

## ORIGINAL ARTICLE

# Numbers of Severely Injured Patients in Germany

A Retrospective Analysis From the DGU (German Society for Trauma Surgery) Trauma Registry

Florian Debus, Rolf Lefering, Michael Frink, Christian Alexander Kühne, Carsten Mand, Benjamin Bücking, Steffen Ruchholtz and the TraumaRegister DGU

## SUMMARY

**Background:** Persons who sustain severe traumatic injury, i.e., those with an Injury Severity Score (ISS) of 16 or above, go on to suffer major physical, emotional, and socio-economic consequences. It is important to know the incidence of severe trauma so that these patients can be cared for optimally.

**Methods:** Data from the year 2012 on severely injured persons with an ISS of 16 or above were obtained from the trauma registry of the German Society for Trauma Surgery (DGU) and analyzed. Further information was obtained from the database of the DGU trauma network. The annual incidence of severe trauma was estimated from these data in three different ways.

**Results:** An extrapolation of hospital-based data to the German population yielded a figure of 16 742 severely injured persons per year. A population-based estimate from the German federal state of Bavaria yielded a figure of 16 514/year, while an area-based extrapolation using data from 17 established networks yielded a figure of 16 554/year. We added 10% to each of these figures as a correction for assumed underreporting. We conclude that the number of persons who sustained a severe traumatic injury in Germany in 2012 lay between 18 209 (95% confidence interval [CI]: 17 751–18 646) and 18 416 (95% CI: 18 156–18 695). This corresponds to an incidence of 0.02% per year.

**Conclusion:** Data from a prospectively maintained nationwide trauma registry were used for the first time to calculate the annual incidence of severe traumatic injury in Germany: the expected number of severely injured persons per year is 18 200–18 400. Previous extrapolations yielded values in the range of 32 500–35 300. A high variability of documentation practices among supraregional trauma centers may have distorted the estimate, along with other factors. The figures were not normalized for age or sex.

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Severely injured patients are treated by pre-hospital emergency medical services and in-hospital emergency departments on a daily basis in Germany (1, 2). Often, young and otherwise healthy patients are affected, usually with severe sequelae (3). Polytrauma therefore has not only serious medical consequences but also high socioeconomic implications (4).

To improve the care of severely injured patients, the German Society for Trauma Surgery (DGU, Deutsche Gesellschaft für Unfallchirurgie) founded the trauma network *TraumaNetzwerk DGU* (TNW-DGU). Following the guidelines given in the Whitebook *Medical Care of the Severely Injured*, hospitals nationwide are being certified according to defined standards (5). Currently, 608 trauma centers (TC) in 51 regional trauma networks (TNW) provide an almost complete coverage for certification nationwide (as of April 2015) (*Figures 1 and 2*). In the future, about 50 hospitals nationwide that are not currently certified are expected to join. Hospitals participating within a TNW document the severely injured patients centrally in the DGU Trauma Registry (TraumaRegister [TR]-DGU). In addition to their importance for the clinical practice, TNW and TR-DGU have also provided data for many quality publications in recent years (6–10).

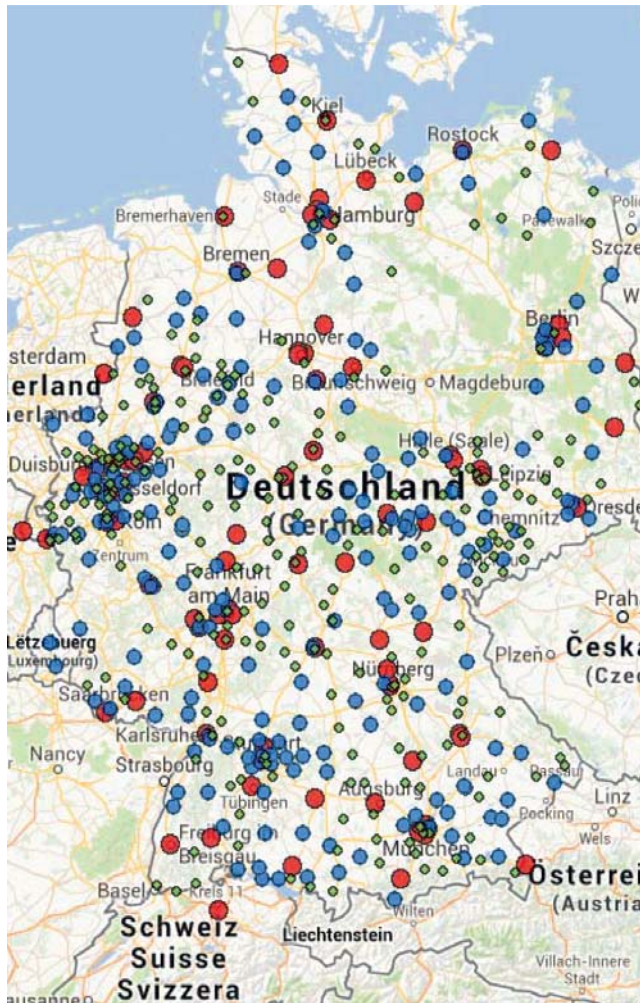
Despite their clinical importance and intense scientific scrutiny, the exact number of severe injuries that occur annually is still not known. When the TNW-DGU and TR-DGU were founded, only two publications, from 2000 and 2006, addressed the number of severe injuries in Germany (11, 12). In fact, recent publications still used these works to estimate the number of severely injured patients. Therefore, the data used to determine management planning for treating severely injured patients and for making resources available to each TC—both of which are associated with considerable costs and much organizational effort—are not up-to-date.

In recent years, increased emphasis has been placed on improving road traffic safety. We can therefore assume that this has also led to a decrease in the number of severe injuries. Now, using the large amount of prospectively collected data from the TR-DGU, we can determine for the first time how many patients actually sustain polytrauma.

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**Figure 1:** Certified trauma centers (TC) in the three different care categories. Local TC are indicated as small and green; regional TC, middle-sized and blue; and supraregional TC, large and red



**Figure 2:** Distribution of 17 established trauma networks (TNW) that had been certified by mid-2011 and their coverage areas. Color coding is provided for clarity only

**Methods**

We analyzed prospectively collected data from 13 040 patients from 430 TC of the TR-DGU. The inclusion criteria were an Injury Severity Score (ISS)  $\geq 16$  and being documented in a German TC in 2012. Patients who were promptly transferred were excluded.

The number of severely injured patients was extrapolated by three different methods:

- Hospital method: A total number was determined based on 1) the number of patients treated annually at different levels of care; and 2) the known number of certified and non-certified hospitals.
- Federal state method: A total number with respect to the population was calculated using the number of severely injured patients treated in Bavaria.
- Network method: A total number was calculated based on the number of severely injured patients from 17 trauma networks and the number of inhabitants/km<sup>2</sup>.

This work, with the TR-DGU project ID 2013–028, has been published according to TR-DGU guidelines.

A detailed description of the TR-DGU and the methods and statistical analysis used are given in the supplementary *eMethods*.

**Results**

**Hospital method**

The cases of severe injuries in 2012 documented in TR-DGU came from a total of 430 hospitals, of which 164 were certified as local TC (LTC), 177 as regional TC (RTC), and 89 as supraregional TC. Adjusting for the known number of not yet certified hospitals, we obtained an additional 204 LTC, 121 RTC, and 3 supraregional TC. By multiplying the caseload per hospital by the number of hospitals at each level of care, we calculated 1472 cases of seriously injured patients in the LTC, 7450 in the RTC, and 7820 in the supraregional TC (Table 1).

**TABLE 1**

**Overview of number of severely injured patients documented annually per hospital and care category\***

Care category	Average number of severely injured patients annually/hospital	Number of hospitals in TR-DGU	Number of non-certified hospitals	Estimated number severely injured patients/year
Local TC	4 (SD: 3.8)	164	204	1472
Regional TC	25 (SD: 16.9)	177	121	7450
Supraregional TC	85 (SD: 42.9)	89	3	7820
Total		430	328	16 742

\* Hospitals documented by the TR-DGU, and non-certified hospitals, in 2012. SD, standard deviation; TR-DGU, trauma registry of the German Society of Trauma Surgery (DGU); TC, trauma center

Accordingly, the hospital method resulted in a total number of 16 742 cases of severely injured patients. Assuming 10% underreporting in the documentation of severe injuries, we calculated a final number of 18 416 patients reported per year (95% confidence interval [CI], 18 137 to 18 695).

**Federal state method**

By the end of 2012, Bavaria had six certified regional trauma networks (TNW), which documented a total of 2367 severely injured patients with an ISS  $\geq$ 16. According to the Federal Statistical Office, Bavaria had 12 595 891 residents, which corresponds to 15.4% of the total German population (of 81 843 743 citizens). Based on this, the number of severely injured persons was extrapolated to the population in Germany. The resulting number of 15 379 severely injured persons was supplemented again by the potentially missing cases from non-certified hospitals in Bavaria for six LTC and eight RTC. Thus, the federal state method resulted in a total of 16 514 severely injured persons. This was increased by 10% to adjust for underreporting, giving a final number of 18 156 patients annually (95% CI, 17 471 to 18 837).

**Network method**

The 17 regional trauma networks documented 6386 severely injured patients in 2012. The areas covered by the trauma networks ranged from 892 km<sup>2</sup> (Berlin) to 16 820 km<sup>2</sup> (East Bavaria). The number of inhabitants per km<sup>2</sup> in the individual networks ranged from 177 per km<sup>2</sup> (Bavaria) to 3785 per km<sup>2</sup> (Berlin). By multiplying the number of inhabitants per km<sup>2</sup> for each TNW by the area covered by the respective TNW in km<sup>2</sup>, the population of the 17 regional networks taken together was determined to be 31 591 079, which is 38.6% of the total population of Germany. Accordingly, the number of 6386 seriously injured persons in the 17 regional net-

works was multiplied by 2.59 to estimate how many patients in Germany sustained polytrauma (*eTable*). After extrapolation, the network method resulted in a total number of 16 554 severely injured persons in Germany. Adjusting for the 10% underreporting gave a final number of 18 209 patients annually (95% CI, 17 751 to 18 646).

**Incidence rate**

An annual number of 18 200 to 18 400 severely injured patients from the total German population of 81 843 743 corresponds to an incidence rate of 0.02% per year.

**Discussion**

**Quality of data**

We were able to determine for the first time the number of severe injuries in Germany due to the nationwide registry with prospectively collected data from the TR-DGU. Despite its professional structure and the high quality of the data, the uncertainties of the results should be discussed, especially for the present extrapolation.

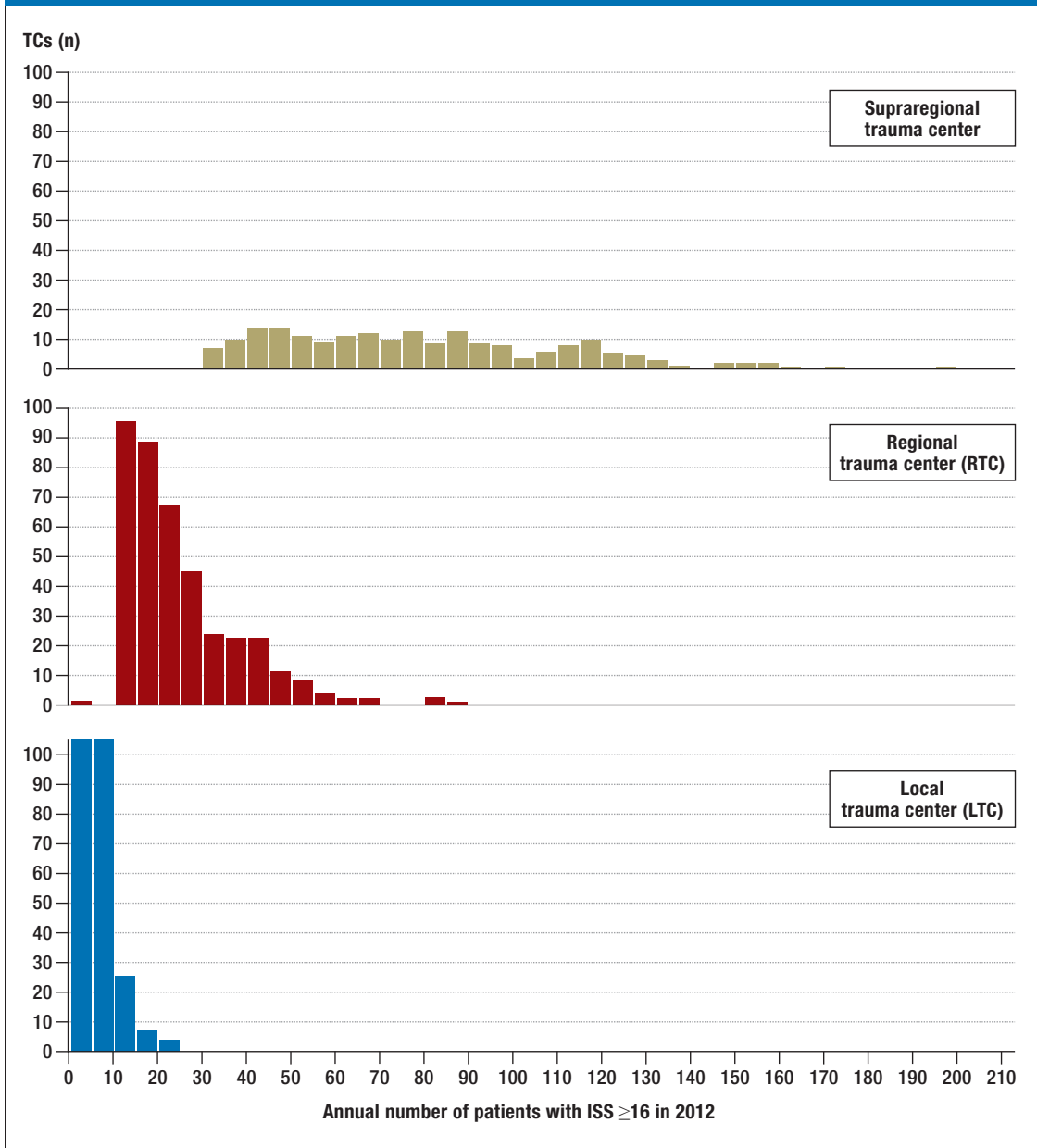
The minor differences between the various methods used to extrapolate could be due to the cross-correlation of data sets and thus be the result of a systematic error in the analysis. The possible advantages and disadvantages of each method, such as structural differences or variability between the various centers, are discussed below. As not all hospitals with emergency surgery capacity are currently registered in TNW-DGU, some hospitals were not considered in this analysis. However, it is unlikely that these few hospitals have high caseloads in their emergency departments, so that no significant changes in the results would be expected if they were to be included. It is very important however to consider the effects of structural differences, such as traffic volume or the population density of the various



**Frequency of distribution of severely injured patients by category of trauma center in the year 2012.**

TCs, trauma centers; ISS, Injury Severity Score

**FIGURE 3**



regions. Nonetheless, it is conceivable that such differences are balanced out in the overall evaluation without influencing the obtained results.

With respect to population density, internal analyses have shown that the various regions are very well represented within TR-DGU. Despite minor differences, there is a maximum variation of 3% between the population densities of the federal states (Bundesländer) and the patient distribution in the TR-DGU. With respect to the regional distributions of the evaluated TC, hospitals in the east are slightly underrepresented. This

is due to the fact that most TNW in the east were certified later and were not able to provide reliable data at the time of this evaluation. The lower population density in the new federal states may mean that a lower number of cases per hospital should be used under certain circumstances. However, Mand et al. (8) showed that there are no significant differences in trauma care between the eastern and western federal states of Germany. Furthermore, general variability between the individual TC should also be taken into account. This is especially true within a supraregional TC, which can

**TABLE 2**

**Comparison of the three methods used to extrapolate the number of severely injured patients**

	Hospital method	Federal state method	Network method
Estimated number of severely injured patients (ISS ≥16)	16 742	16 514	16 554
Adjusted for 10% underreporting	18 416	18 165	18 209

ISS, Injury Severity Score

have a high degree of variability in the number of documented cases, leading to a further distortion of the extrapolation (Figure 3). Nevertheless, as mentioned above, all TC are certified according to the DGU guidelines and meet minimum caseload requirements, so that they are comparable despite any variables. Since this study was designed to address the question about the total number of severe injuries and to extrapolate this from cases of actually treated trauma patients, rather than the general population, we deliberately omitted age and gender standardization of data. The patient collective for severely injured persons is adequately described; further details for this can be found in the annual reports of the TR-DGU. However, due to the high organizational efforts and the increasingly large amounts of data, not every case in the clinical practice can be fully documented in the TR-DGU, which leads to underreporting. Based on expert opinions from internal surveys among those responsible in 50 hospitals for documentation in the TR-DGU, this underreporting is currently estimated to be 10%. Thus, taking into account a 10% underreporting in our analysis, we calculate that 18 200 to 18 400 persons sustain serious injuries annually in Germany (Table 2).

**Comparison to current literature**

It is interesting to compare our resulting number of severely injured patients with the results of previous analyses: we calculated 18 200 to 18 400 serious injuries annually in Germany, which is significantly lower than previously assumed. In 1997, Haas et al. (11) first extrapolated the number of accident patients with the scoring system used at that time, the polytrauma score (PTS) III and IV, to determine the number of severely injured patients. After analyzing for the various accident causes, they calculated a number of 32 500 patients. The main problem in comparing the work of Haas et al. (11) with the present data is the use of distinct definitions of polytrauma: although both PTS and ISS are based on anatomical scores, they differ from each other in numerous ways. Indeed, recent work has verified that, despite the significant correlations between the two scores, differences in the definitions make comparisons difficult (13–15). In 2006, Kühne et al. (12) extrapolated data from 63 hospitals, using 2977 cases, and determined a total number of 35 300 cases of

seriously injured patients. As their work defined a severely injured patient as one with an ISS of ≥16, the methodology used can be compared with this present study. However, the extrapolation used at that time was based on a significantly lower number of cases. Finally, in 2004, Liener et al. (16) used a population-based study to determine a number of 20 400 severely injured persons, a result similar to the present analysis.

Closer examination of these studies shows that the best possible extrapolations were made based on the then available data of seriously injured persons. This improved the structure of care and resulted in reduced mortality (17–19). Additionally, data from these studies led to the establishment of the TNW-DGU and TR-DGU and enabled the DGU to take a global pioneering role in structuring medical care for severely injured patients (20). Large international publications, such as the EuroSafe Report 2013 and the Global Status Report on Road Safety 2013, emphasized the preventive potential in the fields of road traffic accidents and trauma care. The Euro Safe Report highlighted the importance of home and leisure-time accidents, which are also reflected in the TR-DGU (21, 22). The Road Safety Report stressed the importance of road traffic accidents, which also account for 54.7% of the mechanisms of injury in the TR-DGU. Despite accounting for a high percentage of injuries, the rate of fatal accidents in Germany, of 4.4 per 100 000, is well below the international average rate, of 18 per 100 000 (23).

**Decrease in the number of severe injuries**

A large proportion (54.7%) of severely injured patients in Germany were involved in traffic accidents (3). In recent years, traffic and security technology has steadily improved. For instance, a variety of driver assistance systems and numerous airbags are now standard in new vehicles. Nevertheless, road accidents from 2006 to 2012 increased by 6.9%, from 2 235 318 to 2 401 843. Accidents involving injuries decreased during the same period by 8.6% from 327 984 to 299 637, with a 29.3% decrease in the number of traffic fatalities (from 5091 to 3600 fatalities) (24). The number of reported occupational accidents showed a similar trend due to improved occupational safety, with a 3.7% decline from 2011 to 2012, with 919 025 and 885 009 reported injuries, respectively (25). While the

present data do not demonstrate a statistically significant correlation for a reduction in the cases of serious injuries, there is still an evident trend for this, which supports the theory that fewer patients are sustaining a polytrauma.

**Importance of trauma care for the severely injured patient**

Although this report reveals that the number of severely injured persons is lower than assumed, this by no means reduces the importance of trauma care. On average, the severely injured patient is a 45.9-year-old male in the middle of his working life (3). Holtslag et al. (26) showed that only 60% of trauma survivors can return to their professional life. Treatment costs for acute care and rehabilitation are estimated at an average of USD 147 000 per patient, which corresponds to about 106 000 Euros. If the patient is unable to return to work as a consequence of a disability, the incurred costs multiply, to nearly 1.3 million USD, or approximately 935 000 Euros (27). In addition to these socio-economic aspects, the patient usually is confronted with serious physical and psychological consequences (28). Thus, even this reduced number of 18 200 to 18 400 severely injured persons annually in Germany requires an optimally structured care system. In our opinion, the structures already established within the TNW-DGU would be ideal for this; however, this requires a sustained intensive effort to continue improving trauma care. With more than 600 audited or certified hospitals, the TNW is currently ideally positioned to care for severely injured patients.

**Limitations**

Even with the high-quality data obtained from the TR-DGU, the present work has some limitations. In the registry, no data are available for severely injured patients who died in the preclinical phase or who reached the emergency department (ED) with ongoing resuscitation, while records for patients who died in the ED shock room are included. Further limitations are discussed in the Quality of data section.

**KEY MESSAGES**

- For the first time, the number of severely injured persons has been accurately analyzed.
- Annually, 18 200 to 18 400 patients in Germany sustain a polytrauma.
- The current number of severely injured patients is lower than previously assumed.
- The number of severely injured patients follows a trend similar to that seen in the number of (fatal) victims of road traffic accidents.
- Structures present within the trauma network *Trauma-Netzwerk DGU* (TNW-DGU) offer optimal conditions for providing high-quality care to severely injured patients.

**Conflict of interest statement**

Dr. Debus is head of the office of the TraumaNetzwerks (TNW; trauma network) and as such received honoraria and travel expenses from the Akademie der Unfallchirurgie (AUC; Academy for Trauma Surgery) GmbH. He is additionally a consultant for AUC GmbH, which is responsible for the trauma registry.

Prof. Lefering is a consultant for AUC GmbH and has received research support (third-party funds) from AUC GmbH.

Dr. Mand has received travel expenses from AUC GmbH.

Prof. Ruchholtz is spokesperson of AKUT (Arbeitskreis zur Umsetzung Weißbuch [working group to implement the Whitebook]/ TraumaNetzwerk).

The remaining authors declare that no conflict of interests exists.

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[Supplementary material](#)  
[eMethods, eTable:](#)  
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Supplementary material to:

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### eMETHODS

The goal of the multicentric database TR-DGU is to provide an anonymous and standardized documentation of severely injured patients. Data are collected prospectively in four phases:

- Pre-hospital phase
- ED shock room and subsequent surgery phase
- Intensive care unit (ICU)
- Hospital discharge.

The documentation contains detailed information on demographics, injury patterns, comorbidities, pre- and in-hospital management, course on intensive care unit, relevant laboratory findings including transfusion data, and outcome. The inclusion criterion is a hospital admission via the emergency department, followed by a monitored stay in the intensive or intermediate care unit. Information about area size and population was collected from publicly available data of the Federal Statistical Office ([www.destatis.de](http://www.destatis.de)).

The number of severely injured patients was calculated from the above data with three different methods. Included in the evaluation were 13 040 documented patients from 2012 in 758 German hospitals with an Injury Severity Score (ISS)  $\geq 16$ . To avoid double counting, promptly transferred patients—defined in the TraumaRegister (trauma registry) of the DGU (TR-DGU) as patients transferred within the first 48 hours—were excluded. Patients who were transferred later (7.1% in the TR-DGU in 2012) were automatically identified and thus not counted twice. The 95% confidence intervals of the total numbers were determined using Poisson distribution.

Statistical analysis was performed with the program SPSS (version 18.0, SPSS Inc., Chicago, IL). The present work, with the TR-DGU project ID 2013–028, has been published according to TR-DGU guidelines.

#### Hospital method

In this method, the total number of severely injured patients was calculated based on the number of patients cared for within the individual trauma centers (*Figure 1*). Data from the TR-DGU was used to determine the number of patients documented with an ISS  $\geq 16$  in 2012 on average per local trauma center (LTC), regional trauma center (RTC), and supraregional trauma center (TC). RTC and supraregional TC with a sample size of  $<10$  (RTC) or  $<30$  per year were not included

in calculating the average number of cases, since it was highly likely that the documentation was not complete for all cases. Values were oriented on the minimal number of cases required by the DGU for certification of each level of care. On this basis, an average annual number of cases resulted in 4 patients per LTC (standard deviation [SD], 3.8), 25 patients per RTC (SD, 16.9) and 85 patients per supraregional TC (SD, 42.9). The average value of the severely injured patients treated in 2012 was multiplied by the total of 430 of the *TraumaNetzwerk DGU* (TNW-DGU)—registered trauma centers, taking into account the level of care, to determine the total number. The number of active certified hospitals that had not yet been certified at the time of evaluation was calculated from TNW data. Accordingly, 328 hospitals were added.

#### Federal state method

The number of severely injured patients was extrapolated based on the data of a single federal state. Bavaria was chosen because its six regional trauma networks provided an almost full coverage of the entire state. The number of severe injuries in Bavaria was determined using the hospital method described above, and this value was then used to calculate the number of severely injured patients for Germany, based on the known population of the entire country.

#### Network method

In the network method, the number of severely injured patients was extrapolated from established regional trauma networks, which had been certified by mid-2011 and thus should have had standardized case documentation in 2012 (*Table 2, Figure 2*). The extrapolation was done by determining the size of the networks and then averaging the population per km<sup>2</sup>. Using the Germany map from the map server of the Akademie der Unfallchirurgie (AUC; Academy for Trauma Surgery) ([www.dgu-traumanetzwerk.de](http://www.dgu-traumanetzwerk.de)) and the online program ACME Planimeter ([www.acme.com](http://www.acme.com)), the surface area of the respective trauma networks was calculated in km<sup>2</sup>. The average number of inhabitants per km<sup>2</sup> was taken from the data of the Federal Statistical Office, and a number of inhabitants was extrapolated for each trauma network. Using the ratio of this population to the total population in Germany gave a factor that was used to multiply the known number of severely injured patients in the 17 trauma networks.



**eTABLE**

**Extrapolation of the number of severely injured patients with respect to the area and population for 17 established regional trauma networks**

	Area (km <sup>2</sup> )	Inhabitants/km <sup>2</sup>	Estimated number of inhabitants TNW
Schleswig-Holstein	12 670	178	2 255 260
Eastern Westphalia	5036	515	2 593 540
Central Hesse	5516	285	1 572 060
Southern Hesse	3391	285	966 435
Upper Franconia	8183	177	1 448 391
Middle Franconia	4715	177	834 555
Eastern Bavaria	16 820	177	2 977 140
Black Forest	3688	296	1 091 648
Munich Upper Bavaria–South	11 980	177	2 120 460
Ruhr district	7005	515	3 607 575
Düsseldorf	1255	515	646 325
Eastern Hesse	3588	285	1 022 580
Upper Rhine	4460	296	1 320 160
Berlin	892	3785	3 376 220
Saar–(Lor)–Lux–West Palatinate	7220	387	2 794 140
Cologne	4972	515	2 560 580
Anterior Palatinate	2010	201	404 010
Sum of 17 TNW			31 591 079
Federal Republic of Germany			81 890 000
Proportion			38.58%
Factor			2.59
Number of patients in the TR			6386
Extrapolation			16554

TNW, regional trauma network; TR, trauma registry