Korean J Neurotrauma. 2025 Jan;21(1):32-45
https://doi.org/10.13004/kjnt.2025.21.e4
pISSN 2234-8999·eISSN 2288-2243

KJNT

Clinical Article

Check for updates

Incidence and Current Status of Acute Management of Traumatic Brain Injuries in Korea: A National Population-Based Study of 2016–2018

Cheolsu Jwa [1], **Byul Hee Yoon** [2], **Jae Hoon Kim** [1], **Hee In Kang** [1], and **In-Suk Bae** [1]

[1]Department of Neurosurgery, Nowon Eulji Medical Center, Eulji University, Seoul, Korea
[2]Department of Neurosurgery, Uijeongbu Eulji Medical Center, Eulji University, Uijeongbu, Korea

OPEN ACCESS

Received: Nov 1, 2024
Revised: Jan 12, 2025
Accepted: Jan 14, 2025
Published online: Jan 21, 2025

Address for correspondence:
Byul Hee Yoon
Department of Neurosurgery, Uijeongbu Eulji Medical Center, Eulji University, 712 Dongil-ro, Uijeongbu 11759, Korea.
Email: drbhyoon@naver.com

Copyright © 2025 Korean Neurotraumatology Society
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (https://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ORCID iDs
Cheolsu Jwa
https://orcid.org/0000-0002-7688-2842
Byul Hee Yoon
https://orcid.org/0000-0002-4986-1173
Jae Hoon Kim
https://orcid.org/0000-0002-9179-8569
Hee In Kang
https://orcid.org/0000-0001-8638-6212
In-Suk Bae
https://orcid.org/0000-0002-0738-9253

Funding
No funding was obtained for this study.

ABSTRACT

Objective: This study aimed to describe the incidence and status of acute management of traumatic brain injuries (TBIs) in Korea.
Methods: We utilized nationwide administrative data from the National Emergency Department Information System (2016–2018), focusing on patients with TBIs who visited emergency medical centers within 7 days of injury and were treated in neurosurgery.
Results: The study included 117,830 patients, indicating an annual crude incidence of 79.4 TBIs per 100,000 persons. The highest incidence was in the age groups 0–4 and 75–79 years, with men experiencing TBIs more often than women (79.3 vs. 60.4). Traffic accidents were the most common cause (34.2%). Ambulance transport accounted for 65.4% of cases, with a median hospital arrival time of 62 minutes. Only 7.6% of patients were admitted to trauma care units, showing significant regional variations. Craniotomy or craniectomy was performed in 4.8% of cases. Normal discharge occurred in 69.3% of patients, and the overall in-hospital mortality rate was 5.3%, higher in men (3.9% vs. 1.5%).
Conclusion: In Korea, the incidence of TBIs vary by age, sex, and regions. Current status of management of TBIs also differs by regions, especially between metropolitan city and province. Tailored strategies for TBI management are needed based on these differences.

Keywords: Craniotomy; Incidence; Traumatic brain injury; Trauma centers

INTRODUCTION

Traumatic brain injuries (TBIs) are a major global public health concern. Severe traumatic injuries are often accompanied with TBIs, which directly lead to poor patient outcomes. In fact, in Europe, approximately 37% of all injury-related deaths are related to TBIs.[26] Many TBIs are associated not only with death and severe neurological sequelae, but also with psychological problems. This can result in significant socioeconomic losses and burdens.[18,24] In fact, the healthcare costs related to TBIs is difficult to calculate not only because of the burden of acute treatment but also because of rehabilitation and time over a lifetime, and post-treatment community management is more important than acute treatment.[3,13,21]

Generated by Xmlinkpress

Conflict of Interest
The authors have no financial conflicts of interest.

Informed Consent
This type of study does not require informed consent.

Ethics Approval
This study was approved by the Institutional Review Board of the Eulji University (approval No. 2021-02-004).

In addition, the economic impact of TBIs is difficult to estimate based on official statistics, although TBIs are generally known to cost the global economy US $400 billion annually.[14)]

As with other diseases, the social environment surrounding patients with TBIs, such as income level, access to medical care, and race, can affect the accessibility of medical institutions and resources, and thus may impact the prognosis of such patients.[4,6,25)] Traffic incidents are the primary cause of TBIs in low- and middle-income countries, whereas falls in older adults are the main cause of TBIs in high-income countries. Therefore, emphasis on whether to focus on the maintenance of road traffic systems as a preventive measure for TBIs or on the prevention of alcohol misuse and frailty will impact the outcome and incidence of TBIs.[15)]

Consequently, many countries have focused on prevention and response measures. One such initiative is the International Traumatic Brain Injury Research, formed in Canada, Europe, and the United States as part of this effort.[14)] Since the publication of the Lancet Neurology Commission report on TBIs in 2017, a steady interest in subsequent research, comprehensive resource care for clinical care, and policy development has been observed. In Korea, interest in trauma care, particularly after the treatment of casualties during the Aden Emergency, has also increased. Policy support for regional trauma centers has been initiated, leading to improvements in trauma patient care. Hence, many regional trauma centers have been established nationwide. The country has 17 designated regional trauma centers, mainly located around metropolitan areas, which provide medical care to both large and small cities. National policy discussions on management strategies for TBIs and individual strategies between metropolitan cities and provinces are important for improving the prognosis of patients with TBIs. Therefore, obtaining baseline data on TBIs, including the incidence, pre-hospital care, and current status of TBI management in Korea, is necessary. However, to date, nationwide data on the incidence, management, and outcomes of patients with TBIs are limited. Thus, this study aimed to describe the incidence and current status of the acute management of TBIs in Korea.

MATERIALS AND METHODS

Study population

National Emergency Department Information System (NEDIS) data from January 2016 to December 2018 were used. The NEDIS, which was established in 2016 as a registry involving >95% of emergency medical centers (EMCs) or institutions in Korea, stores nationwide administrative data. This study was based on the 2016–2018 data of the NEDIS collected from approximately 414 EMCs in Korea: regional (36 hospitals) or local EMCs (118 hospitals), local emergency medical institutes (260 hospitals) located in seven metropolitan cities (Seoul, Incheon, Busan, Daegu, Gwangju, Daejeon, and Ulsan), and nine regional provinces (Gangwon, Chungnam, Chungbuk, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam, and Jeju).

The inclusion criteria were International Classification of Diseases, 10th revision discharge codes S06.0 (cerebral concussion), S06.1 (traumatic cerebral edema), S06.2 (diffuse cerebral injury), S06.3 (focal cerebral injury), S06.4 (traumatic epidural hemorrhage), S06.5 (traumatic subdural hemorrhage), S06.6 (traumatic subarachnoid hemorrhage), S06.7 (intracranial injury with persistent coma), S06.8 (other intracranial injuries), or S06.9 (unclassified intracranial injuries); managed by the Department of Neurosurgery in an EMC; and presented within 7 days of the onset of head injury. On visiting the EMC, all patients were triaged based on the Korean Triage and Acuity Scale (KTAS) and managed according to their KTAS level.

Data collection

The NEDIS data included age, sex, type and region of EMC, onset of injury, arrival date and time, insurance, injury mechanism, visited route, transportation mode, initial response on admission, KTAS level, level of EMC, specialist care, disposition, admission route, main department, check-out date, admission and discharge date, discharge outcome, check-out diagnostic code, discharge diagnostic code, and each corresponding electronic data interchange code of the National Health Insurance regarding radiological examinations and surgery.

We extracted the following baseline information on the patients from the NEDIS data: age; sex; metropolitan city or province; trauma center; injury mechanism; insurance status; injury type; use of ambulance; initial alert, verbal, painful, and unresponsive (AVPU) scale; KTAS level; presence of specialist or neurosurgeon; management by the neurosurgery department of an EMC; computed tomography scan; endotracheal intubation; cardiopulmonary resuscitation; hypothermia therapy; admission to ward or intensive care unit (ICU) admission or trauma care unit or trauma ICU; transfer to the other hospitals; death in the EMC; emergency surgery; surgery including intracranial pressure monitoring, craniotomy or craniectomy, burr-hole surgery, cranioplasty, shunt surgery, and tracheostomy; and discharge outcomes including normal discharge to home, transfer to rehabilitation or nursing hospitals and death on discharge. Patients with KTAS levels 1–3 were considered emergent.[11)]

We also calculated the following in-hospital information from the NEDIS data: arrival time at the hospital, EMC stay, and hospital stay.

Statistical analysis

Categorical variables are presented as frequencies (percentages), and continuous variables are presented as medians with interquartile ranges (IQRs). The χ^2 and Mann–Whitney *U* tests were used for categorical and non-parametric variables, respectively. The annual crude incidence of TBIs is presented as the annual rate per 100,000 individuals. The annual incidence and in-hospital mortality of TBIs are expressed as medians and IQRs. Statistical analyses were performed using SPSS (version 27.0; IBM Corp., Armonk, NY, USA).

Ethics statement

This study was approved by the Institutional Review Board of the Eulji University (IRB No. 2021-02-004). The NEDIS provided demographic, hospital, and clinical data, from which information on personal and hospital identification was removed.

RESULTS

General characteristics

Data of 117,830 patients recorded in the NEDIS between 2016 and 2018 were analyzed. **FIGURE 1** presents a flowchart describing inclusion and exclusion of the data. The median age of patients with TBIs is 55–59 years, and older adults accounted for >60% of the patients. TBIs were more common in men (63.3%) than in women. Cerebral concussion (37.0%) and traumatic subdural hemorrhage (35.3%) were the most two common types of TBIs in Korea. Approximately half of the TBI (43.2%) cases were recorded in the Seoul metropolitan area, including Incheon and

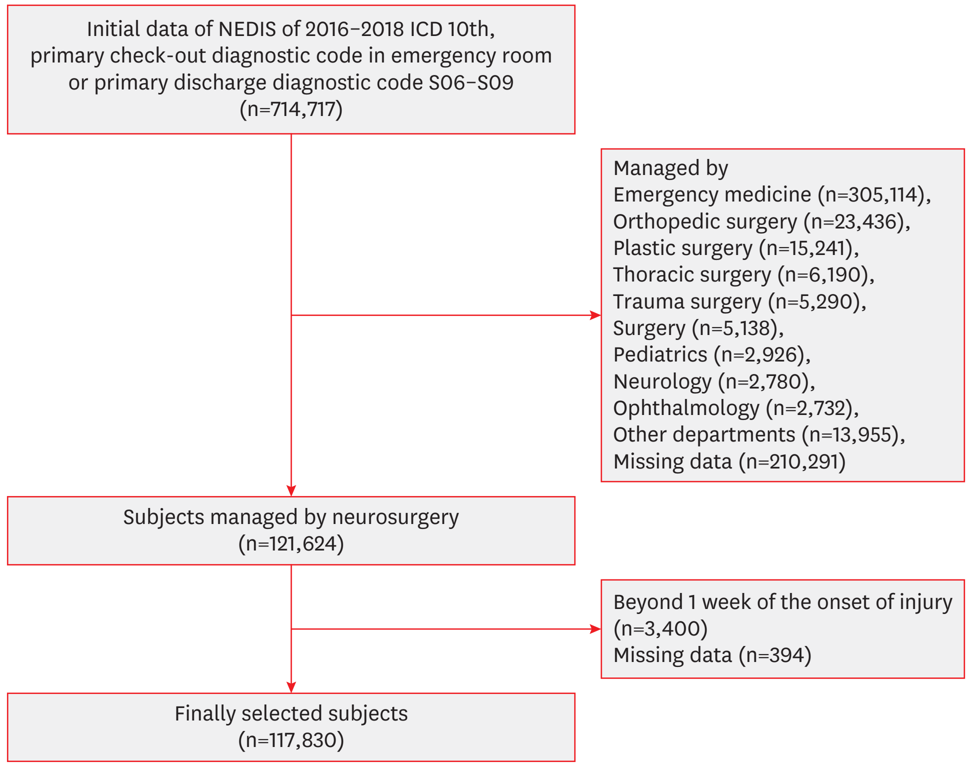

FIGURE 1. Flowchart describing inclusion and exclusion of the data.
NEDIS: National Emergency Department Information System, ICD: International Classification of Diseases.

Gyeonggi. **TABLE 1** summarizes the baseline data of 117,830 TBI patients from 414 EMCs or institutions in Korea. Traffic accidents (34.2%) were the most common cause of TBIs across all age groups and individual regions in Korea. However, falls were the significantly most common cause of TBIs in patients aged ≥75 years. Among traffic accidents, in-car accidents (17.5%) were the most common, followed by pedestrian traffic accidents (7.3%), and motorcycle accidents (3.7%). **FIGURE 2** presents the causes of TBI in Korea.

Incidence of TBIs

The annual crude incidence of TBIs in Korea was 79.4 per 100,000 (IQR, 61.5–118.7). The two peak incidences of TBI were at 0–4 years and 75–79 years, and the lowest incidence of TBIs was at 10–14 years. A modest increase in the incidence of TBIs tended to occur after the age of 40 years, followed by a sharp rise until the age of 65–80 years. The annual incidence in men (79.3/100,000 [IQR, 63.7–110.7]) was higher than that in women (60.4 per 100,000 persons [IQR, 42.3–82.6]).

Distinct regional differences exist in the annual incidence of TBIs in Korea. Jeonbuk, Daejeon, Gwangju, and Gangwon had the highest TBI incidence. The incidence of falls tended to increase at the age of ≥45 years, and traffic accidents had a peak incidence at the age of 75–79 years. Jeonbuk had the highest peak incidence of TBIs owing to traffic accidents and falls. **FIGURE 3** illustrates age or region-specific incidence of TBIs in Korea.

https://doi.org/10.13004/kjnt.2025.21.e4

TABLE 1. The baseline data of 117,830 patients with traumatic brain injuries from 414 EMCs in Korea

Variables	Values (n=117,830)
Age, 5 years	55–59 (40–44, 70–74)
Age ≥65 years	73,437 (62.3)
Male	74,594 (63.3)
Injury mechanism	
Traffic accident	40,288 (34.2)
Slipping down	26,325 (22.3)
Fall	17,473 (14.8)
Struck by person or object	11,520 (9.8)
Others	22,224 (18.9)
Insurance status	
National health insurance	72,612 (61.6)
Car insurance	32,978 (28.0)
Medical aid	6,850 (5.8)
Industrial accident compensation insurance	1,430 (1.2)
No insurance	3,364 (2.9)
Injury type	
Cerebral concussion	43,612 (37.0)
Traumatic subdural hemorrhage	41,597 (35.3)
Traumatic subarachnoid hemorrhage	10,715 (9.1)
Cerebral contusion	9,442 (8.0)
Traumatic epidural hemorrhage	7,962 (6.8)
Others	4,502 (3.8)
Initial AVPU scale	
Alert	93,332 (79.2)
Verbal response	11,026 (9.4)
Painful response	10,364 (8.8)
Unresponsive	3,108 (2.6)
Initial KTAS	
Level 1	2,797 (4.3)
Level 2	10,011 (15.5)
Level 3	26,906 (41.6)
Level 4	23,250 (35.9)
Level 5	1,766 (2.7)

Values are presented as median (interquartile range) or number (%) unless otherwise indicated.
EMC: emergency medical center, AVPU: alert, verbal, painful, and unresponsive, KTAS: Korean Triage and Acuity Scale.

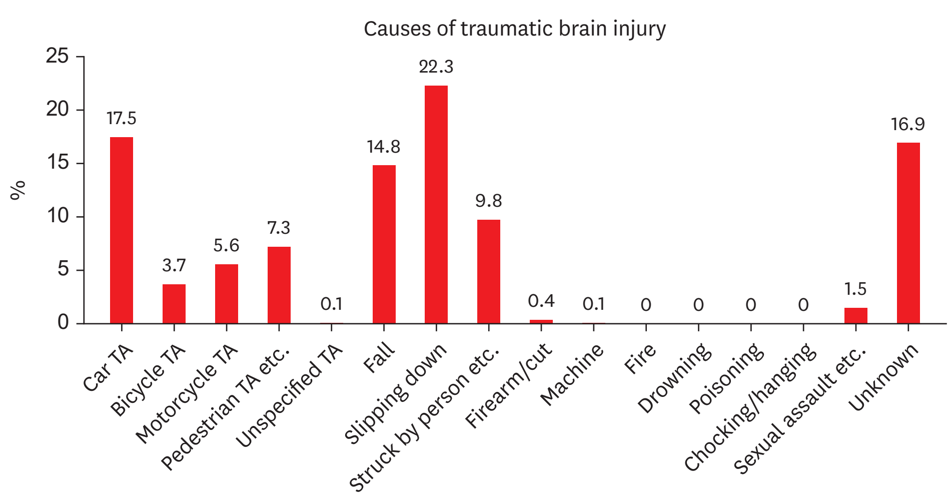

FIGURE 2. Causes of traumatic brain injuries in Korea.
TA: traffic accident.

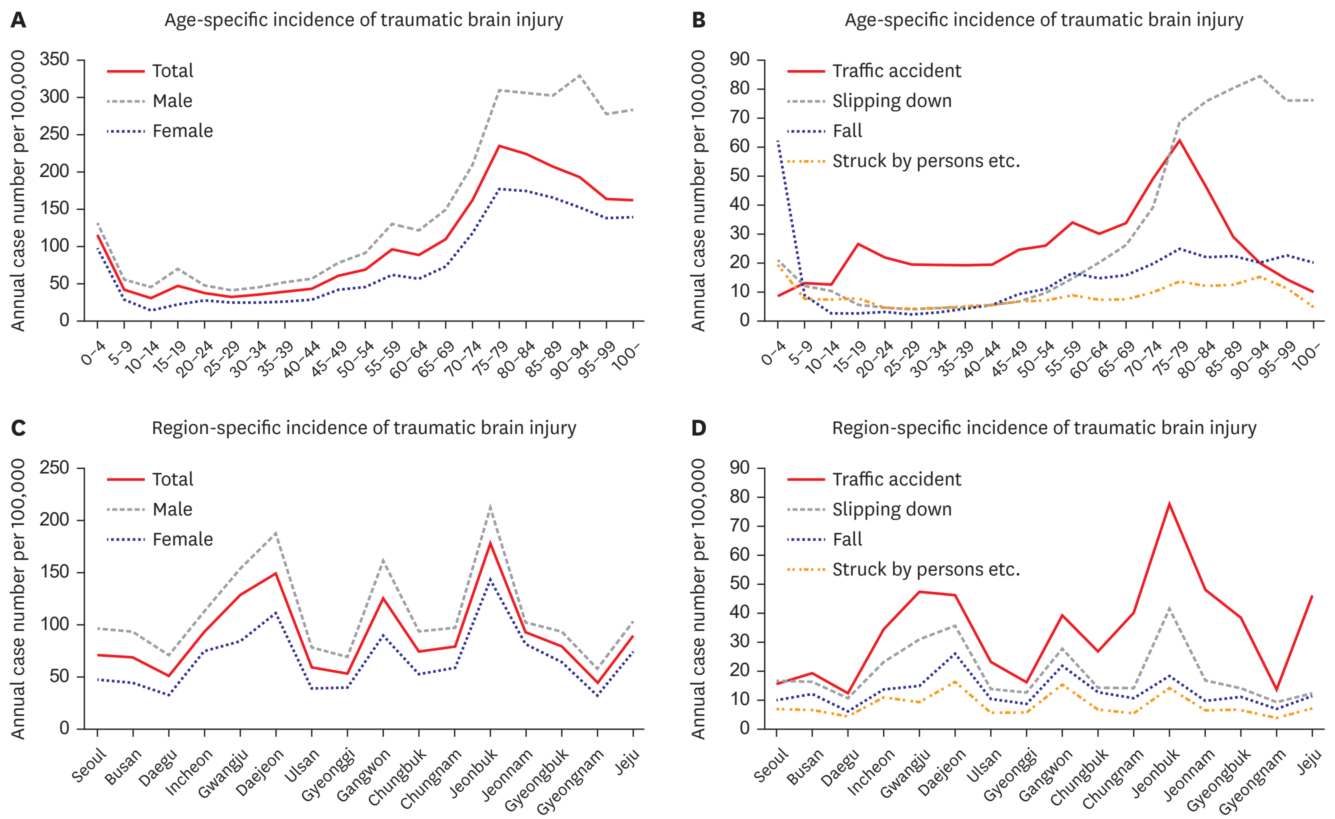

FIGURE 3. Incidence of traumatic brain injuries in Korea. (A) Age and sex-specific incidence. (B) Age and type of accident-specific incidence. (C) Region and sex-specific incidence. (D) Region and type of accident-specific incidence.

Pre-hospital care of TBIs

TABLE 2 presents the pre-hospital, hospital, and clinical characteristics of the 117,830 patients with TBIs. After TBI onset, 76.5% of patients visited an EMC directly without going to other hospitals. Overall, inter-hospital transfer after TBI was 22.7% (12.0% from secondary hospitals, 6.6% from primary hospitals, and 2.5% from tertiary hospitals, respectively) and was significantly higher in metropolitan cities than in provinces (26.3% vs. 19.7%, $p<0.001$). Gwangju is the local region with the largest number of patients transferred from other hospitals. Hospital transportation by ambulance was 65.4%. Among them, only one-third used public ambulances, and transportation by other vehicles was frequent. Use of ambulance was significantly higher in metropolitan cities than in provinces (69.5% vs. 62.0%, $p<0.001$). The median time to hospital arrival from the onset of injury was 62 min (IQR, 32–293). Daegu and Gwangju were the 2 regions with cases that took the longest to reach EMCs. Significant regional differences were observed in the use of ambulances and interhospital transfers in patients with TBIs in Korea. **FIGURE 4** presents the use of ambulances, interhospital transfer, and arrival time to hospital in patients with TBIs in Korea.

General management of TBIs

Upon arrival at EMCs, all patients were triaged using the KTAS system and prioritized depending on KTAS level. The incidence of KTAS levels 1–3, which suggest urgency, was 63.4%. Initial management by specialists in EMC was 80.8%. The percentage of non-requirement of specialist care in EMCs was 16.2%, which was approximately twice higher in metropolitan cities than in provinces (21.7% vs. 11.6%, $p<0.001$). Patients with TBIs spent a median of 158

https://doi.org/10.13004/kjnt.2025.21.e4

TABLE 2. Pre-hospital, hospital and clinical characteristics of 117,830 patients with TBIs

Variables	Total (n=117,830)	Metropolitan city (n=53,110)	Province (n=64,730)	*p*
Inter-hospital transfer	26,706 (22.7)	13,949 (26.3)	12,757 (19.7)	<0.001
Use of ambulance	77,027 (65.4)	36,888 (69.5)	40,139 (62.0)	<0.001
Time to arrival (minutes)	62 (32–293)	67 (32–342)	60 (31–255)	<0.001
Severity of injury				
KTAS	3 (3–4)	3 (3–4)	3 (3–4)	<0.001
Level 1–3 of KTAS	74,752 (63.4)	35,038 (66.0)	39,714 (61.4)	<0.001
Specialist care in EMC				
Absence of specialist	19,036 (16.2)	11,497 (21.7)	7,539 (11.6)	<0.001
Presence of specialist	91,170 (77.4)	37,475 (77.4)	53,695 (83.0)	<0.001
Presence of neurosurgeon	34,894 (29.6)	14,741 (27.8)	20,153 (31.1)	<0.001
Presence of specialist and neurosurgeon	30,935 (26.3)	12,176 (22.9)	18,759 (29.0)	<0.001
General care in EMC				
Computed tomography scan	67,445 (57.2)	29,202 (55.0)	38,243 (59.1)	<0.001
Endotracheal intubation	7,065 (6.0)	3,468 (6.5)	3,597 (5.6)	<0.001
Cardiopulmonary resuscitation	425 (0.4)	213 (0.4)	212 (0.3)	0.036
Disposition				
Trauma care units or trauma ICU	8,989 (7.6)	5,334 (10.0)	3,655 (5.6)	<0.001
Other ICUs	40,349 (34.2)	19,966 (37.6)	20,383 (31.5)	<0.001
Transfer to other hospitals	6,369 (5.4)	3,012 (5.7)	3,357 (5.2)	<0.001
Death in EMC	486 (0.4)	214 (0.4)	272 (0.4)	0.647
Acute management of TBI				
Emergent surgery	10,247 (8.7)	4,994 (9.4)	5,253 (8.1)	<0.001
Intracranial pressure monitoring	1,427 (1.2)	813 (1.5)	614 (0.9)	<0.001
Hypothermia therapy	8 (0.0)	5 (0.0)	3 (0.0)	0.322
Craniotomy or craniectomy	5,668 (4.8)	2,823 (5.3)	2,845 (4.4)	<0.001
Burr-hole surgery	5,609 (4.8)	3,090 (5.8)	2,519 (3.9)	<0.001
Cranioplasty	1,116 (0.9)	607 (1.1)	509 (0.8)	<0.001
Shunt surgery	360 (0.3)	208 (0.4)	152 (0.2)	<0.001
Tracheostomy	2,723 (2.3)	1,646 (3.1)	1,077 (1.7)	<0.001
Discharge outcomes				
EMC stay (min)	158 (96–277)	172 (104–299)	146 (90–258)	<0.001
Hospital stay (days)	6 (1–15)	7 (1–16)	5 (1–14)	<0.001
Normal discharge to home	61,376 (52.1)	27,008 (50.9)	34,368 (53.1)	<0.001
Transfer to rehabilitation hospitals	15,873 (13.5)	8,376 (15.8)	7,497 (11.6)	<0.001
Death on discharge	5,787 (4.9)	3,119 (5.9)	2,668 (4.1)	<0.001

Values are presented as median (interquartile range) or number (%) unless otherwise indicated.
KTAS: Korean Triage and Acuity Scale, EMC: emergency medical center, ICU: intensive care unit, TBI: traumatic brain injury.

min (IQR, 96–277) in EMCs. Transfer to other hospitals after initial management in EMC was 5.4%. Decision of patients or family members to visit high-level hospitals (46.0%) and lack of ICUs (17.6%) were the two common causes of transfer from other hospitals to EMCs. Lack of wards or ICUs was significantly higher in metropolitan cities than in provinces (2.2% vs. 0.7%, $p<0.001$). However, impossibility of emergency surgery or procedures did not indicate a significant difference between metropolitan cities and provinces (0.7% vs. 0.9%).

Only 7.6% of patients with TBIs were admitted to specialized trauma care units or trauma ICUs. The utilization of trauma care units or ICUs varied greatly by region which was significantly twice higher in metropolitan cities than in provinces (10.0% vs. 5.6%, $p<0.001$). Among them, Daejeon and Ulsan were the two regions where trauma center management was most frequently performed (48.6% and 46.1%, respectively). Especially, Ulsan (43.2%) was the only region with the highest number of admissions into trauma ICUs. **FIGURE 5** illustrates the utilization of trauma centers and ICUs for patients with TBIs in Korea.

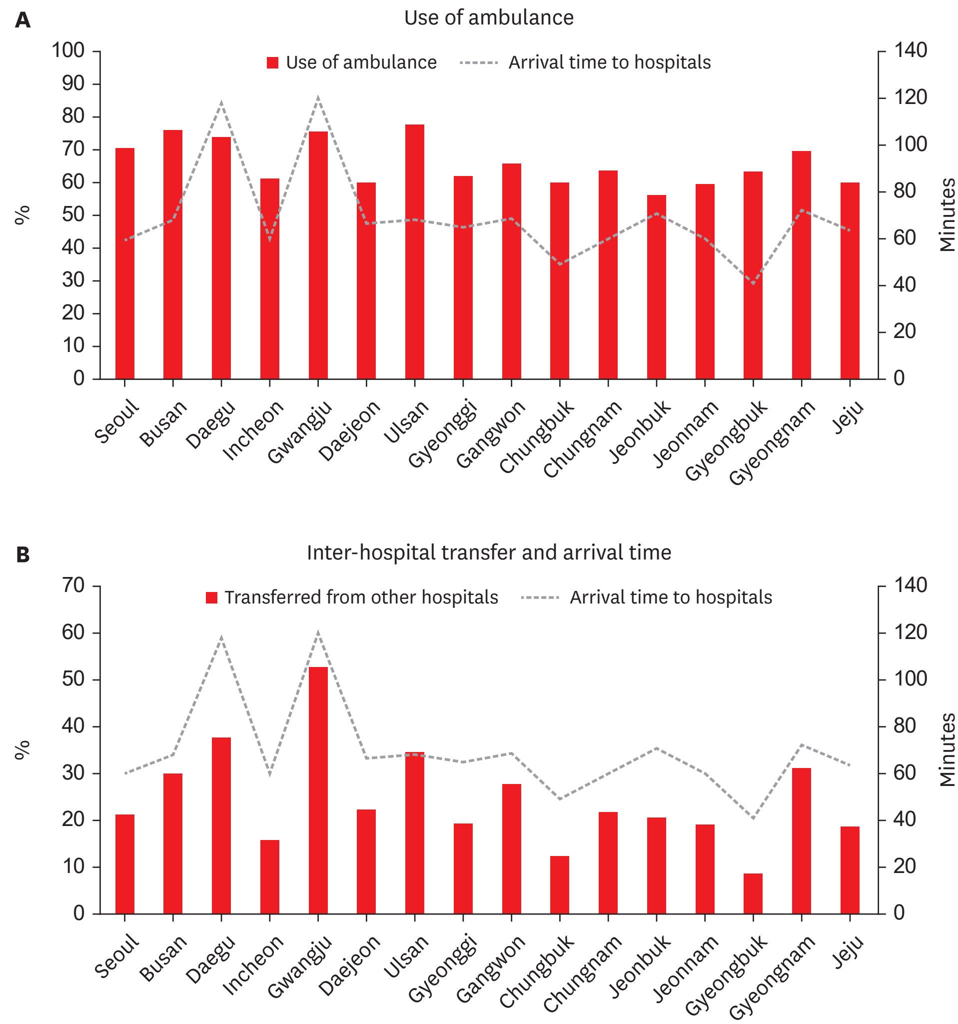

FIGURE 4. Regional trends in transfer status for traumatic brain injury patients in Korea. Use of ambulance (A) and inter-hospital transfer and arrival time (B) in patients with traumatic brain injuries in Korea.

Acute management of TBIs

In the patients with TBIs, craniotomy or craniectomy and burr-hole surgery were performed in 4.8% and 4.8%, respectively, and tended to increase with age until the age of 80 years, especially after the age of 60 years. Intracranial pressure monitoring was performed in 1,427 (1.2%) of the patients, and hypothermic therapy was performed in only 8 patients (0.0%). A clear variation in the annual volume of cranial surgeries was observed by region among patients with TBIs in Korea. Craniotomies or craniectomies were the most frequently performed procedures in Gwangju and Ulsan. However, the overall volume of craniotomies or craniectomies performed did not demonstrate a definite difference between metropolitan cities and provinces (5.3% vs. 4.4%). **FIGURE 6** illustrates the age-related and regional variations in the volume of cranial surgeries performed in patients with TBIs in Korea.

In-hospital outcomes of TBIs

The median length of hospital stay was 6 days (IQR, 1–15). The overall normal discharge to home in EMC or after admission was 69.3%, and tended to a decrease with age. Transfer to other rehabilitation centers or nursing hospitals was 13.5%, which tended to increase in

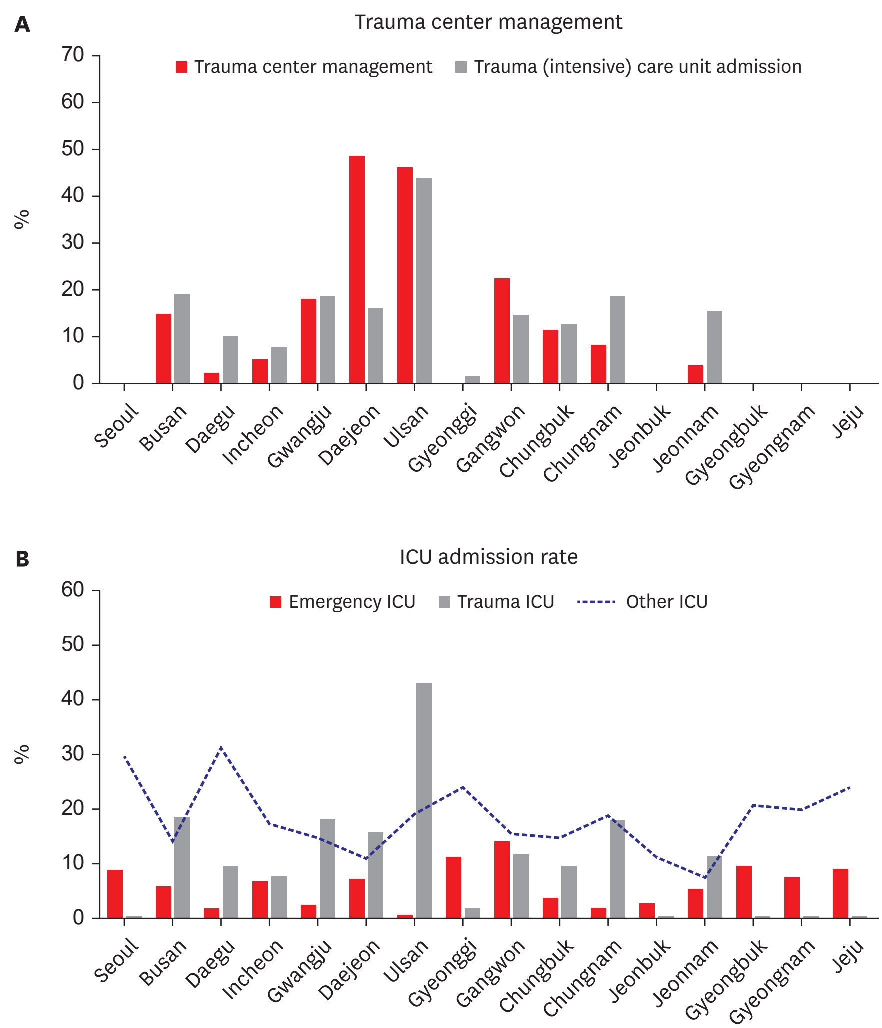

FIGURE 5. Regional trends in intensive care for traumatic brain injury patients in Korea. Trauma center management (A) and trauma intensive care unit admission (B) in patients with traumatic brain injuries in Korea. ICU: intensive care unit.

proportion to age. The overall in-hospital mortality rate of TBIs was 5.3% (male 3.9% vs. female 1.5%), which tended to increase with age. In-hospital mortality was significantly higher in metropolitan cities than in provinces (6.3% vs. 4.5%, p<0.001).

DISCUSSION

This study describes the incidence and management of TBIs using the nationwide NEDIS data. Since the designation of regional trauma centers began in 2012, 15 out of the current 17 centers were designated by 2016, when our data collection started. No additional centers have been designated since 2017. Therefore, after the first four years of enthusiastic operation of the regional trauma centers, this study aims to assess the current situation and analyze whether there are any additional issues to consider in the management of TBI, which significantly impacts the prognosis of trauma patients. The goal is to discuss the future efficiency of resource allocation, both human and material, for specialized neurosurgical

https://doi.org/10.13004/kjnt.2025.21.e4

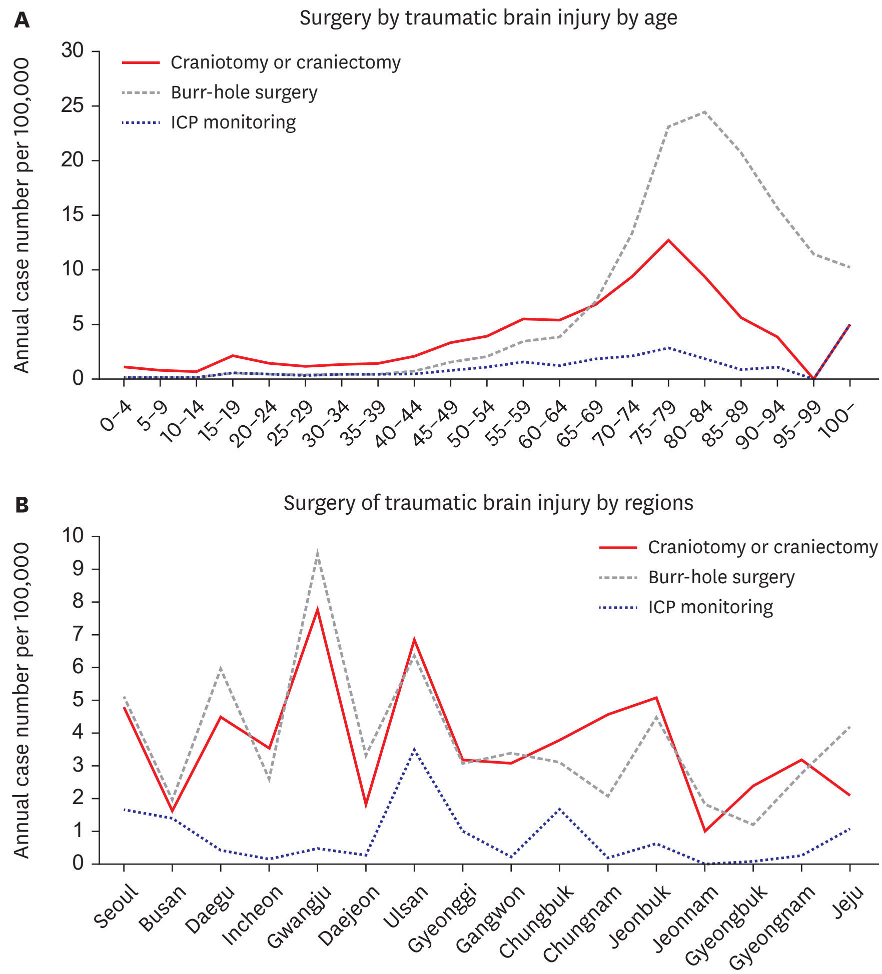

FIGURE 6. Surgical treatment of traumatic brain injuries in Korea. (A) Ages and (B) regions.
ICP: intracranial pressure.

care. In Korea, the incidence of TBIs peaks with age and varies by geographic region. Craniotomy or craniectomy was performed in 4.8% of the patients with TBIs; however, intracranial pressure monitoring (1.2%) and hypothermic therapy (0.0%) was performed in few patients. Regional differences were observed in the volume of craniotomies and craniectomies performed in patients with TBIs. The utilization of trauma care units or trauma ICUs was only 7.6% and varied greatly by regions. To the best of our knowledge, this study is the first to analyze incidence and current status of management of the TBI patients from the nationwide NEDIS data.

Incidence of TBIs

According to statistics on the types and causes of injuries released by the Korea Center for Disease Control and Prevention in 2021, 58,361 cases of TBIs were recorded, with 966 deaths, equivalent to 1,700 cases per 100,000 people. Furthermore, those aged ≥70 years accounted for 42.8% of the cases. In Europe, TBIs result in 2 million hospital admissions and 82,000 deaths annually.[15] In our findings, the two peak incidence patterns suggest a higher occurrence of TBIs among individuals who required assistance from others, emphasizing vulnerability. Additionally, regional variations in the incidence of TBIs may indicate underlying socioeconomic disparities.[4] Considering the elevated TBI rates in physically and

https://doi.org/10.13004/kjnt.2025.21.e4

economically vulnerable populations, policy strategies aimed at reducing the incidence of TBIs should be tailored to address these specific populations.

Pre-hospital care of TBIs

The rates of referral and ambulance utilization were higher in metropolitan cities than in provinces. The higher utilization of ambulances and referral in metropolitan cities compared to provinces may be attributed to the fact that, in provinces, patients are often directly transported for specialized treatment to centers from the accident site, whereas in metropolitan cities, patients are first taken to EMCs. Through the pre-hospital public transport service. After diagnosis, they are transferred to other EMCs, where therapeutic functions can be performed. Ultimately, this indicates a significant gap not only in roles between EMCs through pre-hospital public transport service and specialized trauma centers treating patients with TBIs, but also in medical facilities or resources between metropolitan cities and provinces. Several referrals naturally lead to delayed arrival times at treatment hospitals, which can impact outcomes. Therefore, these issues need to be addressed to ensure timely access to treatment hospitals and to potentially improve patient outcomes. However, the presence of a trauma center may contribute to such situations. This may paradoxically contribute to the higher transfer rate in metropolitan cities than in provinces, as trauma centers are concentrated in specific hospitals, which may result in longer transport times for patients with severe TBIs who first visit a hospital that is not a trauma center. This could potentially delay aggressive treatment, especially in patients with severe TBIs requiring emergency surgery, which cannot be predicted in the pre-hospital stage.

In-hospital management of TBIs

Our results revealed that metropolitan cities have higher in-hospital mortality rates, longer hospital stays, and lower rates of normal discharge, which may reflect a higher severity of TBIs than provinces. This is supported by the higher rates of intracranial pressure monitoring, craniotomy, or craniectomy among patients in metropolitan cities than those in provinces. However, intracranial pressure monitoring and hypothermia treatment, which are now widely used for patients with severe traumatic brain injury and elevated intracranial pressure, showed usage rates of only 0%–1% in the data analyzed at the time, with no significant regional differences observed. Several randomized controlled trials have reported that hypothermia treatment did not improve outcomes in patients with elevated intracranial pressure following TBIs.[7,8] However, recent guidelines strongly recommend targeted temperature management with controlled normothermia (36.0°C –37.5°C) as a therapeutic option to consider in intracranial pressure management.[12] In South Korea, several factors may contribute to the low utilization rates of targeted temperature management, including issues related to insurance coverage, device costs, limited experience with the procedure, and insufficient hospital infrastructure for monitoring multiple parameters required for goal-directed therapy compared to the past. Furthermore, even when these supports are available, some studies have advocated for an "All-in-One" strategy, where all available treatment methods are mobilized simultaneously to avoid missing the "golden time" in TBI management.[19]

Moreover, patients with TBIs with KTAS levels of 1–3 visited EMCs more frequently in metropolitan cities than those in provinces. Furthermore, metropolitan cities, including Daejeon and Ulsan, generally demonstrated more effective specialized trauma center management compared to provinces. Thus, in metropolitan cities, even patients with high TBI severity can receive treatment at appropriate medical institutions, indicating that these

https://doi.org/10.13004/kjnt.2025.21.e4

institutions are fulfilling their roles effectively. By contrast, in provinces, hospitals tend to admit patients with TBIs with lower levels of severity; however, for patients with moderate-to-severe conditions in these areas, the tendency to transfer them to high-level hospitals or large trauma centers in metropolitan cities was higher. However, despite treating more severely ill patients in metropolitan cities than in provinces, lower rates of neurosurgical interventions at the EMC level were observed in metropolitan cities than in provinces. This may reflect a shortage of neurosurgeons, making it challenging to distribute them evenly across all metropolitan hospitals. The concentration of regional trauma centers in metropolitan cities and the likelihood that neurosurgeons are primarily concentrated within trauma centers even within urban regions may have contributed to these findings. Since the establishment of regional trauma centers, there has been a statistically significant increase in direct visits to specialized trauma centers, and I believe that the success of this model may positively impact patient outcomes.[10)]

In-hospital outcomes of TBIs

Increasing age was associated with a higher transfer rate to nursing hospitals and a higher in-hospital mortality rate, underscoring the correlation between poor prognosis and age. Moreover, the higher proportion of patients with severe TBIs in metropolitan cities can lead to an increased in-hospital mortality rate. In essence, both the severity of TBIs itself and age may indicate a poor prognosis, yet these factors remain unalterable from the moment of TBI onset. Consequently, to enhance outcomes, our endeavors should be directed toward improving medical accessibility for patients with TBIs and expanding the availability of neurosurgeons for this purpose.

Studies comparing regional disparities have typically demonstrated that the avoidable mortality rate in provinces is higher than that in metropolitan cities because of social issues such as limited access to medical resources for vulnerable populations, including women and older adults, and highlight inequality in preventable deaths.[2,5,22)] Compared to previous studies that focused on regional disparities, our study revealed paradoxical results of higher avoidable mortality rates in metropolitan cities, indicating that in metropolitan cities, a higher proportion of interhospital transfers and moderate-to-severe TBI cases was observed among patients with TBIs compared to its incidence. Hence, improving access to specialized trauma care in provinces and increasing the number of neurosurgeons in metropolitan cities are necessary to expand the access to neurosurgical treatment for TBIs at the EMC level.

An adequate number of neurosurgeons is clearly needed to perform direct neurosurgical interventions at the EMC level in small- and medium-sized hospitals in metropolitan cities. Previous reports have indicated that specialized neurointensive care is related to improved survival rates in patients with TBIs, highlighting the importance of ensuring sufficient access to neurosurgical care for all patients regardless of hospital or city.[16,20)] Many previous studies have emphasized the need for political investment at this point.[1,9,17,23)]

Study limitations

First, the NEDIS data used the AVPU scale and KTAS levels and did not provide the Glasgow Coma Scale score or follow-up data after discharge. We did not estimate the exact degree of severity or long-term outcomes of patients with TBIs. Further studies on KTAS levels and TBI outcomes are required. Second, the incidence of TBIs according to individual regions was not identified because of interhospital transfers between individual regions. The incidence in metropolitan cities may likely be exaggerated, whereas that in provinces

https://doi.org/10.13004/kjnt.2025.21.e4

is likely to be underestimated. Lastly, the causes of regional inequality in the incidence and current status of management of patients with TBIs demonstrated in this study were not investigated. Further research considering the primary source of interhospital transfers and regional differences in medical facilities and resources is necessary. Additionally, as the data include nationwide emergency medical center records, it has been reported that a significant proportion of patients with mild trauma who do not require trauma care unit utilization are treated in other ICUs without being transferred. The underlying causes of this phenomenon should be further investigated through qualitative research, as the limitations of the NEDIS data preclude an in-depth analysis.

CONCLUSION

In Korea, the incidence of TBIs varies definitely according to age, sex, and geographic regions. The current status of the acute management of TBIs may also differ markedly between individual regions, especially between metropolitan cities and provinces. The use of specialized trauma care facilities and devices may be low nationwide. These findings suggest not only regional inequality in the acute management of TBIs but also the insufficient utilization of trauma centers and lack of awareness of specialized intensive care in Korea. Strategies for acute management of TBIs should be established considering the incidence and current status in individual regions. Further studies are necessary to consider interhospital transfers and regional differences in medical facilities and resources.

ACKNOWLEDGMENTS

This study used the National Emergency Department Information System (NEDIS) data (No. 2020-12-01).

REFERENCES

1. Alkhoury F, Courtney J. Outcomes after severe head injury: a National Trauma Data Bank-based comparison of level I and level II trauma centers. **Am Surg 77:**277-280, 2011 PUBMED | CROSSREF
2. Brown JB, Kheng M, Carney NA, Rubiano AM, Puyana JC. Geographical disparity and traumatic brain injury in America: rural areas suffer poorer outcomes. **J Neurosci Rural Pract 10:**10-15, 2019 PUBMED | CROSSREF
3. Carroll LJ, Cassidy JD, Holm L, Kraus J, Coronado VG; WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. Methodological issues and research recommendations for mild traumatic brain injury: the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. **J Rehabil Med 36:**113-125, 2004 PUBMED | CROSSREF
4. Cho KH, Lee SG, Nam CM, Lee EJ, Jang SY, Lee SH, et al. Disparities in socioeconomic status and neighborhood characteristics affect all-cause mortality in patients with newly diagnosed hypertension in Korea: a nationwide cohort study, 2002-2013. **Int J Equity Health 15:**3, 2016 PUBMED | CROSSREF
5. Choi MH, Moon MH, Yoon TH. Avoidable mortality between metropolitan and non-metropolitan areas in Korea from 1995 to **2019:** a descriptive study of implications for the national healthcare policy. **Int J Environ Res Public Health 19:**3475, 2022 PUBMED | CROSSREF
6. Choi MH, Yoon TH. Trends in amenable mortality to health care across the districts in Korea from 1993 to 2013. **J Crit Soc Policy** 404-432, 2015
7. Cooper DJ, Nichol AD, Bailey M, Bernard S, Cameron PA, Pili-Floury S, et al. Effect of early sustained prophylactic hypothermia on neurologic outcomes among patients with severe traumatic brain injury: The polar randomized clinical trial. **JAMA 320:**2211-2220, 2018 PUBMED | CROSSREF

8. Du Q, Liu Y, Chen X, Li K. Effect of hypothermia therapy on children with traumatic brain injury: a meta-analysis of randomized controlled trials. **Brain Sci 12:**1009, 2022 PUBMED | CROSSREF
9. DuBose JJ, Browder T, Inaba K, Teixeira PG, Chan LS, Demetriades D. Effect of trauma center designation on outcome in patients with severe traumatic brain injury. **Arch Surg 143:**1213-1217, 2008 PUBMED | CROSSREF
10. Ha M, Yu S, Kim BC, Lee JH, Choi HJ, Cho WH. Characteristics of patients with traumatic brain injury in a regional trauma center: a single-center study. **Korean J Neurotrauma 19:**6-19, 2023 PUBMED | CROSSREF
11. Ju SY, Cho SJ, Lee SH, Kim HH, Yeo KH, Hwang SY, et al. Feature of visiting patients to a wide regional emergency center according to insurance status. **J Korean Soc Emerg Med 27:**360-366, 2016
12. Lavinio A, Coles JP, Robba C, Aries M, Bouzat P, Chean D, et al. Targeted temperature control following traumatic brain injury: ESICM/NACCS best practice consensus recommendations. **Crit Care 28:**170, 2024 PUBMED | CROSSREF
13. Liu M, Wei W, Fergenbaum J, Comper P, Colantonio A. Work-related mild-moderate traumatic brain injury and the construction industry. **Work 39:**283-290, 2011 PUBMED | CROSSREF
14. Maas AIR, Menon DK, Adelson PD, Andelic N, Bell MJ, Belli A, et al. Traumatic brain injury: integrated approaches to improve prevention, clinical care, and research. **Lancet Neurol 16:**987-1048, 2017 PUBMED | CROSSREF
15. Maas AIR, Menon DK, Manley GT, Abrams M, Åkerlund C, Andelic N, et al. Traumatic brain injury: progress and challenges in prevention, clinical care, and research. **Lancet Neurol 21:**1004-1060, 2022 PUBMED | CROSSREF
16. Mirski MA, Chang CW, Cowan R. Impact of a neuroscience intensive care unit on neurosurgical patient outcomes and cost of care: evidence-based support for an intensivist-directed specialty ICU model of care. **J Neurosurg Anesthesiol 13:**83-92, 2001 PUBMED | CROSSREF
17. Nielsen K, Mock C, Joshipura M, Rubiano AM, Zakariah A, Rivara F. Assessment of the status of prehospital care in 13 low- and middle-income countries. **Prehosp Emerg Care 16:**381-389, 2012 PUBMED | CROSSREF
18. Oberholzer M, Müri RM. Neurorehabilitation of traumatic brain injury (TBI): a clinical review. **Med Sci (Basel) 7:**47, 2019 PUBMED | CROSSREF
19. Park YS, Kogeichi Y, Shida Y, Nakase H. Efficacy of the all-in-one therapeutic strategy for severe traumatic brain injury: preliminary outcome and limitation. **Korean J Neurotrauma 14:**6-13, 2018 PUBMED | CROSSREF
20. Patel HC, Menon DK, Tebbs S, Hawker R, Hutchinson PJ, Kirkpatrick PJ. Specialist neurocritical care and outcome from head injury. **Intensive Care Med 28:**547-553, 2002 PUBMED | CROSSREF
21. Ponsford JL, Downing MG, Olver J, Ponsford M, Acher R, Carty M, et al. Longitudinal follow-up of patients with traumatic brain injury: outcome at two, five, and ten years post-injury. **J Neurotrauma 31:**64-77, 2014 PUBMED | CROSSREF
22. Rubiano AM, Carney N, Chesnut R, Puyana JC. Global neurotrauma research challenges and opportunities. **Nature 527:**S193-S197, 2015 PUBMED | CROSSREF
23. Rudehill A, Bellander BM, Weitzberg E, Bredbacka S, Backheden M, Gordon E. Outcome of traumatic brain injuries in 1,508 patients: impact of prehospital care. **J Neurotrauma 19:**855-868, 2002 PUBMED | CROSSREF
24. Sandhaug M, Andelic N, Langhammer B, Mygland A. Functional level during the first 2 years after moderate and severe traumatic brain injury. **Brain Inj 29:**1431-1438, 2015 PUBMED | CROSSREF
25. Venkatesh S, Bravo M, Schaaf T, Koller M, Sundeen K, Samadani U. Consequences of inequity in the neurosurgical workforce: lessons from traumatic brain injury. **Front Surg 9:**962867, 2022 PUBMED | CROSSREF
26. Zelinkova V, Brazinova A, Taylor MS, Rusnak M, Plancikova D, Melichova J, et al. Location of traumatic brain injury-related deaths: epidemiological analysis of 11 European countries. **Brain Inj 33:**830-835, 2019 PUBMED | CROSSREF

 https://doi.org/10.13004/kjnt.2025.21.e4