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Original Research Article

How the changes in the system affect trauma care provision: The assessment of and implications for Lithuanian trauma service performance in 2007–2012

Žilvinas Dambrauskas [a,b,*], Vytautas Aukštakalnis [c], Aurika Karbonskienė [d], Dmitrijus Kačiurinas [e], Jolanta Vokietienė [f], Robertas Lapka [f], Algimantas Pamerneckas [g], Narūnas Porvaneckas [g], Kęstutis Stašaitis [c], Nedas Jasinskas [c], Paulius Dobožinskas [h], Dinas Vaitkaitis [h], Raimundas Lunevičius [j]

[a] Institute for Digestive Research, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania
[b] Department of Surgery, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania
[c] Department of Emergency Medicine, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania
[d] Department of Anesthesiology, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania
[e] Alytus County S. Kudirkos Hospital, Alytus, Lithuania
[f] Republican Panevėžys Hospital, Panevėžys, Lithuania
[g] Centre of Orthopaedics and Traumatology, Republican Vilnius University Hospital and Medical Faculty of Vilnius University, Vilnius, Lithuania
[h] Department of Disaster Medicine, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania
[j] Emergency General Surgery Unit, General Surgery Department, Merseyside and Cheshire Major Trauma Collaborative, University of Liverpool, Aintree University Hospital NHS Foundation Trust, Lower Lane, Liverpool, United Kingdom

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ABSTRACT

Objective: The aim of this study was to identify and assess the effects of changes in the Lithuanian trauma service from 2007 to 2012. We postulate that the implications derived from this study will be of importance to trauma policy planners and makers in Lithuania and throughout other countries of Eastern and Central Europe.

Materials and methods: Out of 10,390 trauma admissions to four trauma centers in 2007, 294 patients (2.8%) were randomly selected for the first arm of a representative study sample. Similarly, of 9918 trauma admissions in 2012, 250 (2.5%) were randomly chosen for comparison in the study arm. Only cases with a diagnosis falling into the ICD-10 "S" and "T" codes were included. A survey of whom regarding changes in quality of trauma care from 2007 to 2012 was carried out by emergency medical service (EMS) providers.

Results: The Revised Trauma Score (RTS) mean value was 7.45 ± 1.04 for the 2007 year arm; it was 7.53 ± 0.93 for the 2012 year arm ($P = 0.33$). Mean time from the moment of a call from the site of the traumatic event to the patient's arrival at the trauma center did not differ between the arms of the sample: 49.95 min in 2007 vs. 51.6 min in 2012 ($P = 0.81$). An application of the operational procedures such as a cervical spine protection using a hard collar, oxygen

* *Corresponding author at*: Institute for Digestive Research, Medical Academy, Lithuanian University of Health Sciences, Eivenių 2, 50161 Kaunas, Lithuania.
E-mail address: zilvinas.dambrauskas@gmail.com (Ž. Dambrauskas).

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therapy, infusion of intravenous fluids, and pain relief on the trauma scene was more frequent in 2012 than in 2007. Management of trauma patients in the emergency department improved regarding the availability of 24/7 computed tomography scanner facilities and an on-site radiographer. Time to CT-scanning was reduced by 38.8%, and time to decision-making was reduced by 16.5% in 2012.

Conclusions: Changes in operational procedures in the Lithuanian pre-hospital care provision and management of trauma patients in emergency departments of trauma centers improved the efficiency of trauma care delivery over the 2007–2012 period.

1. Introduction

Trauma constitutes an important public health problem, leading to approximately 10% of the world's deaths [1,2]. In Lithuania, trauma mortality as a proportion of all deaths from external causes was reported to be even higher at 13.2% in 1999 (4091 deaths in males and 1177 deaths in females) than the 11.9% reported in 2006 (4092 deaths in males and 1248 deaths in females) [3]. Not surprisingly, injury is reported to be the third leading cause of mortality in Lithuania, preceded by cardiovascular and oncological diseases, and it is the primary cause of death in the working population [3]. Regarding disability-adjusted life years lost per 100,000 individuals of both genders annually, injury ranks first in the country, followed by neuropsychiatric conditions and cardiovascular diseases [4,5]. The magnitude of the particular problem related to road traffic accidents has been stressed, as well [6].

Globally, the Republic of Lithuania was among the top four countries of the European region regarding age-adjusted, standardized death from external causes in 2006 [4,5]. Russia, Belarus, and Kazakhstan were the other top countries where the age-adjusted, standardized death rates exceeded 150 cases per 100,000 individuals of both genders of all ages. It is important to mention, for the sake of clarifying the magnitude of the problem in those countries, that Germany, the UK, the Netherlands, and Malta were the countries with the lowest age-adjusted, standardized mortality from external causes ≤30 cases per 100,000 individuals of both genders in 2006.

It is well known that an inclusive trauma system, encompassing the coordinated provision of care for a trauma patient in a pre-hospital setting, trauma centers, and rehabilitation facilities within the defined geographical area, has a crucial role in improving the management and outcomes of severely injured patients and reducing the toll of injuries [7–12]. As the toll of traumatic injuries was noted to be disproportionately high in Lithuania, the national trauma service and trauma care provision were openly criticized. An urgent call for discussion about the future of the Lithuanian trauma model was released in 2010 [4].

Few well-budgeted trauma programs aimed to revitalize injury prevention, improve trauma care provision, and create a coordinated trauma system in Lithuania were launched in order to reduce trauma morbidity and mortality rates by 30% and overseen by the Ministry of Health of the Republic of Lithuania in 2000–2012 [13–18]. The programs included an introduction of the key components of a trauma system at the national level. Examples included the broad spectrum of trauma prevention activities; trauma education and training (most of the ED and EMS (emergency medical service) personnel, including physicians, paramedics, nurses and other staff who participated in at least one of the courses: advanced life support and trauma life support course, advanced trauma life support, advanced critical life support and first medical aid); a unified emergency call system; the EMS computerized dispatch protocols; acquisition of new, well-equipped ambulances; formation of trauma teams and activation systems in trauma centers (mean time of trauma team arrival in the ED was 4 min, which is the standard in the USA and western Europe); development and integration of standard operative protocols, care pathways, and clinical guidelines into the practice (criteria for identification of severely injured patients and massive blood transfusion protocols were approved); and modernization, construction, or re-construction of emergency departments for trauma centers. Key changes to the trauma patient pathway are depicted in Fig. 1. In line with this, the structural reorganization of the EMS was completed. It resulted in a decrease in the mean number of EMS teams on call for one shift from 5 to 4.5. Such reduction in personnel was not significant but met the needs of the public, for example, one EMS station serviced a population that decreased by 5000 individuals within the same serviced territory (mean 1200 km^2), i.e. from 64,659 to 59,430 in 2007–2012 [19].

The aim of this study is to identify and assess the effects of the above-mentioned changes on the Lithuanian trauma service within the 2007–2012 period. This study was undertaken to clarify the impact of these changes on the quality of care for trauma patients in the field and in emergency departments. We postulate that conclusions and implications of this study may be of importance for trauma policy planners and makers in Lithuania and other countries of Eastern and Central Europe.

2. Materials and methods

The representatives of 26 EMS stations and four trauma centers agreed to participate in this study that, in fact, was the audit of the national trauma service. Trauma centers were the hospitals integrating the multi-disciplinary trauma teams with necessary technological adjuncts and human resources.

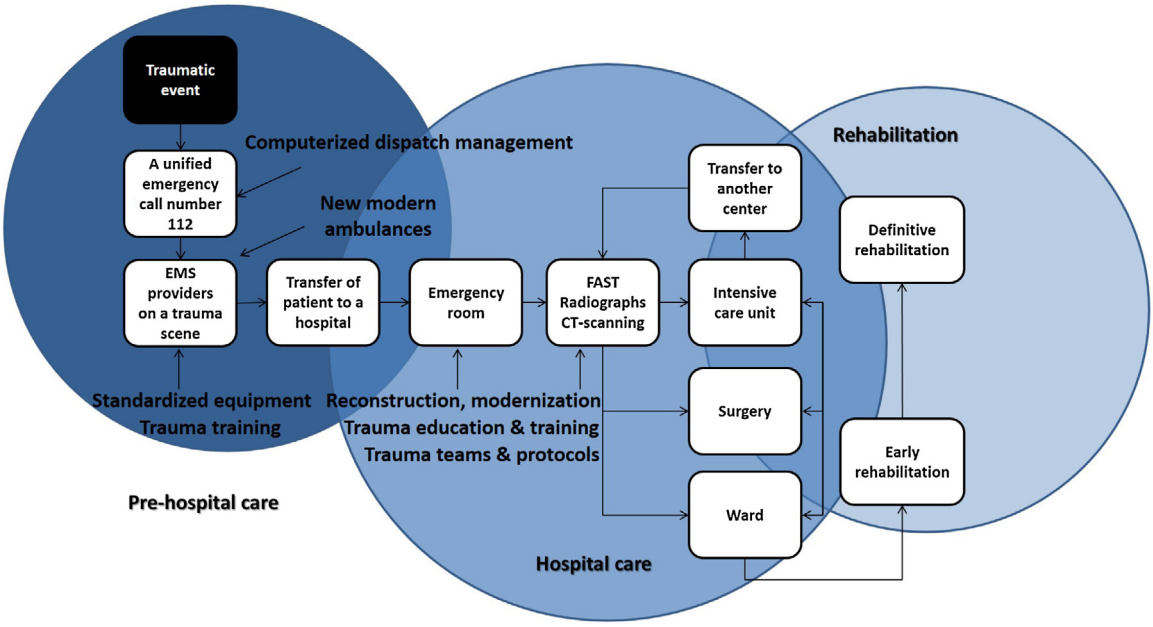

Fig. 1 – Key changes in the trauma patient pathway in Lithuania, 2007–2012.

They were as follows: the Republican Vilnius University Hospital (Level 1 Trauma Centre), Hospital of the Lithuanian University of Health Sciences Kauno Klinikos (Level 1), Alytus County S. Kudirkos Hospital (Level 2), and Republican Panevėžys Hospital (Level 2). A categorization of the Lithuanian hospitals into the trauma centers of three levels was based on the order of the Minister of Health of the Republic of Lithuania.

We randomly (since there is no electronical database or trauma registry from which we could extract certain types or severity of trauma patients, the selection of cases were random) selected 2.7% of adult patients' (≥18 years) charts, primary and secondary trauma surveys, and the remainder of the case notes for further search of relevant data to compile a database for definitive statistical analysis. Only cases with a diagnosis falling into the International Classification of Diseases (ICD)-10 ''S'' and ''T'' codes by body region and nature of injury were included in this study. A study sample was made from the trauma patients hospitalized at trauma centers for definitive management of injuries sustained in 2007 and 2012.

Sample size was estimated using the online calculator[1] based on the number of trauma cases in Lithuania in 2012 (population size, 322.900), with confidence level 95% and confidence interval 5%. It was calculated that sample size needed for this study was 384 cases (192 cases from 2007 and 192 cases from 2012). The number of cases for analysis was proportionally divided amongst the centers included in the study based on the number of annual trauma admissions in each center. Each center randomly selected approximately 2.5%–3% of trauma cases for analysis which is in line with medical audit recommendations.[2]

[1] http://www.calculator.net/sample-size-calculator.html.
[2] http://www.emergencydispatch.org/AccredCalculator.

We accumulated data on cervical spine protection, pelvic binders and splints to the limbs, intravenous infusion, oxygen therapy, airway management, control of external bleeding, pain relief, time from the moment of call from the site of accident to the patient's arrival at the trauma center, and time from the trauma bay at the emergency department to the diagnostic or interventional radiology suite, operating theater, intensive care unit, or trauma ward. We checked the accuracy of a primary trauma survey, which showed the first set of physiologic data obtained on the patient (Glasgow Coma Score, systolic blood pressure, and respiratory rate) for further calculations of the Revised Trauma Score (RTS). As the RTS is known to be reliable and accurate in outcome predictions for trauma patients, it is especially useful to assess those who sustained severe head injuries [20]. A survey of EMS providers regarding changes in the quality of trauma care from 2007 to 2012 was conducted.

Data were analyzed using the SPSS statistical package. The chi-square test was applied for analysis of categorical data. The Student *t* test and the Mann–Whitney *U* test were used for interval data. A statistical difference was considered significant at the level of $P < 0.05$. Bioethics approval to conduct the audit was received (No. BEC-LSMU(R)-09) at the Lithuanian University of Health Sciences in 2014.

3. Results

3.1. *Study sample*

Of 10,390 trauma admissions to four trauma centers in 2007, 294 patients (2.8%) were randomly selected for the first arm of a representative study sample. Similarly, of 9918 trauma admissions in 2012, 250 (2.5%) were randomly selected to create a study sample for comparison. Fig. 2 shows a very

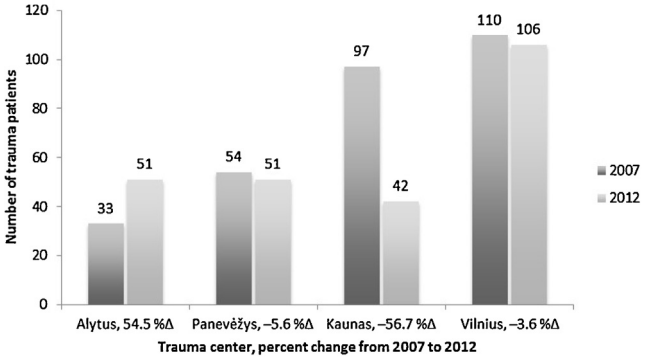

Fig. 2 – Distribution of the trauma cases from a representative study sample by site and year.

similar distribution of cases by year in three sites of four. Regarding the RTS, the two arms of the sample did not differ. The RTS mean value was 7.45 ± 1.04 for the 2007 year arm, and 7.53 ± 0.93 for the 2012 year arm ($P = 0.33$). There were ten trauma patients with the RTS <5 in each arm ($P = 0.66$). There were 133 fatalities on a scene of trauma accident in 2007 (0.96% from all trauma calls) in 2007 and 138 in 2012 (1.2%) ($P = 0.57$). The frequency of hospitalization amongst patients that suffered traumas and were brought to the injury centers by the ambulance did not vary much during the assessment period. The number of patients that died in 2 h since they were brought to the injury center also stayed approximately the same: 5 of such patients died in injury centers in 2007 (0.02% of all patients that suffered injuries) and 3 patients in 2012 (0.01% of all patients that suffered injuries). The number of patients that were transferred to the higher-level injury centers increased: 2200 patients were transferred to the higher-level injury centers during the first day in 2007 and 2 472 patients were transferred in 2012. The number of patients transferred on the 2nd and 3rd days in the same manner are 297 patients in 2007 and 332 in 2012. In hospital mortality did not change significantly: 88 patients (0.9%) died in 2007 and 280 patients (2%) died in 2012 ($P = 0.41$). It is likely that the relatively higher mortality rate in hospital in-patient department care can be explained by the better pre-hospital emergency care and direct patient transfer to the trauma centers, and more severely injured patients being successfully transported to the trauma centers by the ambulance. Our interim conclusion was that both arms of the sample were statistically similar and relevant to further analysis based on these findings.

3.2. *Pre-hospital care*

Mean time from the moment of a call from the site of the accident to the patient's arrival at the trauma center did not differ between the arms of the sample: 49.95 min in 2007 vs. 51.6 min in 2012 ($P = 0.81$). Procedures applied at a trauma scene and on the way to a trauma center are shown in Table 1.

3.3. *Survey*

The anonymous electronical surveys were sent to 46 EMS providers that participated in national trauma program administered by the Ministry of Health of the Republic of Lithuania, 26 surveys were answered, returned and further analyzed. The findings among EMS workers showed that 41% of EMS workers strongly agreed that the quality of trauma care in the pre-hospital setting improved from 2007 to 2012, 45.5% agreed, and 13.6% did not have any opinion. Also, 73.9% of respondents answered that the service was performing more efficiently, 13.1% of responders replied that they were spending less money, 8.7% of them affirmed that the service was working faster, and 4.3% of EMS workers confirmed that it became easier to organize EMS personnel work.

3.4. *Reception and resuscitation in the emergency department*

Table 2 shows the times from arrival of the trauma patient at an emergency room to key imaging, laboratory tests, and decision making (time till patient were hospitalized in a certain ward or intensive care unit or moved to the operation theater) in 2007 and 2012. Only the time from the arrival of the patient to ultrasound scan decreased significantly. The times to obtaining laboratory test results, radiographs, and a computed tomography scan did not have statistically significant differences. Nevertheless, they were better in 2012. There was a significant difference in key decision-making time in 2012.

4. Discussion

This study shows two improvements in the provision of care for patients who sustained traumatic injuries in 2007 and 2012.

Table 1 – Procedures applied by EMS providers in 2007 and 2012.

Procedure	2007	2012	χ^2	P value
Cervical spine protection by collar	90 (30.6)	90 (36)	1.771	0.183
Oxygen therapy	5 (1.7)	16 (6.4)	8.04	0.005*
Airway management	30 (10.2)	23 (9.2)	0.155	0.694
Temporal control of external bleeding	37 (12.6)	19 (7.6)	3.636	0.565
Pelvic binders and splints	114 (38.8)	95 (38)	0.034	0.853
Intravenous fluids	78 (26.5)	89 (35.6)	5.224	0.022*
Pain relief	99 (33.7)	114 (45.6)	8.067	0.005*

Values are number (percentage).
* Statistically significant.

Table 2 – Key performance indicators for emergency room of a trauma center.

Measures	2007	2012	P value
Time to ultrasound-scanning	54.03 ± 64.29	23.32 ± 26.32	<0.0001*
Time to laboratory tests	113.58 ± 242.93	100.34 ± 196.18	0.737
Time to radiography	39.84 ± 35.09	34.66 ± 26.56	0.526
Time to CT-scanning	88.82 ± 131.04	63.97 ± 81.26	0.634
Time to key decision making	118.0 ± 104.21	101.27 ± 82.72	0.039*

Values are mean (standard deviation).
* Statistically significant.

First, application of operational procedures such as cervical spine protection using a hard collar, oxygen therapy, infusion of intravenous fluids, and pain relief at the trauma scene was more frequent in 2012 than in 2007. Furthermore, the results of the survey among EMS workers show that 86.5% of pre-hospital care providers agreed that the quality of care improved in the 2007–2012 period. On the other hand, there remains a degree of uncertainty why the cervical spine was protected in only 36% of trauma patients with high risk for significant injuries in 2012.

Only 45.6% of trauma patients received pain relief in the pre-hospital setting in 2012, according to the findings of this study. It is rather difficult to discuss that, as acute pain – whether mild, moderate, or severe – is a ''satellite'' of nearly every traumatic injury and, therefore, requires adequate pain relief. Similar mean times from the moment of a call from the site of the accident to the patient's arrival at a trauma center in 2007 and 2012 (49.95 min vs. 51.6 min) reflect the trauma philosophy of Lithuanian pre-hospital care providers. It may be named as *scoop and run* for nearly every trauma patient. And, fundamentally, it is the right policy [21], especially in environments with limited resources and capabilities [4,19,22].

Second, management of trauma patients in emergency departments improved regarding the availability of 24/7 computed tomography scanner facilities and an on-site radiographer. However, other reception and resuscitation metrics such as times to radiographs and CT-scanning did not improve enough. Time to CT-scanning is the best example, for the mean time to CT-scanning was above 60 min with a broad range of standard deviation (63.97 ± 81.3 min) in 2012. We assume that a reduction in CT-scanning time by 38.8% was a key reason for a reduction in key decision-making time by 16.5% in 2012.

The value of time to ultrasound scanning, as a reception and resuscitation measure in major trauma centers, is discussable, because a Focused Assessment with Sonography for Trauma (FAST) is sensitive and informative enough in the emergency setting for a quick exclusion of hemoperitoneum and hemopericardium in patients with blunt thoracic and abdominal trauma. Moreover, a FAST should be an integral part of primary (for most cases) or secondary trauma survey to perform the FAST in a few minutes in a trauma bay at an emergency department.

We are inclined to interpret the findings of this study quite freely, because the study itself has a few significant limitations. They are mainly derived from the compound nature of the trauma service and from the difficulty in measuring the changes at the trauma service. The absence of approved national major trauma network standards in all five trauma service areas, such as network governance, pre-hospital care, reception and resuscitation in an emergency room of the trauma center, and definitive care and rehabilitation, complicated the assessment of the trauma service in 2007 and 2012. That made a systematic evaluation of the changes in care provision for major trauma patients challenging. The lack of registered data is another limitation of this audit. It directly shows that the major elements of trauma service were not even considered before 2007 and during the 2007–2012 period. Such a gap within the trauma service generated the chain of methodological shortcomings in this study. There is no other way to explain the percentage change of −56.7% (Kaunas) within the plot of Fig. 2, which shows no equal distribution of cases by year in four sites in a representative sample. Incomplete patient records in any environment demonstrate the absence of trauma network governance at the local and national level. An assumption regarding integrating electronic patient records in order to improve the trauma patient's length of stay in an emergency department and patient data management is worth attention [23]. However, it should be kept in mind that it is just one aspect of a secondary priority within emergency care systems [24]. Finally, the absence of scrutiny of definitive care, at least, and rehabilitation, at most, from a representative sample limits the value of this audit of the trauma service.

4.1. *Implications to the practice*

The aim of this study was to identify and assess the effects of the changes in the Lithuanian trauma service within the 2007–2012 period by scrutinizing a representative sample of trauma admissions to emergency departments of trauma centers in 2007 and 2012. We report that prehospital care provision and management of trauma patients in emergency departments of trauma centers improved partially. However, the key effects on the primary clinical outcomes, i.e. death or survival, remain unknown, because the phase of definitive care of a trauma patient was not analyzed in this audit. Nevertheless, this study empowers us to highlight a few important implications to the practice, driven mainly by health care policy makers.

The first important implication of our study derives from our finding of the non-exemplary completeness of medical-record data. This indicates a governance problem at the national level. To date, there is no central management or trauma governance-specific structure for the existing trauma service in the country. This exposed a gap in an objective selection of hospitals for trauma care provision. For instance, a high-volume hospital providing emergency neurosurgical,

intensive, orthopedic, and general surgical care for a population of a defined geospatial area of the country should be categorized as a Level 1 trauma center providing tertiary trauma services for patients with traumatic injuries. Nevertheless, Republican Panevėžys Hospital, responsible for trauma care provision in northeast Lithuania, was categorized as a hospital with a Level 2 trauma center despite not having a relevant organizational structure and resources required to provide care for traumatic injuries. Republican Siauliai Hospital, which is a Level 2 regional trauma center for northwest Lithuania, is a similar example of inappropriate categorization of a trauma center. So, it is very likely that classification of the hospitals into trauma centers of Levels 1, 2, and 3 was biased and requires new objective reviews.

All in all, the Trauma Network Governance body with a named National Trauma Director is a major component of any inclusive and coordinated trauma system, and, therefore, this organizational body, which is quite complex in nature, has to be discussed, schemed and built, or unified under one umbrella. Adding to this, we are bound to say that an independent enforcement body usually named as National Peer Review within the Trauma Quality Improvement Network System should also be discussed, planned, and built simultaneously in order to define and develop the trauma network governance measures, such as a trauma network configuration, a network governance structure, a network audit of the pre-hospital phase of trauma, individual pre-hospital provider feedback, the network transfusion protocols, a network radiology audit, the trauma audit and research network (TARN), and an emergency planning [25,26]. This point implicitly transfers us to another implication of the study as the measures used for assessment of pre-hospital and in-hospital care provision for trauma patients could be better debated.

So, the second implication stems from our methodology of how to measure the critical areas of trauma service. At least two – pre-hospital care and resuscitation in the emergency department of a trauma center – out of five deserve attention (trauma network governance, definitive care, and rehabilitation measures are the other three areas). Seven measures are used in our study for assessment of the performance of pre-hospital care providers, and five measures are used for evaluation of emergency department performance. Some of them are traditional, such as time to CT-scanning or time to make a crucial clinical decision. However, some of them are unusual, for instance, time to laboratory tests or time to radiography.

All these measures may be the subject of discussion. However, experience and knowledge rising from the established and matured trauma systems should be always kept in mind in discussions of this kind. A total of 115 quality indicators in the adult trauma centers were identified, predominantly measures of hospital processes (62%) and outcomes (17%), in a recent systematic review of quality indicators to evaluate adult trauma care [26]. Without any doubt, every trauma network or trauma center has to choose and work with the best ones. For instance, the National Peer Review Programme for Trauma Networks of England applies 10 measures for assessment of pre-hospital trauma services, 24 measures for evaluation of reception and resuscitation in the emergency department, 17 measures for complete management of trauma patients, and 14 rehabilitation measures [27–29]. Each of them has a different background and logical explanation.

We would like to highlight the reception and resuscitation measures, for they matter to us directly. They are as follows: trauma team lead, trauma team leader training program, trauma team activation protocol, surgical and resuscitative thoracotomy capability, 24/7 CT scanner facilities and on-site radiographer, timeliness and competencies for radiology reporting and documentation, 24/7 MRI scanning facilities, 24/7 interventional radiology capability within 60 min, interventional radiology located in the operating room or resuscitation room, teleradiology facilities, 24/7 access to emergency theater and surgery, damage control training for emergency trauma consultant surgeons, 24/7 access to on-site surgical staff, 24/7 access to key consultants, dedicated orthopedic trauma operating theater, facilities to provide fixation of pelvic ring injuries within 24 h, trauma management guidelines, on-site intensive care unit, audit of the intensive care unit, a specialist in acute pain services, transfusion lead clinician, 24/7 specialist transfusion advice, massive transfusion protocol, and administering tranexamic acid. It is certain that most, but not all, of these facilities are available at trauma centers of Lithuania. However, the system for measurements of emergency department trauma performance has never been introduced therein and assessed on a regular basis. This paper confirms that.

The third important implication of our study derives from our point to an RTS and its similar values in both arms of a representative sample. However, bearing in mind the importance of an Injury Severity Score (ISS) in trauma research, audits, and various comparisons, we need to use ISS in our trauma centers to simplify comparisons and assessments of the performance of trauma centers. For instance, a ratio of the number of patients with an ISS greater than 8 (the indicator of moderate or severe trauma) where a rehabilitation prescription had been issued or where a rehabilitation prescription was deemed not to be appropriate (a numerator) to the total number of patients admitted to the trauma center with an ISS of more than 8 (a denominator) is one of the key performance indicators of trauma centers and trauma networks. It is noteworthy that the importance of ISS in defining injury severity (mild, moderate, severe) was stressed in Lithuanian literature in 2002 [30].

The fourth implication of this study is related to our statement regarding deaths at the scene of an accident. Indeed, an actual number of annual case fatalities is a key mortality indicator within the geographical region and statewide, being convertible into the crude and age-standardized death rates for comparison purposes. Nevertheless, it should not be the identical case for assessment of an individual trauma center and comparisons against other trauma network hospitals of the country. Other metrics for the characterization of the trauma center outcome performance are currently recommended to use. Examples include a case mix standardized rate of survival, a case mix standardized rate of survival at 30 days, a risk-adjusted mortality, a risk-adjusted observed-to-expected (O/E) mortality ratio, an injury-adjusted mortality, an age-adjusted mortality, a

readmission rate to a critical care unit, an excess of survivors per 100 patients, and an excess of deaths per 100 patients [25,27].

The fifth implication of this study is based on declared changes in Lithuanian trauma service during the 2007–2012 period. These were mainly trauma education and training and technical reconstruction or total construction of trauma care facilities (so-called the re-engineering process) substantially catalyzed by structural monetary funds from the European Union [15]. However, to the best of our knowledge, non-systematic and non-regular education is not sufficient enough as a public health intervention to reduce the burden of traumatic injuries at a national level. Technical reconstruction or construction of health care facilities should be regarded as a material base for trauma care provision. Only a systematic, independent, and regular (quarterly, in the ideal circumstances) enforcement of the national and regional trauma services may be highly useful in the years to come.

A common methodology on how to organize a systematic trauma care provision for patients with injuries from external causes in Lithuania was published in July of 2014 [31]. This document should help the health care policy makers and implementers to complete the organizational phase of the work and launch a new inclusive and coordinated trauma system for the country.

5. Conclusions

Pre-hospital care provision and management of trauma patients in emergency departments of trauma centers improved in the 2007–2012 period in Lithuania. The study also revealed five critical areas for further development of a mature inclusive national trauma system: the establishment of a formal National Trauma Network and the Trauma Audit and Research Network, the need to use ISS in all trauma centers to simplify comparisons and assessments of their performance, the use of crude and age-standardized death rates for comparison purposes, and the provision of systematic continuous trauma life support education and training for the health care specialists nationwide.

Conflicts of interest

All the authors declare that there are no conflicts of interest.

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Authors' contribution

Ž.D. conceptualized and designed the study, conducted it, collected data, and made a significant contribution writing the provisional draft of the manuscript. V.A., K.S., N.J., and P.D. performed a literature search, collected data, performed a statistical analysis, conducted the study, and wrote the first draft of the paper. R.L. re-conceptualized the provisional draft of the manuscript, performed an additional literature search and statistical analysis, made a critical revision, and wrote the final version of the manuscript. Other co-authors contributed to the study.

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