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Functional outcome and associations with prehospital time and urban-remote disparities in trauma: A Norwegian national population-based study

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ABSTRACT

Background: There is a lack of knowledge regarding the functional outcomes of patients after trauma. Remote areas in Norway has been associated with an increased risk of trauma-related mortality. However, it is unknown how this might influence trauma-related morbidity. The aim of this study was to assess the functional outcomes of patients in the Norwegian trauma population and the relationship between prehospital time and urban-remote disparities on functional outcome.

Methods: This registry-based study included 34,611 patients from the Norwegian Trauma Registry from 2015 – 2020. Differences in study population characteristics and functional outcomes as measured on the Glasgow Outcome Scale (GOS) at discharge were analysed. Three multinomial regression models were performed to assess the association between total prehospital time and urban-remote disparities and morbidity reported as GOS categories.

Results: Ninety-four per cent of trauma patients had no disability or moderate disability at discharge. Among patients with severe disability or vegetative state, 81 % had NISS > 15. Patients with fall-related injuries had the highest proportion of severe disability or vegetative state. Among children and adults, every minute increase in total prehospital time was associated with higher odds of moderate disability. Urban areas were associated with higher odds of moderate disability in all age groups, whereas remote areas were associated with higher odds of severe disability or vegetative state in elderly patients. NISS was associated with a worse functional outcome.

Conclusions: The majority of trauma patients admitted to a trauma hospital in Norway were discharged with minimal change in functional outcome. Patients with severe injuries (NISS > 15) and patients with injuries from falls experienced the greatest decline in function. Every minute increase in total prehospital time was linked to an increased likelihood of moderate disability in children and adults. Furthermore, incurring injuries in urban areas was found to be associated with higher odds of moderate disability in all age groups, while remote areas were found to be associated with higher odds of severe disability or vegetative state in elderly patients.

Background

Despite severe injuries, most trauma patients who make it to hospital alive survive today [1], but there is a lack of knowledge regarding their functional outcomes and the potential for permanent disabilities, especially in regard to large studies on whole trauma populations, not only small subgroups or trauma cohorts. This is likely related to the focus on mortality as an outcome in the trauma literature and the fact that

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mortality has been established as a quality indicator in trauma management [2,3]. A contributing factor may also be that not all trauma registries provide data on functional outcomes after injury.

One influential attempt at addressing morbidity outcomes is the estimation of global health metrics such as the global burden of disease (GBD). The GBD project, and related projects, are attempts to quantify the impact of health conditions, including trauma-related injuries, on morbidity and mortality. However, these estimates have been criticised for a lack of methodological transparency and the use of inaccurate data [4,5]. Furthermore, the focus of the GBD and related global health metrics has been the aggregated magnitude of health loss from health problems in general on a global scale and neglected equity. Critics point out that these metrics oversimplify complex causal relationships and lack details regarding differentiated outcomes of specific health conditions such as trauma [4].

There is an increasing interest within the trauma community in morbidity as an outcome measure, but to our knowledge, only few studies have investigated the specific functional outcomes of trauma-related injuries. Unfortunately, these studies generally investigate only small cohorts of trauma patient subgroups: e.g. patients with an Injury Severity Score (ISS) > 12 or patients with traumatic brain injury (TBI) [6–10]. In a study on a subgroup of patients with ISS > 12, the authors examined the influence of prehospital advanced life-support on trauma outcomes. In three studies on TBI patients, the influence of prehospital time on functional outcome was investigated [7,9-10]. Two of these studies looked at the influence of total prehospital time [7,10], and one study investigated the effect of response time only [9]. The classification of outcome is also sometimes insufficient, like in one study investigating the influence of, among other variables, total prehospital time on "poor" or "favourable" outcomes [11]. Consequently, there is a need for more comprehensive and detailed knowledge regarding functional outcomes following trauma.

Previous research has suggested that there are factors that differ between remote and urban trauma populations (i.e. differences in types of vehicles, road safety measures, travel speeds, the availability of acute medical care and socio-economic factors) [12–15]. One of the things that characterizes remote areas is the considerable distances and resulting time delays involved in the management of trauma patients, which may exert a notable influence on mortality outcomes [12–15]. A lot of research has been published regarding the effect of prehospital time on survival, but few studies have used population patterns as a discriminator [15]. In Norway, approximately 20 % of the population resides in remote areas [16], where the provision of acute care medical services is challenging due to long distances and variable infrastructure [17]. Therefore, we emphasize the need to investigate the disparities between urban and remote areas as a significant factor in understanding the relationship between prehospital time and morbidity outcomes. As far as we are aware, no studies have previously investigated the influence of prehospital time and urban-remote disparities on functional outcome in trauma.

In an attempt to close this knowledge gap, we conducted a study with data from the Norwegian Trauma Registry (NTR). The main objective of this study was to assess the functional outcome distribution and injury mechanisms in the Norwegian trauma population in relation to geography. In addition, we assessed the association between total prehospital time, urban-remote disparities and functional outcome.

Methods

Study design

We performed a registry-based study on trauma cases included in the NTR between 1 January 2015 and 31 December 2020.

Setting

The study population is based on the entire Norwegian population of 5.5 million people [18]. Norway has a publicly funded healthcare system with a national trauma system [19] with 34 acute care trauma hospitals (ACTH) and four trauma centers (TC) designated to receive and treat trauma patients. These hospitals also actively contribute data to the NTR. All ACTHs offer general surgical and orthopaedic services and are capable of stabilizing severely injured patients before secondary transfer to trauma centers. However, they do not offer services like neurosurgery, intervention radiology and other specialized services. All TCs offer all medical specialities, including neurosurgery, and have the capability to manage all types of injuries. Each ACTH and TC ensures round-the-clock availability of trauma teams, led by a surgical resident with advanced trauma life-support training at the TCs and a surgical consultant with experience in trauma care at the ACTHs. National requirements for each member of the team are provided in the national trauma plan [19].

Data sources and study sample

The NTR is a comprehensive national clinical quality registry containing data on injured patients in Norway, including data from the moment of accident through the rehabilitation process (according to the Utstein template [20]). Table 1 lists the inclusion criteria for the NTR. Patients excluded from our study are listed in table 2.

Variables

The NTR dataset contains information captured at various time points, which we used to compute prehospital time intervals for subsequent analyses (Fig. 1). To identify outliers, we implemented specific time thresholds for all prehospital time intervals. We considered time intervals as outliers if the response time exceeded 120 min, if the on-scene time was either below 5 min or above 120 min, and if transport time was either below 5 min or above 360 min. Total prehospital time was calculated by adding the three above-mentioned prehospital time intervals.

The variable "accident municipality" was included for urban–remote classification (Centrality Index). Other variables include age, gender, dominant injury, injury mechanism, New Injury Severity Score (NISS) and the American Society of Anaesthesiologists' (ASA) physical status classification. We have dichotomized the continuous age variable into age groups for separate analyses on children (age 0–15), adults (age 16–66) and the elderly (age >66) patients. The injury mechanism variable was re-categorized from the original NTR definitions: four traffic-related injury mechanisms (motor vehicle, motorcycle, pedestrian and other) were combined into the category "transport-related", and "shot by firearm", "stabbed by sharp object", "explosion injury" and "other" were combined into the category "other". Patients without a Norwegian national ID number were registered as "missing age".

The NTR measures morbidity as Glasgow Outcome Scale (GOS) score at discharge (according to the Utstein template [20]). GOS is a functional outcome scale, commonly used after brain injury (table 3). Although it was developed for patients with brain injuries, it represents a rough disability outcome and is also used to assess functional outcome after major trauma [20]. Because there were few patients with severe disability or in a vegetative state, we merged the GOS categories "severe disability" and "vegetative state" into one category called "severe disability or vegetative state". We excluded patients who were dead at discharge since the study aimed to assess the functional outcome of survivors. The remaining two categories ("no disability" and "moderate disability") were kept unchanged.

Table 1
Inclusion criteria for the Norwegian trauma registry (NTR).

Inclusion:
- All patients admitted with trauma team activation (TTA) on arrival to the emergency department in all acute care trauma hospitals and trauma centres in Norway, irrespective of injury severity.
- All patients treated at an acute care trauma hospital or trauma centre in Norway, without TTA, with one or more or the following criteria/injuries: penetrating injury to the head, neck, torso or extremities proximal to elbow or knee, head injury with abbreviated injury score (AIS) ≥ 3, and/or New Injury Severity Score (NISS) > 12.
- All patients who suffered trauma-related deaths at site of trauma or during transportation to hospital, who were not referred to hospital, but where prehospital management was initiated.

Table 2
Exclusion criteria for our study.

Exclusion:	Justification:
1. Patients with injuries from drowning, inhalation, hypothermia and asphyxia without concomitant trauma.	1. Non-traumatic injuries.
2. Patients who presented to hospital via private vehicle, police vehicle or transport described as other/unknown.	2. Not registered within the emergency medical communication center (EMCC) and no prehospital data.
3. Trauma team activation, but no trauma.	3. Medical conditions.
4. Patients missing a Centrality Index (CI) score.	4. Not possible to assess urban-remote affiliation.
5. Patients with a preinjury Glasgow Outcome Scale (GOS) of other than "no disability" and patients with a discharge GOS of "dead.	5. We excluded patients with a preinjury GOS of other than "no disability" to be able assess the change in GOS and patients who were dead at discharge.
6. Patients with NISS = 0.	6. Patients with no injury.
7. Multiple registrations on the same patient (i.e., transfers) were counted only once.	7. Multiple registrations.

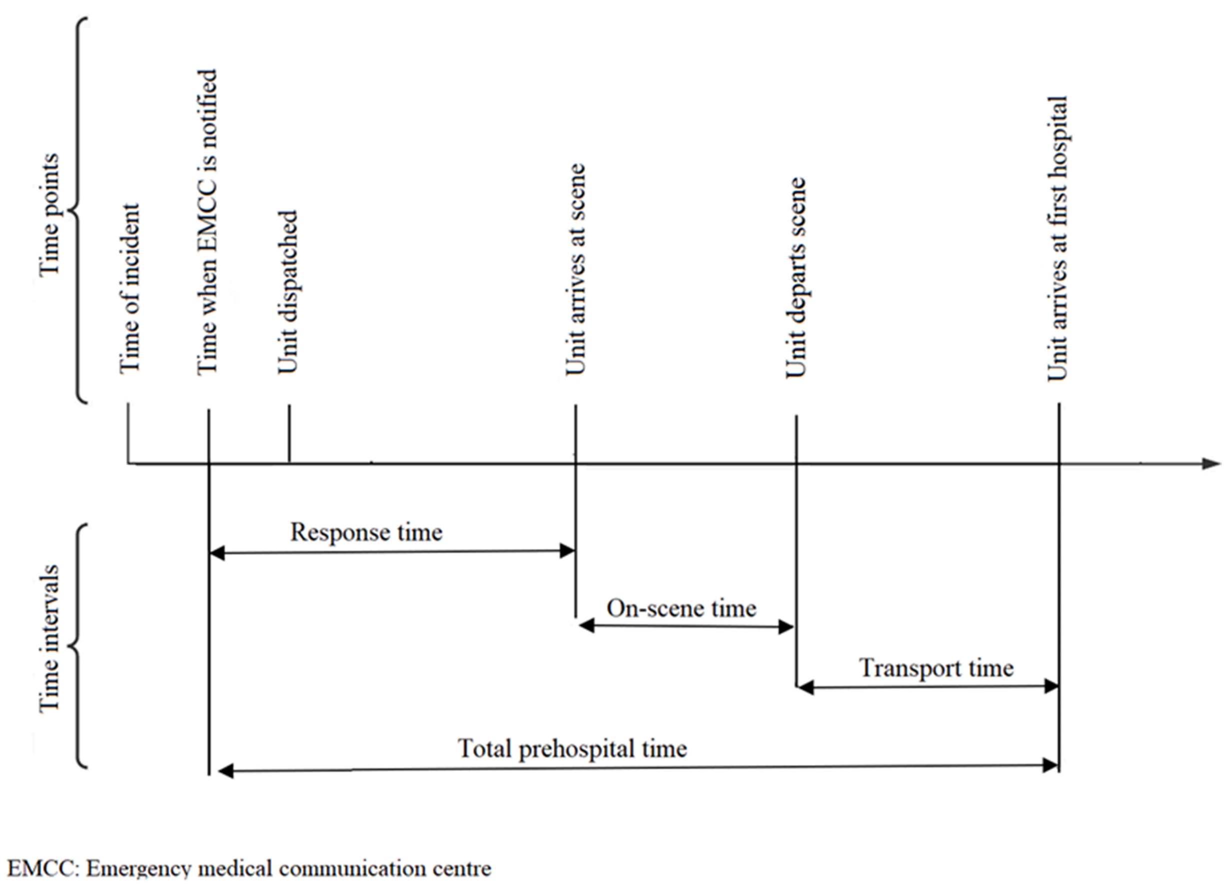

Fig. 1. Illustration of the prehospital time intervals.

Table 3
The Glasgow Outcome Scale.

5 No disability	4 Moderate disability	3 Severe disability	2 Vegetative state	1 Dead
Resumption of normal life	Disabled, but independent in daily life	Disabled and dependent on daily support	Persistent vegetative state	

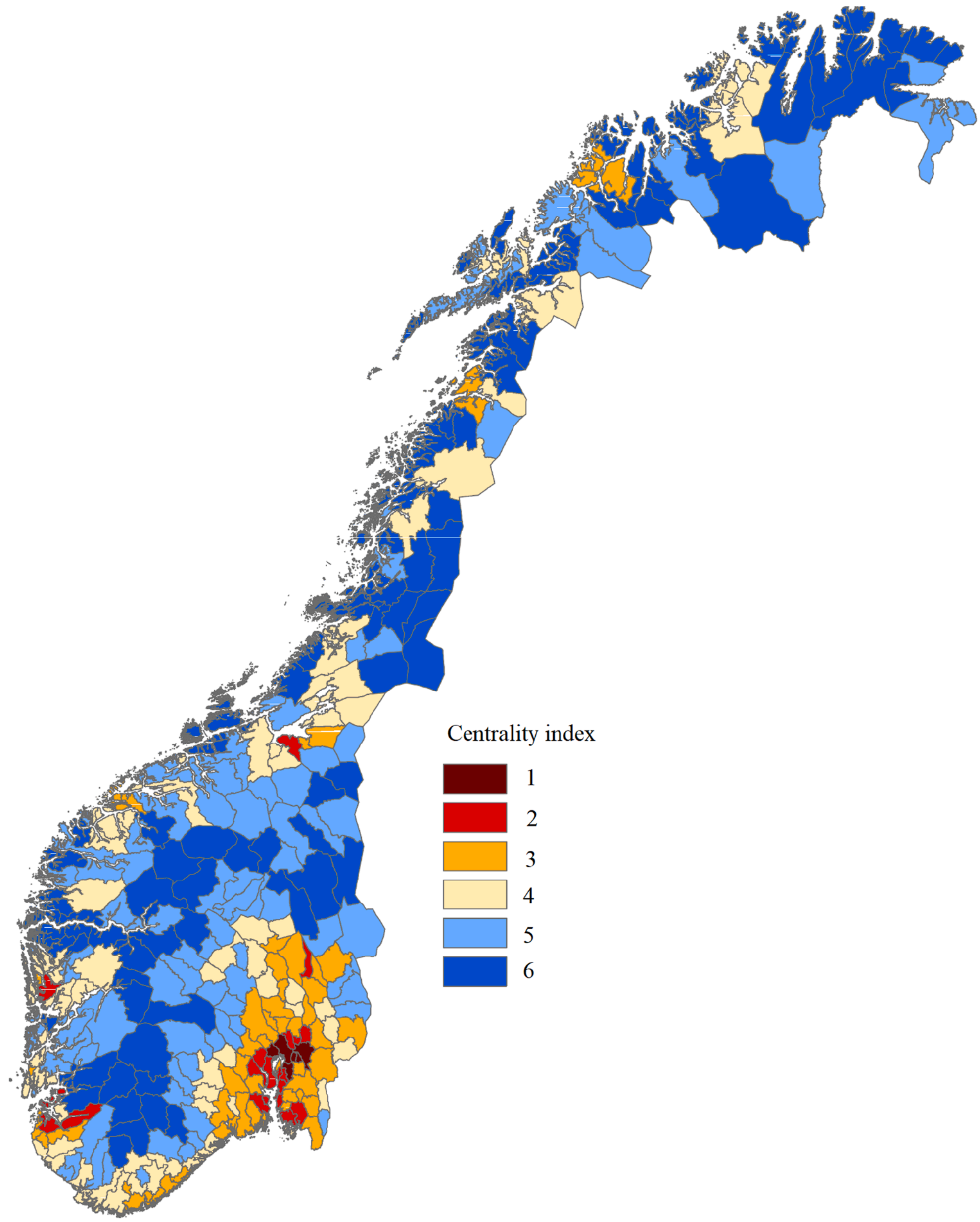

Fig. 2. Map of Norway with centrality index groups 1–6 [21].

Measure of centrality: the centrality index of norway

Statistics Norway's Centrality Index (CI) provides a measure of the municipality's centrality. The CI is based on travel time to workplaces and service functions and the proportion of inhabitants (16). The CI categorizes the municipalities into six groups (Fig. 2).

Because the number of trauma patients in the remote municipalities is low, we reduced the number of CI groups from six to three by merging two neighbouring index groups into one: the CI groups 1 and 2 merged to become "urban areas", 3 and 4 merged to become "suburban areas" and 5 and 6 merged to become "remote areas". In 2020 the geographical structure of several municipalities in Norway was changed, but we have kept the original municipal territories in this study.

Statistical methods

We analysed the registry data using descriptive statistical methods including number, frequency (percentage), mean with standard deviations (SD) and median with 25th and 75th percentiles (Q1 and Q3). To assess the relationship between prehospital time and urban-remote disparities on functional outcome we performed three multinomial logistic regression models for each age group (children, adults and the elderly), adjusted for confounding factors (age, NISS, gender, injury mechanism and preinjury ASA). All independent variables were tested for multicollinearity. A p-value of ≤ 0.05 was considered statistically significant. All analyses were performed using SPSS v. 27.0 (IBM Company, Chicago, IL, USA).

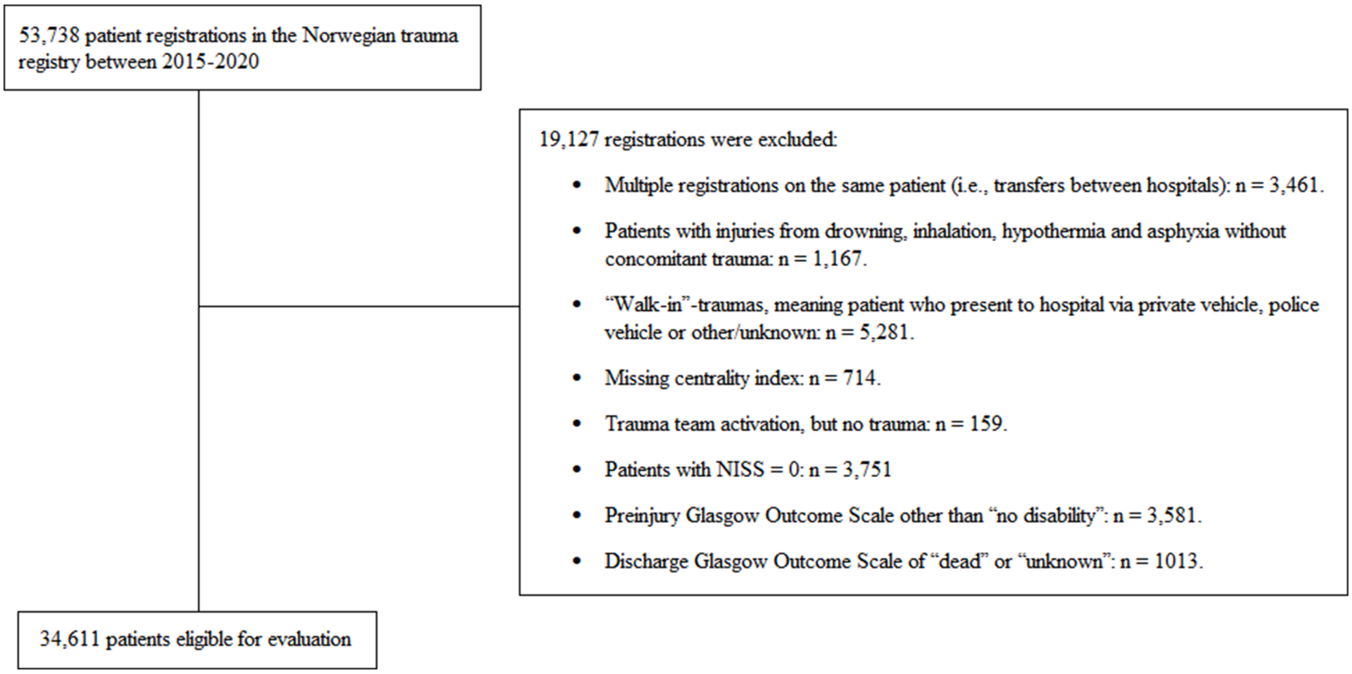

Fig. 3. Flowchart of inclusion/exclusion.

Table 4
Patient characteristics.

Variables				All	Urban	Suburban	Remote
Patients			Number	34,611	12,308	16,480	5823
Age			Median (Q1, Q3)	39 (22, 58)	41 (24, 58)	39 (20, 58)	40 (21, 59)
			Mean (SD)	41 (22)	42 (22)	41 (22)	41 (22)
Age groups	0–15		Per cent	11 %	10 %	11 %	11 %
	16–66		Per cent	74 %	75 %	74 %	74 %
	>66		Per cent	15 %	15 %	14 %	15 %
Male			Per cent	68 %	68 %	66 %	70 %
NISS			Median (Q1, Q3)	5 (2, 13)	5 (2, 14)	5 (2, 12)	6 (2, 13)
			Mean (SD)	9 (10)	10 (11)	9 (10)	9 (9)
Dominant injury		Blunt	Per cent	95 %	92 %	96 %	98 %
Injury mechanism distribution		Transport-related	Per cent	50 %	44 %	58 %	57 %
		Low-energy fall	Per cent	12 %	15 %	9 %	8 %
		High-energy fall	Per cent	23 %	22 %	21 %	23 %
		Struck or hit by blunt object	Per cent	9 %	11 %	7 %	7 %
		Other	Per cent	7 %	9 %	5 %	4 %
Preinjury ASA		ASA 1–2	Per cent	94 %	92 %	95 %	97 %
		ASA 3–4	Per cent	6 %	8 %	5 %	3 %
Total prehospital time*			Median (Q1, Q3)	59 (41, 89)	45 (34, 63)	59 (43, 81)	105 (81, 138)
			Mean (SD)	72 (47)	60 (49)	67 (36)	115 (49)

Q1 = 25th percentile.
Q3 = 75th percentile.
SD = Standard Deviation.
NISS = New Injury Severity Score.
ASA = The *American Society of Anaesthesiologists'* (*ASA*) physical status classification system.
*Time cut-offs were applied in the calculation of total prehospital time:.
• Response time ≤ 120 min, on-scene time ≥ 5 min or ≤ 120 min, and transport time ≥ 5 min or ≤ 360 min.

Table 5
Distribution of Glasgow outcome scale (GOS) at discharge.

	All GOS discharge		Urban GOS discharge		Suburban GOS discharge		Remote GOS discharge	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
No disability	18,352	53 %	5815	47 %	9305	56 %	3232	56 %
Moderate disability	14,283	41 %	5923	48 %	6184	38 %	2176	37 %
Severe disability or vegetative state	1976	6 %	570	5 %	991	6 %	415	7 %

Results

A total of 53,738 patients were registered in the NTR in the study period and 34,611 patients met the inclusion criteria (Fig. 3).

Study population characteristics

The age, NISS and gender distributions were approximately the same in all areas. Transport-related injuries were more common in suburban and remote areas compared to urban areas, whilst low-energy fall injuries and injuries from being struck or hit by a blunt object were more common in urban areas compared to suburban and remote areas. A preinjury ASA of 3 or 4 was more common in urban areas. Total prehospital time increased in remote areas (table 4).

GOS distribution

The majority of trauma patients had no disability or moderate disability at discharge. Patients with severe disability or in a vegetative state at discharge were few (table 5).

We found a relationship between functional outcome, measured by GOS, and injury severity, measured by NISS. Among patients with no disability at discharge, 81 % had NISS ⟨ 9, 12 % had NISS 9–15, and 7 % had NISS ⟩ 15. Among patients with severe disability or in a vegetative state at discharge, 6 % had NISS ⟨ 9, 13 % had NISS 9–15, and 81 % had NISS ⟩ 15.

The relationship between functional outcome, measured by GOS, and injury mechanism is illustrated below (Fig. 4). The injury mechanism with the highest proportion of patients with severe functional impairment at discharge was falls, whereas the injury mechanism with the highest proportion of patients with no disability at discharge was transport-related injuries.

The relationship between functional outcome, measured by GOS, and age is illustrated below (Fig. 5). Elderly patients (age >66 years) had the highest proportion of severe disability and vegetative state.

Transport-related injuries were most common among adults (age 16–66). Low-energy fall injuries were most common among the elderly (age >66) and high-energy fall injuries were most common among children (age 0–15) (Fig. 6).

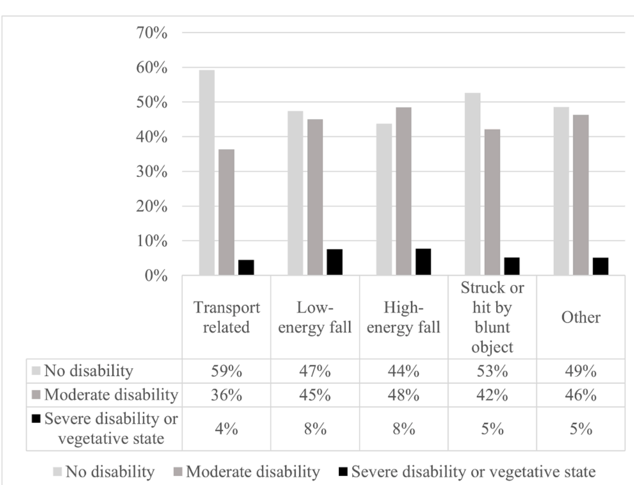

Fig. 4. Functional outcome, measured by Glasgow Outcome Scale (GOS), according to injury mechanism distribution.

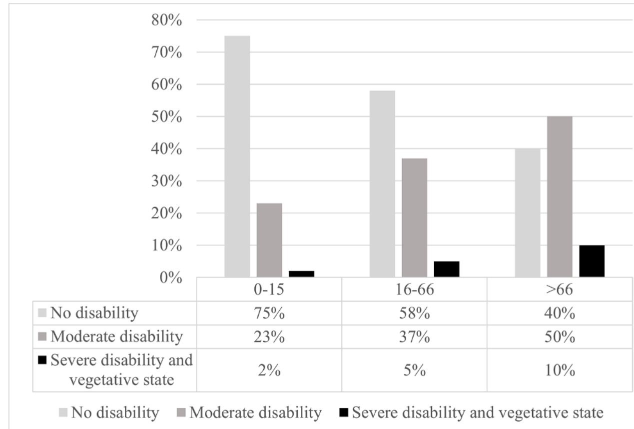

Fig. 5. Functional outcome, measured by Glasgow Outcome Scale (GOS), according to age groups.

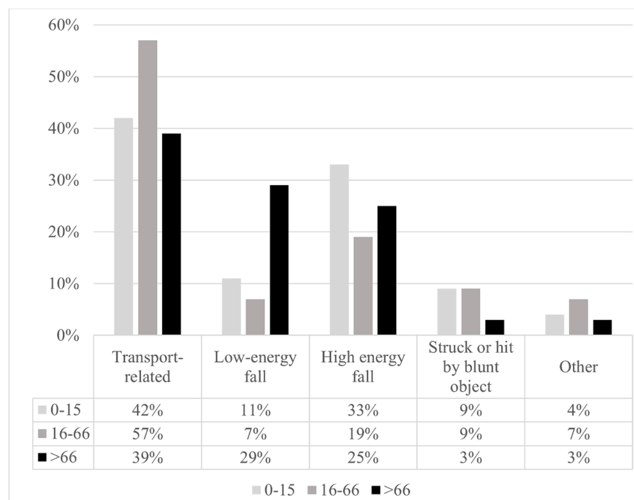

Fig. 6. Injury mechanism according to age groups.

Morbidity model

Children

We found that for every minute increase in total prehospital time, the odds ratio of experiencing moderate disability compared with the group without any disability was 1.005. If we calculate the odds ratio for every 30-minute increase in total prehospital time, we find an odds ratio of 1.2, meaning 20 % higher odds. This association was not significant when comparing the group with severe disability or vegetative state to the group without any disability (table 6). Incurring injuries in urban areas, as opposed to remote areas, was found to be associated with higher odds of experiencing moderate disability in comparison to having no disability (OR = 2.6). However, centrality was not associated with severe disability or vegetative state (table 6).

Adults

We found that for every minute increase in total prehospital time, the odds ratio of experiencing moderate disability compared with the group without any disability was 1.002. If we calculate the odds ratio for every 30-minute increase in total prehospital time, we find an odds ratio of

Table 6
Multinomial logistic regression with discharge GOS as dependent variable and with reference category "no disability" among children (age 0–15).

Independent variables		Moderate disability			Severe disability or vegetative state		
		Odds ratio	95 % CI	p-value	Odds ratio	95 % CI	p-value
Total prehospital time*		1.005	1.002–1.01	< 0.001	1.00	0.99–1.01	0.4
Age		1.03	1.01–1.06	0.004	0.99	0.92–1.08	0.9
NISS		1.17	1.15–1.19	< 0.001	1.28	1.24–1.32	< 0.001
Centrality index	Urban	2.56	1.87–3.50	< 0.001	1.28	0.37–4.47	0.7
	Suburban	1.21	0.91–1.62	0.2	1.74	0.59–5.13	0.3
	Remote	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Gender	Male	1.18	0.97–1.43	0.1	1.63	0.78–3.39	0.2
	Female	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

Reference category: no disability.
CI = Confidence interval.
NISS = New injury severity score.
For the continuous variables total prehospital time, age and NISS the multivariable adjusted odds ratio is given for one unit increase in the independent variable. For total prehospital time unit is minutes.
Nagelkerke R^2 for the model = 0.29.
The model is adjusted for injury mechanism.
*Time cut-offs were applied in the calculation of total prehospital time:.
Response time ≤ 120 min, on-scene time ≥ 5 min or ≤ 120 min, and transport time ≥ 5 min or ≤ 360 min.

Table 7
Multinomial logistic regression with discharge GOS as dependent variable and with reference category "no disability" among adult patients (age 16–66).

Independent variables		Moderate disability			Severe disability or vegetative state		
		Odds ratio	95 % CI	p-value	Odds ratio	95 % CI	p-value
Total prehospital time*		1.002	1.002–1.003	< 0.001	1.0	0.998–1.002	0.8
Age		1.011	1.009–1.013	< 0.001	1.01	1.01–1.02	< 0.001
NISS		1.16	1.15–1.17	< 0.001	1.28	1.27–1.29	< 0.001
Centrality index	Urban	2.3	2.0–2.5	< 0.001	0.9	0.6–1.1	0.3
	Suburban	1.4	1.3–1.6	< 0.001	1.0	0.8–1.3	0.8
	Remote	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Gender	Male	1.1	1.0–1.2	0.06	1.0	0.8–1.2	0.9
	Female	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
ASA	ASA 1–2	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
	ASA 3–4	1.0	0.8–1.3	0.7	1.6	1.1–2.5	0.01

Reference category: no disability.
CI = Confidence interval.
NISS = New injury severity score.
ASA = The American Society of Anaesthesiologists' (ASA) physical status classification system.
For the continuous variables total prehospital time, age and NISS the multivariable adjusted odds ratio is given for one unit increase in the independent variable. For total prehospital time unit is minutes.
Nagelkerke R^2 for the model = 0.39.
The model is adjusted for injury mechanism.
*Time cut-offs were applied in the calculation of total prehospital time:.
Response time ≤ 120 min, on-scene time ≥ 5 min or ≤ 120 min, and transport time ≥ 5 min or ≤ 360 min.

1.06, meaning 6 % higher odds. This association was not significant when comparing the group with severe disability or vegetative state to the group without any disability (table 7). Incurring injuries in urban and suburban areas, as opposed to remote areas, was found to be associated with higher odds of experiencing moderate disability in comparison to having no disability (OR = 2.3 and OR = 1.4 respectively). However, centrality was not associated with severe disability or vegetative state (table 7).

The elderly

We found that total prehospital time was not associated with either moderate disability or severe disability or vegetative state (table 8). Incurring injuries in urban areas, as opposed to remote areas, was found to be linked with higher odds of experiencing moderate disability in comparison to having no disability (OR = 1.5). However, urban areas were found to be associated with lower odds of experiencing severe disability or vegetative state compared with patients with no disability (OR = 0.6) (table 8). The inverse of this odds ratio is equal to 1.7, meaning that patients in remote areas had 70 % higher odds of severe disability or vegetative state, rather than no disability, compared with patients in urban areas.

Control variables

Gender was not associated with outcome among children and adults, but in elderly patients, male gender was associated with a lower odds of severe disability and vegetative state compared with no disability (OR = 0.7). The inverse of this odds ratio is equal to 1.4, meaning that elderly female patients had 40 % higher odds of severe disability or vegetative state compared with elderly male patients. Among adults and elderly patients, a preinjury ASA of 3 or 4 was associated with higher odds of severe disability or vegetative state, compared with the groups without any disability. Preinjury ASA was not included in the regression model for children. Furthermore, we found that across all age groups, NISS demonstrated the strongest association as a predictor of worse outcomes (tables 6, 7 and 8).

Discussion

Summary

The first objective of this study was to investigate the distribution of functional outcomes in the Norwegian trauma population. Firstly, we found no large differences in the distribution of functional outcomes in

Table 8
Multinomial logistic regression with discharge GOS as dependent variable and with reference category “no disability” among elderly patients (age >66).

Independent variables		Moderate disability			Severe disability or vegetative state		
		Odds ratio	95 % CI	p-value	Odds ratio	95 % CI	p-value
Total prehospital time*		1.002	1.0–1.003	0.06	1.001	0.999–1.004	0.4
Age		1.01	1.0–1.02	0.06	1.03	1.01–1.05	0.003
NISS		1.12	1.11–1.14	< 0.001	1.22	1.21–1.24	< 0.001
Centrality index	Urban	1.5	1.1–1.8	0.002	0.6	0.4–0.9	0.008
	Suburban	1.0	0.8–1.3	0.9	0.8	0.5–1.1	0.1
	Remote	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Gender	Male	0.9	0.8–1.1	0.2	0.7	0.5–0.9	0.008
	Female	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
ASA	ASA 1–2	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
	ASA 3–4	1.2	1.0–1.5	0.04	2.1	1.6–2.9	< 0.001

Reference category: no disability.
CI = Confidence interval.
NISS = New injury severity score.
ASA = The American Society of Anaesthesiologists’ (ASA) physical status classification system.
For the continuous variables total prehospital time, age and NISS the multivariable adjusted odds ratio is given for one unit increase in the independent variable. For total prehospital time unit is minutes.
Nagelkerke R^2 for the model = 0.34.
The model is adjusted for injury mechanism.
*Time cut-offs were applied in the calculation of total prehospital time:.
Response time ≤ 120 min, on-scene time ≥ 5 min or ≤ 120 min, and transport time ≥ 5 min or ≤ 360 min.

urban, suburban and remote areas, and the majority of trauma patients had no disability (urban 47 %, suburban 56 %, remote 56 %) or moderate disability (urban 48 %, suburban 38 %, remote 37 %) at discharge. Secondly, among patients with no disability the majority of patients had a low NISS, whereas among patients with severe disability or vegetative state the majority had a high NISS. The injury mechanism with the highest proportion of patients with severe functional impairment at discharge was fall injuries, whereas the injury mechanism with the highest proportion of patients with no disability at discharge was transport-related injuries. Transport-related injuries were most common among adults, while fall-related injuries were most common among children (high-energy falls) and the elderly (low-energy falls).

The secondary objective was to assess the association between total prehospital time and urban-remote disparities and trauma morbidity. Among children and adults, we found that every minute increase in total prehospital time was associated with higher odds of moderate disability. Total prehospital time was, however, not associated with severe disability or vegetative state. Among all age groups, urban areas were associated with higher odds of moderate disability. Suburban areas were also associated with higher odds of moderate disability among adult patients, whereas among elderly patients, remote areas were associated with higher odds of severe disability or vegetative state. As a secondary finding, NISS was strongly associated with a worse functional outcome among all age groups.

GOS distribution and morbidity model

We found that the majority of trauma patients in Norway today are discharged with minimal change in functional outcome. Approximately 7.5 % of patients in the NTR were uninjured (NISS = 0) (Fig. 3), and these patients are excluded from our analyses. Among the investigated trauma population, the median NISS was 5 (table 4), indicating that the majority of patients had a low severity of injury. Also, approximately 50 % of the trauma population in each area were discharged with no disability (table 5). Generally, this is in line with global estimates of short- and long-term disability incidents after injury [22–23]. Similar findings regarding the distribution of functional outcomes among trauma patients were also observed in a previous study examining the impact of advanced life-support on trauma outcomes, where the majority of patients exhibited a favourable recovery upon discharge [6]. It is important to note that the latter study specifically included patients with an ISS above 12. Surprisingly, despite the use of advanced life-support techniques, no significant differences in trauma morbidity were found between the basic life-support and the advanced life-support groups [6].

Our analyses revealed that patients with severe injuries (NISS > 15) experienced the greatest decline in function, although they constituted a minority. Additionally, in our regression models, the NISS was the strongest predictor of worse outcomes (tables 6, 7 and 8). This is not surprising, given that injury severity is a well-established predictor of mortality in trauma populations [24]. Another noteworthy finding was the correlation between injury mechanisms and the distribution of functional outcomes. We found that the injury mechanism with the highest proportion of patients with severe functional impairment at discharge was falls (Fig. 4). Brain injuries are commonly linked to fall incidents, and based on the assessment of disability caused by such injuries, they are associated with increased short- and long-term disability [22–23]. The injury mechanism with the highest proportion of patients with no disability at discharge was transport-related injuries (Fig. 4). This may be attributed to recent advancements in traffic safety and car safety measures.

The critical period from the moment of injury to the initiation of definitive medical care has been shown in the trauma literature to influence patient outcomes [25]. Although multiple factors converge to reinforce this relationship, prehospital time has repeatedly shown to be a predictor of trauma outcomes [25–26]. Considering the trauma literature’s predominant focus on survival outcomes, we consider our morbidity study to be an important contribution. Moreover, within other medical disciplines, there is little research on the relationship between prehospital time and functional outcome.

Based on our study sample, we discovered an association between total prehospital time and poorer outcomes among children and adults, even after adjusting for factors such as injury severity, urban-remote disparities, and injury mechanism (tables 6 and 7). In children, a 30-minute increase in total prehospital time resulted in 20 % higher odds of moderate disability compared with no disability, while in adult patients, a 30-minute increase in total prehospital time resulted in 6 % higher odds of moderate disability compared with no disability. It’s worth noting that previous research also has highlighted the correlation between prolonged on-scene time and prehospital stabilizing procedures [26]. Consequently, we can assume that patients with severe injuries requiring prehospital stabilizing interventions often experience prolonged on-scene times and therefore prolonged total prehospital time. Furthermore, in a prior study investigating outcomes following TBI, shorter response time was identified as one of the predictors for improved outcomes, as indicated by higher scores on the Glasgow Outcome Scale Extended (GOSE) [9]. In contrast, two studies on patients with TBI found no association between unfavourable outcomes (GOS 1–3) at 3 months and 6 months and a total prehospital time of more than an hour [7,10].

To our knowledge, no previous study has investigated the association between urban-remote disparities and morbidity outcomes. As in most trauma outcome literature, the investigations predominantly focused on mortality associations. Our findings indicate that across all age groups, patients injured in urban areas had a higher likelihood of experiencing moderate disability when compared to patients in remote areas (tables 6, 7 and 8). Although the injury severity across all areas were approximately the same, the higher odds of moderate disability in urban areas might be explained by different injury mechanisms (or injury types). We see from table 4 that injury mechanism distribution in urban areas differs from suburban and remote areas. Remote areas were associated with the greatest decline in functional status, although only among elderly patients (table 8). This discrepancy persists even after adjustments for a range of crucial control variables, including prehospital time, injury mechanism, injury severity and preinjury health status.

Previous studies have found that patients who sustain severe injuries in remote areas face an elevated risk of mortality compared to patients in urban areas [27–28]. This discrepancy could be of relevance in our study where patients who might have otherwise experienced a decline in functional status in remote areas die of their injuries before receiving critical medical interventions in a timely manner like patients in urban areas.

Nevertheless, our model-based exploration underscores the possible significance of geographical location in influencing the likelihood of functional impairment following trauma. Further research on underlying factors that explain this relationship is warranted, especially analyses of different injury types and correlations with outcome. Prospective and/or follow-up studies to compare short-term and long-term outcomes in trauma patients are valuable for evaluating the trauma system. Studies assessing the quality of life at 6–12 months after injury would also be useful in the evaluation of trauma treatment, in addition to uncovering possible differences in rehabilitation treatment between urban and remote areas.

Limitations

In large registry studies, the potential for type 1 errors exists. As with other registry-based studies, the potential for selection bias must be acknowledged. To limit selection bias, our analysis included particularly relevant covariates, aiming to “control” this impact [29]. This is especially relevant in the regression model, where our primary focus was to uncover statistical relationships between predictors and outcome variables. Another weakness in our study is the GOS assessment at discharge. We are aware that it is of high value to assess GOS scores after a certain time (6 months +). In the Utstein template, the discharge GOS score was the only one that was feasible to register and is therefore what is included in the NTR. Although our discharge GOS scores might not accurately predict long-term functional outcomes following trauma in Norway, we believe it provides valuable information about short-term functional outcomes, especially as it is based on a national registry with high reliability.

Conclusion

In Norway, the majority of trauma patients are discharged with minimal change in functional outcome following injuries. Patients with severe injuries (NISS > 15) demonstrated the greatest decline in functional outcome. Falls were the primary cause of injuries resulting in the greatest loss of function. Every minute increase in total prehospital time was linked to an increased likelihood of moderate disability for children and adult patients. Incurring injuries in urban areas was found to be associated with higher odds of moderate disability among children and adults, while injuries in remote areas were found to be associated with higher odds of severe disability or vegetative state in elderly patients.

CRediT authorship contribution statement

IMW Nilsbakken: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **T Wisborg:** Conceptualization, Formal analysis, Supervision, Writing – original draft, Writing – review & editing. **S Sollid:** Conceptualization, Formal analysis, Supervision, Writing – original draft, Writing – review & editing. **E Jeppesen:** Conceptualization, Formal analysis, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

none

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