



Comparison of trauma systems in Asian countries: a cross-sectional study

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Objective This study aimed to compare the demographic characteristics and trauma service structures and processes of hospitals in 15 countries across the Asia Pacific, and to provide baseline data for the integrated trauma database: the Pan-Asian Trauma Outcomes Study (PATOS).

Methods Medical directors and emergency physicians at PATOS-participating hospitals in countries across the Asia Pacific were surveyed through a standardized questionnaire. General information, trauma care system data, and trauma emergency department (ED) outcomes at each hospital were collected by email and analyzed using descriptive statistics.

Results Survey data from 35 hospitals across 15 countries were collected from archived data between June 2014 and July 2015. Designated trauma centers were identified as the highest hospital level for trauma patients in 70% of surveyed countries. Half of the hospitals surveyed had special teams for trauma care, and almost all prepared activation protocol documents for these teams. Most hospitals offered specialized trauma education programs, and 72.7% of hospitals had a hospital-based trauma registry. The total number of trauma patients visiting the ED across 25 of the hospitals was 300,376. The overall survival-to-discharge rate was 97.2%; however, it varied greatly between 85.1% and 99.7%. The difference between survival-to-discharge rates of moderate and severe injury groups was highest in Taiwan (41.8%) and lowest in Thailand (18.6%).

Conclusion Trauma care systems and ED outcomes vary widely among surveyed hospitals and countries. This information is useful to build further detailed, systematic platforms for trauma surveillance and evidence-based trauma care policies.

Keywords Trauma; Asian continental ancestry group; Epidemiology



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Capsule Summary

What is already known

Most Asian countries recognized their increasing injury burden and have put forth efforts to build qualified trauma care systems.

What is new in the current study

Half of the hospitals had organized special teams for trauma care and almost all of these prepared activation protocol documents for their teams. Most hospitals offered specialized trauma education programs, and 72.7% of hospitals had a hospital-based trauma registry. The overall survival discharge rate was 97.2%, however, varied greatly between 85.1% and 99.7%. A survival difference between moderate and severe injury groups was highest in Taiwan (41.8%) and lowest in Thailand (18.6%).

INTRODUCTION

The World Health Organization (WHO) reported that injuries cause more than 5 million deaths worldwide each year, and injury mortality is expected to surge by 2030.¹ Injury is one of the leading causes of death during the productive years (<45 years old), leading to significant economic losses.¹ In addition, injury accounts for 8.3% of age-standardized disability-adjusted life years (DALYs), with road traffic injuries ranked 8th out of the 20 leading causes of DALYs in 2012.²

However, the burden of injury differs by region. One of every ten deaths in Asia is attributed to injury, accounting for more than half of injury-related deaths worldwide.³ According to the WHO, injuries were responsible for 87,583 of DALYs per 100,000 people in Southeast Asia in 2012; far more than the 38,903 of DALYs per 100,000 people in high-income countries. Even among Asian countries, there is a large discrepancy. Injury mortality rates vary greatly from 20.6 deaths per 100,000 people in Singapore, to 346.6 per 100,000 people in Myanmar.⁴ Rapid economic development and urbanization are considered contributing factors for the increase in injury-related death and disability in developing countries of this region.³

To reduce the burden of injury, a well-functioning trauma care system is essential. The WHO published "Guidelines for essential trauma care" through the Essential Trauma Care Project, and emphasized the importance of establishing trauma care systems to improve trauma treatment, and hence, patient outcomes. Panel studies reported a 50% average reduction in preventable death rates after the implementation of a trauma system,⁵ and other studies demonstrated a morbidity and mortality decrease with organized optimal trauma care.⁶⁻⁸ The effectiveness of trauma system development has been proven for each component of prehospital, hospital and inter-hospital systems for trauma care.^{5,7,9-11}

Most Asian countries recognize their increasing injury burden and have made efforts to build qualified trauma care systems.¹²⁻¹⁶ However, these efforts have met with varied success because of unequal healthcare resources and resource allocation, along with socioeconomic, cultural, and demographic variance.¹²⁻¹⁶ A comprehensive report-based trauma database for Asian countries is required, to identify trauma characteristics in different contexts, monitor discrete trauma systems, and generate evidence-based trauma care policies.

The Pan-Asian Trauma Outcomes Study (PATOS) is an international, multicenter, population-based, cohort study in the Asia Pacific region, proposed in 2013 to create an integrated trauma database. PATOS will collect standardized data on diverse trauma epidemiology, trauma care processes, and outcomes from participating hospital emergency departments across 15 Asian countries for the next 3 years. The objectives of this web-based, cross-sectional, descriptive survey were to examine and compare the demographic characteristics and trauma care service structures, processes and outcomes of trauma care services of PATOS-participating hospitals. Moreover, this study will provide baseline data for PATOS.

METHODS

Study design and setting

The study protocol was approved by the institutional review board of Seoul National University College of Medicine (H-1509-045-702). This cross-sectional survey was conducted among medical directors and emergency physicians in the emergency medical services (EMSs) and trauma care systems at PATOS-participating hospitals in 15 Asia Pacific countries: Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, Myanmar, Philippines, South Korea, Singapore, Taiwan, Thailand, Uzbekistan, and Vietnam.

These 15 countries have varied population characteristics and health indices (Table 1).¹⁷⁻²⁰ A wide variation in economic status has been observed regarding gross domestic product per capita: five countries have less than \$10,000/capita, four countries have between \$10,000 and \$30,000/capita, and six countries have more than \$30,000/capita. Health indicators also vary within medical settings. The burden of injury is considerable in India and Myanmar, where more than 100 people die from injuries per 100,000 people, and almost 4,800 years of life lost (YLL) per 100,000 people are attributed to injuries. Developed countries, such as Australia, Singapore, and Japan have low injury mortality rates and YLL. Extraordinarily, the injury mortality in South Korea is 53 deaths per 100,000 people, which is 44% higher than the average injury mortality rate of high-income countries. In addition, injury-associated YLL is higher in South Korea, with 2,381 YLLs per 100,000 people, compared to an average of 2,142 per 100,000 people in high-income countries.¹⁷

Study participants

Survey respondents were trauma surgeons, emergency physicians, general surgeons, and public health, EMS, and hospital officials at PATOS-participating hospitals and EMS systems. Only one survey was permitted per hospital.

Data collection and protocols

Data were collected from June 2014 to August 2015, through the standardized survey form developed and revised by a team of

emergency physicians at the PATOS coordinating center in South Korea. The survey form was sent to every individual on the PATOS mailing list, who submitted their responses to the PATOS coordinating center by e-mail. The hospital survey (Appendix 1) comprised seven questions regarding general hospital information, eight questions on trauma care processes, five questions on trauma education programs, six questions on trauma registries, and twelve questions on trauma outcomes. The PATOS committee validated the survey results and communicated with respondents when errors were found.

Measurements

General hospital information, such as a country and hospital name, the number of total visits to the ED, and trauma center or hospital level was collected. Urbanization of the community to which the responding hospital belonged was categorized as urban, suburban, rural, or wilderness. We defined "urban" as a city with more than 2,500 inhabitants/km² and "rural" with fewer than 2,500 inhabitants/km². However, respondents could choose multiple answers from urban, suburban, rural, or wilderness according to their own definition. Trauma center level was categorized as a designated trauma center, a general ED, or a general hospital. Hospital level was classified as tertiary, secondary, or primary care according to their definition.

The trauma care process was identified from the answers to specific questions, such as "Who takes responsibility for the trauma care? Is it a trauma surgeon, emergency physician, general

Table 1. Population characteristics and health indices

	Population (July 2014) ¹⁷	Population growth rate (% annual rate, 2014) ¹⁷	Urban population (% of 2015) ¹⁷	Rate of urbanization (% annual rate of change, 2010-2015) ¹⁷	GDP per capita (PPP, 2014, \$) ¹⁷	Life expectancy at birth (yr, 2013) ¹⁷	Infant mortality rate (/1,000, 2014) ¹⁷	Death rate (/1,000, 2014) ¹⁷	Age-standardized injury mortality rate (/100,000, 2012) ¹⁸	Years of life lost (/100,000, 2012) ¹⁸
Australia	22,507,617	0.01	89.4	1.47	46,600	82.07	4.43	10.38	28	1,326
China	1,355,692,576	0.44	55.6	3.05	12,900	75.15	14.79	7.44	50	2,208
Hong Kong	7,112,688	0.41	100	0.74	55,200	82.78	2.73	6.93	-	-
India	1,236,344,631	1.25	32.7	2.38	5,800	67.80	43.19	7.35	116	4,785
Indonesia	253,609,643	0.95	53.7	2.69	10,200	72.17	25.16	6.34	49	2,116
Japan	127,103,388	-0.13	93.5	0.56	37,800	84.46	2.13	9.38	40	2,005
Malaysia	30,073,353	1.47	74.7	2.66	24,500	74.52	13.69	5.00	63	2,450
Myanmar	55,746,253	1.03	34.1	2.49	4,800	65.94	44.91	8.01	102	4,767
Philippines	107,668,231	1.81	44.4	1.32	7,000	72.48	17.64	4.92	54	2,698
Korea	49,039,986	0.16	82.5	0.66	35,400	79.80	3.93	6.63	53	2,381
Singapore	5,567,301	1.92	100	2.02	81,300	84.38	2.53	3.42	18	794
Taiwan	23,359,928	0.25	58.4 ¹⁹	-	43,600	79.84	4.49	6.97	43.7 ²⁰	-
Thailand	67,741,401	0.35	50.4	2.97	14,400	74.18	9.86	7.72	73	3,379
Uzbekistan	28,929,716	0.93	36.4	1.45	5,600	73.29	19.84	5.29	47	2,713
Viet Nam	93,421,835	1.00	33.6	2.95	5,600	72.91	18.99	5.93	59	2,730

GDP, gross domestic product; PPP, purchasing power parity.

surgeon, or another department surgeon?" and "Which hospital level is the highest for trauma patients?" In addition, we collected detailed information regarding trauma resources, including trauma teams, trauma surgeons, and trauma centers.

If present, trauma structures, trauma education programs, and registries were described by respondents, who clarified whether their trauma education programs were mandatory, and if the program included operation and critical care practices. Respondents were also asked whether hospital registries were linked to prehospital registries.

ED outcomes included the total number of ED visits, trauma patients' survival-to-discharge rate, and proportion of EMS users among trauma patients. Trauma severity was assessed using the injury severity score (ISS) index: 9–15, 16–24, and > 24.

Statistical analysis

All survey responses were entered into Microsoft Excel (Redmond, WA, USA), and analyzed using descriptive statistics. Although data were collected from individual hospitals, they were compared by country. Trauma care outcomes were only partially reported because of lack of the available information from some hospitals.

RESULTS

Characteristics of participating hospitals

PATOS members from thirty-five hospitals received the survey and responded by June 2014 (response rate, 100%). The total number of ED visits to these hospitals at the time of the survey was 2 million per year, and average visits per hospital was approximately 71,000. Singapore had the largest number of ED patients per hospital (154,541 visits), and Uzbekistan had the smallest (15,000 visits). Three-quarters of surveyed hospitals were located in urban areas. Twenty-six percent of hospitals (n = 9) were designated trauma centers, and others were general hospitals with EDs. The majority of participating hospitals were tertiary care hospitals (77%, n = 27). Table 2 details the general characteristics of participating hospitals.

Trauma care system: process

Seventy-two percent of respondents indicated that designated trauma centers were at the highest hospital level for trauma patients, yet respondents in Indonesia, Malaysia, and Uzbekistan all reported that general hospitals with EDs were at the highest hospital level for trauma care. Half of the hospitals in this survey had designated teams for trauma care, and most were prepared with trauma team activation protocols. Australia, Japan, and Indonesia did not have trauma teams, but respondents indicated that docu-

mented trauma protocols existed. Trauma care services were provided by emergency physicians and trauma surgeons in 60% of the surveyed hospitals. Ten countries issued a specific trauma surgeon certification or license. Table 3 details the trauma care process of surveyed hospitals.

Trauma care system: structure

Most hospitals offered specialized trauma education programs for medical staff (91%, n = 30). However, only one-third of programs were mandatory. Hospital-based registries for trauma were used at 72.7% of hospitals. Trauma registries in Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, and Uzbekistan contained prehospital information, such as intubation treatment, and some of these registries were even more comprehensive as they were connected to an EMS-based registry. Systematic review programs for trauma care existed in approximately half of the hospitals (53.8%). Table 4 details the trauma care system of surveyed hospitals.¹⁷

Trauma outcomes

Patient data were available for 25 of the 35 EDs. The total number of trauma patients across these sites was 300,376. Eleven (45.6%) of these hospitals, located in Japan, Korea, Philippines, Singapore, and Thailand, reported outcomes for ED trauma patients. The overall survival-to-discharge rate in these hospitals was 97.2%, and rates varied from 85.1% (Taiwan) to 99.7% (Singapore). The outcomes of trauma patients using EMS were reported in 10 of these hospitals, and these patients tended to have a worse outcome compared to trauma patients in general (survival-to-discharge rate 94.7% vs. 97.2%, respectively). The average survival-to-discharge rate was 96.3% in patients with an ISS of 9 to 15, and 65.1% in patients with an ISS of > 24. The difference between survival-to-discharge rate of patients with an ISS of 9 to 15 and patients with an ISS of > 24 was highest in Taiwan (41.8%) and lowest in Thailand (18.6%). Table 5 details trauma outcomes among surveyed hospitals.

DISCUSSION

We collected and described survey data regarding sociodemographic characteristics, trauma care processes, trauma care structures including education programs and registries, and ED trauma outcomes from 35 individual hospitals across 15 Asia Pacific countries. Our findings showed a wide variety of trauma care systems and outcomes among countries.

Specific trauma care education for medical staff is an essential component of adequate trauma care.^{14,21,22} For example, the Ja-

Table 2. General hospital information of surveyed hospitals

	No. of surveyed hospitals	Total no. of ED visits	Average no. of ED visits/hospital	Urbanization ^{a)} (no. of hospitals)	Trauma center level (no. of hospitals)	Hospital level (no. of hospitals)	Census year
Total	35	2,276,938	71,154	Urban (25), Suburban (4), Rural (2)	Designated trauma center (9) General hospital with ED (26)	Tertiary (27), secondary (8), primary (1)	
Australia	1	24,272	24,272	Urban (1)	General hospital with ED (1)	Secondary (1)	2012
China	1	150,000	150,000	Urban (1)	General hospital with ED (1)	Tertiary (1)	2014
Hong Kong	1	146,000	146,000	Urban (1)	Designated trauma center (1)	Tertiary (1)	2013
India	1	15,000	15,000	Urban (1)	General hospital with ED (1)	Tertiary (1)	-
Indonesia	1	-	-	-	General hospital with ED (1)	Secondary (1)	-
Japan	3	34,409	17,204	Urban (3)	Designated trauma center (1) General hospital with ED (2)	Tertiary (3)	2013
Korea	12	699,905	58,325	Urban (8), suburban (3), rural (1)	Designated trauma center (3) General hospital with ED (9)	Tertiary (10), secondary (2)	2013 (Samsung) 2014 (Others)
Malaysia	2	209,865	104,932	Urban (1)	General hospital with ED (2)	Tertiary (2)	2013 (Sungai Buloh) 2014 (HUSM)
Myanmar	1	18,256	18,256	-	General hospital with ED (1)	Tertiary (1)	2013
Philippine	1	72,000	72,000	Urban (1)	General hospital with ED (1)	Tertiary (1)	2014
Singapore	2	309,021	154,510	Urban (2)	Designated trauma center (1) General hospital with ED (1)	Secondary (2)	2013
Taiwan	2	235,749	117,874	Urban (2)	Designated trauma center (2)	Tertiary (2)	2013 (National Taiwan) 2014 (Far Eastern Memorial)
Thailand	1	50,991	50,991	Rural (1)	Designated trauma center (1)	Tertiary (1)	2013
Uzbekistan	1	5,000	5,000	Suburban (1)	General hospital with ED (1)	Secondary (1)	-
Vietnam	5	306,470	76,617	Urban (4)	General hospital with ED (5)	Tertiary (3), secondary (1), primary (1)	2013 (Bach Mai) 2014 (Viet Tiep Friendship)

ED, emergency department; HUSM, Hospital Universiti Sains Malaysia.

^{a)}Hospitals which chose more than one option of urban, suburban, and rural were excluded (Sungai Buloh Hospital in Malaysia and Mandalay Hospital in Myanmar).**Table 3.** Trauma care process of surveyed hospitals

	Highest hospital level for trauma patient in country ¹⁷ (no. of hospitals)	Healthcare provider leader level for trauma (no. of hospitals)			Defined trauma team			Documented trauma care protocol in ED (no. of hospitals)	Certification/ license for trauma surgeons (no. of hospitals)
		No. of trauma surgeons	No. of emergency physicians	No. of general or department surgeons	No. of hospitals with trauma team	Average no. of persons in a trauma team	Protocol for trauma team (no. of hospitals)		
Total	Designated trauma center (23) General hospital with ED (10)	18	28	12	18	6	16 (88.9%)	25 (75.8%)	22 (66.7%)
Australia	Designated trauma center (1)	0	1	0	0	-	-	1	0
China	Designated trauma center (1)	1	0	1	1	5	1	1	1
Hong Kong	Designated trauma center (1)	0	1	0	1	5	1	1	0
India	Designated trauma center (1)	1	1	1	0	-	-	0	0
Indonesia	General hospital with ED (1)	1	0	1	0	-	-	1	1
Japan	Designated trauma center (2) General hospital with ED (1)	1	3	0	0	-	-	2 (66.7%)	2 (66.7%)
Korea	Designated trauma center (11)	5	11	4	5	6.6	5	8 (72.7%)	10 (90.9%)
Malaysia	General hospital with ED (2)	0	2	0	1	7	1	1 (50%)	1 (50%)
Myanmar	-	1	1	1	1	-	1	1	1
Philippine	Designated trauma center (1)	0	1	0	1	4	1	1	1
Singapore	Designated trauma center (1) General hospital with ED (1)	2	1	1	2	8	2	1	0
Taiwan	Designated trauma center (2)	2	2	0	2	9.5	2	1 (50%)	1 (50%)
Thailand	Designated trauma center (1)	1	0	0	1	3	1	1	1
Uzbekistan	General hospital with ED (1)	1	1	1	0	-	-	0	0
Vietnam	Designated trauma center (1) General hospital with ED (4)	2	3	2	3	3	2	4 (80%)	3 (60%)

ED, emergency department.

Table 4. Trauma care structure of surveyed hospitals

	Trauma education											Trauma registry (no. of hospitals, yes/no)			
	No. of hospital, yes/no				No. of target audience of the program							Hospital based Trauma registry	Prehospital information	Linked with EMS-based registry	Hospital trauma review/audit program
	Education program for specialized trauma practice	Operation practice trauma program	Critical care practice	Mandatory for healthcare provider	TS	EP	GS	DS	RN	EMT	Other				
Total	30/3	23/7	25/5	11/18	11	17	11	10	11	5	3	24/9	14/10	13/11	14/12
Australia	1/0	1/0	1/0	0/1	-	-	-	-	-	-	-	1/0	-	-	0/1
China	1/0	1/0	1/0	1/0	1	-	1	1	1	-	-	0/1	-	-	0/1
Hong Kong	1/0	1/0	1/0	0/1	-	1	1	1	1	-	-	1/0	1/0	1/0	1/0
India	1/0	1/0	1/0	0/1	1	1	1	1	1	1	1	0/1	-	-	-
Indonesia	1/0	1/0	1/0	0/1	-	-	-	-	-	-	-	0/1	-	-	-
Japan	3/0	2/1	1/2	0/3	-	1	-	-	-	-	-	3/0	2/1	0/3	2/1
Korea	8/2	5/3	7/1	2/5	2	3	1	1	1	1	-	10/1	7/3	10/0	5/5
Malaysia	2/0	1/1	1/0	1/1	-	2	1	-	2	-	1	1/1	1/0	1/0	1/0
Myanmar	1/0	1/0	0/1	1/0	1	1	1	1	-	-	-	1/0	0/1	0/1	0/1
Philippine	1/0	1/0	1/0	0/1	-	-	-	-	-	-	-	1/0	0/1	0/1	1/0
Singapore	2/0	2/0	2/0	1/1	1	1	1	1	1	-	-	2/0	1/1	1/1	2/0
Taiwan	2/0	2/0	1/1	1/1	2	2	1	1	2	2	-	2/0	1/1	0/1	1/1
Thailand	1/0	1/0	1/0	0/1	1	1	1	1	-	-	-	1/0	0/1	0/1	1/0
Uzbekistan	1/0	0/1	1/0	1/0	-	-	-	-	-	-	1	1/0	1/0	0/1	0/1
Vietnam	4/1	3/1	4/0	3/1	2	4	2	2	2	1	-	0/4	0/1	0/2	0/1

TS, trauma surgeon; EP, emergency physician; GS, general surgeon; DS, department surgeon; RN, registered nurse; EMT, emergency medical technician; EMS, emergency medical service.

Table 5. Trauma ED outcomes of surveyed hospitals

	Trauma patients in ED		Trauma patients via EMS in ED		Trauma severity					
	Total visits (n = 25)	Survival to discharge (n = 11)	Total visits (n = 17)	Survival to discharge (n = 10)	ISS 9–15		ISS 16–24		ISS > 24	
					Survival discharge		Survival discharge		Survival discharge	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	300,376	97.2	32,556	94.7	4,369	96.3	1,540	91.3	1,090	65.1
Australia	-	-	-	-	-	-	-	-	-	-
China	7,000	-	1,000	-	-	-	-	-	-	-
Hong Kong	600	-	-	-	-	-	-	-	-	-
India	-	-	-	-	-	-	-	-	-	-
Indonesia	-	-	-	-	-	-	-	-	-	-
Japan	2,656	99.3	3,870	97.8	402	98.0	269	94.4	229	68.1
Korea	147,928	98.8	20,273	97.2	2,400	94.5	806	88.2	439	63.6
Malaysia	19,327	-	1,117	-	267	-	113	-	32	-
Myanmar	18,256	-	-	-	-	-	-	-	-	-
Philippine	14,400	95.7	-	-	-	-	-	-	-	-
Singapore	25,400	99.7	3,064	97.7	527	98.9	143	96.5	165	60.0
Taiwan	14,370	85.1	2,307	72.2	674	99.6	180	96.7	116	57.8
Thailand	10,049	99.3	925	98.6	366	95.9	142	90.8	141	77.3
Uzbekistan	2,000	-	-	-	-	-	-	-	-	-
Vietnam	38,390	-	-	-	-	-	-	-	-	-

ED, emergency department; EMS, emergency medical service; ISS, injury severity score.

pan Advanced Trauma Evaluation and Care education program significantly reduced trauma mortality.²² Most hospitals in our

study had established trauma-specialized education programs, but 60% of them were not mandatory, and education programs

for paramedics were insufficient. The shortage of standardized and organized educational programs for trauma care in Asian countries has also been reported by other studies.^{14,21,22}

Injury surveillance guidelines,²³ published by the WHO in 2001, strongly recommended injury surveillance systems with qualified, extensive injury data. The American College of Surgeons also emphasizes the importance of trauma registries for evaluating trauma systems.²⁴ We expect the PATOS to function in a similar way to the National Trauma Data Bank of the United States,²⁵ National Trauma Registry of Canada,²⁶ Trauma Registry of the German Society for Trauma Surgery,²⁷ and EuroTARN—the Collaborative European Registry of Trauma of 14 European countries,²⁸ by serving as a platform for analyzing trauma indices, comparing trauma care systems, and examining various risk factors and predictors of trauma in this region. We found that some hospitals in Hong Kong, Malaysia, Singapore, and Korea had linked registries for prehospital and hospital data, but others lacked this resource. PATOS will provide a reference to compare the benefits of resources like these to trauma outcomes across the Asia Pacific.

In our study, 75% of participating hospitals offered tertiary care, but only 25% had designated trauma centers. In Indonesia, Malaysia, and Uzbekistan, the highest hospital level for trauma patients was a general hospital, not designated as a trauma center; however, some hospitals in these countries were equipped with trauma teams. Designated trauma centers have been shown to improve survival and cost-effectiveness in several studies.^{11,29} The United States has more than 1,000 trauma centers and manages the quality of services through American College of Surgeons certification.³⁰ India has established the Jai Prakash Narayan Apex Trauma Center at the All India Institute of Medical Sciences in New Delhi,¹⁰ and in South Korea, regional trauma centers have been designated and are currently being built.³¹ In Australia, the introduction of a statewide trauma system was associated with significant improvements in trauma care outcomes.³²

It was not possible to collect ED trauma outcome data from some of the countries in this study. This may be attributed to the lack of trauma registries. One previous study reported that the mortality rate of injuries (ISS \geq 9) rose from 35% in high-income settings to 63% in low-income settings,³³ and a similar study showed that moderate injuries were associated with a 6% mortality rate in high-income countries, and a much higher 36% mortality rate in low-income countries.³⁴ In the current study, it is notable that survival-to-discharge rates for total trauma patients and trauma patients transferred using the EMS in Taiwan were both lower (85.1% and 72.2%, respectively) compared to other developed countries, and survival-to-discharge rates from moderate-to-severe trauma in South Korea did not meet the av-

erage. A previous study found trauma care outcomes in Japan to be unfavorable; the preventable death rate in Japan was 11%¹³ compared to between 1% and 7% in the United States.^{35,36}

One limitation of this study was the small number of respondents for trauma outcomes (total ED survival [$n = 11$] and survival rate by ISS [$n = 9$]), which reduces the impact of comparisons between components of trauma care and mortality. Another limitation was lack of representation; our study generally included one to three hospitals per country, apart from the 11 hospitals in South Korea and the five hospitals in Vietnam. This potential selection bias makes it difficult to generalize our results, leaving us with only a partial understanding of the overall state of trauma care systems in each country. Moreover, we need to be careful when interpreting the results of this study because of profound discrepancies in the definitions of variables, and data quality. For example, standards for a designated trauma center could be different between countries, and the curriculum of education programs for trauma care could be more or less comprehensive in different countries. Some countries provided estimates rather than predefined and measured data, and exact data was often not available because trauma registries were not yet organized sufficiently. Missing or roughly estimated data for several variables, particularly trauma treatment outcomes, limited a robust description and comparison.

Our findings emphasize the differences in trauma ED outcomes across Asian trauma care settings, and support the need for a detailed, customized, and systematic trauma surveillance platform like PATOS. This study provides evidence-based data for the construction of organized trauma care systems based on a comprehensive trauma database, thereby helping to improve trauma outcomes in this region.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

1. World Health Organization. Injuries and violence: the facts. Geneva: World Health Organization; 2010.
2. World Health Organization. Global health estimates 2014 summary tables: DALY by cause, age and sex, 2000–2012. Ge-

- neva: World Health Organization; 2014.
3. Organization for Economic Co-operation and Development; World Health Organization. Health at a glance: Asia/Pacific 2012. Paris: OECD Publishing; 2012.
 4. Calland JF, Xin W, Stukenborg GJ. Effects of leading mortality risk factors among trauma patients vary by age. *J Trauma Acute Care Surg* 2013;75:501-5.
 5. Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. *J Trauma* 1999;47:S25-33.
 6. Sampalis JS, Denis R, Lavoie A, et al. Trauma care regionalization: a process-outcome evaluation. *J Trauma* 1999;46:565-79.
 7. Rhodes M, Aronson J, Moerkirk G, Petrash E. Quality of life after the trauma center. *J Trauma* 1988;28:931-8.
 8. MacKenzie EJ, Siegel JH, Shapiro S, Moody M, Smith RT. Functional recovery and medical costs of trauma: an analysis by type and severity of injury. *J Trauma* 1988;28:281-97.
 9. Bazzoli GJ, Madura KJ, Cooper GF, MacKenzie EJ, Maier RV. Progress in the development of trauma systems in the United States. Results of a national survey. *JAMA* 1995;273:395-401.
 10. Prada SI, Salkever D, MacKenzie EJ. Level-I trauma centre treatment effects on return to work in teaching hospitals. *Injury* 2014;45:1465-9.
 11. Mullins RJ, Veum-Stone J, Helfand M, et al. Outcome of hospitalized injured patients after institution of a trauma system in an urban area. *JAMA* 1994;271:1919-24.
 12. Nguyen TL, Nguyen TH, Morita S, Sakamoto J. Injury and pre-hospital trauma care in Hanoi, Vietnam. *Injury* 2008;39:1026-33.
 13. Motomura T, Mashiko K, Matsumoto H, et al. Preventable trauma deaths after traffic accidents in Chiba Prefecture, Japan, 2011: problems and solutions. *J Nippon Med Sch* 2014;81:320-7.
 14. Joshipura MK. Trauma care in India: current scenario. *World J Surg* 2008;32:1613-7.
 15. Jiang BG. Status of road traffic injury rescue and current work in China. *Chin Med J (Engl)* 2011;124:3850-1.
 16. Yin XF, Wang TB, Zhang PX, et al. Evaluation of the effects of standard rescue procedure on severe trauma treatment in china. *Chin Med J (Engl)* 2015;128:1301-5.
 17. Central Intelligence Agency. The world factbook [Internet]. Washington, DC: Central Intelligence Agency [cited 2018 Oct 9]. Available from: <https://www.cia.gov/library/publications/resources/the-world-factbook/fields/335rank.html>.
 18. World Health Organization. World health statistics 2015. Geneva: World Health Organization; 2015.
 19. United Nations. World population prospects: 2015 revision [Internet]. New York, NY: United Nations; 2015 [cited 2018 Oct 9]. Available from: <https://www.un.org/en/development/desa/publications/world-population-prospects-2015-revision.html>.
 20. National Statistics. National statistics of Taiwan [Internet]. [place unknown]: National Statistics; 2014 [cited 2018 Oct 9]. Available from: <http://statdb.dgbas.gov.tw/>.
 21. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med* 2006;354:366-78.
 22. MacKenzie EJ, Hoyt DB, Sacra JC, et al. National inventory of hospital trauma centers. *JAMA* 2003;289:1515-22.
 23. Byun CS, Park IH, Oh JH, Bae KS, Lee KH, Lee E. Epidemiology of trauma patients and analysis of 268 mortality cases: trends of a single center in Korea. *Yonsei Med J* 2015;56:220-6.
 24. Zong ZW, Li N, Cheng TM, et al. Current state and future perspectives of trauma care system in mainland China. *Injury* 2011;42:874-8.
 25. Hondo K, Shiraishi A, Fujie S, Saitoh D, Otomo Y. In-hospital trauma mortality has decreased in Japan possibly due to trauma education. *J Am Coll Surg* 2013;217:850-7.
 26. Holder Y, Peden M, Krug E, Lund J, Gururaj G, Kobusingye O. Injury surveillance guidelines. Geneva: World Health Organization; 2001.
 27. American College of Surgeons, Committee on Trauma. Resources for optimal care of the injured patient 2014. Chicago, IL: American College of Surgeons; 2014.
 28. National Trauma Data Bank. Welcome to the NTDB Data Center [Internet]. Chicago, IL: American College of Surgeons [cited 2018 Oct 9]. Available from: <https://www.ntdbdatacenter.com/Default.aspx>.
 29. National Trauma Registry. Trauma and injuries [Internet]. Ottawa, ON: Canadian Institute for Health Information [cited 2018 Oct 9]. Available from: <https://www.cihi.ca/en/types-of-care/specialized-services/trauma-and-injuries>.
 30. Ruchholtz S. The trauma registry of the German society of trauma surgery as a basis for interclinical quality management. a multicenter study of the German society of trauma surgery. *Unfallchirurg* 2000;103:30-7.
 31. EuroTARN. The Trauma Audit & Research Network: introduction [Internet]. Salford: TARN [cited 2018 Oct 9]. Available from: <https://www.tarn.ac.uk/Content.aspx?ca=8>.
 32. Mock CN, Jurkovich GJ, Amon-Kotei D, Arreola-Risa C, Maier RV. Trauma mortality patterns in three nations at different economic levels: implications for global trauma system development. *J Trauma* 1998;44:804-12.
 33. Mock CN, Adzotor KE, Conklin E, Denno DM, Jurkovich GJ.

- Trauma outcomes in the rural developing world: comparison with an urban level I trauma center. *J Trauma* 1993;35:518-23.
34. Sanddal TL, Esposito TJ, Whitney JR, et al. Analysis of preventable trauma deaths and opportunities for trauma care improvement in Utah. *J Trauma* 2011;70:970-7.
35. Teixeira PG, Inaba K, Hadjizacharia P, et al. Preventable or potentially preventable mortality at a mature trauma center. *J Trauma* 2007;63:1338-46.
36. Cameron PA, Gabbe BJ, Cooper DJ, Walker T, Judson R, McNeil J. A statewide system of trauma care in Victoria: effect on patient survival. *Med J Aust* 2008;189:546-50.