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Research Article

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Impact of hospital type on risk-adjusted, traffic-related 30-day mortality: a population-based registry study

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Abstract

Background: Traffic incidents are still a major contributor to hospital admissions and trauma-related mortality. The aim of this nationwide study was to examine risk-adjusted traffic injury mortality to determine whether hospital type was an independent survival factor.
Methods: Data on all patients admitted to Swedish hospitals with traffic-related injuries, based on International Classification of Diseases codes, between 2001 and 2011 were extracted from the Swedish inpatient and cause of death registries. Using the binary outcome measure of death or survival, data were analysed using logistic regression, adjusting for age, sex, comorbidity, severity of injury and hospital type. The severity of injury was established using the International Classification of Diseases Injury Severity Score (ICISS).
Results: The final study population consisted of 152,693 hospital admissions. Young individuals (0–25 years of age) were overrepresented, accounting for 41% of traffic-related injuries. Men were overrepresented in all age categories. Fatalities at university hospitals had the lowest mean (SD) ICISS 0.68 (0.19). Regional and county hospitals had mean ICISS 0.75 (0.15) and 0.77 (0.15), respectively, for fatal traffic incidents. The crude overall mortality in the study population was 1193, with a mean ICISS 0.72 (0.17). Fatalities at university hospitals had the lowest mean ICISS 0.68 (0.19). Regional and county hospitals had mean ICISS 0.75 (0.15) and 0.77 (0.15), respectively, for fatal traffic incidents. When regional and county hospitals were merged into one group and its risk-adjusted mortality compared with university hospitals, no significant difference was found. A comparison between hospital groups with the most severely injured patients (ICISS $\leq$0.85) also did not show a significant difference (odds ratio, 1.13; 95% confidence interval, 0.97–1.32).
Conclusions: This study shows that, in Sweden, the type of hospital does not influence risk adjusted traffic related mortality, where the most severely injured patients are transported to the university hospitals and centralization of treatment is common.

Highlights

- In this large national registry investigation, care of traffic-related trauma was found to be centralized in Sweden.
- The university hospitals received the most injured patients.
- However, when examining the risk-adjusted mortality, it was not found to be lower at university hospitals, compared to regional or county hospitals.

Key words: Epidemiological, International classification of diseases injury severity score, Injury, Risk-adjusted mortality, Trauma

Background

Improvements in road and car safety have reduced traffic-related mortality over the years [1–4]. However, traffic-related injuries still make up approximately 10% of all hospital admissions for injuries in Sweden, and the 30-day mortality of this subgroup contributes to 4% of the total injury-related mortality [3]. Studies have shown that age and sex are independent factors for outcome after traffic incidents [5], although questions have been raised as to what degree admission to different types of hospitals plays a role in determining survivability. Reports from North America [6, 7] and Finland [8] have shown that admission to a university hospital is associated with a lower mortality, which suggests that the centralization of treatment for trauma may be advantageous. The Scandinavian pattern of trauma care differs from many other countries, due to many areas being poorly populated [9]. It is not known if the same favourable effects of such centralization of treatment can be found in Sweden; however, as it has a similar demography to Finland, it may be hypothesized that such findings will be similar.

To avoid selection bias, and to allay concerns about coverage, the Swedish National Patient Registry (NPR) was used for this study instead of specific trauma registries. Using the International Classification of Diseases Injury Severity Score (ICISS) as a risk adjustment strategy has been advocated in a recent review because of its robustness and reliability when adjusting for risk in larger populations [10]. A further advantage of using the ICISS on a Swedish population is that, in the Swedish setting, this measurement has been found to be both adequate and reliable [10, 11].

Further, there is a trend towards the centralization of specialized trauma care in Sweden [12, 13] and international studies support such organization [14, 15]. It is therefore important to look further into the matter using Swedish national data to recognize what should be recommended from a national perspective.

The aim of this study was to investigate the effect of the type of admitting hospital on risk-adjusted 30-day mortality after traffic accidents. The underlying hypothesis is that there is a survival advantage by being admitted to a university hospital, and especially so for the most injured patients (i.e. those with an ICISS score $\leq$0.85).

Methods

Hospital categorization

Hospital categorization was based on the classification made by the Swedish PeriOperative Registry (SPOR). Depending on the intensive care unit ability, the degree of specialized care, access to laboratories and radiology, and whether research and education was part of the hospital's mission, 3 categories were used: university hospitals, regional hospitals and local county hospitals. In SPOR, local county hospitals are divided into 2 groups, depending on access to maternal care, but this distinction was not made in this study as childbirth was not an area of interest. The categorization made by SPOR is supported by the Swedish Department of Health and Welfare (Socialstyrelsen), the Swedish Counties and Regions, the Regional Insurance Company and the Swedish Association of Anaesthesia and Intensive Care, and is also widely approved and recognized within the Swedish healthcare system [16]. See Appendix 1 for in-depth inclusion criteria. The Linköping University Institutional review board (IRB) approved this retrospective cohort study of all adult patients admitted to Swedish Hospitals with a trauma diagnosis between 1987 and 2012. Patients were identified through the Swedish Hospitals in patient registry, which contains hospital related records of the patients. Only traffic related trauma patients were included in the data sampling.

All university and regional hospitals were covered in the SPOR categorization, but the list could not be implemented for all local county hospitals in our database. This is because SPOR did not cover all Swedish hospitals when the categorization list was retrieved [16] and reorganization in the healthcare system had taken place in the time period of 2001–2019. For the local county hospitals not included in SPOR, their function was confirmed by communication with the head of hospital, the head of operations, trustees, county administrators, or through an in-depth web search to reach a face-validity of inclusion, subjectively affirming the categorization made (see online supplementary material).

Hospitals that did not meet the inclusion criteria of having an emergency room and not being assigned traffic-related trauma throughout the study period were excluded from the list (see online supplementary material).

Patients studied

The study population consisted of the same database that was used in several previous publications from our research group [3]. The use of each patient's unique personal identification number (PIN) enabled links between the NPR, which covers all Swedish patients who have been admitted to hospital since 1987, and the Cause of Death Registry, which covers the deaths of all Swedish citizens. Thus, any person fitting the inclusion criteria could be traced thorough the system, as long as they had a Swedish PIN.

With the Swedish NPR as the source, all hospital admissions with trauma-related injuries between 2001 and 2011 were retrieved. Patients who were not admitted to hospital as a result of minor injuries and patients who died before reaching the emergency room were excluded from the study. In the event of patients being transferred between clinics during their hospital stay, the first record in the registry was used as the date of admission and the last as the date of discharge. Definitions of diagnosis were therefore made throughout the patient's duration of treatment, regardless of the clinic temporarily responsible. The admitting hospital is, in this study, the corresponding hospital level used in all calculations throughout the article.

Based upon the International Classification of Diseases version 10 (ICD-10), trauma diagnoses (S00–T80) and external cause of injury codes (V01–Y98.9) were selected. The category of adverse effects (T78) did not involve trauma and was therefore excluded. Records where the mechanism of injury was not defined, or age, sex, or date of admission was missing were excluded and not used in the analysis; these data accounted for <1% of the total database.

In the next step, the diagnoses for the predefined subgroups were organized. In case of duplicates, one of the items were excluded from the dataset. Traffic-related injuries itemized as V01–V99 were selected from the final trauma database to make up the traffic database, which consisted of 153,708 participants (Figure 1).

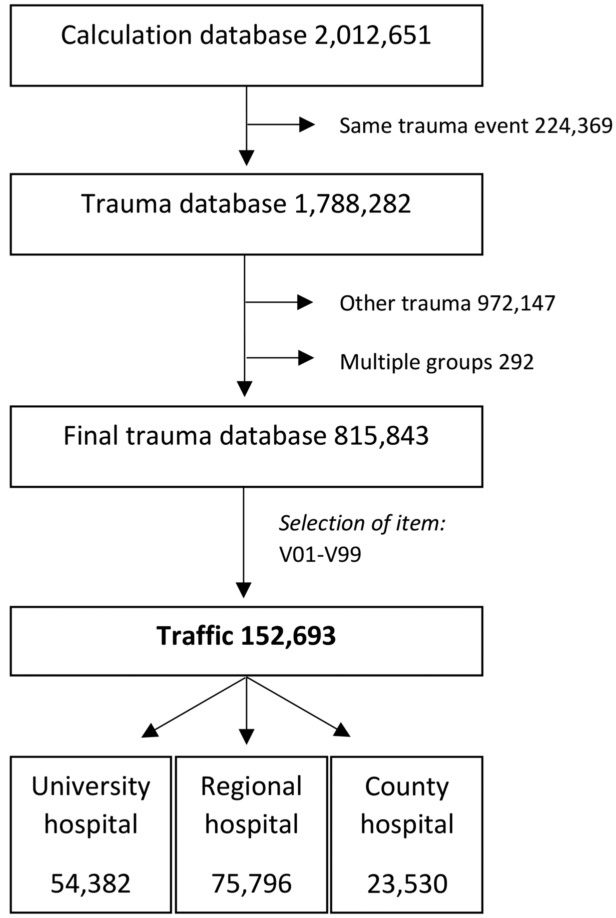

Figure 1. Flow chart showing the selection of patients studied. 'Multiple groups' are the duplicates—injuries that were coded in 2 groups at the same time. 'Other trauma' includes all other injuries that do not fit under the groups of 'fall, assault and traffic'. The diagnosis-specific survival probability and the International Classification of Diseases Injury Severity Score, was calculated on the 'Traffic' database

Severity of injury

Based on consensus and military experience, the Injury Severity Score has previously been regarded as the standard measure of the severity of an injury. In 1996 Osler *et al.* improved this scoring system by basing it on ICD-9 diagnoses to facilitate the handling of large datasets; this system was termed the ICISS. In comparison to the Injury Severity Score, it had the advantage of taking all the injuries of a patient into account, describing their anatomical anomalies, and therefore gave a more accurate prediction of the severity of their injuries. Later studies showed that calculating the ICISS from the updated ICD-10 system further improves its estimation [10, 17]. Both European and Swedish material supports its value in predicting mortality outcome after trauma [3].

There is no consensus about what the exact ICISS value should be in order to define a cut-off for a severely injured patient. However, an ICISS value of 0.85 has previously been used as the threshold for severe injury [3, 18], which is why the 15% mortality rating was also used in the present study to define the severely injured.

The diagnosis-specific survival probability (DSP) were multiplied to calculate an ICISS value for each individual in the dataset. The DSP is the proportion of patients with a specific injury (corresponding to an ICD-10 diagnosis) who survived after their first admission, giving a product of probability of survival for that particular injury. Setting a limit of 30 days assured the inclusion of patients who died as a direct consequence of the trauma, while excluding those who died mainly of other causes [3]. Before the DSP was calculated, all duplicated ICD-10 codes were removed. The DSP was calculated based on ICD-10 codes from the calculation database (Figure 1).

Comorbidity

To calculate comorbidity, the Charlson Comorbidity Index (CCI) was used. It is widely acknowledged to be an applicable method to estimate the mortality risk of comorbid diseases [19] and its predictions are coherent with cohorts from intensive care units [20]. Adaptation of CCI to the ICD-10-system was done according to the method set out by Christensen *et al.* [20].

Statistical modelling

Statistical modelling was undertaken on the whole dataset in a stepwise manner. First the ICISS was applied in a logistic regression model, adjusting mortality for the severity of

Table 1. Characteristics of patients by hospital type

Variables	University hospital	Regional hospital	County hospital	Total
Patients, *n* (%)	50,578 (33)	61,791 (41)	40,324 (26)	152,693 (100)
Male, *n* (%)	31,060 (61)	37,401 (61)	24,209 (60)	92,670 (61)
Female, *n* (%)	19,518 (39)	24,390 (39)	16,115 (40)	60,023 (39)
Age years, median (IQR)	32 (17, 51)	33 (17, 54)	34 (18, 55)	33 (18, 55)
Age years, *n* (%)				
0–14	8739 (36.5)	9835 (41.1)	5372 (22.4)	23,946 (15.7)
15–25	11,788 (30.9)	15,480 (40.6)	10,878 (28.5)	38,146 (25.0)
26–35	7095 (36.5)	7517 (38.7)	4829 (24.8)	19,441 (12.7)
36–45	6751 (35.5)	7546 (39.6)	4745 (24.9)	19,042 (12.5)
46–55	5798 (33.7)	6861 (39.9)	4526 (26.3)	17,185 (11.3)
56–65	4722 (32.7)	5884 (40.7)	3849 (26.6)	14,455 (9.5)
66–75	2779 (28.7)	4078 (42.1)	2840 (29.3)	9697 (6.4)
76–85	2286 (27.0)	3641 (42.9)	2553 (30.1)	8480 (5.6)
86 and over	620 (26.9)	949 (41.2)	732 (31.8)	2301 (1.5)

Data are number (%) unless otherwise stated. For categorized ages, percentages show the distribution between university, regional and county hospitals. For the total column in the same categories, percentages show the distribution out of all 152,693 patients. *IQR* interquartile range

injury. Data were then adjusted for sex and age, and then CCI inclusion.

Statistical analysis

Data are presented as median and interquartile range (IQR) or mean and SD.

Working with mortality prediction means studying binary figures, which is why logistic regression was used throughout. Nonlinear data were categorized. How well the model coincides with reality can be defined as its discrimination. The model accurately separates those who died from those who survived.

The statistics software package Stata (StataCorp, College Station, USA) was used for statistical analyses and data management. Where $p < 0.05$, this was considered to be significant.

Results

Patient characteristics

The final study population consisted of 152,693 hospital admissions resulting from traffic accidents. Apportioned between the 3 different hospital types, a total of 50,578 patients were admitted to university hospitals, 61,791 to regional hospitals and 40,324 to county hospitals (Table 1). Those admitted were aged 0–110 years, with a mean (SD) age of 37 (22) years. Younger patients (0–25 years of age) were overrepresented, accounting for 41% of the traffic-related injuries. Men were overrepresented in all age categories and the gap between the sexes narrowed as age increased.

Severity of injury

Patients reaching hospital had a median (IQR) ICISS 0.963 (0.92, 0.98). Severity of injury had a falling order, with university hospitals accounting for the highest degree of injury, with a median (IQR) ICISS 0.959 (0.91, 0.98). Patients at regional and county hospitals had median (IQR) ICISS 0.963 (0.93, 0.98) and 0.964 (0.93, 0.98), respectively.

Hospital type and mortality

The crude overall mortality in the study population was 1198, with a median (IQR) ICISS 0.75 (0.60, 0.87). Fatalities at university hospitals had the lowest median (IQR) ICISS 0.70 (0.54, 0.83). Regional and county hospitals had median (IQR) ICISS 0.77 (0.64, 0.88) and 0.81 (0.69, 0.89), respectively, for fatal traffic incidents (Table 2).

In the overall model, examining type of hospital as an independent risk factor did show a significant difference between the different hospital types in terms of the risk-adjusted 30-day mortality. Using university hospitals as a reference, the logistic regression shows a significantly lower risk-adjusted 30-day mortality for patients admitted to both regional and county hospitals (Table 3).

We merged regional and county hospitals into one group, to increase the statistical power, and made a risk-adjusted mortality comparison with university hospitals. A comparison between hospital groups with the most severely injured patients (ICISS $\leq$0.85) did not reach significance (Table 4).

There was no significant difference between hospital types for the group consisting of the most severely injured patients, ICISS $\leq$0.85 (Table 5). Iteration for years, looking if individual years would effect the outcome, did not show a significant difference between hospital types. (Table 6).

Discussion

The fact that there is a falling order in the severity of injury between the different types of hospital, in which patients at university hospitals suffer from worse injuries, indicates that a process of centralization is taking place in the treatment of trauma in Sweden. This assertion is further supported by the finding that the 30-day mortality carries a lower ICISS score

Table 2. Characteristics of traffic-related death by hospital type

Variables	University hospital	Regional hospital	County hospital	Total
Total number of deaths, *n* (%)	552 (46)	507 (43)	134 (11)	1193 (100)
Age in years, median (IQR)	56 (31, 78)	67 (43, 80)	70 (46, 81)	62 (36, 80)
Male, *n* (%)	374 (68)	360 (71)	90 (67)	824 (69)
ICISS, median (IQR)	0.70 (0.54, 0.83)	0.77 (0.64, 0.88)	0.81 (0.69, 0.89)	0.75 (0.60, 0.87)

Data are number (%) unless otherwise stated. *IQR* interquartile range, *ICISS* International Classification of Diseases Injury Severity Score

Table 3. Grouped comparison of university hospitals with all other hospital types. Logistic regression for death within 30 days after admission among those with severe injuries (ICISS ≤0.85)

Variables	OR	*P*	95% CI
Sex (male as reference)	0.82	0.014	0.70 to 0.96
Age (years, 0–14 years as reference)			
15–25	1.69	0.047	1.01 to 2.82
26–35	1.43	0.190	0.84 to 2.46
36–45	1.33	0.305	0.77 to 2.30
46–55	1.54	0.118	0.90 to 2.63
56–65	2.13	0.005	1.26 to 3.61
66–75	3.03	<0.001	1.78 to 5.16
76–85	6.80	<0.001	4.07 to 11.41
86 and over	15.55	<0.001	8.89 to 27.19
CCI (0 points as reference)			
1	1.01	0.945	0.74 to 1.39
2	2.10	0.009	1.20 to 3.67
>2	3.20	0.025	1.16 to 8.85
Year (2001 as reference)			
2002	1.01	0.952	0.73 to 1.39
2003	0.98	0.897	0.71 to 1.35
2004	0.81	0.199	0.58 to 1.12
2005	0.92	0.596	0.67 to 1.26
2006	0.68	0.026	0.48 to 0.95
2007	1.00	0.985	0.73 to 1.37
2008	0.83	0.253	0.60 to 1.14
2009	0.65	0.014	0.46 to 0.92
2010	0.52	0.001	0.36 to 0.76
2011	0.60	0.005	0.43 to 0.86
Hospital type (university hospital as reference)			
Regional and county hospitals grouped	0.90	0.176	0.78 to 1.05

Total *n* = 14,066

Data were risk adjusted for ICISS ≤0.85, sex, age, CCI, year and hospital type (university hospitals vs. regional and county hospitals grouped)

ICISS International Classification of Diseases Injury Severity Score, *CCI* Charlson Comorbidity Index, *OR* odds ratio

at university hospitals, in comparison to the other hospital types. When looking at 30-day risk-adjusted mortality for the entire dataset, surprisingly, the university hospitals seem to have a higher risk-adjusted mortality than the other 2 hospital types. However, we think that the major finding in this study is that, when looking at the most severely injured (ICISS ≤0.85) patients, there was no difference between university hospitals and the other 2 hospital levels.

Taking time into consideration, Swedish hospitals in general show a trend of survival improvement throughout the years, and this improvement is significant from 2009 onwards. Regardless, time does not seem to discriminate between hospital types, since no significant difference was found between the groups when iterated for years. The only significant difference was found in the year of 2002, when regional hospitals carried a significantly higher odds ratio than university hospitals for the most severely injured (ICISS ≤0.85). No trend nor consistency could be shown after, which is why that result is most probably an outlier.

The logistic regression analyses in Table 3 were carried out in a similar fashion to the investigation by Ala-Kokko *et al.* [8], but no significant difference could be seen when looking at the most severely injured patients (ICISS ≤0.85). These findings contradict previous ones [8, 14, 15]. To our knowledge, no other studies have examined traffic-related injuries from this perspective and in such a detail (having as large a study population) as the present study.

Similar to other studies [21, 22], men were overrepresented in all age groups and the gap between the sexes narrowed as

Table 4. Categorization of hospital types. Logistic regression for death within 30 days after admission

Variables	OR	*P*	95% CI
ICISS (≥0.99 as reference)			
0.97–0.98	0.75	0.315	0.42 to 1.32
0.93–0.96	1.82	0.017	1.11 to 2.97
0.86–0.92	7.77	<0.001	4.98 to 12.13
≤0.85	58.64	<0.001	38.06 to 90.34
Sex (male as reference)	0.75	<0.001	0.66 to 0.86
Age (years, 0–14 years as reference)			
15–25	1.90	0.002	1.27 to 2.84
26–35	1.64	0.025	1.06 to 2.52
36–45	1.75	0.010	1.14 to 2.68
46–55	2.17	<0.001	1.43 to 3.30
56–65	2.71	<0.001	1.70 to 4.10
66–75	4.55	<0.001	3.02 to 6.86
76–85	8.93	<0.001	6.00 to 13.31
86 and over	19.56	<0.001	12.82 to 29.86
CCI (0 points as reference)			
1	1.22	0.100	0.96 to 1.55
2	1.50	0.069	0.97 to 2.31
>2	3.11	<0.001	1.77 to 5.48
Year (2001 as reference)			
2002	1.13	0.367	0.87 to 1.46
2003	1.12	0.407	0.86 to 1.46
2004	0.90	0.462	0.69 to 1.19
2005	0.97	0.832	0.75 to 1.27
2006	0.85	0.259	0.64 to 1.13
2007	1.08	0.582	0.83 to 1.40
2008	0.92	0.551	0.70 to 1.21
2009	0.71	0.021	0.53 to 0.95
2010	0.66	0.008	0.49 to 0.90
2011	0.66	0.006	0.49 to 0.89
Hospital type (university hospital as reference)			
Regional hospital	0.82	0.003	0.72 to 0.94
County hospital	0.75	<0.001	0.64 to 0.88

Total n = 152,693
Data were risk adjusted for ICISS, sex, age, CCI, year and hospital type (categorized)
OR odds ratio, *ICISS* International Classification of Diseases Injury Severity Score, *CCI* Charlson Comorbidity Index

age increased. This is likely because women tend to outlive men [23]. Younger people, between the ages of 0–25 years, account for most traffic-related injuries (41%) in comparison with other age groups (Table 1), which is consistent with findings showing that this is a population with risk-prone behaviour [22, 24].

Consistent with a study by Larsen [5], sex is an independent risk factor, with females having a survival advantage over men. For the cohort of ICISS ≤0.85, the effect of sex decreases (p = 0.015).

Strengths of the study

A common concern when using a registry is the quality of coding, with regard to both the accuracy of the actual code as well as the likelihood that a clinician will register a patient's condition appropriately. It is a legal requirement for Swedish doctors to document each patient's individual medical record, within which the ICD codes are incorporated. Together with economic incentives that push for the correct coding, the Swedish NPR has previously been validated and ICD codes have been claimed to have a good precision to the fourth position of the code [3].

The ICISS provides an accurate estimation of the severity of injury. Previous studies have shown that ICISS data from 8 different countries had substantial similarities in terms of the classification of severity. Swedish and American data are comparable to a large extent when grading the severity of injury, and when providing data to support the ICISS estimation in cases that are rare in Sweden because of its relatively smaller population [25]. The ICISS also has the advantage of being widely accessible because it uses ICD codes.

Merging the Swedish NPR with the Swedish Cause of Death Registry, and using PINs, provides a unique possibility to track each patient, with minimal loss of eligible trauma patients. With a retrospective approach, including all cases that fit the inclusion criteria, there is no drop-out in the study material. The true strength of the study lies in the data

Table 5. Categorization of hospital types. Logistic regression for death within 30 days after admission among those with severe injuries (ICISS ≤0.85)

Variables	OR	*P*	95% CI
Sex (male as reference)	0.82	0.015	0.70 to 0.96
Age (years, 0–14 years as reference)			
15–25	1.70	0.046	1.01 to 2.83
26–35	1.44	0.189	0.84 to 2.47
36–45	1.34	0.298	0.77 to 2.31
46–55	1.54	0.114	0.90 to 2.65
56–65	2.15	0.004	1.27 to 3.64
66–75	3.06	<0.001	1.80 to 5.21
76–85	6.86	<0.001	4.10 to 11.50
86 and over	15.65	<0.001	8.95 to 27.36
CCI (0 points as reference)			
1	1.01	0.934	0.74 to 1.39
2	2.09	0.010	1.20 to 3.66
>2	3.23	0.024	1.17 to 8.96
Year (2001 as reference)			
2002	1.00	0.954	0.73 to 1.39
2003	0.98	0.891	0.71 to 1.35
2004	0.80	0.194	0.58 to 1.12
2005	0.91	0.573	0.66 to 1.26
2006	0.67	0.023	0.48 to 0.95
2007	1.00	0.984	0.73 to 1.37
2008	0.82	0.238	0.60 to 1.14
2009	0.64	0.014	0.45 to 0.91
2010	0.52	0.001	0.35 to 0.76
2011	0.60	0.005	0.42 to 0.86
Hospital type (university hospital as reference)			
Regional hospital	0.95	0.548	0.81 to 1.12
County hospital	0.82	0.061	0.67 to 1.01

Total $n = 14{,}066$
Data were risk-adjusted for ICISS ≤0.85, sex, age, CCI, year and hospital type (categorized)
ICISS International Classification of Diseases Injury Severity Score, *OR* odds ratio, *CCI* Charlson Comorbidity Index

Table 6. Logistic regression for death within 30 days after admission comparing hospital types per year (university hospital as reference)

Hospital type	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Regional hospital	0.732	0.089	0.198	0.057	0.245	0.904	0.248	0.742	0.547	0.477	0.581
County hospital	0.529	0.155	0.656	0.301	0.998	0.912	0.116	0.115	0.674	0.920	0.342

Data are *p* values

integrity of th NPR, which records more than 99% of all hospital discharges [26].

Choosing 30 days as the cut-off for mortality was a strength in this study as it facilitated comparison to similar studies done outside Sweden. When examining mortality rates, the inclusion time is usually standardized to either 30, 90 or 120 days after the injury to facilitate international comparisons. The benefit of choosing the shorter period of 30 days is that mortality within that timeframe is likely to be linked to the actual traffic accident. Calculations using the 90-day mortality (data not shown) support this assumption, as such a time limit for inclusion does not substantially affect the dataset [3]. In the case of having a longer inclusion time, such as 90–120 days, there is instead a risk that some patients will return to the hospital with an unrelated disease or possibly a second injury, and therefore will skew the outcome measure (data not shown).

The population-based study design supports the assertion that there was no selection bias and that the 'real-world population' was represented in this study. This supports the generalizability of the study's data and conclusions, especially for the Scandinavian countries.

Limitations of the study

One significant limitation of this study is that the data were gathered from the 2001–2011 period. It is therefore debatable how current the information is and how applicable the data is today. The reason for the chosen period was that this study is part of a larger project using the same database and this is the last paper planned for the cohort.

It is important to emphasize that people who died at the trauma scene or during transportation to hospital were not included in the study. The initial care by emergency staff at the site of the accident has therefore not been considered. The level of expertise amongst emergency personnel is another factor that may have affected the results and should be the target for future studies.

The possibility of stabilizing the patient before arrival at hospital is desirable, and is in line with the quick sepsis-related organ failure assessment score, which suggests that fluctuating physiological variables increase the risk of mortality and the duration of intensive care treatment [27, 28]. To have accounted only for the mechanism of injury, excluding the direct physiological condition of the injured patients, was therefore a limitation of the study. Nevertheless, a severe mechanism of injury is likely to have a severe effect on the vital signs, and even though physiology is not used as a measurement it can be assumed as being indirectly included in the DSP calculation.

Another limitation is that the data came from a high-income country, and therefore the results of this study might not be applicable to patients from middle- or low-income countries.

As always with the chosen study design, a causal relationship could not be concluded, but the significant correlations should still have some impact as a result of the population-based design. Because of the size of the dataset, small differences will have led to statistical significances, and one might argue that some of these differences may have lacked clinical significance. However, working with big datasets means that even small differences in statistical measures implicate hundreds of real life patients, and it s difficult to argue that they should not be considered to be clinically relevant.

Meaning of the study

There is an ongoing debate as to the value of centralizing the treatment of major trauma. Recently, several studies have supported such procedures [6–8]. On the other hand, death before arrival at hospital after severe injuries is almost 90% in Scandinavia, and this would argue for a transport distance as short as possible to immediate care or the receiving hospital. This study shows that trauma centralization is taking place in Sweden, but the type of admitting hospital does not seem influence the risk-adjusted mortality, especially not for the most severely injured.

Conclusions

This study shows that, despite the fact that the most severely injured patients are transported to university hospitals, and contrary to the pre-study hypothesis, the risk-adjusted mortality is not reduced.

Supplementary data

Supplementary data is available at *Burns & Trauma Journal* online.

Abbreviations

CCI: Charlson Comorbidity Index; DSP: diagnosis-specific survival probability; ICD-10: International Classification of Diseases version 10; ICISS: International Classification of Diseases Injury Severity Score; IQR: interquartile range; NPR: National Patient Registry; PIN: personal identification number; SPOR: Swedish PeriOperative Registry; OR: odds ratio may be worth mentioning as such an abbreviation as also used.

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Authors' contributions

Study design: RL, RG, FS. Data collection: RL. Analysis: RL, MF, VY. Interpretation: RL, DB, MF, IS, MC, RG, FS, VY. Writing: RL, IS, FS, VY. Revision: RL, DB, MF, IS, MC, RG, FS, VY.

Ethics approval and consent to participate

This study was approved by the International Review Board at the University of Linköping, Linköping, Sweden.

Conflicts of interest

The authors have no conflicts of interest to declare.

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