

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

Dijkink, S.

#### 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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Author: Dijkink, S. Title: Polytrauma patient management: Processes and performance in the Netherlands and beyond Issue Date: 2020-10-29



# 1

## General introduction, aim and outline of the thesis



On average, every six seconds someone dies as a consequence of accidental or intentional trauma, resulting in more than 5 million deaths per year around the globe.<sup>1</sup> Trauma is one of the leading causes of death in people under 45 years of age. It is estimated that injuries are responsible for 16% of the total disease burden and 9% of total mortality worldwide.<sup>1</sup> Data from the World Health Organization (WHO) estimate that the number of deceased caused by violence and injuries to be nearly twice as high as the combined number of deaths from HIV / AIDS, tuberculosis, and malaria worldwide. [Figure 1]



**Figure 1.** Number of deaths (in millions per year) as a consequence of traumatic injuries and HIV/AIDS, tuberculosis and malaria<sup>1</sup>

Even so, the millions of deaths that occur each year due to injuries are only the tip of the iceberg of the entire burden of trauma-related disease, as shown in Figure 2. For every death there are many more who survive their injuries but are left with permanent disability. Injuries are estimated to be responsible for up to 6% of all years lived with disability.<sup>1</sup> Therefore, despite trauma being recognized as a major public health problem for over 50 years, it still remains "the neglected disease of modern society".<sup>2</sup>

Besides leading to physical, emotional, and economic losses for the victims and their families, the financial burden of trauma affects nations as a whole, primarily in relation to the young and working population, as they are being precluded from production.<sup>3</sup> For example, it has been estimated that the consequences of road traffic crashes consume approximately 2% of the gross domestic product (GDP) of high-income countries and around 5% of the GDP of low- and middle-income countries.<sup>1</sup> Costs are expected to increase even further in the future. The WHO indicates that the number of injury-related deaths will rise dramatically, partly due to a projected 65% increase in road traffic deaths and injuries worldwide.<sup>4,5</sup>



Figure 2. Pyramid of injuries reported in the health care system.<sup>1</sup>

#### **DEVELOPMENT OF TRAUMA CARE SYSTEMS**

Up until the second half of the 20<sup>th</sup> century trauma was managed in an unstructured and unpredictable way, without any organized approach or system. The patient was usually transferred directly to the closest hospital and trauma care was provided by the on-call general surgeon, regardless of interest or expertise in trauma. Thus, the quality of care the injured patient received was more or less dependent upon chance. This became painfully obvious after the tragic airplane crash of Dr. Styner and his family.<sup>2</sup> The care that he and his family received in rural Nebraska was considered below the standards of customary clinical care. This event and the finding that a large proportion of the trauma deaths were *"preventable deaths"* further motivated improvements in trauma care.<sup>6, 7</sup> Among multiple processes and interventions, it led to the introduction of the Advanced Trauma Life Support (ATLS) and the extensive document of the American College of Surgeons (ACS) that describes the guidelines on optimizing hospital resources for the injured patient.<sup>8,9</sup>

Following the establishment of the ATLS course and the dissemination of the ACS guidelines, the *first trauma systems* were developed and implemented. In these systems the care of the severely injured patients was centralized to designated trauma centers. If the patient was instead transferred to a non-trauma center, stabilization was ensued and transport to a trauma center followed according to pre-established protocols. Often, transport times were long, and delays plagued transport to the places of definitive care. Although this *exclusive* trauma system worked well in urban areas with a sufficient number of acute care facilities and relatively short transport times, it produced suboptimal

results in rural areas. Therefore, an *inclusive* trauma system was proposed. In this system, trauma care is regionalized and coordinated throughout the entire chain of trauma care. All hospitals in a certain region participate in trauma care to the extent that their resources allow.<sup>10, 11</sup> In 1999 the American College of Surgeons - Committee on Trauma (ACS-COT) proposed criteria for the *inclusive* trauma system by categorizing hospitals according to their available resources.<sup>12</sup>

Based on these criteria, hospitals providing trauma care were categorized into five different levels; a level I trauma center provides comprehensive trauma care and is required to have around-the-clock immediate availability of a trauma team with high level facilities; level II and III hospitals have the ability to provide prompt assessment, perform emergent operations, maintain intensive care facilities, and function as a supplement to the level I facilities; level IV and V centers, often located in remote areas, have the capacity to stabilize polytrauma patients according to ATLS principles before transferring the patient to a center with a higher level of care.<sup>13</sup> After the introduction of this trauma system in the United States, other countries, such as Canada, Hong Kong, Australia, the United Kingdom, Israel, the Netherlands, and Germany implemented an inclusive trauma system based on the ACS-COT guidelines adapted to their local needs and policies.<sup>14-24</sup>

The implementation of inclusive trauma systems has since proven its positive effect on outcomes, resulting in lower overall mortality rates in numerous countries, especially for the severely injured.<sup>25-29</sup> However, despite the obvious and evidence-based advantages of a trauma system, international differences in the organization of trauma care remain. There is neither consensus about the ideal organization of trauma systems worldwide nor is a trauma system implemented in every country.<sup>30, 31</sup>

#### TRAUMA SYSTEMS IN THE NETHERLANDS

Similar to the rest of the world, injuries present a public health problem in the Netherlands, affecting all ages and strata of society. Currently, more than one-third of the approximately 2,000,000 annual Emergency Department (ED) visits are injury-related. In 150,000 cases, hospital admission is required, of which more than 5,000 patients are admitted with serious or multiple injuries.<sup>32</sup>

Annually, an average of 8,000 people die as a result of an accident or violence in the Netherlands.<sup>33</sup> An even greater number of patients suffer disabilities.<sup>34</sup> Approximately 6% of the victims of injuries have a permanent handicap.<sup>32</sup> It has been estimated that the total economic burden due to injuries in the Netherlands is approximately €3.5 billion annually, of which €2.0 billion is attributable to direct health care costs and €1.5 billion to loss of productivity.<sup>35, 36</sup>

In the early 1980s, Dutch surgeons first expressed their concern about the absence of trauma care standardization, collaboration, organization, and the suboptimal quality of both prehospital and in-hospital care provided to injured patients.<sup>16, 37</sup> Following this concern and the subsequent increase in political and societal awareness, the Dutch Association for Trauma Surgery was founded in 1982. Directly thereafter the association joined the discussion about the organization of trauma care in the Netherlands. The first mission and vision report was published in 1985 and described an initial set of criteria that hospitals receiving trauma should meet.<sup>38-40</sup> However, despite good intentions, none of the Dutch hospitals met those criteria and a formal system for transferring patients between hospitals continued to be non-existent.<sup>38</sup>

A horrifying airplane crash in Amsterdam (The Bijlmer Disaster, 1992) and a compelling report by the Public Health Inspectorate were needed to make trauma care a matter of political and public priority. This report showed that a formal prehospital and in-hospital trauma system was lacking in both daily practice and during a disaster.<sup>39, 41</sup>. In 1998, almost 20 years after these first concerns about the organization of trauma care, the Dutch Government appointed ten (later 11) trauma centers in the Netherlands [Figure 3].



Figure 3. Eleven trauma centers and their trauma regions in the Netherlands



Figure 4. Chain of trauma care in the Netherlands

The aim of the trauma center appointment was to optimize Dutch trauma care through regionalization of care with one coordinating center per trauma region. Consequently, the entire chain of trauma care, from prevention to recovery was to be improved [Figure 4].<sup>42, 43</sup> Quality measures were installed to guarantee quality of care and its ongoing improvement: trauma hospital level criteria were defined for level 1, 2 and 3 centers, a national trauma registry became mandatory for all hospitals, and the certification for specialist (orthopedic) trauma surgeons was established. Since then, the outcomes for the injured patients have improved significantly with a mortality rate reduction of 16% in all injured patients and a striking 21% mortality rate reduction in the most severely injured patients.<sup>28, 29, 44</sup>

#### CHALLENGES IN OPTIMIZING TRAUMA CARE

Significant improvements in outcomes were seen after the implementation of allinclusive trauma systems. Nevertheless, it is still a challenge to define the most efficient way to provide structured and optimal care. Considerable variation in the organization of trauma care remains between and even within countries, despite internationally accepted standards for trauma care. However, not all of these standards are evidencebased. Many factors that influence trauma system functionality and their relationship to clinically important outcomes remain unclear.

Although the American and Dutch trauma systems share many similarities, there are also considerable differences. Amongst others, the incidence and nature of the trauma mechanisms, patient volumes, trauma training, prehospital care, clinical experience and rehabilitation differ between the two countries. These differences in demographics and healthcare processes could potentially affect outcomes. Clarifying the differences and the resulting effects by comparing trauma system characteristics and demographics internationally might help us identify modifiable factors that could improve outcomes.

Since the first introduction of the concept of trauma systems, the trade-off between centralization of care and accessibility of trauma centers has been controversial. On the one hand, centralization of care resulting in higher hospital volumes will increase the expertise of the trauma teams and pose organizational and process of care advantages. On the other hand, trauma center accessibility and population coverage could be better achieved by multiple, and consequently smaller-volume trauma centers. Given that the advantages and disadvantages of these differing organizational approaches have not been rigorously studied, the ideal trauma center configuration is still unknown. There is a need for a generally applicable model that could be modified to a trauma region's needs, based on local injury data, capacity, and demographical data. Identifying factors that influence trauma center accessibility, such as traffic flow, in combination with -for example- population coverage, is essential in order to determine the optimal geographic location of trauma centers in a certain region.

As important as it is to seek structural improvement in broad organizational aspects, the care of the individual patient and the improvements we can create on a case-by-case base are equally important. One of the areas in which progress is direly needed relates to the nutrition therapy of trauma patients, particularly during the acute phase of care. About 20-40% of all hospitalized patients are affected by malnutrition, a percentage that is even higher in critically ill patients.<sup>45-48</sup> Malnutrition is considered a risk factor for poor clinical outcomes, such as higher morbidity and mortality, in hospitalized patients.<sup>45,49-51</sup> However, little is known about the influence of malnutrition in trauma patients during hospitalization. More insight into malnutrition, how to recognize it and eventually prevent it, is necessary. Therefore, the Department of Trauma Surgery of the Leiden University Medical Center, initiated in collaboration with its American research partners a multi-center prospective study to investigate the occurrence and effect of malnutrition in trauma patients admitted to the Intensive Care Unit.

#### **AIM AND OUTLINE OF THIS THESIS**

Differences in trauma care between countries result in inconsistent care and present an opportunity to identify areas of improvement. The primary aim of this thesis is to analyze the presence and structure of trauma systems and evaluate specific care-delivery processes and their parameters. The second aim is to evaluate one of these parameters, the role of the nutritional status in the outcome of polytrauma patients.

Chapter 2 gives an overview of the current state of trauma systems globally. Chapter 3 aims to compare the demographics, injury characteristics, and outcomes of patients with blunt polytrauma treated in two comparable, urban, academic, Level I Trauma Centers, one in the United States and the other one in the Netherlands. Chapter 4 discusses the characteristics and outcomes of patients with penetrating injuries treated at multiple urban level-1 trauma centers in the United States and the Netherlands. Chapter 5 introduces a new model for the quantification of the effects of trauma center distribution on transportation time. In chapter 6 we aim to evaluate the impact of structured trauma care on the concentration of severely injured patients over time. Chapter 7 provides an overview of the current knowledge about the pathophysiology, prevalence, and effects of malnutrition in severely injured patients. Chapter 8 shows the proportion of total caloric and protein deficit that is attributable to the RAMP-UP protocol (i.e. initiating enteral nutrition (EN) at a low rate and slowly increasing the rate) in patients admitted to the Surgical Intensive Care Unit. Chapter 9 discusses the study protocol of the international multicenter prospective Malnutrition in Polytrauma Patients [MaPP] study, which aims to describe the effect and consequences of malnutrition in polytrauma patients admitted to the Intensive Care Unit. In chapter 10 a discussion on the topics described above is presented, as are the future perspectives and potential implications of the findings in this thesis.

#### REFERENCES

- 1. World Health Organization. Injuries and violence: the facts 2014. Geneva; 2014.
- 2. National Academy of Sciences, National Research Council Committee on Trauma, Accidental Death and Disability: The Neglected Disease of Modern Society. Washington (DC): National Academies Press (US) Copyright (c) National Academy of Sciences.; 1966.
- Patton GC, Coffey C, Sawyer SM, Viner RM, Haller DM, Bose K, Vos T, Ferguson J, Mathers CD. Global patterns of mortality in young people: a systematic analysis of population health data. Lancet. 2009;374(9693):881-92.
- World Health Organization. Saving millions of lives: decade of action for road safety 2011-2020. Geneva; 2011.
- 5. Peden M, Scurfield R, Sleet D, Hyder AA, Mathers C, Jarawan E, Hyder A, Mohan D, Jarawan E. World report on road traffic injury prevention: World Health Organization; 2004.
- 6. Van Wagoner FH. A three year study of deaths following trauma. Journal of Trauma and Acute Care Surgery. 1961;1(4):401-8.
- Cales RH, Trunkey DD. Preventable Trauma Deaths: A Review of Trauma Care Systems Development. JAMA. 1985;254(8):1059-63.
- 8. Carmont MR. The Advanced Trauma Life Support course: a history of its development and review of related literature. Postgraduate Medical Journal. 2005;81(952):87-91.
- 9. Hospital resources for optimal care of the injured patient. Prepared by a Task force of the Committee on Trauma of the American College of Surgeons. Bull Am Coll Surg. 1979;64(8):43-8.
- 10. Nathens AB, Brunet FP, Maier RV. Development of trauma systems and effect on outcomes after injury. The Lancet. 2004;363(9423):1794-801.
- 11. Narad RA, Becker JL, Frecceri C. A decentralized trauma system design for a rural area. Prehospital and disaster medicine. 1996;11(2):134-40.
- 12. American College of Surgeons Committee on Trauma. Resources for optimal care of the injured patient 1999. Chicago: American College of Surgeons; 1999.
- Nathens AB, Brunet FP, Maier RV. Development of trauma systems and effect on outcomes after injury. Lancet. 2004;363(9423):1794-801.
- 14. Sturm JA, Pape HC, Dienstknecht T. Trauma care in Germany: an inclusive system. Clin Orthop Relat Res. 2013;471(9):2912-23.
- 15. Oestern H-J, Garg B, Kotwal P. Trauma Care in India and Germany. Clinical Orthopaedics and Related Research<sup>®</sup>. 2013;471(9):2869-77.
- 16. ten Duis HJ, van der Werken C. Trauma care systems in The Netherlands. Injury. 2003;34(9):722-7.
- 17. Zakrison T, Ball CG, Kirkpatrick AW. Trauma in Canada: a spirit of equity & collaboration. World J Surg. 2013;37(9):2086-93.
- 18. Kortbeek JB, Buckley R. Trauma-care systems in Canada. Injury. 2003;34(9):658-63.
- 19. Blackwell T, Kellam JF, Thomason M. Trauma care systems in the United States. Injury. 2003;34(9):735-9.
- Westhoff J, Hildebrand F, Grotz M, Richter M, Pape HC, Krettek C. Trauma care in Germany. Injury. 2003;34(9):674-83.
- 21. Albert J, Phillips H. Trauma care systems in the United Kingdom. Injury. 2003;34(9):728-34.
- 22. DeKeyser F, Avitzour M, Watts DD, Trask AL, Muggia-Sullam M. International trauma care: a comparison between Jerusalem, Israel, and Fairfax County, Virginia, USA. Isr Med Assoc J. 2002;4(2):103-8.

- 23. Cheng CH, Graham CA, Gabbe BJ, Yeung JH, Kossmann T, Judson RT, Rainer TH, Cameron PA. Trauma care systems: a comparison of trauma care in Victoria, Australia, and Hong Kong, China. Ann Surg. 2008;247(2):335-42.
- 24. Delprado AM. Trauma systems in Australia. J Trauma Nurs. 2007;14(2):93-7.
- MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, Salkever DS, Scharfstein DO. A national evaluation of the effect of trauma-center care on mortality. N Engl J Med. 2006;354(4):366-78.
- 26. Lansink KW, Leenen LP. Do designated trauma systems improve outcome? Curr Opin Crit Care. 2007;13(6):686-90.
- 27. Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, Flint L. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. J Trauma. 2006;60(2):371-8; discussion 8.
- 28. Spijkers AT, Meylaerts SA, Leenen LP. Mortality decreases by implementing a level I trauma center in a Dutch hospital. J Trauma. 2010;69(5):1138-42.
- 29. Twijnstra MJ, Moons KG, Simmermacher RK, Leenen LP. Regional trauma system reduces mortality and changes admission rates: a before and after study. Ann Surg. 2010;251(2):339-43.
- 30. ROBERT J. WINCHELL RMS, MICHELLE PRICE. Committee on Trauma introduces needs assessment tool aimed at resolving trauma center debat. 2016.
- 31. Dijkink S, Nederpelt CJ, Krijnen P, Velmahos GC, Schipper IB. Trauma systems around the world: a systematic overview. Journal of trauma and acute care surgery. 2017;83(5):917-25.
- 32. RIVM. SEH bezoeken cijfers en context Bilthoven2017 [cited 2019 September 12]. Available from: https://www.volksgezondheidenzorg.info/onderwerp/letsels/cijfers-context/seh-bezoeken.
- 33. Statistics Netherlands (CBS). CBS Doodsoorzakenstatistiek [Available from: https://www.volksgezondheidenzorg.info/onderwerp/letsels/cijfers-context/sterfte#node-sterfte-door-letsels.
- 34. Christine Stam BB. Letsels 2017. Kerncijfers LIS. Amsterdam; 2017.
- 35. Polinder S, Haagsma J, Panneman M, Scholten A, Brugmans M, Van Beeck E. The economic burden of injury: Health care and productivity costs of injuries in the Netherlands. Accident Analysis & Prevention. 2016;93:92-100.
- 36. RIVM. Kosten letsels door ongeval 2016 [cited 2019 September 12]. Available from:https://www. volksgezondheidenzorg.info/onderwerp/letsels/kosten/kosten.
- 37. Goris RJA DJ. De zorg voor detrauma-patiënt: meer en beter onderzoek nodig. . Medisch Contact 1984;39:301-2.
- Goris R. De acute zorg voor ernstig gewonde patienten. Ned Tijdschr Geneeskd. 1990;134:1439-42.
- Goris R. Honderd jaar Nederlandse Vereniging voor Heelkunde. v. Traumatologie. Ned Tijdschr Geneeskd. 2002;146(24):1144-7.
- 40. Nederlandse Vereniging voorTraumatologie. Organisatietraumatologie in Nederlandse algemene ziekenhuizen. Utrecht; 1985
- 41. Inspectie voor Volksgezondheid. De keten rammelt. 1995.
- 42. Ministerie van Volksgezondheid Welzijn en Sport. Met Zorg Verbonden. 1997.
- 43. Nederlandse Vereniging voor Traumatologie. Traumazorg; onze zorg1997.
- 44. Lansink KW, Gunning AC, Spijkers AT, Leenen LP. Evaluation of trauma care in a mature level I trauma center in the Netherlands: outcomes in a Dutch mature level Itrauma center. World J Surg. 2013;37(10):2353-9.
- 45. Mogensen KM, Robinson MK, Casey JD, Gunasekera NS, Moromizato T, Rawn JD, Christopher KB. Nutritional Status and Mortality in the Critically III. Crit Care Med. 2015;43(12):2605-15.

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  - 46. Barker LA, Gout BS, Crowe TC. Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system. Int J Environ Res Public Health. 2011;8(2):514-27.
  - 47. Pirlich M, Schütz T, Norman K, Gastell S, Lübke HJ, Bischoff SC, Bolder U, Frieling T, Güldenzoph H, Hahn K, et al. The German hospital malnutrition study. Clinical Nutrition. 2006;25(4):563-72.
  - Edington J, Boorman J, Durrant ER, Perkins A, Giffin CV, James R, Thomson JM, Oldroyd JC, Smith JC, Torrance AD, et al. Prevalence of malnutrition on admission to four hospitals in England. The Malnutrition Prevalence Group. Clin Nutr. 2000;19(3):191-5.
  - 49. Correia MI, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. Clin Nutr. 2003;22(3):235-9.
  - 50. Keel M, Trentz O. Pathophysiology of polytrauma. Injury. 2005;36(6):691-709.
  - 51. Kruizenga H, van Keeken S, Weijs P, Bastiaanse L, Beijer S, Huisman-de Waal G, Jager-Wittenaar H, Jonkers-Schuitema C, Klos M, Remijnse-Meester W, et al. Undernutrition screening survey in 564,063 patients: patients with a positive undernutrition screening score stay in hospital 1.4 d longer. Am J Clin Nutr. 2016;103(4):1026-32.