ORIGINAL ARTICLE

Are there missed warning signals before traffic-related traumatic spinal cord injury? An exploratory case–control study using electronic health records

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ABSTRACT

BACKGROUND: Traumatic spinal cord injury (TSCI) is a catastrophic outcome frequently resulting from road-traffic crashes. We investigated whether routinely recorded pre-injury healthcare utilization patterns in electronic health records (EHRs) can serve as pragmatic warning signals for TSCI among drivers and motorcyclists.

METHODS: We conducted a retrospective age- and sex-matched case–control study using national EHR data. Adults aged 18–45 years with traffic-accident-related TSCI as drivers or motorcyclists (2024–2025) were matched 1: 1 with controls (n=35 per group). Pre-index utilization during the preceding 24 months included trauma-related emergency department (ED) visits, orthopedics/traumatology department (OTD) visits, total trauma-related visits, and psychiatry visits. Between-group comparisons used Mann–Whitney U tests. Receiver operating characteristic analyses were used to summarize discriminative performance. Binary risk flags (≥1 ED visit; ≥1 psychiatry visit) were evaluated using multivariable logistic regression.

RESULTS: The analytic sample included 70 participants. Compared with controls, TSCI cases had higher trauma-related ED visits (p<0.001; r=0.45), psychiatry visits (p=0.010; r=0.31), and total trauma-related visits (p=0.035; r=0.25), whereas OTD visits did not differ (p=0.920). ED visits showed the highest discrimination (area under curve [AUC]=0.726). In this sample, the ≥1 versus 0 contrast yielded sensitivity 60.0% and specificity 82.9%. Psychiatry visits showed modest discrimination (AUC=0.649). In this sample, the ≥1 versus 0 contrast yielded sensitivity 45.7% and specificity 80.0%. In multivariable analysis, ≥1 ED visit (odds ratio [OR]=8.85, 95% confidence interval [CI] 2.68–29.23; p<0.001) and ≥1 psychiatry visit (OR=4.52, 95% CI 1.34–15.20; p=0.015) were independently associated with TSCI.

CONCLUSION: Traffic-related TSCI may be preceded by measurable pre-injury patterns – particularly trauma-related ED utilization and psychiatry visits – captured in routinely collected EHR data. These findings support a pragmatic risk-flagging approach that may help identify individuals who could benefit from targeted preventive education, injury-risk counseling, and psychosocial risk-reduction interventions. These findings should be interpreted with caution and require validation in larger prospective studies.

Keywords: Electronic health records; emergency; psychiatry; spinal cord injury; traffic accidents; trauma.

INTRODUCTION

Spinal cord injury (SCI) is damage to the spinal cord resulting in neurological impairment. It is one of the most devastating conditions in clinical practice, often resulting in long-term motor, sensory, and autonomic deficits, severe disability, and high healthcare and societal costs, frequently impacting individuals at relatively young ages.[1] Traumatic SCI (TSCI) mainly affects young and middle-aged adults and usually happens after high-energy events, such as car accidents, falls, and violence between people.[1-3]

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The incidence of TSCI ranges from 8 to 150 cases per million population per year.[4] SCI has a big impact on the economy. The total global macroeconomic cost of SCI, which includes healthcare costs and lost productivity that lowers savings, investment, and capital accumulation, is expected to reach INT$5.58 trillion between 2020 and 2050.[5] Global estimates indicate that by 2050, there will be around 422,611 new cases of SCI each year, with approximately 12.0 million individuals currently living with SCI worldwide.[3]

Epidemiological datasets indicate that men constitute the majority of new SCI cases (approximately 78%), and long-term morbidity is prevalent. Persistent spasticity is frequently observed, cervical injuries often lead to tetraplegia, and the resultant disability burden significantly diminishes employment rates among individuals with SCI compared to the general population.[6] It is known that a significant number of victims of road traffic injuries live with some degree of limitation after injury, and nearly half of them cannot return to work.[7] Together, these features show how important it is to predict an accident before it happens and stop the injury.

Primary prevention continues to be the most efficacious approach to alleviate this burden. Current strategies predominantly depend on extensive public health initiatives, including safety regulations and injury-prevention curricula in schools or communities that focus on road safety, helmet usage, violence prevention, and other safety practices, supplemented by emails, posters, and informational brochures.[8-10] Although crucial at the population level, these "blanket" strategies may not effectively target individuals at disproportionately elevated risk.

Sometimes, a major trauma happens after a person has been to the doctor for less serious injuries several times. Studies on trauma recidivism indicate that individuals who experience recurrent injuries are at a heightened risk for mental health issues.[11,12] Simultaneously, previous utilization of emergency services has been suggested as an early indicator of potential escalation toward severe harm.[13]

Based on these observations, we formulated trauma-related emergency department (ED) and Orthopedic and Traumatology Department (OTD) visits as quantifiable indicators of recurrent exposure to hazardous environments and Psychiatry Department (PD) utilization as an indicator of psychiatric vulnerability.[13,14] Thus, we defined pre-injury healthcare utilization over 24 months as a practical risk-flagging indicator for risk stratification. Previous research in various clinical fields substantiates the conceptual feasibility of utilizing routinely gathered health records to detect heightened risk prior to the manifestation of adverse outcomes.[15,16]

The aim of this study was to identify pre-injury signals associated with a higher risk for TSCI before a catastrophic event happened. This would give us a group of people to focus on for education and prevention efforts. In this study, we aimed to identify pre-injury warning signals in the electronic health records (EHRs) of car drivers and motorcyclists who subsequently sustained a significant trauma leading to SCI. We hypothesized that these individuals would exhibit significantly increased rates of pre-injury healthcare utilization – specifically trauma-related ED and OTD visits, along with interactions with the PD – during the 24 months preceding their injury in comparison to matched controls.

To the best of our knowledge, this study is among the initial investigations into whether routinely collected EHR data contain measurable pre-injury "warning signals" associated with subsequent TSCI resulting from traffic accidents. If validated in independent cohorts, these signals could enable targeted, low-intensity preventive measures before severe injury, including brief traffic safety counseling, referral pathways for psychosocial assessment when required, and structured rehabilitation for individuals at high risk. In theory, even small drops in the number of serious injuries could help people a lot and save health systems money in the long run.

MATERIALS AND METHODS

Study Design and Setting

The study was a retrospective case–control study matched for age and sex. Ethical approval was obtained from the Ethics Committee of the Ministry of Health Antalya City Hospital (08.01.2026–20/176), and EHRs were subsequently screened. Patients who were 18–45 years old and had been seen in the Physical Medicine and Rehabilitation (PMR) clinic of a tertiary hospital with a diagnosis of TSCI between January 1, 2024, and December 31, 2025, were eligible.

Participants, Eligibility Criteria and Matching

Study participants were identified through a systematic screening of the national EHR system between 1 January 2024 and 31 December 2025. To ensure a homogeneous cohort of active-participation road-traffic users, cases were eligible if they were adults aged 18–45 years diagnosed with TSCI (cervical, thoracic, or lumbar) with documented neurological deterioration, provided that accessible longitudinal data were available in the national EHR system. Eligible mechanisms were strictly restricted to "active-participation" road-traffic events, specifically car drivers and motorcyclists.

Exclusion criteria were predetermined to delineate specific risk-taking behaviors and minimize confounding etiologies. We excluded individuals with ineligible mechanisms such as passive road-traffic roles (passengers or bystanders), falls, occupational injuries, and sports-related trauma. In addition, patients with non-traumatic etiologies – such as tumors or iatrogenic complications – were excluded, along with those whose mechanisms of injury involved intentional harm, including self-harm, suicidal intent, or penetrating interpersonal violence. To maintain a clean baseline, individuals with pre-existing neurological disorders or documented deficits before the index event were also excluded from the analytic sample.

Controls were selected from the same PMR clinic and calendar period to maintain consistency. They were people aged 18-45 years who presented with non-traumatic mechanical musculoskeletal complaints like myalgia or arthralgia. Each case was matched 1:1 to a control based on sex and age using a nearest-available match approach. The final analytic sample comprised 70 participants (35 TSCI cases and 35 matched controls). This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology statement for observational studies.[17]

Variables and Data Sources

The index date for cases was the date of the TSCI event, while for controls it was the date of the outpatient PMR visit used to choose the controls. In both groups, exposures were evaluated during the 24 months immediately preceding the index date. Data were obtained from the national EHR system, which was connected to the hospital information system.

The primary pre-index variables were trauma-related ED visits, trauma-related OTD visits, the combined total of trauma-related visits (ED+OTD), PD visits, and documentation of alcohol use. Trauma-related utilization was defined as ED/OTD visits in which injury was documented in the EHR (e.g, epicrisis, diagnosis list, and clinical history fields); visits not involving injuries were excluded from the count. Visits were defined as documented outpatient department encounters recorded in the EHR. The driver or motorcycle-rider status of the TSCI patient at the time of the accident was verified by hospital records. Before the analysis, all the data that was taken out was de-identified by taking out personal identifiers and giving each participant a unique study ID number.

Addressing Bias, Study Size and Quantitative Variables

To minimize confounding variables, we employed an age- and sex-matched (1:1) case–control design, selecting controls from the same hospital, clinic environment, and temporal context as the cases. Selection bias is possible because inclusion required accessible longitudinal EHRs; we report exclusions due to restricted access and acknowledge this limitation. Information bias may persist due to underdocumentation of alcohol use and limited detail of psychiatric records; therefore, alcohol use was examined as "documented versus not documented" and interpreted cautiously.

The study size was dictated by case availability: all qualifying TSCI cases within the study timeframe were incorporated and paired with a single control. Quantitative exposures were operationalized as 24-month pre-index count variables (ED trauma visits, OTD trauma visits, total trauma visits, and PD visits) and summarized as medians interquartile range (IQR) due to skewed distributions. Receiver operating characteristic (ROC) analyses were conducted as exploratory assessments of discriminative performance. Youden's index was used descriptively to summarize performance across potential thresholds; no prespecified or clinically validated cut-off values were assumed.

Statistical Analysis

IBM Statistical Package for the Social Sciences Statistics (version 30.0.0.0) was used. Matching was used at the design stage to control for age and sex. Continuous variables were summarized as mean (standard deviation) and as median (IQR) when skewed; categorical variables were summarized as counts and percentages. Due to the non-normal distribution of utilization variables, comparisons between groups were conducted using the Mann–Whitney U test; the effect size was expressed as r.

ROC analyses were conducted as exploratory summaries of discriminative performance within this case–control sample. Given the case–control design, these ROC analyses are presented as descriptive and exploratory assessments rather than as tools for defining clinically applicable thresholds. Youden's index was used descriptively to compare performance across selected contrasts; no clinically validated thresholds or decision cut-offs were proposed. Binary indicators (≥1 vs. 0) for ED visits and psychiatry visits were entered into a multivariable logistic regression model, and associations were reported as odds ratios (ORs) with 95% confidence intervals (CIs). Two-sided $p<0.05$ was considered statistically significant.

RESULTS

Participants and Descriptive Data

The participant selection process is shown in Figure 1. Initially, 64 patients with SCI were screened; after stepwise eligibility assessment, 35 TSCI cases in drivers/motorcyclists were included and matched 1:1 with controls, yielding a final analytic sample of 70 participants.

Baseline demographic characteristics were comparable between groups. Among TSCI cases, thoracic injuries were most common (n=16), followed by lumbar (n=11) and cervical injuries (n=8). Motorcycle accidents accounted for 19 cases, while 16 cases resulted from automobile collisions. Traumatic brain injury accompanied TSCI in 14 cases. Baseline characteristics and pre-index healthcare utilization measures are summarized in Table 1.

Outcome Data

Because all count-based utilization variables showed significant deviation from normality (Supplementary Table 1), between-group comparisons were conducted using the Mann–Whitney U test. Compared with controls, individuals who later faced TSCI had significantly higher numbers of trauma-related ED visits ($p<0.001$; $r=0.45$), PD visits ($p=0.010$; $r=0.31$), and total trauma-related visits ($p=0.035$; $r=0.25$) during the 24 months preceding the index date. In contrast, trauma-related OTD visits did not differ between groups ($p=0.920$; $r=0.01$). Detailed comparisons are presented in Table 2.

Main Results

ROC analyses were performed for utilization variables that differed between groups to evaluate their discriminative abil-

Table 1. Participant characteristics and trauma-related healthcare utilization during the 24 months preceding the index date in TSCI cases and controls

	Control (n=35)	TSCI patients (n=35)
Age	31.97 (9.10)	31.37 (8.55)
Male (%)	29 (82.9)	29 (82.9)
Female (%)	6 (17.1)	6 (17.1)
Trauma-related ED visits	0 (0–0)	1 (0–1)
Trauma-related OTD visits	0 (0–0)	0 (0–0)
Total trauma-related visits	0 (0–1)	1 (0–2)
PD visits	0 (0–0)	0 (0–2)
Alcohol use documented (%)	3 (8.6)	1 (2.9)

Values are presented as mean (standard deviation) for age, median (Q1-Q3) for count variables, and n (%) for categorical variables. TSCI: Traumatic spinal cord injury, ED: Emergency department, OTD: Orthopedics/traumatology department, PD: Psychiatry department.

ity for TSCI within this case–control sample. Trauma-related ED visits demonstrated the highest discrimination (area under curve [AUC]=0.726, 95% CI 0.606–0.847; p<0.001). In this sample, the ≥1 versus 0 contrast provided sensitivity 60.0% and specificity 82.9%. PD visits showed modest discrimination (AUC=0.649, 95% CI 0.519–0.778; p=0.024). In this sample, the ≥1 versus 0 contrast provided sensitivity 45.7% and specificity 80.0%. For total trauma-related visits, the ≥2 versus <2 contrast showed limited discrimination (AUC=0.630, 95% CI 0.499–0.761; p=0.052). Performance metrics for selected contrasts are detailed in Table 3, and ROC curves are provided in Figure 2 for visualization of discriminative performance. ROC coordinate outputs are provided in Supplementary Table 2. These findings should be interpreted with caution, as discriminative performance estimates derived from case–control data may be subject to overestimation.

For interpretability, binary indicators (≥1 vs. 0) were defined for ED visits and psychiatry visits and used in subsequent analyses. Individuals who later sustained TSCI were significantly more likely to have had at least one trauma-related ED visit in the preceding 24 months compared with controls (60.0% vs. 17.1%, χ^2=13.6, p<0.001). A history of psychiatry visits was also more common among TSCI cases (45.7% vs. 20.0%), although the association was weaker (χ^2=5.25, p=0.022).

These binary risk flags were subsequently entered into a multivariable logistic regression model. Both pre-injury ED utilization and psychiatry visits were independently associated with subsequent TSCI. Individuals with at least one trauma-related ED visit had markedly higher odds of TSCI (OR=8.85,

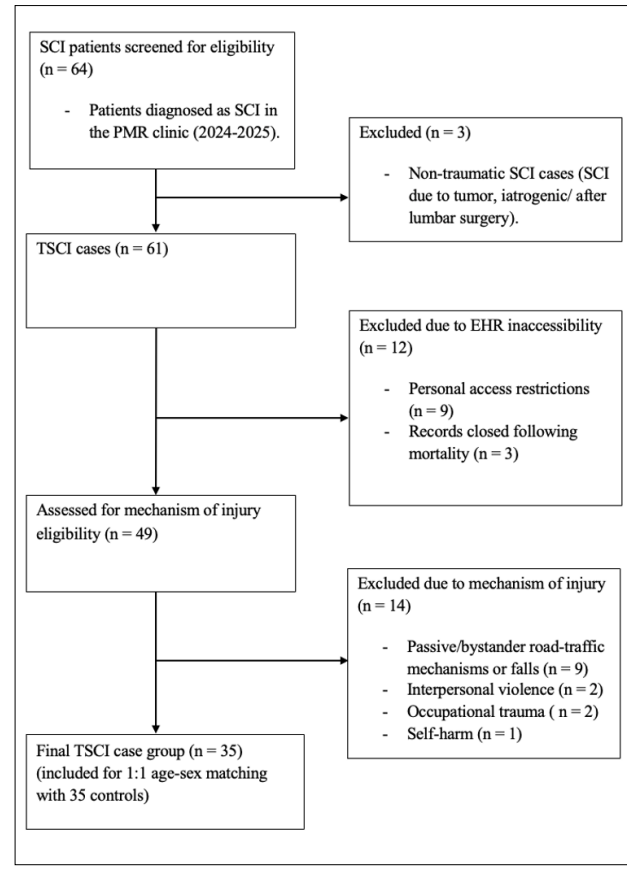

Figure 1. Strengthening the Reporting of Observational Studies in Epidemiology flow diagram. TSCI: Traumatic spinal cord injury; SCI: Spinal cord injury; HER: Electronic health records.

Table 2. Between-group comparison of trauma-related healthcare utilization during the 24 months preceding the index date

	Control group median (Q1-Q3)	TSCI group median (Q1-Q3)	U value	p	Effect size (r)
Trauma-related ED visits	0 (0–0)	1 (0–1)	335.500	<0.001	0.45
Trauma-related OTD visits	0 (0–0)	0 (0–0)	606.500	0.920	0.01
Total trauma-related visits	0 (0–1)	1 (0–2)	453.000	0.035	0.25
PD visits	0 (0–0)	0 (0–2)	430.000	0.010	0.31

Values are presented as median (Q1–Q3); effect size (r) was calculated as |Z|/√N (n=70); p-values are two-tailed. TSCI: Traumatic spinal cord injury; ED: Emergency department; OTD: Orthopedics/traumatology department; PD: Psychiatry department.

Table 3. Discriminative performance of selected contrasts for pre-index utilization measures within the case–control sample

Predictor	AUC (95% CI)	p	Cut-off	Sensitivity (%)	Specificity (%)
Trauma-related ED visits	0.726 (0.606–0.847)	<0.001	≥1	60.0	82.9
Total traumatic visits	0.630 (0.499–0.761)	0.052	≥2	34.3	88.6
PD visits	0.649 (0.519–0.778)	0.024	≥1	45.7	80.0

Cut-offs were selected using Youden's index (J=sensitivity + specificity−1). TSCI: Traumatic spinal cord injury; AUC: Area under curve; CI: Confidence interval; ED: Emergency department; PD: Psychiatry department.

Table 4. Multivariable logistic regression for TSCI

Predictor	OR	95% CI	p
≥1 ED visit	8.85	2.68–29.23	<0.001
≥1 PD visit	4.52	1.34–15.20	0.015

Reference=no prior trauma-related ED visit and no prior psychiatric visit. OR: Odds ratio; CI: Confidence interval; ED: Emergency department; PD: Psychiatry department.

95% CI 2.68–29.23; p<0.001). A history of psychiatry visit was also independently associated with increased TSCI risk (OR=4.52, 95% CI 1.34–15.20; p=0.015). The model demonstrated acceptable explanatory performance (McFadden R2=0.21). Regression results are summarized in Table 4.

DISCUSSION

In this study employing national EHRs, we examined the disparities in healthcare utilization patterns between patients with TSCI among drivers/motorcyclists and control subjects. Individuals with TSCI exhibited a greater frequency of trauma-related ED visits, increased PD visits, and a higher overall count of trauma-related visits; however, trauma-related outpatient department visits did not show significant differences between the groups. These findings collectively validate our hypothesis that routinely collected health records may contain quantifiable pre-injury indicators associated with subsequent TSCI.

Key Results

Among the evaluated metrics, trauma-related ED visits exhibited the highest discrimination (AUC=0.726). In this sample, the ≥1 versus 0 contrast for trauma-related ED visits showed moderate sensitivity and high specificity, supporting its potential utility as a hypothesis-generating risk flag. PD visits demonstrated modest discrimination (AUC=0.649), suggesting that psychosocial vulnerability may contribute to elevated risk, although PD contacts are likely heterogeneous and may proxy multiple mechanisms (e.g., comorbidity, mental health, substance use, social adversity).

Importantly, when these binary risk flags were jointly evaluated in a multivariable model, both prior ED utilization and psychiatry visit remained independently associated with TSCI, indicating that their predictive value was not solely driven by shared exposure to healthcare services. Together, these findings support a multi-domain risk-flagging framework that integrates injury-related exposure and psychosocial vulnerability.

The absence of intergroup differences in OTD visits indicates that the most significant signals in our dataset were recorded at the ED level. The ED is the first place people go for acute injuries, and small injuries and dangerous exposures can add up. This pattern is theoretically consistent with a "prodromal" phase of significant trauma. Importantly, these findings should not be interpreted as predictive at the individual level but rather as hypothesis-generating signals that may help identify subgroups with relatively increased risk.

Comparison with Previous Research

Building on this risk-flagging interpretation, EHR-based identification of a higher-risk subgroup could be operationalized to deliver targeted, structured injury-prevention content, adapted from programs that have demonstrated effectiveness in improving safety behaviors such as seatbelt and helmet use.[18] A study identified high-risk adolescents using police input, field observations, and community reports; they then received a brief educational intervention on the risks of street racing and safer driving practices.[19] Although their identification method differs from ours, the underlying logic is similar: defining a high-risk subgroup first, then focusing preventive intervention where it is most needed.

More broadly, EHR-based risk flagging has been used for trauma in other clinical settings. For example, studies have shown that EHR data can distinguish patients at higher risk of in-hospital falls and fall-related outcomes.[20-22] These fall-risk models are different from our outpatient, pre-injury setting and TSCI outcome, but they show that it is possible to use health-record signals that are collected regularly to find higher-risk groups.

Our findings also align with trauma recidivism literature, where repetitive injury-related healthcare contacts are considered informative. In a trauma-center cohort of 954 operatively treated high-energy orthopedic trauma patients, Heimke et al.[11] reported that 14.3% returned to the ED with

a new, unrelated injury within a mean of 21 months, and recidivism was most strongly associated with pre-existing mental illness. Bauer et al.[12] similarly found that mental illness increased the likelihood of trauma recidivism. In addition, Strong et al.[14] reported that trauma recidivists had substantially higher long-term mortality after discharge, highlighting recidivism as a marker of a particularly vulnerable population. These studies collectively validate our findings by indicating that TSCI may develop following recurrent trauma-related healthcare interactions and impose a considerable mortality burden.

In addition, prior ED utilization has been proposed as an early warning signal in other injury domains, including suspected non-accidental trauma in children, where repeated healthcare contacts may precede formal recognition.[13] A broader EHR prediction and risk-stratification literature supports the general approach of leveraging routinely collected health data – demographics, diagnoses, labs, prescriptions, and utilization patterns – to identify higher-risk patients and support proactive interventions across multiple outcomes.[15] Other studies have also demonstrated that EHRs can be used to anticipate clinically important events before they occur, including mental health crises and relapse, suicidal behavior, multiple sclerosis relapse, inpatient acute kidney injury through continual updating, and even increased risk of acute myeloid leukemia years before diagnosis.[16,23-25] In this context, our findings position TSCI – an infrequent but clinically devastating event that can cause lifelong disability and markedly reduce productivity at a young age – within the same EHR-enabled risk-stratification paradigm, suggesting that routinely collected health-record data may be sufficient to generate pragmatic pre-injury risk flags.

Limitations

There are a few problems with this study. First, the sample was small and came from only one center, and the ROC-based thresholds were created using a case–control design. This means that the suggested cut-offs need to be tested and adjusted in larger, more prospective groups. The findings should be consistently interpreted as hypothesis-generating, given the small sample size and case–control design, and should not be considered confirmatory. In addition, discriminative performance measures derived from this case–control sample may be overestimated and should be interpreted with caution.

Second, a significant number of screened cases were excluded due to restricted or inaccessible EHRs, potentially leading to selection bias. Third, our cohort consists of TSCI patients who subsequently attended a PMR clinic; those managed solely through alternative pathways (e.g., neurosurgery, orthopedics) may not have been included. Fourth, alcohol consumption is probably not well-documented, and it was looked at as "documented vs. not documented." Furthermore, psychiatric data were limited by rules about privacy, which made it impossible to look at diagnostic detail or narrative content. Furthermore, individual behavioral traits (e.g., impulsivity, attention-deficit symptoms) and contextual factors (e.g., socioeconomic status, driving behaviors, and occupational hazards) could not be directly evaluated. Ultimately, we concentrated on a singular catastrophic outcome and did not assess the existence of analogous pre-injury utilization patterns for other significant trauma phenotypes (e.g., traumatic brain injury, multiple bone fractures), indicating a need for future research. Given the case–control design and sample size, ROC-based contrast findings should be interpreted as descriptive and hypothesis-generating; external validation is required before any operational use.

In addition, important behavioral and socioeconomic confounders – such as risk-taking behavior, driving patterns, and socioeconomic status – could not be assessed, which may have influenced the observed associations. Due to the retrospective case–control design, causal inference cannot be established, and the observed associations should be interpreted within this methodological constraint.

Despite these limitations, the study offers proof-of-concept evidence that routine pre-injury healthcare utilization – especially trauma-related ED visits and PD contacts – may harbor measurable indicators that could facilitate pragmatic risk identification. Although the analytic cohort was derived from a single center, pre-index healthcare utilization histories were obtained from a national longitudinal EHR system capturing encounters across multiple facilities. Future research must prospectively validate these signals, encompass wider risk domains, and evaluate the efficacy of trigger-based preventive outreach in mitigating severe trauma outcomes.

Interpretation

Individuals with at least one trauma-related ED visit and at least one psychiatry visit in the preceding 24 months constituted a subgroup with substantially higher odds of subsequent TSCI among drivers/motorcyclists. Because these visits are routinely documented, such individuals can be readily identified within existing EHR systems without additional screening burden.

Rather than implying deterministic prediction at the individual level, this pattern supports a pragmatic interpretation: Recurrent trauma-related ED utilization and psychiatry contact may function as early warning signals that enrich for risk. This creates an opportunity for timely, low-intensity preventive interventions – such as brief injury-prevention counseling, reinforcement of seatbelt and helmet use, and referral for psychosocial support – delivered at the point of care before catastrophic injury occurs. Therefore, these indicators should not be considered deterministic or predictive markers, nor are they clinically actionable; rather, they serve as pragmatic signals that may support targeted preventive strategies in appropriate contexts.

Generalizability

Generalizability may be highest in similar environments with

national longitudinal EHR coverage and analogous trauma-care pathways. Our cohort was limited to 18–45-year-old drivers/motorcyclists involved in traffic accidents, identified through subsequent PMR presentation; thus, the findings may not be generalizable to other age groups or non-driver mechanisms. In addition, given the small sample size and case–control design, the findings should be interpreted as hypothesis-generating, with limited generalizability. Before broader use, external validation in multi-center cohorts and across different healthcare entry points is needed.

CONCLUSION

Our data indicate that significant driver/motorcyclist-related trauma is not invariably a random event; it may be preceded by detectable patterns of prior healthcare utilization characterized by previous injuries and psychiatric interactions. By identifying these pre-injury warning signs in national EHRs, these findings support further research toward proactive, targeted prevention strategies. This could allow them to step in with high-risk drivers/motorcyclists before a serious TSCI happens. A potential implication, if validated, is that ED encounters could serve as opportunities for brief safety counseling and psychosocial support (e.g., seatbelt/helmet use and avoidance of distracted or impaired driving). These findings support the hypothesis that pre-injury healthcare utilization patterns may contain measurable signals worthy of further investigation.

In this sense, traffic-related TSCI may not be entirely unforeseeable and may be preceded by detectable patterns.

Ethics Committee Approval: This study was approved by the Ministry of Health Antalya City Hospital Ethics Committee (Date: 08.01.2026, Decision No: 20/176).

Informed Consent: The study was a retrospective case–control study matched for age and sex

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: S.Y.M.; Design: S.Y.M., V.A.; Supervision: S.Y.M., V.A.; Resource: S.Y.M., V.A.; Materials: S.Y.M., V.A.; Data collection and/or processing: S.Y.M., V.A.; Analysis and/or interpretation: S.Y.M., V.A.; Literature review: S.Y.M., V.A.; Writing: S.Y.M., V.A.; Critical review: S.Y.M., V.A.

Conflict of Interest: None declared.

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REFERENCES

1. Hu X, Xu W, Ren Y, Wang Z, He X, Huang R, et al. Spinal cord injury: molecular mechanisms and therapeutic interventions. Signal Transduct Target Ther 2023;8:245. [CrossRef]
2. Eli I, Lerner DP, Ghogawala Z. Acute traumatic spinal cord injury. Neurol Clin 2021;39:471–88. [CrossRef]
3. Lu Y, Shang Z, Zhang W, Hu X, Shen R, Zhang K, et al. Global, regional, and national burden of spinal cord injury from 1990 to 2021 and projections for 2050: A systematic analysis for the Global Burden of Disease 2021 study. Ageing Res Rev 2025;103:102598. [CrossRef]
4. Jazayeri SB, Maroufi SF, Mohammadi E, Dabbagh Ohadi MA, Hagen EM, Chalangari M, et al. Incidence of traumatic spinal cord injury worldwide: A systematic review, data integration, and update. World Neurosurg X 2023;18:100171. [CrossRef]
5. Gao F, Liu W, Deng C, Wang Z, Wang B, Deng H, et al. The global macroeconomic burden of spinal cord injury: A Dynamic Modeling Study from 2020 to 2050. Neuroepidemiology 2026:1–10. [CrossRef]
6. Lo J, Chan L, Flynn S. A systematic review of the incidence, prevalence, costs, and activity and work limitations of amputation, osteoarthritis, rheumatoid arthritis, back pain, multiple sclerosis, spinal cord injury, stroke, and traumatic brain injury in the united states: a 2019 update. Arch Phys Med Rehabil 2021;102:115–31. [CrossRef]
7. Denu ZA, Yassin MO, Yesuf M, Azale T, Biks GA, Gelaye KA. Disability scores rate changes and predictors among road traffic injury victims admitted at Gondar specialized comprehensive hospital northwest Ethiopia: A prospective follow-up study. Traffic Inj Prev 2022;23(1):40–5. [CrossRef]
8. Youngers EH, Zundel K, Gerhardstein D, Martínez M, Bertrán C, Proctor MR, et al. Comprehensive review of the thinkfirst injury prevention programs: a 30-year success story for organized neurosurgery. Neurosurgery 2017;81:416–21. [CrossRef]
9. Phelps TB, Archer AD, Leonard M, Collins H, Burns JB Jr. Outcome of Seatbelt Education and Safety Program Among Teenagers. Am Surg 2024;90:1931–3. [CrossRef]
10. Joseph B, Zangbar B, Bains S, Kulvatunyou N, Khalil M, Mahmoud D, et al. Injury prevention programs against distracted driving: Are they effective? Traffic Inj Prev 2016;17:460–4. [CrossRef]
11. Heimke IM, Connelly M, Clarke A, DeMario B, Furdock R, Moore TA, et al. Trauma recidivism is pervasive and is associated with mental and social health opportunities. Injury 2023;54:519–24. [CrossRef]
12. Bauer MA, Mayo AM, Bush RA. Concomitant mental illnesses diagnoses and likelihood of trauma recidivism. J Trauma Nurs 2023;30:193–201. [CrossRef]
13. Eldredge RS, Lin J, Zimmerman S, Mirea L, Harootunian G, Sayrs LW, et al. Prior emergency department utilization association with nonaccidental trauma in children. J Surg Res 2025;308:19–25. [CrossRef]
14. Strong BL, Greene CR, Smith GS. Trauma recidivism predicts long-term mortality: missed opportunities for prevention (retrospective cohort study). Ann Surg 2017;265:847–53. [CrossRef]
15. Hossain ME, Khan A, Moni MA, Uddin S. Use of electronic health data for disease prediction: a comprehensive literature review. IEEE/ACM Trans Comput Biol Bioinform 2021;18:745–58. [CrossRef]
16. Garriga R, Mas J, Abraha S, Nolan J, Harrison O, Tadros G, et al. Machine learning model to predict mental health crises from electronic health records. Nat Med 2022;28:1240–8. [CrossRef]
17. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Intern Med 2007;147:573–7. [CrossRef]
18. Azeredo R, Stephens-Stidham S. Design and implementation of injury prevention curricula for elementary schools: lessons learned. Injury Prevention 2003;9:274–8. [CrossRef]
19. Suryawan RF, Febrian WD. Socialization of prevention patterns of wild racing and suppressing the number of traffic accidents. Asian Journal of Community Services 2023;2:945–54. [CrossRef]
20. Hsu Y, Kao YS. Can the electronic health record predict risk of falls in hospitalized patients by using artificial intelligence? A meta-analysis. Comput Inform Nurs 2023;41:531–38. [CrossRef]

21. Moskowitz G, Egorova NN, Hazan A, Freeman R, Reich DL, Leipzig RM. Using electronic health records to enhance predictions of fall risk in inpatient settings. Jt Comm J Qual Patient Saf 2020;46:199–206. [CrossRef]
22. Yang A, Shi M, Lau ESH, Yu J, Luk AOY, Ma RCW, et al. A novel electronic-health-record based, machine-learning model to predict 1-year risk of fall hospitalisation in older adults: a Hong Kong territory-wide cohort and modelling study. Age Ageing 2025;54:afaf285. [CrossRef]
23. Simon GE, Shortreed SM, Johnson E, Rossom RC, Lynch FL, Ziebell R, et al. What health records data are required for accurate prediction of suicidal behavior? J Am Med Inform Assoc 2019;26:1458–65. [CrossRef]
24. Ahuja Y, Kim N, Liang L, Cai T, Dahal K, Seyok T, et al. Leveraging electronic health records data to predict multiple sclerosis disease activity. Ann Clin Transl Neurol 2021;8:800–10. [CrossRef]
25. Abelson S, Collord G, Ng SWK, Weissbrod O, Mendelson Cohen N, Niemeyer E, et al. Prediction of acute myeloid leukaemia risk in healthy individuals. Nature 2018;559:400–4. [CrossRef]

ORİJİNAL ÇALIŞMA - *ÖZ*

Trafikle ilgili travmatik omurilik yaralanmalarından önce gözden kaçan uyarı sinyalleri var mı? Elektronik sağlık kayıtları kullanılarak yapılan keşifsel olgu-kontrol çalışması

AMAÇ: Travmatik omurilik yaralanması (OY), sıklıkla trafik kazaları sonucunda ortaya çıkan yıkıcı bir durumdur. Bu çalışmada, elektronik sağlık kayıtlarında (ESK) rutin olarak kaydedilen yaralanma öncesi sağlık hizmeti kullanım paternlerinin, sürücüler ve motosiklet kullanıcıları arasında travmatik OY için pratik uyarı sinyalleri olarak işlev görüp göremeyeceğini araştırdık.
GEREÇ VE YÖNTEM: Ulusal ESK verilerini kullanarak retrospektif, yaş ve cinsiyet açısından eşleştirilmiş bir olgu-kontrol çalışması gerçekleştirdik. Trafik kazasına bağlı travmatik OY gelişen, sürücü veya motosiklet kullanıcısı olan 18–45 yaş arası yetişkinler (2024–2025) 1: 1 oranında kontrol grubu ile eşleştirildi (her grupta n=35). İndeks tarihinden önceki 24 ay içinde yaralanma ile ilişkili acil servis (AS) başvuruları, ortopedi/travmatoloji departmanı (OTD) başvuruları, toplam travma ilişkili başvurular ve psikiyatri başvuruları değerlendirildi. Gruplar arası karşılaştırmalarda Mann–Whitney U testi kullanıldı. Ayırt edici performansı özetlemek amacıyla ROC analizleri yapıldı. İkili risk göstergeleri (≥1 ED başvurusu; ≥1 psikiyatri başvurusu) çok değişkenli lojistik regresyon ile değerlendirildi.
BULGULAR: Analize dahil edilen örneklem 70 katılımcıdan oluştu. Kontrollerle karşılaştırıldığında, travmatik OY olgularında travma ilişkili AS başvuruları (p<0.001; r=0.45), psikiyatri başvuruları (p=0.010; r=0.31) ve toplam travma ilişkili başvurular (p=0.035; r=0.25) daha yüksek bulundu; buna karşın OTD başvuruları açısından fark saptanmadı (p=0.920). AS başvuruları en yüksek ayırt edici performansı gösterdi (AUC=0.726). Bu örneklemde ≥1'e karşı 0 karşılaştırması için duyarlılık %60.0 ve özgüllük %82.9 idi. Psikiyatri başvuruları orta düzeyde ayırt edicilik gösterdi (AUC=0.649). Bu örneklemde ≥1'e karşı 0 karşılaştırması için duyarlılık %45.7 ve özgüllük %80.0 idi. Çok değişkenli analizde, ≥1 AS başvurusu (OR=8.85, %95 GA 2.68–29.23; p<0.001) ve ≥1 psikiyatri başvurusu (OR=4.52, %95 GA 1.34–15.20; p=0.015) travmatik OY ile bağımsız olarak ilişkili bulundu.
SONUÇ: Trafik ilişkili travmatik OY, rutin olarak toplanan ESK verilerinde yer alan ölçülebilir yaralanma öncesi paternlerle—özellikle travma ilişkili AS kullanımı ve psikiyatri başvuruları ile—önceden izlenebilir olabilir. Bu bulgular, hedefe yönelik önleyici eğitim, yaralanma riski danışmanlığı ve psikososyal risk azaltma girişimlerinden fayda görebilecek bireylerin belirlenmesine yardımcı olabilecek pragmatik bir risk işaretleme yaklaşımını desteklemektedir. Bu bulgular dikkatle yorumlanmalı ve daha büyük ölçekli prospektif çalışmalarla doğrulanmalıdır.

Anahtar sözcükler: Acil; elektronik sağlık kayıtları; psikiyatri; Spinal kord hasarı; trafik kazaları; travma.

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Supplementary Table 1. Normality test results for count-based healthcare utilization variables

Variable	Group	Kolmogorov-Smirnov statistic	df	p	Shapiro–Wilk statistic	df	p
Trauma-related ED visits	TSCI	0.271	35	<0.001	0.672	35	<0.001
Trauma-related OTD visits	TSCI	0.464	35	<0.001	0.495	35	<0.001
Total trauma-related visits	TSCI	0.258	35	<0.001	0.766	35	<0.001
PD visits	TSCI	0.306	35	<0.001	0.751	35	<0.001
Trauma-related ED visits	Control	0.492	35	<0.001	0.477	35	<0.001
Trauma-related OTD visits	Control	0.454	35	<0.001	0.457	35	<0.001
Total trauma-related visits	Control	0.394	35	<0.001	0.611	35	<0.001
PD visits	Control	0.477	35	<0.001	0.511	35	<0.001

TSCI: Traumatic spinal cord injury; ED: Emergency department; OTD: Orthopedics and traumatology department; PD: Psychiatry department. Notes: Kolmogorov–Smirnov p values use the Lilliefors significance correction. All variables showed significant deviation from normality in both groups (p<0.001), supporting the use of non-parametric comparisons.

Supplementary Table 2. Coordinates of the ROC curves for candidate predictors of TSCI within the case–control sample

Test result variable	Positive if ≥ (cut-off)*	Sensitivity	1 − specificity
Trauma-related ED visits	-1.0	1.000	1.000
	0.5	0.600	0.171
	1.5	0.229	0.029
	2.5	0.057	0.000
	5.0	0.029	0.000
	8.0	0.000	0.000
Total trauma-related visits	−1.0	1.000	1.000
	0.5	0.514	0.314
	1.5	0.343	0.114
	2.5	0.200	0.029
	3.5	0.086	0.029
	4.5	0.057	0.000
	6.0	0.029	0.000
	8.0	0.000	0.000
PD visits	−1.0	1.000	1.000
	0.5	0.457	0.200
	1.5	0.314	0.086
	2.5	0.200	0.000
	3.5	0.114	0.000
	5.0	0.029	0.000
	7.0	0.000	0.000

TSCI: Traumatic spinal cord injury; ED: Emergency department; PD: Psychiatry department. For discrete count variables (0,1,2,…), Statistical Package for the Social Sciences reports cut-offs as midpoints between ordered values; thus, 0.5 corresponds to ≥1, 1.5 to ≥2, etc.