The Dutch nationwide trauma registry

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The Dutch nationwide trauma registry: The value of capturing all acute trauma admissions

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ABSTRACT

Introduction: Twenty years ago the Dutch trauma care system was reformed by the designating 11 level one Regional trauma centres (RTCs) to organise trauma care. The RTCs set up the Dutch National Trauma Registry (DNTR) to evaluate epidemiology, patient distribution, resource use and quality of care. In this study we describe the DNTR, the incidence and main characteristics of Dutch acutely admitted trauma patients, and evaluate the value of including all acute trauma admissions compared to more stringent criteria applied by the national trauma registries of the United Kingdom and Germany.

Methods: The DNTR includes all injured patients treated at the ED within 48 hours after trauma and consecutively followed by direct admission, transfers to another hospital or death at the ED. DNTR data on admission years 2007-2018 were extracted to describe the maturation of the registry. Data from 2018 was used to describe the incidence rate and patient characteristics. Inclusion criteria of the Trauma Audit and Research (TARN) and the Deutsche Gesellschaft für Unfallchirurgie (DGU) were applied on 2018 DNTR data.

Results: Since its start in 2007 a total of 865,460 trauma cases have been registered in the DNTR. Hospital participation increased from 64% to 98%. In 2018, a total of 77,529 patients were included, the median age was 64 years, 50% males. Severely injured patients with an ISS≥16, accounted for 6% of all admissions, of which 70% was treated at designated RTCs. Patients with an ISS≤ 15were treated at non-RTCs in 80% of cases.

Application of DGU or TARN inclusion criteria, resulted in inclusion of respectively 5% and 32% of the DNTR patients. Particularly children, elderly and patients admitted at non-RTCs are left out. Moreover, 50% of ISS≥16 and 68% of the fatal cases did not meet DGU inclusion criteria

Conclusion: The DNTR has evolved into a comprehensive well-structured nationwide population-based trauma register. With 80,000 inclusions annually, the DNTR has become one of the largest trauma

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databases in Europe The registries strength lies in the broad inclusion criteria which enables studies on the burden of injury and the quality and efficiency of the entire trauma care system, encompassing all trauma-receiving hospitals.

Introduction

Trauma registries have been established to collect comprehensive data for quality assessment, quality improvement and research purposes. These registries document a range of information on injured patients such as demographics, injury details, pre-hospital care, hospital presentation, interventions, and outcomes. Tohira et al. [1] identified 11 national trauma registries in 2011. Five of these National registries are in Europe of which the England and Wales, Trauma Audit and Research (TARN) registry and the German, Deutsche Gesellschaft für Unfallchirurgie (DGU) Trauma Register, are the most cited in European literature.

In- and exclusion criteria differ extensively between trauma registries. This results in significant differences in demographics between the selected cohorts [1,2]. Exclusion of trauma patients based on their age, injury type or mechanism from trauma registries result in an underestimation of resource utilisation and give limited view on the quality of trauma care and the epidemiology [3].

In 1999, the Dutch government decided to reform the trauma care system on behalf of the Dutch Trauma Society and designated ten level one Regional trauma centres (RTCs). These RTCs (eleven since 2008), in collaboration with ambulance services and regional hospitals, have managed to set up regionalized inclusive trauma systems [4]. The RTCs are fully equipped to deliver the highest level of emergency and surgical care for the most severely injured with 24/7 coverage of all specialities including thoracic and neurosurgery. Four RTCs are equipped with 24/7 Helicopter Emergency Medical Service (HEMS) and a Mobile Medical Team which is able to dispatch by helicopter or car [4]. Within the regional trauma systems all trauma-receiving hospitals have a direct linkage to a RTC, to facilitate expeditious transfer of injured patients within the network, to the hospital with the medical expertise and functional/instrumental capacity that matches their alleged resources.

The RTCs succeeded in implementing the Dutch National Trauma Registry (DNTR) in 2007. In this resource all acute trauma related hospital admissions are included, to evaluate the adequacy of the total system, and for quality benchmarking at national, regional and hospital level. Furthermore, injury epidemiology for targeted prevention and to monitor patient distribution, and patient flow to definitive care were evaluated.

The Dutch registry differs from other European national registries by capturing all acute trauma related hospital admissions regardless of their age, injury type or severity, resource use or length of stay. The primary aim of this study was to describe the Dutch National Trauma Registry, to illustrate its current status and to assess the impact of registering all acute hospital admissions of trauma victims in comparison to selected populations from national trauma registries in England, Wales and Germany.

Methods

Patients and dataset

The DNTR includes all injured patients directly admitted to the hospital through the Emergency Department (ED), transferred to another hospital, deceased during ER treatment, within 48 hours after trauma. Patients declared dead before hospital arrival or without vital signs upon arrival at the ED are excluded.

The DNTR dataset includes the items of the Major Trauma Outcome study (MTOS) as well as prehospital items [5]. In 2014 the dataset was extended to correspond to the Utstein template for uniform reporting of data following major trauma [6]. Up to 2014 injuries were coded according to the Abbreviated Injury Scale 1990, update 1998 [7]. As from 2015 the injuries are coded according to the Abbreviated Injury Scale 2005, update 2008 [8].

Data collection

The Netherlands encloses about 41.500 km^2 and counted 17.2 million inhabitants in 2018. The number of inhabitants varies between 750.000 and 2.5 million for the 11 trauma regions.

The DNTR is composed by the data collected in the 11 trauma regions. The RTCs coordinate these regional trauma registries. For the data collection the RTC's collaborate closely with the regional ambulance services, HEMS and non-RTC. Data collection is done by hired trained personnel or trained medical professionals, that work according to a strict protocol.

The DNTR is embedded in a web based relational database (SQL). A trusted third party secures privacy sensitive information and encrypts personal data. Data can be entered through an online data-entry application with plausibility checks or by import of an electronic file.

DNTR organization

For the DNTR a board, a scientific advisory committee, a data manager platform and a program manager have been appointed. Furthermore, the Dutch Trauma Centre Council, composed of leading trauma surgeons from the 11 RTCs, provide their advice for the trauma registry. One data manager per trauma centre, responsible for the coordination of the regional trauma registry, participates in the national data manager platform. Quarterly the platform discusses cases and definitions of data items to ensure consistency across the regional trauma registries. Furthermore, operational aspects of the data management system are discussed.

An online reporting tool is available for the participants including hospital, regional and national benchmark data. Furthermore, annual national and regional reports are published and handed out at a national conference about the trauma registry results. Finally, the RTCs have agreed on terms and conditions for scientific analyses on the national trauma registry database. The RTCs receive annual governmental funding to cover expenditures of DNTR infrastructure and wages, providing continuity in sustaining and developing the registry system.

Analyses

To describe the DNTR maturation we included all cases registered between 2007 and 2018. Annual hospital participation rate, i.e. percentage of hospitals contributing data to the DNTR, was calculated.

Data of the most recent admission year 2018 were selected for the description of the main patient characteristics, to examine the distribution of trauma patients to RTCs and non RTCs and to look at the value of including all acute hospital trauma admissions.

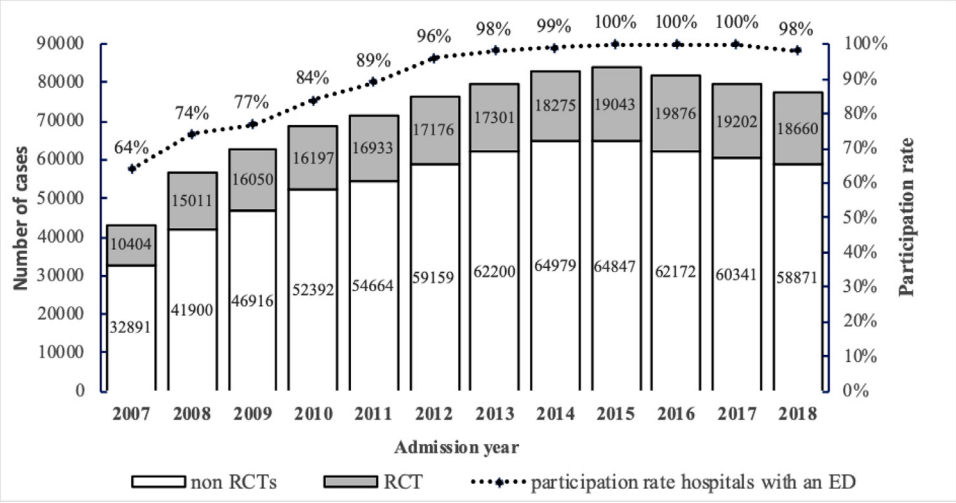

Fig. 1. Number of acute trauma admissions registered by the RTCs and non RTCs and participation rate EDs in the Dutch Trauma Registry, 2007–2018.

To describe and classify the sustained injury, the Revised Trauma Score (RTS) [9] and the Abbreviated Injury Score (AIS) [10] were noted and the injury Severity Score (ISS) [11] was calculated for each patients. Severely injured patients were defined as patients with an ISS ≥16. A subgroup of isolated hip fractures was defined as patients with an ISS 9-15 and a femoral neck fracture (853161.3; 853162.3) or an intertrochanteric femur fracture (853151.3;853152.3).

In the DNTR patients transferred within 48 h after the incident to another hospital are likely to be registered twice. For the distribution and incidence of patients admitted and treated in RTCs and non-RTCs, the patients who were secondarily transferred into hospital after ED treatment at another hospital were excluded.

To assess the value of registering all acute admissions, the inclusion criteria of the TARN and DGU Trauma Register were applied. The TARN inclusion criteria are described in detail in their procedures manual and are, in short, a significant injury, admission for >72 h, admission to a high-dependency area, or death following arrival at hospital. Isolated fractures of the hip in patients ≥65 years are not registered within TARN [12]. To apply the selection criteria of a significant injury we consulted the TARN to select AIS2008 injury codes that were to be excluded if occurred in isolation (or with an accompanying skin injury). The official inclusion criteria for documenting a patient in the Trauma Register DGU (DGU) are admission via the shock room and in need for intensive care treatment or death before ICU admission [13]. We applied the DGU criteria by selecting the DNTR patients who were presented at the ED and were either directly admitted to the ICU or directly to the operating room and also had ICU treatment or died at the ED.

Statistical analysis was performed using IBM SPSS statistics 24. The Chi-square and the Mann-Whitney-*U* test were performed to analyse significant differences in patients characteristics. A *p*-value of <0.05 was considered as significant. Data are presented as mean, as interquartile range (IQR) and as absolute numbers and percentages.

Missing variable values were considered as not available for analysis. No method for imputation of missing data was performed. Percentages presented within the tables were calculated without missing values. Percentage of missing values for the respective variables are presented in the footnotes of the tables.

Results

From 2007 to 2018 a total of 865,460 trauma cases were registered in the DNTR. In 2007 64% of all Dutch hospitals with an ED participated. As from 2008 all 11 RTCs centres provide data for the registry. The participation rate increased to 100% in 2015 as shown in Fig. 1. In 2018 two non RTCs did not participate due to closure and issues with data-extraction from the electronic patients files.

In 2018 a total of 77,531 acute trauma admissions were registered of which 3,850 patients (5%) were transferred from another hospital and are likely to have been registered twice. Excluding these patients resulted in an incidence rate of 429 acute trauma admissions per 100,000 inhabitants in 2018.

Table 1 shows the main characteristics for all cases and the subgroups of patients treated in the RTCs and non RTCs in 2018. Half of the injured patients (50%) concerned males. Males had a median age of 48 years (IQR, 22-73) versus a median age of 63 years (IQR, 50-85) for females. The overall median age was 56 years (IQR, 29-81). In 2018, 43% of the patients concerned elderly ≥ 70 years of age of whom 57% were females.

Overall, non-RTC's treated 80% of all cases. In comparison to regional hospitals the patients treated in the RTCs were averagely younger (49 vs 58, $p<0.001$) and more often males (58% vs 47%, $p<0.001$) Furthermore RTC patients were more often, transported by ambulance (74% vs 68%, $p=0.013$), more severely injured with an ISS ≥16 (2,4% vs 17,5%, $p<0.001$), more often admitted to ICU (18% vs 5%, $p<0.001$), and had a higher in-hospital mortality (4% vs 2%, $p<0.001$) than the trauma patients treated in the non RTCs.

In 2018, there were 1,867 trauma related in-hospital deaths in the Netherlands. Overall incidence of in-hospital deaths after trauma was 11 per 100,000 population. Overall in-hospital mortality rate of acute trauma admission was 3% and respectively 2% and 4% in non-RTCs and RTCs.

Patients with an ISS≥16 had an overall in-hospital mortality rate of almost 17%. Severely injured patients with an ISS≥16, most frequently sustained an extremity injury (69.0%) followed by head and thorax injuries with respectively 16.3% and 16.1%.

Almost one out of every four patients (22.5%) concerned a patient with an isolated hip fracture, of which in 66.0% were females. Of the patients with an isolated hip fracture 79.0% were ≥ 70 years of age, and 88.0% of these cases were treated in a non-RTC.

Table 1
Main characteristics acute trauma admissions in the Netherlands (n=77.531).

		All cases	Non RTC	RTC
Total 2018		77531	58871	18660
Age	Age median (IQR)	56 (29-81)	58 (33-83)	49 (23-74)
	Children (≤15 years)	16.5%	16.2%	17.5%
	Elderly (≥ 70 years)	43.2%	47.2%	30.8%
Gender (%)	Male	49.8%	47.2%	58%
Injury cause (%)	Home and leisure	60.5%	68.6%	53.2%
	Traffic	20.4%	17.6%	29.1%
	Sport	6.1%	6.0%	6.2%
	Work	3.2%	2.7%	4.7%
	Assault	2%	1.5%	3.5%
Transportation (%)	Ambulance	70.8%	68.0%	74.0%
Referrer (%)	Ambulance	54.0%	51.1%	63%
	GP	28.5%	32.8%	15.2%
	Self-referrer	8.5%	7.5%	12.1%
Mechanism of injury (%)	Blunt	91.2%	90.0%	94.8%
ISS	ISS median (IQR)	6.9 (4–9)	6 (3–9)	9.5 (4–10)
	ISS ≥16	6.0%	2.4%	17.5%
AIS	Head ≥3	6.8%	4.0%	15.6%
	Thorax ≥3	6.7%	4.5%	13.9%
	Extremities ≥3	28.8%	31.6%	20.0%
Hip fracture (%)	Hip fracture ISS 9-15	22.5%	25.9%	19.7%
Hospital LOS	Days median (IQR)	6 (2–8)	5.8 (2–7)	7.2 (2–8)
ICU admission (%)		7.8%	4.6%	17.9%
ICU LOS	Days median (IQR)	4.7 (1–4)	3.2 (1–3)	6.0 (2–6)
Hospital mortality (%)		2.5%	1.9%	4.4%

Abbreviations: RTS, Revised Trauma Score; ED, Emergency Department; ICU, Intensive Care Unit; ISS, Injury Severity Score; GOS, Glasgow Outcome Scale. Missing values: ICU stay (3.4%); referrer (4.1%); transportation (5.7%); mechanism injury (5.8%), injury cause (6.4%).

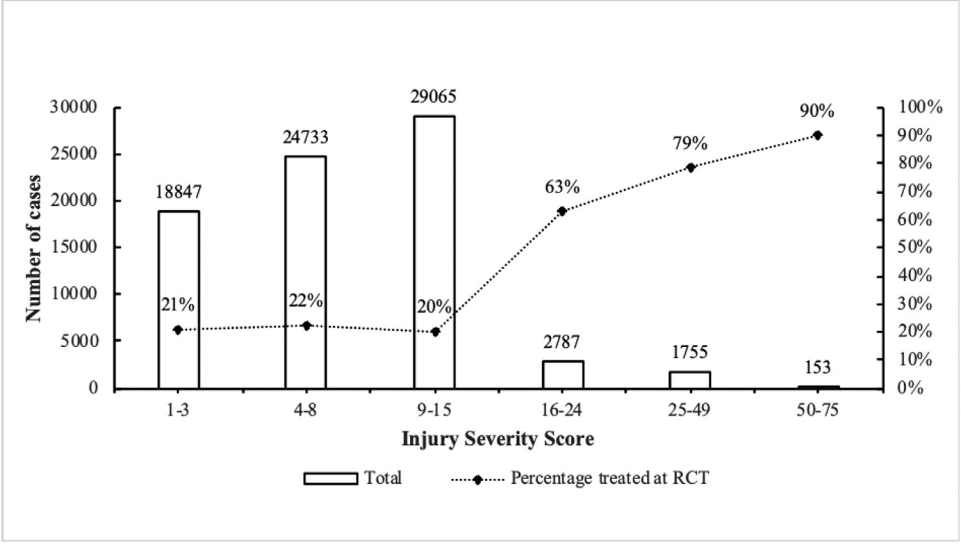

Fig. 2. ISS distribution and percentage treated at RTC.

Fig. 2 shows the distribution of patients to RTCs and non RTCs by injury severity after exclusion of the transfers in. The proportion treated at a RTC increases with increasing injury severity. Patients with an ISS≥16 were received primary treatment (70.0%) at designated RTCs.

Value of including all admissions

Overall, respectively, 5% and 32% of the DNTR patients met DGU or TARN inclusion criteria. Table 2 displays the number of DNTR patients for specific items as; ISS- and RTS-score, age, IC admission, hospital mortality, and Glasgow outcome scale at discharge. Furthermore it shows which percentage of these patients would have been included after application of the DGU and TARN inclusion criteria. The table shows that, next to less severely injured patients, relatively large proportions of especially children, adolescents and elderly are not registered if DGU and TARN inclusion criteria are applied.

Regarding mortality, respectively 32% and 64% of fatal cases recorded in the DNTR, would have been included when DGU/TARN inclusion criteria would have been applied. Of these otherwise left out casualties, respectively 92% and 81% were ≥70 years old of whom 55% and 30% had a diagnosis other than an isolated hip fracture.

Fig. 3 shows that with increasing ISS, the degree of patients included in the TR-DGU and TARN increases.

Missing data

The quantity of missing data differed between variables and hospitals. The overall missing values per variable are displayed below the associated table. Missing values used in this study, that

Table 2
Number DNTR cases for specific subgroups included after application TARN and DGUTR inclusion criteria.

	DNTR	Number (%) DNTR cases included by DGU inclusion criteria	Number (%) DNTR cases included by TARN inclusion criteria
Total	77531	4167 (5%)	24795 (32%)
RTS ED ≤ 10	1239 (16%)	750 (60%)	922 (74%)
ICU admission	6019 (8%)	4082 (68%)	4827 (80%)
ISS ≥ 16	4695 (6%)	2331 (50%)	4448 (95%)
Fatal cases	1955 (2.5%)	628 (32%)	1258 (64%)
GOS discharge <5	36976 (47%)	2864 (77%)	14595 (39%)
Age ≤ 19	15046 (19%)	612 (4%)	1807 (12%)
Age 20–49	13103 (17%)	1281 (10%)	4736 (36%)
Age 50–69	15793 (20%)	1183 (75%)	7298 (46%)
Age ≥70	33521 (43%)	1090 (3%)	10926 (32%)

Abbreviations: RTS, Revised Trauma Score; ED, Emergency Department; ICU, Intensive Care Unit; ISS, Injury Severity Score; GOS, Glasgow Outcome Scale.

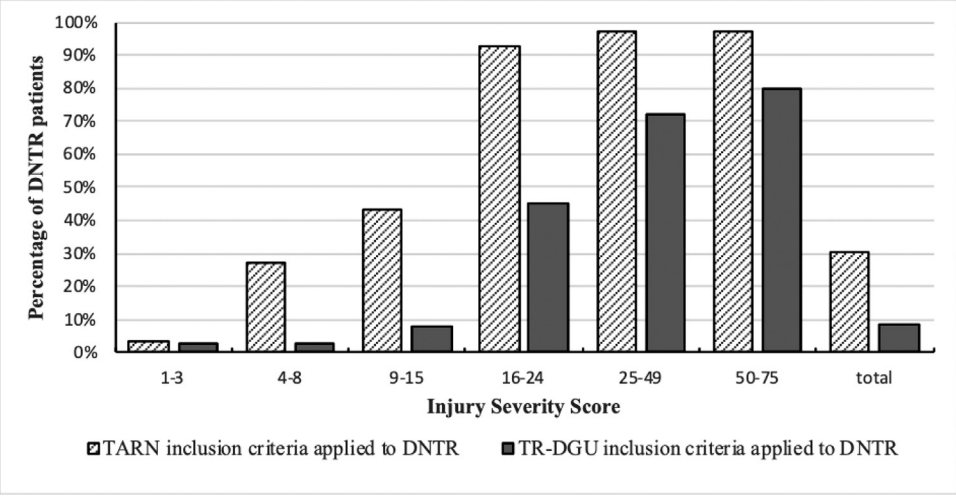

Fig. 3. Percentage of DNTR included patients per ISS subgroup, after application of TR-DGU and TARN inclusion criteria.

were missing in more than five percent of patients were; transportation (5.7%); mechanism injury (5.8%), injury cause (6.4%), RTS ED (49%).

Discussion

In this paper we present the Dutch Trauma Registry, which is a comprehensive trauma database encompassing all acutely admitted trauma patients in all hospitals with an ED, in the Netherlands. One of the key elements of the successful implementation of the DNTR is the fact that it was initiated and is supported by the trauma surgeons at the RTCs. The bureaus at the RTCs play an essential role in reaching full participation of the regional hospitals and in the quality assurance of the data.

Our study demonstrates the value of capturing all acute trauma admissions. Application of more stringent inclusion criteria, such as those of the TARN and DGU, result in a very restricted view on the magnitude and impact of injury. For instance large percentages of children and elderly would be left out, when solely focussed on severely injured patients. Moreover, fatalities, functional outcomes (i.e. Glasgow Coma Scale in our study) and resource use would be largely underestimated and outcome evaluations is incomplete. Also, including all acute trauma admissions (in all hospitals) is a prerequisite to evaluate trauma system performance in terms of getting the patient at the right place at the right time. This is an essential part of inclusive trauma systems. Finally, data collected when broad inclusion criteria are applied, which among others things enables policy-makers to make weighted decisions on injury prevention and control, workforce and financial resource allocation.

We specifically want to derive attention to the importance of including elderly (≥70) in view of an ageing population and the frailty of this group. Over the last twenty years, an increase has been observed in the incidence of major trauma in elderly. [14,15]. Elderly patients represent an increasingly larger proportion of hospital trauma admissions [16,17]. The physiological response to trauma in older adults is different from that in the young [18,19]. Furthermore, prehospital triage tools are relatively insensitive for identifying high-risk elderly trauma patients, which leads to a high under triage rate in elderly trauma patients [20,21]. All leading to a relatively high mortality in this group, and association with worse non-fatal outcomes after traumatic injury regardless of injury severity [15,19,24].

In this study we applied the inclusion criteria of two well-known national registries in Europe, i.e. the German (TR-DGU) and UK (TARN). Outside Europe, large and well-known trauma registries are the US National Trauma Data Bank (NTDB) and the Australian New Zealand Trauma Register (ATR). The NTDB is the largest trauma data repository in the world, it contains prehospital and in-hospital data on 7,5 million trauma patients. In general, the DNTR inclusion criteria are in line with the NTDB criteria including trauma hospital admissions, patient transfers and deaths resulting from traumatic injury [22]. The DNTR differs from the NTDB by an additional criterion treatment at the ED previous to hospitalization, a defined maximum of 48 hours between the incident and ED presentation and the Dead on arrival are nog registered in the DNTR

[22]. International comparison is restricted due to the fact that the NTDB partly consists of voluntarily submitted data, as only trauma centres verified by the American college of Surgeons are obliged to submit data [21,22]. Moreover a significant variability of in- and exclusion criteria between participating hospitals in the NTDB, results in selection bias, making comparison of outcome impossible and not nationally representative [20,22,28–30].

The ATR is a bi-national register with over 8,000 records annually. Only including patients presenting to one of the 24 level one designated or equivalent trauma centres across Australia who subsequently died after injury. Or patients who sustained major trauma, defined as trauma patients with an ISS $\geq$12 (using the AIS08) [23]. They exclude patients with a delayed admission (>7days), poisoning, drug of foreign body ingestion that did not cause injury, isolated femoral neck fractures and older adults (>64 years of age) who died with superficial injuries only [24].

Although it is set-up nicely, the most obvious limitation is that data only applies to level one trauma centres and restricted to major trauma injuries. And not linked to non-trauma centre data, prehospital/scene data and post discharge data. Furthermore they lack data on elderly trauma patients which is of significant importance as advocated earlier [25].

The DNTR has limitations. Whenever in- and exclusion criteria are applied, there are patients being left out. For the DNTR it was a conscious choice to focus only on the acutely admitted patients. One can argue if patients that receive primary treatment in de ED and undergo semi-elective wrist, elbow or ankle surgery a few days later should be included. Compared to acute trauma admissions, these patients require a different approach for trauma care and outcome evaluation they are not registered in the DNTR. The quantity of these patients and their impact on medical resource use, remains unclear.

Secondly, by registering all trauma patients admitted within 48 h after trauma, the demand on data managers is high. At the moment, more extensive datasets, such as for instance the DGU and TARN datasets, including comorbidities, consulted practitioners and laboratory findings would pose to larger workload.

Thirdly, outcome should be more elaborate than mortality. Starting with measuring the impact of trauma on the 97% non-fatal trauma patients. Recent studies on patients reported outcome measures after injury, have shown that trauma patients are significant impaired on mobility, self-care and pain up to one year after trauma [26,33].

Lastly, DNTR numbers on missing data show that there is room for improvement on completeness and consistency of registration in the Netherlands and registries in general [31].

To address these issues in the future, the DNTR and other Trauma registries should move away from labour-intensive and inefficient data entry and strive for more automated techniques based on electronic health record data and other existing platforms [20,32]. Hereby reducing the number of missing values, lowering the workload and expanding datasets.

To compare the burden of injury we need to compare it as if it were a disease and focus on functional outcomes, quality of life and disability adjusted life years [27].

Ideally a standardized international data script should be implemented, were data can be compared across countries and even continents. All reflecting a desire to address, understand, and optimize care for trauma patients across the world [32–34].

Finally, we find it important to demonstrate that injuries are a major health problem. The DNTR reports over 80.000 acute trauma admissions. This exceeds the sum of hospital admissions for important acute illnesses such as stroke (41,203 in 2018) and acute myocardial infarction (33,849 in 2018) in the Netherlands [35]. These figures emphasize the impact of trauma and hopefully draw the attention on prevention and the resources needed for trauma care.

Conclusion

The DNTR has evolved into a comprehensive well-structured nationwide population-based trauma register. With an annual number of 80,000 cases being entered in the database the DNTR has grown to be one of the largest trauma databases in Europe. The registries strength lies in the broad inclusion criteria which enables studies on the burden of injury and on the quality and efficiency of the entire trauma care system encompassing all trauma-receiving hospitals.

Declaration of Competing Interest

None.

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