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Intentionally self-injured patients have lower mortality when treated at trauma centers versus non-trauma centers in South Korea

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ABSTRACT

Objective This study investigated the characteristics and survival rates of patients with intentional severe trauma (self-harm or suicide) who were transported to either a regional trauma center (TC) or a non-TC facility.
Methods This retrospective, national, population-based, observational, case-control study included patients who sustained intentional severe trauma and had an abnormal Revised Trauma Score at the injury site between January 2018 and December 2019. The data were a community-based severe trauma survey based on data collected from severe injury and multiple casualty patients transported by 119 emergency medical services (EMS), distributed by the Korea Disease Control and Prevention Agency. The treatment hospitals were divided into two types, TC and non-TCs, and several variables, including in-hospital mortality, were compared. Propensity score matching (PSM) was used to mitigate the influence of confounding variables on the survival outcomes.
Results Among the 3864 patients, 872 and 2992 visited TC and non-TC facilities, respectively. The injury severity did not differ significantly between patients treated at TCs and non-TCs (TC, 9; non-TC, 9; p=0.104). However, compared with those treated at non-TCs, patients treated at TCs had a higher rate of surgery or transcatheter arterial embolization (14.2% vs 38.4%; p<0.001) and a higher admission rate to the emergency department (34.4% vs 60.6%; p<0.001). After PSM, 872 patients from both groups were analyzed. Patients treated at TCs exhibited a higher overall survival rate than those treated at non-TCs (76.1% vs 66.9%; p<0.001), and multiple variable logistic regression analysis demonstrated that the causes of injury and transport to the TC were significantly associated.
Conclusion Using Korean EMS data, the results of this study revealed that initial transport to TCs was associated with reduced mortality rates. However, considering the limitations of using data from only 2 years and the retrospective design, further research is warranted.
Study type Retrospective national, population-based observational case-control study.
Level of evidence Level III

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Clinical an Experimental Emergency Medicine (CEEM) in 2023, it can be observed that initial transport to a Trauma Center (TC) for patients with unintentional severe trauma effectively reduces mortality. However, research on the effectiveness of transport to TC for patients with suicide attempts has not been conducted, despite these patients having a higher average injury severity, as reported in papers published in the European Journal of Trauma and Emergency Surgery in 2012 and 2022.

WHAT THIS STUDY ADDS

⇒ This article approached us to conduct a follow-up study that examined the case of patients with intentional severe trauma. While pursuing this project, we discovered both transportation to TC and treatment TC not only reduce the mortality rates but also have a positive impact on the survival rates of patients with intentional injuries, as well as unintentional injuries.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ As the utility of TC becomes increasingly evident, there may be a demand for continued support for existing TCs and further activation of TCs to positively impact the treatment of more trauma patients. Additionally, there may be an encouragement to emphasize the importance of integrating mental health treatment alongside trauma care for intentional trauma patients.

BACKGROUND

The WHO (1968) defines suicide as a self-inflicted act with a fatal outcome, whereas self-harm refers to the intentional and deliberate harm inflicted on one's own body.[1] Self-harm can be categorized into non-suicidal and suicidal self-harm based on intention. Regardless of intent, the severity of injuries can range from mild to severe, and the methods can vary from physical harm, such as cutting the wrists or hanging, to chemical harm, such as exposure to toxic substances.[2,3]

The suicide rate in South Korea is more than twice the average in other Organization for Economic Co-operation and Development countries, ranking highest among these nations. Suicide is an urgent public health concern. According to 2019 cause-of-death statistics, 13 799 suicide deaths were reported in South Korea, with a suicide rate of 26.9 per 100 000 individuals (38.0 for men and 15.7 for women), ranking it as the fifth-leading cause of death. Suicide tops the list of causes of death in age groups ranging from teenagers to those in their 30s.[4] Given the high proportion of injuries caused

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by suicide, appropriate triage and treatment in proper facilities could positively impact reducing the country's mortality rate.

Emergency medical services (EMS) have evolved since the 1960s, and most advanced countries have established and implemented systems to classify and transfer patients with trauma to the prehospital stage. In 2012, the South Korean government formulated a plan to design a national trauma system with the main goal of establishing 17 trauma centers (TCs) nationwide.[5] As of 2020, 17 TCs have been designated nationwide, 15 of which are operated as trauma-exclusive treatment centers with facilities such as trauma intensive care units (ICUs), trauma operating rooms, trauma resuscitation rooms, trauma wards, equipped with the facilities, equipment, and personnel capable of performing emergency surgery immediately on arrival at the hospital for severe trauma patients with conditions such as multiple fractures, organ damage, and excessive bleeding, and receive intensive government funding focused on trauma-specialized personnel.[6] Regional TCs operate within 10 min of essential care delivery by trauma teams (traumatology, neurosurgery, and emergency medicine).[7] This study investigated whether appropriate transfer through EMS to TCs for the treatment of patients with severe trauma due to self-harm has a positive impact on survival rates.

METHODS

Ethical statements

This study adhered to the ethical guidelines of the 1975 Declaration of Helsinki. The requirement for informed consent was waived due to the retrospective nature of the study.

Study design and setting

This domestic retrospective cohort study included severely injured patients who self-harmed among multiple casualties and were transported by the Korean EMS. The study period was from 2018 to 2019 and focused on patients with an abnormal Revised Trauma Score (RTS) at the injury site (the full score of RTS is 12 points, and all patients with a score of 11 or lower were included). Patients with unknown RTS (including those who experienced out-of-hospital cardiac arrest and arrived at the hospital already deceased), patients with typical RTS (transported for non-traumatic reasons or with minor injuries), or missing records were not considered patients with trauma and were not included. These data are composed of the scale of severe injury occurrence, postoccurrence treatment, disabilities, and mortality due to trauma. Data corresponding to self-harm and suicide were used from the data set classified according to the intent of the accidents.[8] This study excluded patients with chemical injuries primarily treated with internal medical management to assess the benefits of transporting and treating physically injured patients to TCs.

The Korean EMS is a single-tier government-provided system that offers basic life support ambulance services through 17 provincial fire departments. All EMS providers can provide advanced airway management and intravenous fluids to patients after EMS cardiopulmonary resuscitation (CPR) protocols.[9] The RTS and the Injury Severity Score (ISS) are indicators used for trauma treatment and early severity assessment. The RTS consists of physiological scores based on the Glasgow Coma Scale, systolic blood pressure, and respiratory rate,[10] whereas the ISS is the most widely used scoring system for evaluating the severity of injuries in hospitalized patients with severe injuries.[11] The ISS is based on the Abbreviated Injury Scale, which describes the degree of injury in different body regions (head, face, chest, abdomen, extremities, and external). The ISS is calculated by squaring and summing the scores of the three most severely injured regions.[12]

Data collection and process

Patient data were a community-based severe trauma survey based on data collected from severe injury and multiple casualty patients transported by 119 EMS from 2019 to 2020, distributed by the Korea Disease Control and Prevention Agency. It aims to produce statistics on the occurrence and treatment outcomes of severe injuries and multiple casualties by region and emergency medical institution, to provide a basis for evaluating national and regional emergency medical systems. The survey questionnaire was developed by reviewing international trauma registries such as the National Trauma Data Bank in the USA and the Trauma Audit and Research Network in the UK and was modified and supplemented considering the feasibility of data collection in Korea.[8] De-identification was conducted in accordance with the Personal Information Protection and Statistics Acts. The Korea Centers for Disease Control and Prevention dispatches trained medical record investigators to hospitals to collect data through medical record reviews and ensure compliance with the National Statistics Act. Investigators responsible for community injury status confirmed the information provided by 119 emergency medical institutions to analyze whether patients were severely injured or among multiple casualties and collected necessary data. Additional treatments and outcomes were verified through interinstitutional transfer investigations.

Trauma data included sociodemographic information, injury details, treatment progress, and posthospitalization outcomes.[8] Patients were categorized into either the TC or non-TC groups. The primary outcome variable was in-hospital mortality as reported by the National Trauma Registry. In addition to the primary exposure variable (TC vs non-TC), multiple confounding variables, predictor variables, and effect modifiers were considered, such as sex, cause of injury (hanging, falling, penetrating trauma, etc), insurance status, and interinstitutional transfer status, for all multiple outcome models.[13]

Variable description

Continuous variables include age (years), ISS, time taken from 119 to site arrival by 119 emergency medical technician (EMT) (minutes), time taken from emergency room (ER) arrival to operation (minutes) and time taken from ER arrival to transcatheter arterial embolization (TAE) (minutes). Categorical variables include sex (male vs female), insurance (medical insurance, medicaid, and others), mechanism of injury (hanging, fall, penetrating trauma, and others), surgery or TAE performed (yes or no), result in ER (survival to discharge, survival to admission, survival to transfer, and died after CPR), ICU admission (yes or no), result after admission (survival or death), result at the ER variables (survival, death, and transfer to other institution). The variables for propensity score matching (PSM) are age (years), ISS, time taken from call to 119 to site arrival by 119 EMT (minutes), sex (male vs female), insurance (medical insurance, medicaid, and others), mechanism of injury (hanging, fall, penetrating trauma, and others), surgery or TAE performed (yes or no) and time taken from ER arrival to operation (minutes). Result in ED variable indicates outcomes such as admission, transfer, discharge, or death in the emergency department (ED). Result after ER variable includes the survival rates of patients where patients survived and were discharged from the emergency room, as well as patients where they survived after admission. The mortality rate of result after ER includes deaths in the emergency room and after admission.

Statistical analysis

Continuous variables are presented as medians and IQRs. Categorical variables are presented as numbers and percentages. To compare the TC and non-TC groups, Mann–Whitney U and χ^2 tests or Fisher's exact test were used for continuous and categorical variables, respectively. Patients were also divided into two groups (patients who transferred from non-TC and from TC) and compared using the χ^2 test. As age, ISS, and time elapsed from emergency phone number (119) call to site arrival, time from ED arrival to operation, and time from ED arrival to TAE did not follow a normal distribution, a non-parametric test was used.

To reduce the effects of confounding variables that influence outcome variables in comparisons of basic characteristics, PSM was used to collect data from both groups. Patients not transported to a TC were matched 1:1 with those transported to a TC according to their propensity scores using exact matching. Using matched data, the differences between TC and non-TC variables were analyzed again. To assess the bias reduction in the PSM method, absolute standardized differences were calculated, with values >20% indicating a significant imbalance in the baseline covariate. Even with PSM, the TC and non-TC groups showed significant differences. Therefore, multivariate logistic regression analysis was performed using the significant variables.

All statistical analyses were performed using R V.4.3.1 (R Foundation for Statistical Computing), and values of p were based on a two-sided significance level of 0.05.

RESULTS

Characteristics of the study subjects

Among the 101 320 patients who were transferred to EDs in South Korea during the study period, 3864 were eligible for inclusion in the analysis. Patients with unintentional injury (n=80 230), injuries caused by violence or homicide (n=2324), cardiac arrest before ED arrival (n=1408), missing records or ISS data (n=17 984), or drug overdose (n=6859) were excluded. Of the included patients, 872 visited TCs and 2992 visited non-TCs (figure 1).

Main results

This study compared patient characteristics, including demographic variables, ISS, and injury mechanisms, between the two TC and non-TC groups. Patients treated at TCs were younger (p=0.002) than those treated at non-TCs. The sex distribution did not differ significantly between the groups (p=0.567). The most common injury mechanisms in patients transported to TCs and non-TCs were self-harm (36.4 %) and neck injuries (48.4 %), respectively, with a significant difference in the injury mechanism ratios between the two groups (p<0.001). The ISS did not differ significantly between the groups (p=0.104), and most patients in both groups were covered by medical insurance.

Patients transported to non-TCs had a shorter time interval between 119 emergency calls and ED arrival (p<0.001), whereas those transported to TCs had a shorter time to undergo surgery or TAE (p<0.001). The rate of actual surgical or TAE procedures was higher in patients transported to TCs (p<0.001) (table 1).

TC-transferred patients had a significantly higher hospital admission rate and a higher rate of admission to the ICU (p<0.001). Conversely, non-TC-transferred patients had a higher rate of discharge or transfer to another facility and a higher rate of cardiac arrest after CPR (p<0.001). The survival rate during hospitalization was slightly higher in patients transported to a TC, and the final survival rate after ED arrival was also higher in patients transported to a TC. By contrast, the non-TC group showed a higher likelihood of transfer to other institutions (p<0.001) (table 2).

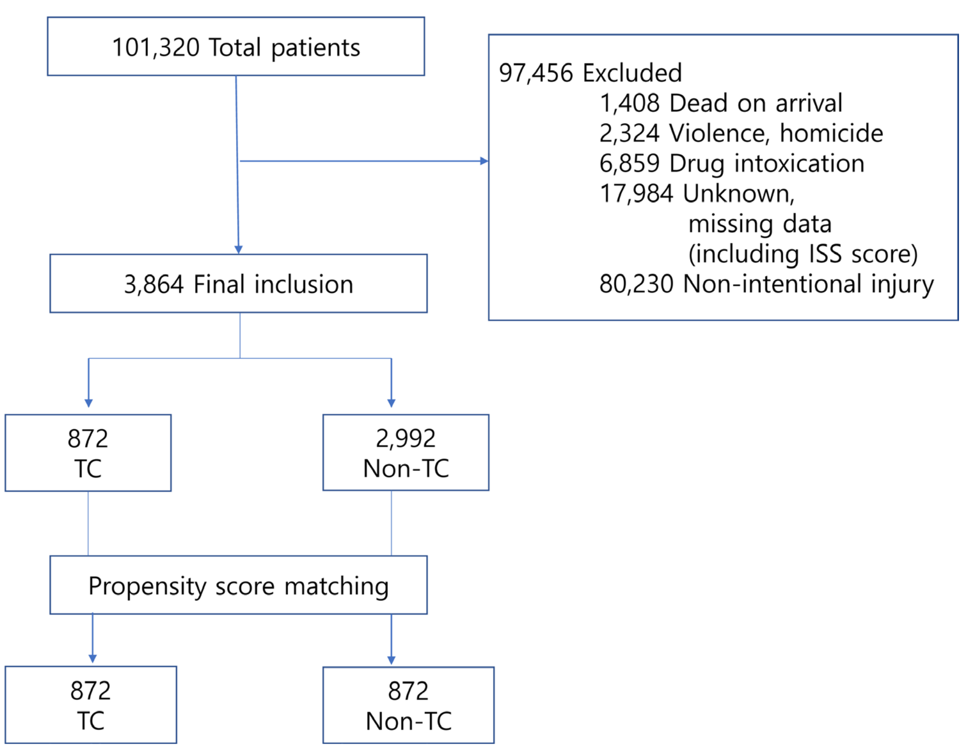

Figure 1 Study flow diagram. ISS, Injury Severity Score; TC, trauma center.

Table 1 Basic characteristics of trauma patients in the ED (n=3864)

Variables	Non-trauma center (n=2992)	Trauma center (n=872)	P value
Age (years), median (IQR)	45 (30–58)	41 (27–56)	0.002
ISS, median (IQR)	9 (4-25)	9 (4-22)	0.104
Time taken from call 119 to site arrival by 119 EMT, minutes (median (IQR))	27 (21–35)	30 (24–43)	<0.001
Sex, N (%)			
Male	1666 (55.7)	476 (54.6)	0.567
Female	1326 (44.3)	396 (45.4)	
Insurance, N (%)			
Medical insurance	2519 (84.2)	703 (80.6)	0.030
Medicaid	239 (8.0)	79 (9.1)	
Others	234 (7.8)	90 (10.3)	
Mechanism of injury, N (%)			
Hanging	1447 (48.4)	246 (28.2)	<0.001
Falls	672 (22.5)	286 (32.8)	
Penetrating trauma	769 (25.7)	317 (36.4)	
Others	104 (3.5)	23 (2.6)	
Surgery or TAE performed, N (%)	426 (14.2)	335 (38.4)	<0.001
Time taken from ER arrival to operation, minutes (median (IQR))	620 (240–3839)	428 (141–2288)	<0.001
Time taken from ER arrival to TAE, minutes (median (IQR))	229 (193–370)	189 (141–297)	0.088

ED, emergency department; EMT, emergency medical technician; ISS, Injury Severity Score; TAE, transcatheter arterial embolization.

To investigate the outcomes after transfer to another institution, this study analyzed 25 patients transferred from a TC and 383 patients transferred from non-TCs. Patients transferred from the TC did not have any discharge, CPR after cardiac arrest, or re-transfer to another institution. Patients transferred from non-TC institutions had a higher proportion of discharges, re-transfers to another institution, and CPR after cardiac arrest. A higher proportion of patients transferred from non-TC patients were admitted to the ICU at the transfer hospital (p<0.001). All patients transferred from a TC survived, with a higher survival rate than those transferred from non-TCs (table 3).

Table 2 Comparison of trauma patient outcomes (total=3864)

Variables	Non-trauma center (n=2992)	Trauma center (n=872)	P value
Result in ED, N (%)			<0.001
Survival-to-discharge	776 (25.9)	211 (24.2)	
Survival-to-transfer	457 (15.3)	37 (4.2)	
Survival-to-admission	1030 (34.4)	528 (60.6)	
Died after CPR	729 (24.4)	96 (11.0)	
Intensive care unit admission, N (%)	743 (72.1)	439 (83.1)	<0.001
Result after admission, N (%)			
Survival	835 (81.1)	453 (85.8)	0.020
Death	195 (18.9)	75 (14.2)	
Result after ER, N(%)			
Survival	1611 (53.8)	664 (76.1)	<0.001
Death	924 (30.9)	171 (19.6)	
Transfer to other institution	457 (15.3)	37 (4.2)	

CPR, cardiopulmonary resuscitation; ED, emergency department.;

Table 3 Comparison of outcomes of transferred patients in the ED (total number=408)

Variables	Transferred from non-trauma center (n=383)	Transferred from trauma center (n=25)	P value
Result in ED on second hospital, N (%)			
Survival-to-discharge	36 (9.4)	0 (0)	0.196
Survival-to-transfer	12 (3.1)	1 (4.0)	
Survival-to-admission	310 (80.9)	24 (96.0)	
Died after CPR	25 (6.5)	0 (0)	
Intensive care unit admission on second hospital, N (%)	218 (70.3)	2 (8.3)	<0.001
Result after admission on second hospital, N (%)			
Survival	248 (80.0)	24 (100)	0.015
Death	62 (20.0)	0 (0)	

CPR, cardiopulmonary resuscitation; ED, emergency department.;

Due to the presence of variables showing differences in the comparison of basic characteristics, PSM was conducted on patients transported to non-TCs to match the number of patients transported to TCs. Although variables related to transfer time, mechanism, insurance type, and surgery time were not fully adjusted, PSM substantially reduced these differences (table 4).

The results were analyzed based on PSM data for both groups. Patients in the TC group had higher survival and discharge rates than those in the non-TC group. Conversely, the non-TC group had higher rates of transfer and mortality. Although the TC group had a higher rate of admission to the ICU, the survival rate after admission was lower than that of the non-TC group. Comparison of the overall survival rates during emergency room care and after admission showed higher survival rates and lower rates of mortality and transfer in the TC group rates than in the non-TC group (table 5).

Table 4 ED after PSM (total=1744)

Variables	Non-trauma center (n=872)	Trauma center (n=872)	P value
Age (years), median (IQR)	42 (27–54)	41 (27–56)	0.919
ISS, median (IQR)	9 (4-18)	9 (4-22)	0.09
Time taken from call to 119 to site arrival by 119 EMT, minutes (median (IQR))	27 (21–37)	30 (24–43)	<0.001
Sex, N (%)			0.630
Male	486 (55.7)	476 (54.6)	
Female	386 (44.3)	396 (45.4)	
Insurance, N (%)			0.039
Medical insurance	713 (81.8)	703 (80.6)	
Medicaid	96 (11)	79 (9.1)	
Others	63 (7.2)	90 (10.3)	
Mechanism of injury, N (%)			0.005
Hanging	257 (29.5)	246 (28.2)	
Falls	231 (26.5)	286 (32.8)	
Penetrating trauma	341 (39.1)	317 (36.4)	
Others	43 (4.9)	23 (2.6)	
Surgery or TAE performed, N (%)	332 (38.1)	335 (38.4)	0.882
Time taken from ER arrival to TAE, minutes (median (IQR))	246 (208.5–383.5)	189 (141–297)	0.062

ED, emergency department; EMT, emergency medical technician; ISS, injury severity score; PSM, propensity score matching; TAE, transcatheter arterial embolization.

Table 5 Comparison of trauma patient outcomes after PSM (total=3864)

Variables	Non-trauma center (n=872)	Trauma center (n=872)	P-value
Result in ED, N (%)			<0.001
Survival-to-discharge	187 (21.4)	211 (24.2)	
Survival-to-transfer	102 (11.7)	37 (4.2)	
Survival-to-admission	433 (49.7)	528 (60.6)	
Died after CPR	150 (17.2)	96 (11.0)	
Intensive care unit admission, N (%)	281 (64.9)	439 (83.1)	<0.001
Result after admission, N (%)			
Survival	396 (91.5)	453 (85.8)	0.007
Death	37 (8.5)	75 (14.2)	
Result after ER, N (%)			<0.001
Survival	583 (66.9)	664 (76.1)	
Death	187 (21.4)	171 (19.6)	
Transfer to other institution	102 (11.7)	37 (4.2)	

CPR, cardiopulmonary resuscitation; ED, emergency department; PSM, propensity score matching.

As the matched data still showed some differences in variables related to transfer time, mechanism, insurance type, and surgery time, multiple logistic regression analysis was performed with survival status as the dependent variable. The results showed that even with a 1 minute increase in the time from 119 emergency calls to scene arrival, the survival rate did not significantly change. Low-income patients with medical insurance had a slightly higher survival rate than those with other insurance types; however, this difference was not statistically significant. Regarding injury mechanisms, survival rates were significantly higher for falls, self-harm, and other injuries than for neck injuries. Patients transferred to TCs had a significantly higher survival rate compared with patients transferred to non-TCs (table 6).

DISCUSSION

Reducing the time to appropriate treatment after injury of patients with severe trauma is associated with decreased mortality rates; however, patients with severe trauma may not receive high-quality treatment promptly when transferred to non-TC facilities. Repetitive interfacility transfers and imaging examinations may also affect patient prognosis.[14–16] In Korea, patients with severe trauma are transferred to TC and non-TC facilities without clear guidelines.[17] Although TC transfer improves survival rates in patients with unintentional severe trauma, patients of intentional injury have not been investigated. The current study analyzed 2 years of nationwide data to assess whether TC transfer of patients with severe intentional trauma positively affected survival rates and minimized the risk of sample bias.

Table 6 Multiple logistic regression analysis of survival

Variables	OR	CI	P value
Time taken from call to 119 to site arrival by 119 EMT (1 minute increase)	1.001	0.999 to 1.003	0.226
Insurance			
Medical insurance	1		
Medicaid	1.063	0.656 to 1.724	0.804
Others	0.811	0.508 to 1.295	0.380
Mechanism of injury			
Hanging	1		
Falls	1.769	1.346 to 2.326	<0.001
Penetrating trauma	26.516	15.77 to 44.583	<0.001
Others	6.389	2.666 to 15.269	<0.001
Time taken from ER arrival to operation, minutes (1 minute increase)	0.998	0.995 to 1.001	0.256
Hospital class			
Non-trauma center	1		
Trauma center	1.454	1.122 to 1.886	0.005

EMT, emergency medical technician.

In this study, the proportion of male patients was higher among those treated at TCs. Some studies have reported higher risks among young men than among women due to factors such as speeding, alcohol or drug consumption, and risky behaviors.[18–21] Particularly, severe injuries due to suicide attempts are more common in men and are influenced by various factors, including societal expectations and gender roles, emotional repression, mental health issues, substance abuse, and the selection of suicide methods.[22–24] Overall mortality and neurological outcomes are also less favorable in younger male patients.[25] All these factors may influence treatment outcomes in TCs. The existence of selection bias, in which patients with more severe conditions were prioritized for transfer to TCs, is consistent with previous research.[26] This bias can lead to systematic differences between TC and non-TC populations, making the comparison of survival rates complex and requiring control for such bias in statistical analyses.

Surgery and bronchial artery embolization (BAE) for patients with severe trauma are considered at a definite treatment level.[27 28] Since patients with suicide attempts tend to have higher average injury severity, they may require surgery and BAE more frequently, leading to higher rates of hospital admission at TCs. In addition, patients treated at TCs have a higher rate of ICU admission. Moreover, patients with intentional injuries (assault and self-harm) have a relatively poor prognosis due to higher injury severity, longer ICU stay, and longer hospitalization.[29 30]

PSM was conducted by re-sampling in the present study to control for factors influencing survival rates. Unlike studies on unintentional injuries,[31] TC patients showed higher survival rates than non-TC patients in terms of survival after hospital admission and final survival rate after ED arrival. Although patients with intentional trauma injuries have a higher severity of injuries compared with patients with intentional trauma,[29 30] TC treatment may lead to quicker transfer to the operating room and BAE, resulting in shorter ED stays and higher survival rates. In countries with TCs worldwide, the survival rate of severe trauma patients is high, and the mortality rate is significantly lower.[32] When compared with non-TC, patients at TC exhibit similar outcomes despite higher severity of trauma.[33] This aligns with the findings of this study. It can be inferred that TCs, currently well operated, positively impact the survival rates of severe patients. Continuous investment in existing TCs and, if possible, establishment of more TCs could lead to even greater expectations for the survival of more severe patients.

Individuals who attempt suicide have a higher likelihood of attempting suicide than the general population.[34] Therefore, in addition to trauma-related treatment, mental health treatment is crucial.[35] Recognizing the importance of psychological and mental healthcare for patients with intentional injuries is essential and relevant support should be provided.

This study has several limitations. First, it was not possible to analyze whether the patients transferred to follow-up hospitals were sent to TCs or non-TCs. Thus, this study could only compare the outcomes based on the type of initial hospital arrival. Future research should focus on collecting and supplementing patient records from the follow-up hospitals. Second, the data used in this study covered only 2 years, providing a representation of EMS in Korea at the national level. However, more meaningful and constructive results could be obtained by accumulating data over multiple years and conducting further studies. Third, as is evident from the results of the London Trauma Center Study,[35] mental health services should be appropriately integrated and provided alongside trauma care. However, the present study only included treatments related to trauma and did not adequately address the aspects of self-harm and suicide. Fourth, although excluded from this study, future research should focus on drug intoxication, which plays a significant role in self-harm and suicidal ideation. Establishing systems and centers for appropriate treatment is necessary.

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Patient consent for publication Not applicable.

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Data availability statement Data are available in a public, open access repository. All the data used can be obtained from the Korea Disease Control and Prevention Agency.

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