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Preventable Trauma Death Rate after Establishing a National Trauma System in Korea

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ABSTRACT

Background: This study aimed to evaluate the current overall preventable trauma death rate (PTDR) in Korea and identify factors associated with preventable trauma death (PTD).
Methods: The target sample size for review was designed to be 1,131 deaths in 60 emergency medical institutions nationwide. The panels for the review comprised trauma specialists working at the regional trauma centers (RTCs); a total of 10 teams were formed. The PTDR and factors associated with PTD were analyzed statistically.
Results: Of the target cases, 943 were able to undergo panel review and be analyzed statistically. The PTDR was 30.5% (6.1% preventable and 24.4% possibly preventable). Those treated at a RTC showed a significantly lower PTDR than did those who were not (21.9% vs. 33.9%; $P = 0.002$). The PTDR was higher when patients were transferred from other hospitals than when they directly visited the last hospital (58.9% vs. 28.4%; $P = 0.058$; borderline significant). The PTDR increased gradually as the time from accident to death increased; a time of more than one day had a PTDR 14.99 times higher than when transferred within one hour (95% confidence interval, 4.68 to 47.98).
Conclusion: Although the PTDR in Korea is still high compared to that in developed countries, it was lower when the time spent from the accident to the death was shorter and the final destined institution was the RTC. To reduce PTDR, it is necessary to make an effort to transfer trauma patients to RTCs directly within an appropriate time.

Keywords: Injuries and Wounds; Trauma Center; Trauma System; Preventable Death Rate; Korea

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Disclosure

The authors have no potential conflicts of interest to disclose.

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INTRODUCTION

Preventable trauma death rate (PTDR) is defined as the rate of deaths of individuals who are considered to have survived if they would have been properly transported to the appropriate hospital within the appropriate time and received the appropriate treatment.[1] PTDR is widely used as a key indicator of trauma system performance. In Korea, PTDR has been estimated periodically since the late 1990s, declining from 50.4% in 1997–1998 to 35.2% in 2009–2010; however, these values remain high.[2-4] Since 2012, the Ministry of Health and Welfare in Korea has commenced a project to install regional trauma centers (RTCs) to reduce the PTDR to less than 20% by 2020.[5,6] The project aims to establish nationwide regionalized trauma system so that patients can be transferred to the RTCs within one hour whenever and wherever serious trauma patients are located in Korea. As of December 2015, 15 hospitals were designated as candidates for RTCs, and 8 RTCs are open officially in Korea. However, the national PTDR has not yet been fully evaluated since the Korean government started running the master plan to establish national trauma system based on the implementation of RTCs.

This study aimed to evaluate not only the current overall PTDR in Korea but also the differences in PRDR between gender, ages, final institutions destined for the death, and transfer status. Furthermore, we explored factors associated with PTDs.

METHODS

Study design and data collection

The data was extracted from the National Emergency Department Information System (NEDIS) of Korea. The NEDIS is a nationwide database that contains clinical and administrative data of patients visiting emergency department. The target population for sampling of the main survey was selected from 7,307 deaths with a diagnosis code of S, T based on the Korean Standard Classification of Diseases (KCD) 6th edition of patients who visited the emergency medical institution from January 1, 2015 to December 31, 2015. Among them, 6,988 deaths were selected as the final target population, excluding those with associated frostbite, poisoning, or other and unspecified effects of external causes and complications regarding surgical and medical care. Among the final target population, 1,142 cases were dead on arrival (DOA), 599 cases died in the emergency room, 3,257 cases died after hospitalization, and 1,990 cases died after transfer from another hospital. Emergency medical institutions with more than 5 deaths were selected as sampling targets. As a result, approximately 96% of the target population was included in the survey population. For sampling, the stratified two-stage cluster sampling method was applied, and stratification was designed as a double layer. The region (Seoul, Gyeonggi/Incheon, Chungbuk, Chungnam/Gangwon/Daejeon, Jeonbuk, Jeonnam/Jeju, Gyeongbuk, Gyeongnam), type of emergency medical institution (regional emergency medical center, local emergency medical center, local emergency medical institution), and number of deaths (less than 30 deaths, more than 30 deaths) were used as the first stratification variable for sampling hospitals. Next, we used the death place (DOA, death in emergency room, death after hospitalization) and the age of patient (age 14 years or less, age 15–54, age 55 years or more) as the second stratification variable for sampling sample deaths in hospitals. However, children aged 14 years or less were all included in the sample because of the small sample size. In addition, to identify the exact cause of PTD, all deaths of patients who visited the regional emergency medical center, which mainly deals with the treatment of severe emergency patients, were

Table 1. Distribution of the sample institutions and the trauma deaths according to the regions and types of institutions

Regions	Total	Regional emergency medical center	Local emergency medical center		Local emergency medical institution	
			< 30 deaths	≥ 30 deaths	< 30 deaths	≥ 30 deaths
Total	60 (1,131)[a]	20 (571)	12 (120)	14 (280)	12 (120)	2 (40)
Seoul	11 (161)	1 (11)	3 (30)	4 (80)	2 (20)	1 (20)
Gyeonggi/Incheon	12 (240)	5 (150)	3 (30)	2 (40)	2 (20)	0 (0)
Gangwon/Daejeon/Chungbuk, Chungnam	12 (240)	5 (140)	2 (20)	2 (40)	2 (20)	1 (20)
Jeonbuk, Jeonnam/Jeju	11 (210)	4 (120)	2 (20)	2 (40)	3 (30)	0 (0)
Gyeongbuk, Gyeongnam	14 (280)	5 (150)	2 (20)	4 (80)	3 (30)	0 (0)

[a]All of the values were presented as the number of sample institutions (the number of trauma deaths).

included in the sample subjects. Ultimately, the target sample size was designed to be 1,131 deaths in 60 emergency medical institutions. The number of regional sample sizes was 11 hospitals in Seoul (161 deaths, 14.2%), 12 hospitals in Gyeonggi/Incheon (240 deaths, 21.2%), 12 hospitals in Gangwon/Daejeon/Chungbuk, Chungnam (240 deaths, 21.2%), 11 hospitals in Jeonbuk, Jeonnam/Jeju (210 deaths, 18.6%), and 14 hospitals in Gyeongbuk, Gyeongnam (280 deaths, 24.8%) (**Table 1**).

Constituting the panel and multidisciplinary review

The panels for the case review mainly comprised trauma specialists working at the RTCs. A total of 10 teams were formed, and each team consisted of two general surgeons, one thoracic surgeon, one neurosurgeon, and one emergency physician. Apart from this, the Trauma Death Review Committee (TDRC), which was also comprised five trauma specialties, was responsible for developing the guidelines for the whole review process and for training the panels. A workshop was held for the purpose of introducing the guidelines and training regarding the panel review process. Furthermore, when preventability was not decided by the primary panel review, the committee reviewed the cases again and confirmed final decisions for inclusion and preventability. To evaluate the reliability of panel review, three panel teams were selected. They repeated review for the 8% of overall cases that had already been reviewed by other panel teams. The cases were selected from the three hospitals, which were selected one by one from each region throughout the country after the country was divided into 3 regions based on the location mapping of 15 RTCs.

Criteria for preventability of trauma deaths

The criteria for preventability of trauma deaths were based on World Health Organization guidelines for trauma quality improvement programs.[7] The main factors underlying the decision regarding preventability of trauma deaths comprised severity of injuries and appropriateness of trauma care. Definitions were as follows.

1) “PTDs” were deaths that could have been prevented if appropriate steps had been taken, with accompanying injuries and sequelae considered survivable. These cases had frank deviations from standard of care that, directly or indirectly, caused the patient's death.
2) “Potentially PTDs” were deaths that potentially could have been prevented if appropriate steps had been taken, with accompanying injuries and sequelae considered severe but survivable. These cases had some deviations from standard of care that, directly or indirectly, caused the patient's death.
3) “Non-PTDs” were deaths that were unavoidable, as accompanying injuries and sequelae were considered non-survivable even with optimal management. Evaluation and management were appropriate according to accepted standards. If the patient had co-morbid factors that were major contributors to death, such cases were considered non-PTDs.

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Statistical analysis

The weight of sample for deaths is $\omega^{b}_{higk} = \omega^{(1)}_{higk} \times \text{non}_{adjh} \times \omega^{(2)}_{higk}$, where $\omega^{(1)}_{higk}$ is the design weight of sample hospitals. The non_{adjh} is the adjustment value for non-response of sample hospitals, and $\omega^{(2)}_{higk}$ corresponds to death weight in the sample hospitals. In the benchmarking adjustment using the population information, the death distribution of the population in respect of region × type of emergency medical institutions, type of emergency medical institutions × characterization of deaths, region × characterization of deaths was used. The characteristic layer of death distinguished between age and location of death, divided into 7 layers. We applied the raking ratio method to the population information to calculate the final weights by correcting the primary weights of the sample deaths.

We used a modified Clopper-Pearson method to analyze the PTDR and 95% confidence intervals (CI) for each factor. The PTDRs and their 95% CIs were calculated according to the components of risk factors to cause PTDR differences and the PTDR difference among groups by factors was conducted with Pearson's χ^2 test, and the difference between the RTC and non-RTC was calculated using the Cochran-Mantel-Haenszel test. The agreement between the first and the second reviews and between review panel teams were evaluated using Cohen's Kappa index.

To examine the association between the likelihood of preventable death and its relating factors, we constructed two multivariate logistic regression models with weights such as (Model 1: F(Y) = α + β1[Age] + β2[Hospital type] + β3[Regions] + β4[Transfer status]; Model 2: F(Y) = α + β1[Age] + β2[Hospital type] + β3[Regions] + β4[Time from accident to death]). We did not construct one model considering both variables of [Transfer] and [Time from accident to death] because all subjects experienced in twice or more hospital transfer (n = 14) were included in only the category of [time duration from accident to death > 24 hours]. The likelihood of PTD according to relating factors was expressed with odds ratios (ORs) and their 95% CIs relative to reference value.

Ethics statement

This study was approved by the Institutional Review Board (IRB) of Seoul National University (IRB No. E-1607-001-771). Informed consent was waived by the board due to the observational nature of the study.

RESULTS

Baseline characteristics of the study patients

The target sample size of this study was originally 1,131 patient deaths. Since 156 patients, however, should have been excluded due to insufficient information for review, 975 cases were able to undergo panel review. Of those, there were 7 cases where there was an inability to reach an agreement for preventability even after TDRC review, and 25 cases appeared to have characteristics that could not be weighted statistically. Eventually, the number of cases included for the analysis was 943 (**Fig. 1**). The mean age of those was 58.9 (standard deviation, 22.5) years, 658 were men, and an overwhelming 97.1% were blunt trauma. Moreover, 272 patients (27.5%) transferred from one or more hospitals. The designated 15 RTCs covered 28.5% of the enrolled trauma patients (**Table 2**).

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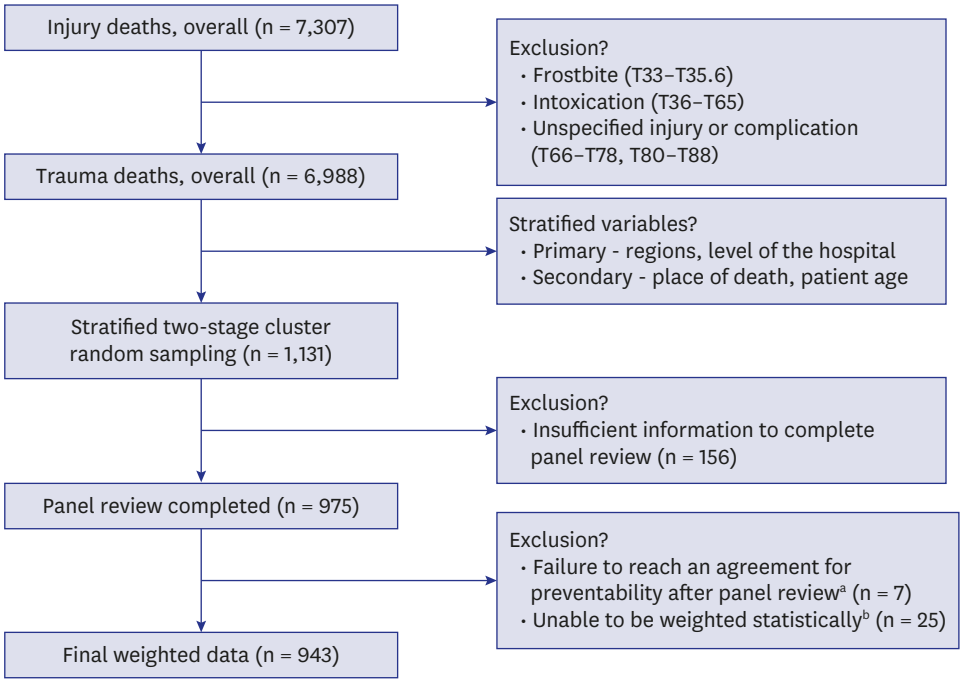

Fig. 1. Study design and sampling.
[a]The cases were unable to reach an agreement for preventability even after additional review by Trauma Death Review Committee; [b]Raking ratio method was used for weighted value calculation.

PTDR by multidisciplinary panel review

The PTDR of Korea was 30.5%. Of these, 6.1% were preventable deaths, and 24.4% were possibly or potentially preventable deaths (**Table 3**). Among those with a penetrating injury mechanism, there were no preventable deaths, but there was a 12.7% possible preventable death rate. Although the rate was lower than that in the blunt trauma group, the number of cases (n = 2) was too low to show a statistically significant difference between the two groups (P = 0.513). The PTDR in those 14 years of age or less was 9.8% (95% CI, 1.6–18.1), in those 15–54 years was 25.2% (95% CI, 18.4–32.1), and in those 55 years and more was 33.2% (95% CI, 27.3–39.1). In the comparison of RTC group with the non-RTC group, the RTC group showed a significantly lower PTDR than did the non-RTC group (21.9 vs. 33.9; P = 0.002). On the other hand, the PTDR was high (58.9%) when the patients were transferred from two or more other hospitals. This rate was approximately 2 times higher than the 28.4% rate in the group of patients who directly visited the last hospital for trauma care (P = 0.058; borderline significant). Furthermore, the PTDR increased gradually as the time from accident to death increased, with a rate of 4.2% at 1 hour or less, 24.4% at 1 to 6 hours, and 38.6% at 1 day or more (P < 0.001) (**Table 4**). In terms of evaluating reliability between three panel teams, the Kappa index showed a value of 0.44 (95% CI, −0.15, 1.00), 0.33 (95% CI, −0.18, 0.83) and 0.75 (95% CI, 0.30–1.00) indicating moderate, fair, strong agreement, respectively.

Factors associated with PTDs

Factors associated with PTDs are shown in **Table 5**. Variables for which the difference in PTDR was identified above borderline significance were age, type of hospital, transfer y/n, time from accident to death, and RTC y/n. From the multivariate model after adjusting for confounding factors, the PTDR in the those 55 years of age or more was 4.45 times higher than that in those 14 years of age or less (95% CI, 1.68–11.75). Tertiary hospitals (OR, 2.18; 95% CI, 1.30–3.67) and

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Table 2. Base-line characteristics of the study patients (n = 943)

Characteristics	Patients, No. (%[a])
Gender	
Men	658 (69.4)
Women	285 (30.6)
Age, yr	
≤ 14	44 (1.8)
15–54	310 (29.1)
≥ 55	589 (69.1)
Area	
Seoul, Incheon, and Gyeonggi	296 (36.4)
Gangwon	69 (7.8)
Daejeon, Chungbuk, and Chungnam	138 (12.2)
Gwangju, Jeonbuk, and Jeonnam	154 (15.2)
Busan, Daegu, Ulsan, Gyeongbuk, and Gyeongnam	249 (25.6)
Jeju	37 (2.8)
Type of emergency care center	
RTC	401 (28.5)
Regional emergency medical center	183 (7.2)
Local emergency medical center	257 (50.2)
Local emergency medical service	102 (14.1)
Mechanism of injury	
Blunt	903 (97.1)
Penetrating	10 (0.7)
Not further specified	30 (2.2)
Transfer y/n	
Directly visited to the last hospital	614 (67.6)
Transferred from the other hospital	272 (27.5)
One time via other hospital	258 (26.0)
More than two times via other hospital	14 (1.5)
Unknown	57 (4.9)
Mode of transport	
119	569 (61.7)
129	88 (7.4)
Hospital ambulance	123 (13.4)
Others and unknown	167 (17.5)
Time from accident to death	
Time ≤ 1 hour	143 (15.2)
1 hour < time ≤ 6 hours	186 (19.7)
6 hours < time ≤ 24 hours	127 (13.5)
1 day < time ≤ 7 days	232 (24.6)
7 days < time ≤ 30 days	192 (20.4)
Time > 30 days	58 (6.2)
Unknown	5 (0.5)

RTC = regional trauma center.
[a]All of the percentage values were weighted ones.

Table 3. PTDR (n = 943)

Variables	Patients, No. (%[a])	95% CI
PTD (P + PP)	280 (30.5)	25.9–35.0
P	55 (6.1)	3.6–8.6
PP	225 (24.4)	20.2–28.6
Non-PTD (NP + NPCI)	663 (69.5)	65.0–74.1
NP	462 (53.9)	49.0–58.8
NPCI	201 (15.6)	12.7–18.5

PTDR = preventable trauma death rate, CI = confidence interval, P = preventable, PP = possibly preventable, NP = non-preventable, NPCI = non-preventable, but with care that could have been improved.
[a]All of the percentage values were weighted ones.

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Table 4. PTDR according to each factor of the study patients (n = 943)

Variables	No. of patients	P, %[a] (95% CI)	P + PP, %[a] (95% CI)	*P* value[b]
Gender				0.539
Men	658	7.5 (4.0–11.0)	29.6 (24.0–35.1)	
Women	285	3.0 (1.2–4.7)	32.6 (24.5–40.7)	
Age, yr				0.018
≤ 14	44	3.3 (0.0–8.0)	9.8 (1.6–18.1)	
15–54	310	4.7 (1.3–8.0)	25.2 (18.4–32.1)	
≥ 55	589	6.8 (3.5–10.1)	33.2 (27.3–39.1)	
Mechanism of injury				0.513
Blunt	903	6.0 (3.4–8.5)	30.6 (26.0–35.3)	
Penetrating	10	0.0	12.7 (0.0–36.0)	
Not further specified	30	13.7 (0.0–27.5)	30.8 (10.9–50.7)	
RTC y/n				0.002[c]
RTC	401	3.9 (1.4–6.3)	21.9 (16.9–26.9)	
Non-RTC	542	7.0 (3.6–10.3)	33.9 (27.9–39.9)	
Non-RTC				
Tertiary hospital	213	5.7 (1.3–10.3)	37.5 (27.5–47.4)	0.003[c]
General hospital	329	8.0 (3.2–12.9)	30.7 (23.7–37.7)	0.038[c]
≥ 500 beds	158	9.5 (3.7–15.4)	26.4 (17.6–35.2)	0.366[c]
300–499 beds	119	3.9 (0.0–7.9)	35.8 (24.7–46.9)	0.013[c]
≤ 300 beds	52	12.0 (0.0–27.6)	29.3 (11.4–47.2)	0.386[c]
Transfer y/n[d]				
Directly visited	614	5.5 (2.6–8.3)	28.4 (22.9–34.0)	0.058
Transferred	272	6.6 (1.4–11.8)	34.0 (25.1–42.9)	0.283[e]
Once	258	7.0 (1.5–12.5)	32.6 (23.4–41.8)	0.436[e]
Twice or more	14	NA	58.9 (24.9–92.9)	0.034[e]

PTDR = preventable trauma death rate, CI = confidence interval, P = preventable, PP = possibly preventable, RTC = regional trauma center, NA = not available.
[a]All of the percentage values were weighted ones; [b]The differences in weighted P + PP rates by factors using chi-square test; [c]The difference in P + PP rates for each hospital compared to P + PP rate of RTC; [d]Fifty seven cases with unknown transfer status and its frequency were not included; [e]The difference in P + PP rates for each transfer status compared to P + PP rate of non-transfer (direct visit).

Table 5. Factors associated with PTDs[a]

Variables	P + PP	NP + NPCI	OR (95% CI[b]), Overall trauma	OR (95% CI[b]), Blunt trauma
Age, yr				
≤ 14	6	38	1.00	1.00
15–54	81	230	3.08 (1.14–8.34)	3.02 (1.11–8.24)
≥ 55	193	395	4.45 (1.68–11.75)	4.44 (1.67–11.82)
According to type of hospital				
RTC	95	306	1.00	1.00
Non-RTC				
Tertiary hospital	76	137	2.18 (1.30–3.67)	2.25 (1.32–3.83)
General hospital				
≥ 500 beds	49	109	1.28 (0.72–2.29)	1.38 (0.76–2.50)
300–499 beds	40	79	2.02 (1.13–3.61)	2.09 (1.15–3.79)
≤ 300 beds	20	32	1.24 (0.48–3.21)	1.30 (0.50–3.36)
Transfer y/n[c]				
Directly visited	171	443	1.00	1.00
Transferred				
Once	83	175	1.07 (0.66–1.76)	1.06 (0.64–1.75)
Twice or more	8	6	2.99 (0.83–10.82)	2.88 (0.78–10.58)
Time from accident to death[d]				
Time ≤ 1 hour	6	137	1.00	1.00
1 hour < time ≤ 6 hours	45	141	9.18 (2.69–31.39)	8.68 (2.53–29.72)
6 hours < time ≤ 24 hours	44	83	11.67 (3.12–3.72)	11.27 (3.01–42.22)
Time > 1 day	181	301	14.99 (4.68–7.98)	14.89 (4.65–47.71)

PTD = preventable trauma death, P = preventable, PP = possibly preventable, NP = non-preventable, NPCI = non-preventable, but with care that could have been improved, OR = odds ratio, CI = confidence interval, RTC = regional trauma center.
[a]Statistics were analyzed by post-weighted multivariate logistic regression; [b]OR and 95% CI for age, type of hospital, and transfer y/n were calculated from the model excluding the factor of time from accident to death. Furthermore, OR and 95% CI for time from accident to death were calculated from the model including the time factor but excluding the transfer factor; [c]Fifty seven cases with unknown transfer status and its frequency were not included; [d]Five cases with unknown for time from accident to death were not included.

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general hospitals with 300–499 beds (OR, 2.02; 95% CI, 1.13–3.61) were also associated with PTDs more than RTC. Having a hospital transfer showed an OR of 2.99 for PTD, but was not statistically significant (95% CI, 0.83–10.82). The PTDR increased gradually as the time from accident to death time increased, and a time of more than 1 day displayed a 14.99 times higher rate than did cases transferred within 1 hour (95% CI, 4.68–47.98).

DISCUSSION

This study shows that the overall PTDR in Korea has been decreasing since its initial measurement in the late 1990s, but the rate is still high (30.5%; 95% CI, 25.9%–35.0%) compared with that in countries with an established trauma care system such as the US and Canada. In particular, the overall PTDR was substantially lower in RTCs than that in non-RTCs. The PTDR was 21.4% (95% CI, 16.4%–26.4%) when the final destined institution for the patient was an RTC; this was lower than the PTDR of 33.9% (95% CI, 28.0%–39.9%) in non-RTCs. In addition, the PTDR was higher with an increase in the number of times passing other hospitals or the elapsed time from the accident to the death. In case of passing two or more hospitals before arrival of the final destined institution, the PTDR was 58.9% (95% CI, 24.9%–92.9%), which was much higher than 28.4% (95% CI, 22.9%–34.0%) when directly visiting the final destined institution. These results imply that to reduce the PTDR in Korea, trauma patients need to be transferred to the RTC urgently from the time of the accident.

The PTDR in Korea has been slowly declining since its initial measurement in the late 1990s. Using data from emergency medical centers of secondary and tertiary hospitals, the PTDR was 50.4% in Korea from 1997–1998.[2] Kim et al.[3] reported a PTDR of 39.6% in 2003–2004 in a survey conducted in 9 hospitals in Korea. Furthermore, Kim et al.[4] reported a PTDR of 35.2% in the 20 trauma specialization centers across the country in 2009–2010. All of these studies were done by multidisciplinary panel review, and our results showed similar level of agreement when compared inter-rater reliability of preventable death judgements between panel teams with these previous studies in Korea and the United States.[2-4,8] Although a direct comparison is difficult due to differences in the study subjects, judgment of prevention possibilities, and statistical methods, the PTDR in Korea has been consistently higher than that of some other industrialized countries. Recently, Motomura et al.[9] reported a PTDR of 29.0% in Chiba, Japan, Sandal et al.[10] reported a PTDR of 6.7% in Utah, USA in 2005, and Teixeira et al.[11] reported a PTDR of 2.4% in California, USA from 1998 to 2005.

The PTDR in the hospitals running RTCs was 21.4% (95% CI, 16.4%–26.4%), which was significantly lower than that in non-RTCs. Similar results were derived in the multivariate analysis. In Korea, RTCs began to be designated in 2012 and have been opened and operated from 2014. The RTC differs from the former domestic trauma treatment system. The RTC requires the operation of essential equipment and dedicated personnel in the operating room, an intensive care unit, trauma resuscitation room, and angiogram room to perform the treatment immediately after the severe trauma patient is transferred to the hospital. A general surgeon, thoracic surgeon, neurosurgeon, and orthopedic surgeon must be assigned to the trauma team.[5] The operation of the nationwide RTC is estimated to be one of the factors contributing to the reduction of PTDR in Korea.

The results of this study show that the PTDR increases when the time from accident to death is lengthened or the time to final treatment is delayed (data not shown here). When factors

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associated with inappropriate treatment were divided into pre-hospital and hospital phases, factors such as delayed transfer between hospitals (29.5%) and inappropriate hospital selection (25.1%) accounted for the largest portion following circulatory assistance (30.3%) at the pre-hospital stage. When problems associated with the pre-hospital stage was divided by means of transportation, for 119 paramedics, delayed transfer was the main reason, whereas for hospital ambulances, inappropriate transfer hospital selection was the main reason.[3] Furthermore, when comparing PTDR-related problems in Korea and Australia, Korea had a relatively higher rate of problems than did Australia in the pre-hospital stage and the transfer stage between hospitals.[4] Therefore, to reduce the PTDR in Korea, it is necessary to transfer within a short time to the appropriate treatment institution to receive the final treatment.

This study has the following limitations. Despite the number of samples increased from the previous studies, there still existed regions where accurate PTDR could not be calculated for each metropolitan city or health service region due to an insufficient number of samples. Therefore, there is a need to increase the number of samples to calculate a more accurate regional PTDR. Furthermore, we could not consider individual patient factors such as the residential area, socioeconomic status, and concomitant diseases that might be associated with preventability of death, as the NEDIS dataset used for this study does not include this detailed information.

Despite these limitations, this study has implications for the purpose of calculating the PTDR in Korea using structured panel review methods and nationally representative samples. Although the PTDR in Korea has been steadily declining, it is still high compared with the PTDR in developed countries. In this study, the PTDR was lower as the time elapsed from accident to death was shorter and the final destined institution was an RTC. To reduce the PTDR in Korea, it is necessary to make an effort to transfer trauma patients to RTCs directly within an appropriate time after the proper field triage is performed. This study showed that continuous and systematic evaluation of PTDR is essential to monitor the trauma system performance and identify opportunities for improvement.

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