prevalence among common mechanisms (13.6%), followed by falling object/impact (11.5%) and caught-in/crush injury (10.8%); no fracture was identified in the cutting/penetrating, ocular foreign-body, or thermal/chemical/electrical groups (Table 2; Figure 2). Fracture prevalence also differed by injured region ($\chi^2=25.25$, $df=8$; Monte Carlo $p=0.005$; Cramér $V=0.171$) (Table 3). The high percentages in the trunk and multiple-region categories should be interpreted cautiously because their denominators were small.

Table 2. Injury mechanism and within-mechanism fracture prevalence.

Mechanism	Total n	Total %	Fracture n	Fracture %
Falling object/impact	262	30.5	30	11.5
Cutting/penetrating	177	20.6	0	0.0
Caught-in/crush	139	16.2	15	10.8
Fall	118	13.7	16	13.6
Strain/sprain	85	9.9	2	2.4
Ocular foreign body	43	5.0	0	0.0
Thermal/chemical/electrical	35	4.1	0	0.0
Other/unclear	1	0.1	0	0.0

Overall association: $\chi^2=39.11$, $df=7$; Monte Carlo $p<0.001$ (50,000 replicates); Cramér $V=0.213$. Percentages in the final column use the mechanism-specific denominator.

Table 3. Injured body region and within-region fracture prevalence.

Body region	Total n	Total %	Fracture n	Fracture %
Hand/wrist/fingers	356	41.4	31	8.7
Foot/ankle/toes	146	17.0	17	11.6
Other lower extremity	80	9.3	5	6.2
Head/face/eye	128	14.9	1	0.8
Other upper extremity	77	9.0	3	3.9
Spine/back	45	5.2	1	2.2
Trunk	4	0.5	1	25.0
Multiple regions	17	2.0	4	23.5
Other/unclear	7	0.8	0	0.0

Overall association: $\chi^2=25.25$, $df=8$; Monte Carlo $p=0.005$ (50,000 replicates); Cramér $V=0.171$. The high percentages for trunk and multiple regions are based on small denominators.

Patients with fracture were older than those without fracture (mean, 39.1 ± 12.1 vs 32.4 ± 11.0 years; median, 39 [IQR, 30–48] vs 31 [IQR, 23–41] years; $p<0.001$). In logistic regression, each 10-year increase in age was associated with 66% higher fracture odds (aOR, 1.66; 95% CI, 1.33–2.07; $p<0.001$). Male sex was not independently associated with fracture (aOR, 1.24; 95% CI, 0.57–2.70; $p=0.579$) (Table 4). Fracture prevalence did not differ significantly by ED arrival shift ($p=0.194$), weekend status ($p=1.000$), ambulance arrival ($p=0.653$), or sex in unadjusted analysis ($p=0.592$).

Table 4. Multivariable logistic regression for validated fracture (n=860; 63 events).

Predictor	β	SE	aOR	95% CI	p value
Age (per 10-year increase)	0.505	0.114	1.66	1.33–2.07	<0.001
Male sex (vs female)	0.219	0.394	1.24	0.57–2.70	0.579

aOR, adjusted odds ratio; CI, confidence interval; SE, standard error. Model included age and sex simultaneously.

Fracture-related findings

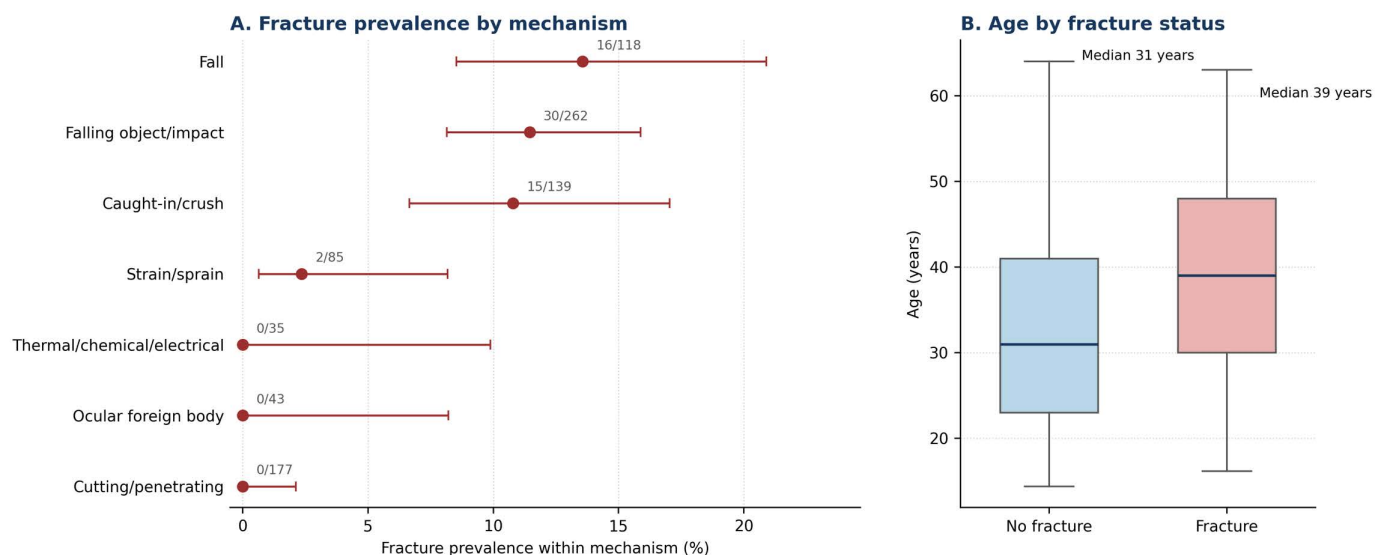


Figure 2. Fracture-related findings. Panel A shows fracture prevalence and Wilson 95% confidence intervals for mechanism groups with at least 35 cases; fractions indicate fracture events/total cases. Panel B shows age distributions by validated fracture status. Age difference: Mann–Whitney $U=33,254$; $p<0.001$.

4. Discussion

In this two-month series from an ED adjacent to a large organized industrial zone, occupational injuries predominantly affected men in their early thirties and most commonly involved the distal upper extremity. Four mechanisms (falling object/impact, cutting/penetrating injury, caught-in/crush injury, and falls) accounted for more than four fifths of presentations. Fractures occurred in 7.3% of cases and were concentrated in impact, crush, and fall events. Age emerged as the principal patient-level correlate of fracture, with a 1.66-fold increase in adjusted odds per decade. These findings define a focused local prevention agenda and add an analytic fracture outcome to the mainly descriptive Turkish ED literature.

The demographic profile was consistent with prior Turkish studies. Özkan et al. reported a mean age of 31.6 years among 1,038 ED occupational injuries⁷, and Celik et al. reported a mean age of approximately 33 years with 93.4% male patients⁸. More recent series likewise found mean ages near 33 years, although the male proportion ranged from 81.7% to 95.9%^{4,5}. Our male proportion of 84.2% is close to the lower end of this range and may reflect the mixed composition of nearby food, plastics, appliance, and machinery workplaces. The presence of 33 patients younger than 18 years warrants separate attention; however, the data did not include employment status, apprenticeship, task assignment, or legality of employment, and therefore do not permit conclusions about the circumstances of work among minors. Population-based research indicates that age patterns

in occupational injury are partly shaped by job characteristics and the hazards assigned to young and inexperienced workers^{10,11}.

Mechanism distributions differed from some earlier Turkish reports, illustrating the influence of local industrial structure and classification methods. In the Özkan et al. series, machinery entrapment was the leading mechanism, whereas Celik et al. reported penetrating and blunt mechanisms as the most common^{7,8}. Hakkoymaz et al. found incision/rupture (30.2%), crush (29.5%), and falls (26.8%)⁴. In our cohort, falling object/impact ranked first, followed by cutting/penetrating and caught-in/crush injuries. This pattern suggests hazards related to material transfer, stacked or suspended loads, moving machine parts, and manual handling. Prevention should prioritize elimination or isolation of falling-object and pinch-point hazards, secure storage, machine guarding and interlocks, lockout procedures during maintenance, and task-specific training. Personal protective equipment should complement, rather than substitute for, these engineering and administrative controls.

The prominence of hand/wrist/finger injuries is also biologically and operationally plausible in manufacturing. Serinken et al. found that isolated wrist, hand, or finger injuries accounted for 32.7% of all occupational injuries in a tertiary-care series in western Türkiye, with lacerations, punctures, and abrasions as the leading injury types¹². Celik et al. reported upper-extremity involvement in 53.7%⁸, and a 2025 organized-industrial-zone study again identified the upper extremity among the leading regions⁶. Detailed occupational-clinic data have likewise shown the hand to be vulnerable across multiple acute traumatic injury types¹³. Our more granular classification showed that the hand/wrist/fingers alone accounted for 41.4%.

Fractures were less frequent than soft-tissue injuries but are clinically consequential because they may require surgery, prolonged absence, rehabilitation, and medicolegal assessment. Previous compensation data showed particularly high work-related fracture incidence in agriculture, mining, construction, and manufacturing¹⁴. In our ED cohort, falls produced the highest fracture prevalence among common mechanisms, followed closely by impact and crush events. Moreover, age was associated with fracture even after adjustment for sex. Hayashi et al., using 34,580 occupational same-level falls in Japan, similarly found greater fracture risk among workers aged 55 years or older in primary industries¹⁵. A recent Turkish analysis restricted to workers aged 65 years or older also linked falls and multiple-region injury patterns to hospitalization¹⁶.

Most emergency department presentations occurred during the daytime shift, consistent with prior Turkish reports^{4,5,8}. Temporal analyses were based primarily on emergency department arrival time, which was available for all patients. Actual injury time was missing in 67.0% of records and was therefore not used as the principal temporal variable. Arrival time may lag behind the injury event and should not be interpreted as the exact time of injury. Furthermore, because the number of workers at risk during each shift was unavailable, the observed temporal distribution describes emergency department workload rather than shift-specific occupational-injury incidence. Nevertheless, the concentration of presentations during 08:00–15:59 has practical implications for emergency department staffing and for workplace safety rounds, supervision, and material-handling oversight during the main production period.

The study also demonstrates the surveillance value of structured ED documentation. Mustard et al. found substantially more work-related ED visits than accepted lost-time compensation claims, supporting ED data as a complementary population surveillance source¹⁷. Trauma registries have similarly been used to identify severe occupational injuries and hazards¹⁸. Combining an explicit occupational-accident flag with the examination form and clinical/radiological verification is a more defensible case definition.

Ocular foreign-body injuries accounted for 5.0% of our cohort, closely matching the 3.9% reported in a previous Turkish emergency department series⁷. Although frequently managed as superficial injuries, their occurrence in an industrial-zone population is noteworthy because they are largely preventable. In a prospective Turkish study of 816 work-related eye injuries, 66.4% of patients worked in the metal and machinery sectors, corneal abrasion/foreign body was the most common diagnosis (30.7%), and lack of protective measures was the leading workplace-related cause (18.7%)¹⁹. These findings support the provision and enforced use of task-appropriate protective eyewear, particularly during grinding, cutting, drilling, and welding activities.

This study has several strengths. The cohort was large relative to many single-center Turkish reports; the hospital's proximity to a diverse industrial zone increased the relevance of the case mix; and review of detailed forms together with sequential blinded orthopaedic image assessment and specialist verification strengthened anatomical and fracture classification. The analysis reported confidence intervals, effect sizes, sparse-table Monte Carlo tests, and an adjusted fracture model rather than relying only on descriptive frequencies.

Several limitations should be considered. First, this was a single-center retrospective study restricted to a consecutive two-month period covering January and February 2024. Consequently, the study could not assess seasonal variation, should not be considered representative of year-round occupational-injury epidemiology, and cannot estimate annual incidence or risk per worker. Second, the single-center design may have introduced selection and referral bias. Some minor injuries may have been managed at workplace health units, private hospitals, or other healthcare facilities, while some severe injuries may have been transferred directly to alternative referral centers. Therefore, the observed case mix may not represent all occupational injuries occurring in the industrial zone. Third, the analysis relied on existing occupational-accident forms, emergency department documentation, and radiological records. Incomplete documentation, recording errors, and misclassification may therefore have introduced information bias. Fourth, workforce denominators and factory-level information were unavailable, precluding comparisons of risk by sex, industrial sector, occupation, shift, or factory. Finally, data on employment duration, safety training, personal protective equipment, fatigue, substance use, validated injury severity scores, admission/discharge outcomes, work loss, and long-term disability were not available.

5. Conclusion

Occupational injuries presenting to an emergency department adjacent to a large organized industrial zone predominantly affected young and middle-aged men, occurred during daytime hours, and involved the hands and feet. Falling-object/impact, cutting/penetrating, crush, and fall mechanisms dominated the case mix. Fractures occurred in 7.3% of patients, clustered in impact, crush, and fall events, and became more likely with increasing age. These findings support locally targeted engineering controls for material handling and machinery, task-specific hand and foot protection, and age-sensitive fall prevention. Because this analysis represents a consecutive two-month sampling window, the findings describe the local emergency department case mix during the study period and should not be extrapolated to annual or seasonal occupational-injury epidemiology.

Ethics approval and consent to participate: The study was approved by the local ethics committee (Sincan Training and Research Hospital Scientific Research Ethics Committee BAEK-2026-161 numbered approval) and was conducted in accordance with the principles of the Declaration of Helsinki, using retrospective data collection through the hospital automation system.

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Authors' contributions: N.K.Ü. conceptualized and designed the study, supervised data collection, conducted the statistical analysis, interpreted the data, and drafted the manuscript. A.S.N., N.Y., S.E.E., V.Ö., A.K.A., and M.O.A. contributed to data acquisition, review of occupational-accident records and radiological images, and interpretation of the results. A.S. contributed to the study methodology, interpretation of the findings from an emergency medicine perspective, and critical revision of the manuscript. All authors reviewed and approved the final manuscript and agreed to be accountable for all aspects of the work.

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