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## **Polytrauma patient management: Processes and performance in the Netherlands and beyond**

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### **Citation**

Dijkink, S. (2020, October 29). *Polytrauma patient management: Processes and performance in the Netherlands and beyond*. Retrieved from <https://hdl.handle.net/1887/137986>

Version: Publisher's Version

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**Note:** To cite this publication please use the final published version (if applicable).

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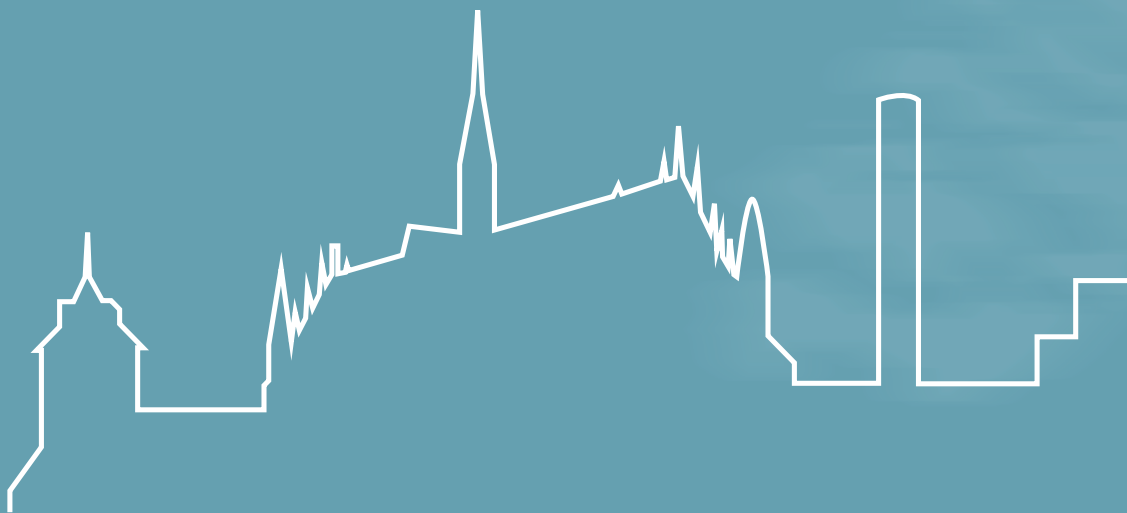


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**Issue Date:** 2020-10-29



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Summary





Annually around 5 million people die as a consequence of injuries and many more suffer from lifelong disabilities. Although implementation of trauma care systems and structured trauma training has led to decreased mortality and disability in several countries, controversies remain to exist. The awareness of the current trauma burden and its expected increase has led to new initiatives for scientific research in an attempt to eventually improve trauma care worldwide. Despite the improvements there is room for further optimization of care. The primary aim of this thesis was to analyze the presence and structure of trauma systems, evaluate specific care-delivery processes, and focus on patient-centered and clinically important parameters and outcomes. The second aim is to evaluate one of these parameters, the role of the nutritional status in the outcome of polytrauma patients.

In **chapter 1** the historic development of trauma systems and the trauma system in the Netherlands is discussed. In addition, background information about malnutrition in polytrauma patients is described.

**Chapter 2** gives an overview of the recent literature on the state of trauma systems globally. Despite the presence of seemingly sufficient resources and the evidence-based benefits of trauma systems, only nine of the 23 high-income countries in this review had a well-defined and documented national trauma system according to the identified studies. Although 90% of all lethal traumatic injuries occur in middle and low income countries, according to the literature, to which our study is limited to, only few of these countries hold a formal trauma system and/or trauma registry. Much improvement in the trauma systems in these countries might be achieved, but unfortunately the economic situation of many countries may render trauma systems not at their top priority list.

The review showed that there are still many differences in trauma care worldwide. By studying these differences, factors of influence on outcome of care may be identified. **Chapters 3** and **4** describe the differences in patient characteristics, outcomes and processes of trauma care between the Netherlands and the United States. **Chapter 3** discusses the characteristics and outcomes of 1367 blunt polytrauma patients (Injury Severity Score  $\geq 16$ ) admitted to a level I trauma center in the US (USTC) or in the Netherlands (NLTC). Although several outcome parameters differed between the two urban area trauma centers in the USA and the Netherlands, such as a higher injury severity and more comorbidity in the USTC patients, the in-hospital survival of the trauma patients in these trauma centers was similar. Other outcome parameters, such as the length of stay in hospital and in the Intensive Care Unit, varied between the trauma centers, suggesting that differences in local policies and processes do influence the care system, but not so much the outcome of care as reflected by in-hospital mortality. Similar results were seen in the study described in **chapter 4**, on the characteristics and clinical outcomes of 1331 patients with penetrating injuries treated at urban Level-1 trauma centers in the USA (USTC) or the Netherlands (NLTC). Despite the higher incidence of penetrating trauma,

particularly firearm-related injuries, and higher hospital volumes in the USTC compared to the NLTC, the in-hospital mortality was similar. In this study, outcome of care was not significantly influenced by differences in incidence of firearm-related injuries.

Since the introduction of trauma systems in the Netherlands, the trade-off between centralization of care with sufficient hospital volumes on one hand and adequate trauma center access in terms of transport times and population coverage by means of more but smaller centers on the other hand is an important but complex issue. **Chapter 5** discusses the use of geographical information system (GIS) technology as a potential methodology for objectifying trauma access. The goal of this study was to determine the influence of trauma center distribution (the number and geographical location) during high and low traffic flow in a densely-populated region with 3 trauma centers in the Netherlands using GIS-technology. Not only was the current three trauma center scenario analyzed, but also six other scenarios with a varying number of trauma centers on different locations. This study showed that a GIS-model for trauma center access offered a quantifiable and objective method to evaluate trauma system distribution in areas with different geography and demography. Applying this technology to one of the most densely populated areas in the Netherlands shows that the transport time from accident to trauma center would remain acceptable if the current situation with three trauma centers would be changed to a scenario with two geographically well-spread trauma centers.

In 1998, after years of discussion, an inclusive trauma system was implemented in the Netherlands. The objective of the study, described in **chapter 6**, was to evaluate the impact of structured trauma care on the concentration of polytrauma patients over time in the Netherlands. This study shows that over the past 20 years trauma care has been progressively centralized, with more polytrauma patients primarily being brought to a trauma center. During the entire study period, the patients primarily brought to a trauma center were more severely injured, reflected by a higher median Injury Severity Score and higher median total Abbreviated Injury Score than the patients that were primarily brought to a non-trauma center. However, despite the well-organized Dutch EMS system, still roughly 30% of the polytrauma patients were primarily brought to a non-trauma center, indicating a need for improving pre-hospital triage.

The second part of this thesis focuses on the individualized care of polytrauma patients and more specifically on the role of malnutrition in severely injured patients admitted to the intensive care unit (ICU). **Chapter 7** gives an overview of the current knowledge about the pathophysiology, prevalence, and effects of malnutrition in severely injured patients. This review showed that despite the widespread belief about the importance of nutrition in severely injured patients, the quantity and quality of available evidence is sparse, mainly of low-quality, and outdated. Based on the malnutrition-associated

adverse outcomes, the nutritional status of severely injured trauma patients should be routinely and carefully monitored.

Malnutrition is associated with, but not only due to, calorie and protein deficits. It is customary to initiate enteral nutrition at a low rate and slowly increase the delivery rate to goal rate (RAMP-UP-protocol). Increasing evidence suggests that RAMP-UP may contribute to iatrogenic malnutrition. In **chapter 8** it was determined which proportion of total Surgical Intensive Care Unit calorie/protein deficit is attributable to RAMP-UP. In Surgical Intensive Care Unit patients initiating enteral nutrition, the RAMP-UP period accounted for 41% and 53% of the overall caloric and protein deficits, respectively. Starting enteral nutrition immediately at goal rate may therefore prevent a significant proportion of macronutrient deficit in the SICU.

It seems that polytrauma patients are at risk of considerable harm from malnutrition due to the metabolic response to trauma. However, little is known about (the risk of) malnutrition and its consequences in these patients. Recognition and acknowledgment of sub-optimally nourished polytrauma patients and their nutritional needs is crucial to prevent complications and optimize their clinical outcomes. Therefore, the trauma department of the LUMC initiated a multicenter international observational prospective cohort study. This Malnutrition in Polytrauma Patient (MaPP) study aims to gain more insight into the effect and consequences of malnutrition in polytrauma patients admitted to the ICU. The research protocol of the study is described in **chapter 9**. The objective is to investigate whether polytrauma patients admitted to the Intensive Care Unit, who are already malnourished before admission or develop malnutrition during admission, have a higher complication rate than patients who are and remain well-nourished. This study is performed at three Level-1 trauma centers in the United States and two Level-1 trauma centers in the Netherlands.

The general discussion in **chapter 10** presents an overview of issues that remain to be studied and future perspectives both on the organization of trauma care worldwide as well as malnutrition in polytrauma patients. Although substantial improvements were seen in the care for the injured in the past few decades, there are still many opportunities for improvement. In the future, we need to further focus on the continuum of trauma care, recognizing that strengthening each element of the trauma care chain improves outcomes for the severely injured patient. Malnutrition is still an underestimated problem in the polytrauma patient population, especially severely injured patients who are particularly susceptible to malnutrition and its related complications. New studies should focus on better defining the optimal nutritional treatment of severely injured patients. However, standardized data dictionaries and reasonable outcome measures are required for meaningful interpretation and application of results in malnutrition related research.