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Federaal Kenniscentrum voor de Gezondheidszorg
Centre Fédéral d'Expertise des Soins de Santé
Belgian Health Care Knowledge Centre

TOWARDS AN INCLUSIVE SYSTEM FOR MAJOR TRAUMA

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HEALTH SERVICES RESEARCH

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TOWARDS AN INCLUSIVE SYSTEM FOR MAJOR TRAUMA

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Disclaimer:

- **The external experts were consulted about a (preliminary) version of the scientific report. Their comments were discussed during meetings. They did not co-author the scientific report and did not necessarily agree with its content.**
- **Subsequently, a (final) version was submitted to the validators. The validation of the report results from a consensus or a voting process between the validators. The validators did not co-author the scientific report and did not necessarily all three agree with its content.**
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LIST OF ABBREVIATIONS

ABBREVIATION	DEFINITION
A&E	Accident & Emergency
ACS-COT	American College of Surgeons Committee on Trauma
AIOS	Assistent in Opleiding tot Specialist
AMSTAR	A Measurement Tool to Assess Systematic Reviews
ANIOS	Arts Niet in Opleiding tot Specialist
ATS	American Trauma Society
AUC	Academy for Trauma Surgery – Akademie der Unfallchirurgie GmbH
BFM	Budget of Financial Means
CAG	Clinical Advisory Group
CBZ	College Bouw Zorginstellingen
CCG	Clinical commissioning groups
COAMU – PCDGH	Commission for urgent medical care
CPA	Centrale Post Ambulancevervoer
DGU	German Society of Trauma Surgery – Deutsche Gesellschaft für Unfallchirurgie
DH	Department of Health
DTC	Designated Trauma Centre
ED	Emergency Department
EMS	Emergency Medical Services
ER	Emergency Room
ESTES	European Society for Trauma & Emergency Surgery
EuSEM	European Society for Emergency Medicine
GGZ	Geestelijke gezondheidszorg
GHOR	Geneeskundige Hulpverlening bij Ongevallen en Rampen

GRADE	Grading of Recommendations Assessment, Development and Evaluation
HDU	High dependency unit
HIT	Health system in Transition
HRG	Healthcare resource group
ICD	International Classification of Diseases
ICISS	International Classification of Diseases (ICD-9) Injury Severity Score
ICU	Intensive care unit
IGZ	Inspectie voor de Gezondheidszorg
INAMI – RIZIV	National Institute for Health and Disability Insurance
ISP – WIV	The Scientific Institute of Public Health
ISS	Injury Severity Scale
LBTC	Landelijke Beraadsgroep Traumatologie
LEH	Local Emergency Hospital
LNAZ	Landelijk Netwerk Acute Zorg (Previously called Landelijke Vereniging van Traumacentra (LVTC))
LTC	Local trauma centre
MICU	Mobiele intensive care unit
MMT	Mobiel Medisch Team
MOOSE	Metaanalysis of Observational Studies in Epidemiology
MRI	Magnetic Resonance Imaging
MTC	Major Trauma Centre
NAO	National Audit Office
NCAT	National Clinical Advisory Team
NCEPOD	National Confidential Enquiry into Patient Outcome and Death
NHS	National Health Service

NHSAT	NHS area teams
NHSCR	NHS commissioning regions
NICE	National Institute for Health and Care Excellence
NPRP	National Per Review Programme
NTC	Non Trauma Centre
NVvH	Nederlandse Vereniging voor Heelkunde
NW	Local trauma networks
NZA	Nederlandse Zorg Autoriteit
PbR	Payment by Results
PIT	Paramedical Intervention Team
PRISMA	Preferred Reporting Items For Systematic Review And Meta-Analysis
QI	Quality Improvement
RAV	Regionale Ambulance Voorziening
RCS	Royal College of Surgeons in England
RCT	Randomised controlled trial
RGF	Regionaal Geneeskundig Functionaris
RHM – MZG	Hospital discharge dataset
ROAZ	Regionaal Overleg Acute Zorg
RTC	Regional trauma centre
SCI	Science Citation Index
SEH	Spoedeisende hulp
SHA	Strategic Health Authorities
SMH	Spoedeisende Medische Hulpverlening
SMUH – MUGH	Helicopter intensive care unit

SMUR – MUG	Mobile intensive care unit
SMUREG – MUGEG	Mobile intensive care unit data
SPF – FOD	Federal Public Service
SSCI	Social Sciences Citation Index
STC	Supraregional trauma centre
STZ	Samenwerkende Top Ziekenhuizen
TARN	Trauma Audit and Research Network
TC	Trauma Centre
TCAA	Trauma Centre Association of America
TN	Trauma Network
TNW	TraumaNetzwerk DGU®
TR – DGU	TraumaRegister DGU®
TU	Trauma Unit
TWAZ	Tijdelijke Wet Ambulancezorg

SCIENTIFIC REPORT

PART 1: INTRODUCTION AND SCOPE

1 INTRODUCTION

1.1 General context

Major trauma: a common cause of mortality and morbidity

Major Trauma is a serious public health problem and is worldwide one of the leading causes of deaths and a significant cause of short- and long-term morbidity.[1-4]

Several definitions are used to identify major trauma patients

Internationally there is not one single definition for major trauma but recurrent themes in definitions are that the injuries are multiple and serious and that they could result in permanent disability or death. Injuries might include serious head injuries, falls, severe gunshot or stab wounds or road traffic accidents. Some definitions of major trauma focus only on life-threatening injuries while others also include life-changing injuries (injuries that result in permanent disability).

In the scientific literature a number of tools have been developed to score injuries and assess physiological derangement. The Injury Severity Score (ISS) is the most omnipresent summary score derived from Abbreviated Injury Scale (AIS) data. The most commonly used threshold to classify patients as 'major trauma' is an ISS above fifteen.[5, 6] However, other thresholds are also used (e.g. ISS above 12 in Canada[7] and Australia[8]; ISS above eight in England[9] and ISS equal or higher to 20 in Switzerland[10]).

The different thresholds are linked to different versions of the Abbreviated Injury Scale (AIS)[5, 11] as well as to the choice to define a major trauma as life-threatening or a life-changing event. Whatever the reason is behind the selected threshold, it impacts the number of patients that is classified as 'major trauma' and the estimation of resources required to care for them.

International focus on trauma network development

Internationally, trauma networks (or systems) are the dominant way to organise the care for patients with a major trauma. This was pioneered in the USA but is now also widely implemented in Europe (e.g. England, the Netherlands, Germany, Norway), Australia and beyond.[7-9, 12-22]

These systems or networks are typically geographically organised with major trauma centres as focal nodes. Major trauma centres are hospitals that specialise in, and are designated for, the treatment of the major trauma patients. They see such patients with sufficient frequency to gain expertise in their management. In addition they have a central role in providing support to other centres and monitor their performance. Other European countries that are preparing a similar reform of trauma care include Switzerland, Scotland, Wales and Ireland.[23-26]

The trauma pathway: from pre-hospital care to rehabilitation

The organisation of trauma care involves the entire care pathway: pre-hospital care, initial and ongoing acute care, and rehabilitation. A typical characteristic of organisational models that target the entire trauma care pathway is that care is not organised via stand-alone institutions but via trauma care networks, often addressed as 'Inclusive Trauma Systems'.[7, 15, 18, 27, 28] The crux of a trauma system is getting the patient to the right place at the right time for the right care:

- In the pre-hospital care setting the seriousness of the injury should be identified as early as possible to enable the transportation of the major trauma patient to a specialised care setting. The pre-hospital care entails the response to the emergency call, the care on the scene, triage, and transfer to a hospital.
- In the initial acute trauma care and surgery phase patients are admitted to the hospital in the emergency department with an initial assessment and acute stabilisation of physiology and injuries. This phase also includes immediate diagnostic testing (e.g. computed tomography facility scanning immediately after arriving at the hospital and stabilisation) and immediate trauma care (e.g. urgent surgical interventions).
- The ongoing care and reconstruction phase starts immediately after any resuscitation and urgent surgery and continues until discharge from the acute setting.
- The rehabilitation phase includes therapies aiming to restore patients to optimal mobility, independence and employment following injury.

One of the improvements major trauma networks aim for is to minimize variance from an accepted standard of care throughout the entire care pathway via standardisation of care processes for the entire territory (or at least for the geographical area that is covered by a particular trauma system).

1.2 Objective of the report

The current study provides a second analysis of the organisation of emergency departments[29], this time with a focus on major trauma. The previous Ministry (Laurette Onkelinkx) along with scientific organisations working in the field of trauma (Belgian society of emergency and disaster medicine (BeSEDiM), Belgian Trauma Society (BTS), Belgian Orthopaedic Trauma Association (BOTA) and Trauma Task Force (TTF)) asked the KCE to conduct this study. The research questions addressed were:

- How is the care for major trauma patients organised in Belgium?
- What is the organisational framework of MTCs in European countries and what lessons can be learned from their implementation process?
- What is the evidence about the effectiveness of a major trauma centre (MTC) on mortality (up to 30 days after discharge), length of hospital stay and length of ICU stay?

This study focused on the organisation of the acute phase of major trauma treatment. Therefore, the description of injury prevention programs and of the organisation of the rehabilitation services for major trauma were outside of the scope of this report. We did neither include an evaluation of the tools and thresholds used to group or discriminate trauma patients nor the accuracy of existing pre-hospital triage tools. Nevertheless, the current KCE study describes the applied definitions and tools found in the literature and in the different countries.

1.3 Structure of the report

From this point, the scientific report includes three chapters.

Chapter 2 includes a description of the framework for 'urgent medical care' in Belgium and an analysis of the degree of dispersion of care for 'major trauma' patients.

Chapter 3 includes an in-depth analysis of the organization of trauma care in three neighbouring countries: England, The Netherlands and Germany.

Chapter 4 includes a review of the literature on the effectiveness of a major trauma centre (MTC) on mortality (up to 30 days after discharge), length of hospital stay and length of ICU stay.

The main **messages and conclusions** drawn from the scientific research can be found in the **short report of this study** as a separate document[a].

[a] Syntheses in French and in Dutch are also published as separate documents.

PART 2: BELGIUM CHAPTER

2 CARE FOR SEVERELY INJURED PATIENTS IN BELGIUM

2.1 Belgian Context

In Belgium, there is neither a formal 'trauma system' for the territory nor an official adopted definition for a 'major trauma patient[b]'' in hospital settings. In pre-hospital settings, a severe trauma ('Trauma sévère/ 'Ernstig trauma') can be registered/flagged as one out of eight pathologies and conditions (severe trauma, cardiac arrest, respiratory distress, acute coronary syndrome, stroke, intoxication, suicide and other) included in the Mobile intensive care unit (SMUR – MUG) registry. The flag is ticked by the EMS team according to their clinical experience. However, the instructions included in the SMUR – MUG manual mention that a severe trauma occurs when the patient has a Revised Trauma Score (RTS) of less or equal to five and whose International Classification of Diseases (ICD) code is between 800 et 959.9.[39]

Concentration of specialised trauma care in reference centres: part of the larger reform of the hospital landscape

The re-organisation of trauma care is also relevant in light of the larger reform of the Belgian hospital sector. The Action Plan for the reform of the hospital landscape (April 2015)[38] from Maggie De Block, Minister of Social Affairs and Public Health, stipulates that hospitals have to become part of larger partnerships, in which they will need to join forces to better coordinate patient care and to efficiently distribute tasks. The basic principles in the Action Plan were operationalised in a vision statement of October 2016[39] (see Box 1). In the Plan, the Minister states that the healthcare landscape will have 25 loco-regional networks where hospitals will collaborate for loco-regional care assignments in order to rationalise the care supply (e.g. by merging maternity services with low activity rates). Emergency departments will also be rationalised and their link with primary care services optimised.

[b] In this document we will use 'severely injured patient' or 'major trauma patient' for victims of a serious injury that can result in permanent disability or death.

Supraregional collaborations will also be implemented to provide highly specialised care ('supraregional care assignments') that will not be available in all loco-regional networks but only in a limited number of hospitals 'reference points' (e.g. for the treatment of rare cancers).

Box 1 – Principles of the vision strategy of the Minister De Block[2]

- The healthcare landscape consists of 25 loco-regional clinical hospital networks, covering catchment areas of about 400 000 to 500 000 inhabitants (or potential patients).
- The partners in the loco-regional network are hospitals (not hospital functions, departments, care programmes, etc.).
- Each loco-regional network provides general and specialised care assignments. General care assignments can be provided in each hospital of the loco-regional network while specialised care assignments are provided in a limited number of hospitals of the loco-regional network.
- Care assignments that are not provided in each loco-regional network are called 'supraregional care assignments'. The latter can be categorised into reference assignments (that can be provided by university and non-university hospitals) and university assignments (that are only provided by some university hospitals).
- The partners in such a 'supraregional collaboration' are the loco-regional networks and the hospital providing the care assignment at the supraregional level ('reference point').
- In addition to the creation of clinical hospital networks, programming of services is considered as an instrument to rationalise the care supply. A new procedure for programming (evidence-based, transparent, evolving and proactive) will be implemented.

Specialised trauma care is one of the examples of a supraregional care assignment that is to be assigned to a limited number of hospitals or 'reference points' (in *casu* major trauma centres) and that will be the gravity centre of the supraregional collaboration.

2.1.1 Data available to assess the impact of injury

Due to the absence of a national trauma registry in Belgium, it is currently not possible to fully assess the incidence of life-altering and life-threatening trauma related incidents. Some Belgian hospitals have chosen to participate in the trauma registry from the German Trauma Registry founded by the German Society of Trauma Surgery.[32]

Belgian studies on the epidemiology of major trauma patients are rare[33, 34] and relevant information on the clinical practices in emergency departments on the management of major trauma patients is scarce.[35-38] A study of 2008, estimated that paediatric trauma made up about 10% of the overall workload of the emergency department. Most of these patients had minor injuries, and severe trauma amounted to 1 per 1000 cases per year. The authors pointed out that the chance to seeing a severe paediatric trauma in the emergency department occurs once every two-three weeks.[35]

The absence of a trauma registry and coding issues with existing databases is an issue of concern (see section 2.3.4). It is expected that new registries for any illness or condition will be implemented as a part of the Healthdata.be initiatives (see Box 2).[40]

Box 2 – e-Health initiative: towards larger and improved data registration in Belgium

The Scientific Institute of Public Health (ISP – WIV)[40] is in charge of the project aiming to elaborate an inventory and to consolidate current healthcare registries in Belgium. All registries are organised via the same platform (Healthdata.be) allowing to facilitate the recording of data on healthcare, through the implementation of simple processes. The list of ongoing projects (Waves 1, 2 and 3) for the redesign and registry collection can be found on the Healthdata.be web page (https://healthdata.wiv-isp.be/fr/projets).

2.2 Organisation of care for injured patients in Belgium

2.2.1 The choice of the hospital is determined by the transport rules for Emergency Medical Service

Transfer from emergency scene to emergency department of a hospital

As a general rule, the Royal Decree of 2 April 1965 on the organisation modalities for Urgent Medical Care ('Aide médicale urgente' – 'Dringende Geneeskundige Hulpverlening')[41] obliges emergency medical services (EMS) to transport the victim to the nearest hospital with a specialised emergency department (ED) ('soins urgents spécialisés' – 'Gespecialiseerde spoedgevallenzorg', see Box 3 for a description).

The emergency medical dispatchers ('opérateurs' – 'operatoren') contact the nearest EMS team and inform them which hospital can be reached within the shortest travel time. There are some exceptions to this general rule than can be applied under specific conditions. The article points out that the medical doctor of the mobile intensive care unit ('Service Mobile d'Urgence et de Réanimation' (SMUR) – 'Mobiele Urgentie Group' (MUG)) may suggest to access another hospital if: [41-44]

- The care capacity of the nearest hospital is overwhelmed after a collective emergency or disaster;
- The victim requires a specific diagnostic or therapeutic procedure that is not available in the nearest hospital;
- The treating physician (present with the patient) indicates that (s)he has a medical record in another hospital having a specialised emergency department.

If there is no intervention of the mobile intensive care unit (SMUR – MUG), the patient can be transported to another hospital if:

- The victim requires a specific diagnostic or a therapeutic procedure that is not available in the nearest hospital;
- The treating physician (present with the patient) indicates that (s)he has a medical record in another hospital having a specialised emergency department.

In addition to the previously mentioned exceptions, the Royal Decree foresees that:

- The victims aged 14 years or younger are transported to the nearest hospital with specialised emergency department that also has a care programme for children[c].

The emergency medical dispatcher verifies whether the nearest hospital has the appropriate capacity to treat the patient and transfers this information to the EMS team. The Commission for Urgent Medical Care ('Commission de l'aide médicale urgente' (COAMU) – 'Commissie voor Dringende Geneeskundige Hulpverlening (CoDGH)) of each province establishes a list of hospital specificities consulted by the dispatcher centres.[45] The COAMU – CoDGH may also establish specific protocols that can determine the transfer of patient to a given hospital.[44]

Although available in each province, the criteria are not standardised, which can be a potential barrier when a national trauma system is envisaged. In addition, triage protocols, based on the mechanism of injury and physiological and anatomical parameters have not been established by the Commissions for urgent medical help.[44]

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[c] 'd'un service des maladies infantiles agréé' – 'Dienst voor kindergeneeskunde'

Box 3 – Specialised and non-specialised emergency departments

A detailed description of the requirements for emergency departments is Belgium can be found in the KCE report 263.[29] The following description summarises the differences between specialised and non-specialised emergency departments.

Specialised EDs should be able to "secure, stabilize and restore the vital functions" and are "responsible for the care of anyone who presents himself or is brought to the service with a health condition that can or may require immediate care".[46] This role includes: intake; first aid and, if required, the resuscitation, stabilization and restoration of vital functions; first diagnostic and therapeutic guidance/orientation; if required, a first observation period (less than 24 hours) with the aim of the diagnostic work-up and therapeutic guidance; required actions to preserve the continuity of care to patients whether they are admitted to the hospital or not.[47] Besides other recognition standards (e.g. architecture) it is stipulated that a 24/7 hour service must be provided by at least two nurses (with at least one nurse with a 'special title in intensive and emergency care' or equal) and one physician.[46]

Acute hospitals without a 'specialised ED' are obliged to have a non-specialised ED that is capable to deal with the first care[46] and treatment of patients with an acute pathology. The recognition standards for non-specialised EDs are lighter compared to those of specialised EDs (e.g. nursing staff is not required to have a special title in emergency and intensive care; one nurse instead of two; medical 24/7 service provided by physician on call for the entire hospital).

Most acute hospitals have a specialised emergency department (101 on the 102 acute hospitals). In 2015, 102 acute hospitals encompassing 199 different sites (with one closing in June 2015) covered the territory. There were 131 hospital sites with a specialised emergency department (ED).

From these 131 sites, 69 (53%) had a MICU linked directly to their site and 30 (23%) sites work in collaboration with a MICU from another site. Thirty-two (24%) hospital sites with a specialised ED do not have a MICU or do not have an agreement with other hospitals ('hospital association') to run a MICU collaboratively. It is well-known that Belgian acute hospitals have a large capacity and that most hospitals provide the broadest possible number of services with the latest technological innovations, resulting in a wide diffusion of technologies and heavy equipment.[48]

Secondary transfers

Secondary transfers between hospitals can be divided into two groups: urgent and non-urgent transport of patients[d]. In the case of an urgent transfer, the patient needs to be transported without delay, to the nearest hospital where the necessary therapeutic or diagnostic resources are available. The physician in charge of the patient contacts the hospital where the patient is referred to in order to determine:[43, 49]

- The level of urgency;
- The hospital's availability to treat the patient.

Two possible transport arrangements can be organised and depend on the availability of resources and whether they participate on the provision of urgent medical care.

[d] For a non-urgent transport of the patient, different rules apply. These rules are not discussed within the scope of this project. For a detailed description of the rules for non-urgent transport of patients, we refer the interested reader to Cierkens et al. (2015).[43]

- Available resources at one of the two hospitals
  - Resources linked to the provision of urgent medical care: If the applicant or recipient hospital has sufficient resources on site (e.g. employee(s) and/or a vehicle) then they can use them for the transfer. The dispatching centre needs to be informed of the decision;
  - Resources not linked to the provision of urgent medical care: If the medical team in charge of the patient considers that one of the two hospitals has sufficient and appropriate resources for the transport of the patient, then these resources are used for the transfer;
- Resources for the transfer are not available in any hospital
  - In the absence of transport means directly available in one of the two hospitals, the dispatching centre shall be contacted and the most rapidly available vehicle shall be made available.

A secondary transfer between two sites of the same hospital is not considered as a secondary transfer but as a movement within a same hospital (no additional charges for the hospital).

2.2.2 Organisation of pre-hospital emergency services

The organisation of 'Urgent Medical Care' in Belgium ('Aide médicale urgente' – 'Dringende Geneeskundige Hulpverlening') encompasses all actors involved in pre-hospital emergency medical services: dispatching centres ('centres d'appel unifiés' – 'eenvormige oproepcentra'), mobile intensive care units ('Service Mobile d'Urgence' (SMUR) – 'Mobiele Urgentie Groep' (MUG)), pilot projects for helicopter emergency medical service ('Services Médicaux d'Urgence Héliportés' (SMUH) – 'Medische UrgentieGroepen per Helikopter' (MUGH)), ambulances and paramedical intervention teams (PITs).

2.2.2.1 Description and organisation of dispatching centres

Calling in case of emergency: The role of dispatching centres

Throughout Europe the number '112' can be called free of charge for all emergencies. The introduction of the number '112' required to reform four aspects of the dispatching centres that dealt with the calls requiring a police intervention ('101') or an intervention for a medical emergency or requiring the fire brigade (previously using the number '100'):

- all medical dispatchers ('opérateurs' – 'operatoren') obtained a federal status;
- all dispatching centres must use the same technology platform (Computer Aided Dispatching 'Astrid');
- a single dispatching centre must be established per province and all medical dispatchers and police dispatchers ('call takers') dealing with emergency calls must work in the same location (this process is ongoing). The dispatching centres are located in Antwerp, Arlon, Bruges, Brussels, Ghent, Hasselt, Liège, Leuven, Mons and Namur and, all demands for a fire intervention or medical emergency in the Walloon Brabant are handled by neighbour centres;[50]
- multidisciplinary 'call takers' will progressively answer and transfer essential information and urgent calls to dispatchers in charge of dealing with an emergency situation. Approximatively 650 medical and police dispatchers work in Belgian dispatching centres.[51]

In order to avoid losing precious time in case of a medical emergency, calls for police services are transferred towards the '101' centre and it is recommended to dial '101' directly when only a police intervention is required.[29, 52]

Dispatching for Urgent Medical Care: Staffing requirements

The Royal Decree of 17 October 2011[53] determines the staffing rules for the dispatching centres dealing with a 'Medical Urgency Service'. The dispatching team in charge of a medical emergency is composed of:

- a medical director ('directeur médical' – 'medisch directeur'). The medical director has to be a specialist in emergency medicine ('médecins spécialistes porteurs du titre professionnel particulier en médecine d'urgence' – 'artsen-specialisten houders van de bijzondere beroepstitel in de urgentiegeneeskunde', 'des médecins spécialistes en médecine d'urgence' – 'artsen-specialisten in de urgentie-geneeskunde');
- a medical assistant director ('directeur médical adjoint' – 'adjunct-medisch directeur') and a nurse regulator ('infirmier régulateur' – 'verpleegkundige-regulator'). The assistant medical director and the nurse regulator are nurses specialised in intensive care and emergency ('infirmier spécialisé en soins intensifs et d'urgence' – 'verpleegkundige gespecialiseerd in de intensieve zorg en spoedgevallenzorg');
- medical dispatchers ('opérateurs' – 'operatoren') follow a basic training and do not have a clinical background. After the introduction of the number '112', the training program for dispatchers was modified. The basic training consists of a course of 540 hours (during 3 to 4 months) and is followed by an in-service training in a dispatching centre under the supervision of a more experienced colleague. The basic training encompasses the legal and organisational framework including deontology and confidentiality, lessons on the technical and technological tools used in the dispatching centre and the techniques regarding communication and the management of the calls and the callers.

Dispatching for Urgent Medical Care: roles of the team members

Each medical director and each medical assistant collaborate through the executive committee but also in the Commission of Urgent Medical Health of their province (see Box 4). Different Royal Decrees determine the role of each of dispatching team's members. **The medical director**[54] is in charge of managing the dispatching centre and ensures his proper functioning. The **assistant medical director**[55] organises and coordinates the activity of the dispatching centre.

Box 4 – Composition and role of the Commissions on urgent medical health (COAMU – CoDGH)

The COAMU – CoDGH involves all actors of the urgent medical care of each province. Members of the commission must meet at least once per year and aims to: [45]

- ensure a good collaboration and agreements between all actors involved in the provision of urgent medical care;
- oversee the training of rescuers – ambulance drivers ('secouristes-ambulanciers' or 'hulpverleners-ambulanciers');
- ensure the collaboration between all actors in the case of a major incident and disaster;
- ensure an appropriate management of emergency calls;
- establish rules and protocols between all hospitals participating in the provision of urgent medical care. The rules and protocols define the system of exceptions in favour of transporting the patient to a hospital that does not correspond to the nearest one. The rules and protocols encompassed the therapeutic and diagnostic resources needed in the referral hospital as well as a list of pathologies for which the patient medical record may determine where the patient has to be referred;

- provide advices regarding the enforcement and/or implementation of legal rules;
- approve annual activity report.

The members of the COAMU – CoDGH include:[45]

- one representative from each ambulance services (private and public);
- one representative doctor from each emergency services participating in the provision of Urgent Medical Health;
- one representative doctor and one representative nurse from each mobile intensive care unit;
- one representative from each on-call services;
- one representative from emergency services of Red Cross;
- an authority of the province (a governor of the province or the representative of the Brussels arrondissement).

The Health Inspector ('inspecteur d'hygiène' – 'gezondheidsinspecteur') presides the COAMU – CoDGH.

The nurse regulator[56] advises and supports dispatchers, providing them with operational support and medical training.

The emergency medical dispatchers handle 'medical calls' based on an initial standardised inquiry and a standardised 'process book' ('Manuel de la régulation médicale' – 'Handleiding voor medische regulatie').[57] This process book aims to help the dispatcher to gather necessary information in order to identify the scene of the accident and make a decision in terms of the required means and medical personnel that need to be dispatched to the emergency scene.

In all situations, the process book recommends to make, during the call, a check-up based on a set of basic instructions, the circumstances surrounding the accident and of the vital functions of the patients. In some cases, the operator may provide medical advices to the caller before the arrival of medical services. For example in case of heart attack, the caller could perform a cardio pulmonary resuscitation and/or use an automatic external defibrillator.[57]

The dispatcher asks several questions to the caller to assess the health status of the victim. Based on the observations of the caller, the vital functions are evaluated using a five levels scale for 3 dimensions:

- the level of awareness of the patient;
- the severity of the respiratory distress;
- an altered marker of the circulatory system.

Box 5 – Missions of the National Council for Emergency Medical Relief ('Conseil national des secours médicaux d'urgence' – 'Nationale raad voor dringende geneeskundige hulpverlening')

The National Council for Emergency Medical Relief is an advisory body organised at the national level. Its missions, defined by the Royal Decree of 4 July 2004[58] are to advise the Minister of Public Health on:

- the organisation, operation, training and information of persons, functions and services which collaborate on urgent medical care or on a non-urgent transport of patients (in the latter case on aspects which have an impact on the urgent medical care);
- data collection and registration for urgent medical care;
- the quality control and the evaluation of practices according to scientific criteria;
- the accreditation standards of ambulance services[59] for urgent medical health and the rules applicable to implement these services.

Choice of means and resources transferred to the accident scene (EMS)

When the assessment of the patient's vital functions suggests a potential emergency situation, the dispatcher will use one the 40 specific protocols available classifying the more common emergency situations (e.g. traffic accidents, falls from heights or head trauma). Based on these, an 'emergency level' is established and the dispatcher decides which type of emergency medical services will be sent out:

- severe to very severe situation – an apparent life-threatening situation: 112 ambulance and mobile intensive care units (SMUR – MUG);
- moderate to severe situation – a potential life-threatening situation: Paramedical Intervention Team (PIT);
- minor but urgent situation: 112 ambulance.

If the most appropriate type of transport is not available within a reasonable timeframe, deviations are possible (e.g. PIT instead of SMUR – MUG, etc.). Indeed, some geographical regions are better covered than others but for more than 90% of the Belgian territory emergency care transport can arrive within a 15 minute delay.[29, 60] Table 1 provides a description of the organisation and characteristics of emergency medical services available.

Table 1 – Description of emergency medical services in Belgium used for urgent medical care

	Mobile intensive care units (MICU)[61]	Paramedic intervention teams PIT[62]	Ambulance[63, 64]
Responsibility of organisation	• Hospitals or an association of hospitals • Linked with a specialised emergency department	• Hospitals or an association of hospitals • Linked with a specialised emergency department	• Public entities (hospitals, fire brigades); or • Private entities having concluded an agreement with the Federal Public Service (FPS) Health, Food Chain Safety and Environment (private enterprises, Red Cross)
Mission	• Transport medical staff and equipment to the accident scene on a 24 hour basis	• Intermediate position between ambulance and MICU service on a 24 hour basis.	• Transport ill or injured patients to a specialised ED on a 24 hour basis
Staffing	• At least one medical doctor and a nurse	• At least a rescuer – ambulance driver and a nurse	• At least 2 rescuers – ambulance driver
Education of the staff	• The medical doctor has to be a medical specialist or a specialist in training in emergency medicine • The nurse has a diploma in emergency and intensive-care medicine or at least 5 years of experience in an ED	• The rescuer – ambulance driver has a basic training of a minimum of 160 hours provided at a recognised emergency medical training centre[65] • The nurse has a diploma in emergency and intensive-care medicine	• Basic training of a minimum of 160 hours provided at a recognised emergency medical training centre[65]
Location	• Hospitals with a specialised emergency department	• Hospitals with a specialised emergency department	• Fire brigades • Police stations • Hospitals
Activity and accessibility	• Provision of advanced care	• Provision of intermediate care • They could be supported by a medical doctor via a secure radio connection	• Provision of basic care.
Funding	• Budget of Final Means (BFM) on the part B4 that includes pilot projects or legal obligations (e.g. data registration)[66]	• Federal subsidies are dedicated to the implementation of PIT services [67]	• Federal subsidies are dedicated to ambulance services[68]

Source: [a]'Service public fédéral (SPF) Santé publique, Sécurité de la Chaîne alimentaire et Environnement – Overheidsdienst (FOD) Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu). [b]'SMUR – MUG stands for mobile intensive care units ('Service Mobile d'Urgence et de reanimation' (SMUR) – 'Mobiele Urgentie Groep' (MUG). [c]PIT stands for 'Paramedical Intervention Teams'.

The FPS certifies Ambulances and those having a certification can participate in the urgent medical care (112 ambulance). Non-certified ambulances are only used in case of non-urgent transport. According to the Law of 8 July 1964[59], a 112 ambulance is defined as a special vehicle used by the ambulance team to ensure safe urgent medical transport for ill or injured person towards a specified hospital indicated by the dispatcher.

The SMUR – MUG teams are considered as a hospital function and can provide all necessary medical and nursing care at the accident scene but also supervision during the transport to the hospital. The federal level implements programming rules for the SMUR – MUG function that depend on the number of inhabitants in each region (i.e. 140 000 inhabitants).[69] In October 2016, SMUR – MUG functions were present in 97 acute hospital sites with a specialised emergency department (out of 128 sites with a specialised ED). A SMUR – MUG function was set as a collaborative effort in 26 acute hospital sites. Two pilot projects for helicopter emergency medical service (SMUH – MUGH) are located in Bruges and Bra-sur-Lienne (Province of Liège). This type of transport can be used:[43]

- To send, in the shortest delay possible, a doctor to the accident scene; or
- To transport a patient more rapidly to the hospital.

The paramedical team (PIT) can intervene when the presence of a medical doctor is not required or to provide first aid assistance whenever the SMUR – MUG is not available. Since 2006, the federal government finances this experimental project in order to develop medical transport. The PIT is considered as a hospital function and differs from a 112 ambulance by the composition of the team. In 2014, 12 PIT were functioning at the moment of the evaluation of the project.[60]

2.3 Data Analyses

2.3.1 Aim of the analysis

The aim of this part of the study was to analyse the degree of dispersion of the current demand and supply for patients with severe trauma in Belgium using two data sources: the MICU registries and the MHD data.

2.3.2 Data sources

The data sources used for this analysis were chosen accordingly to evaluations performed in other countries (see chapter 2 on the international comparison). For example, in England, at the moment of the implementation of the trauma network, it was recommended to evaluate the health needs of the population based on:[27]

- the registry for trauma cases (Trauma Audit Research Network (TARN));
- ambulance service data;
- hospital data (Hospital Episode Statistics (HES) and Emergency Department attendance).

Due to the absence of a trauma registry in Belgium we used two different approaches with two different databases:

- The Mobile intensive care unit (SMUR – MUG) database restricted to pre-hospital emergency medical services interventions for severe trauma cases.
- The Minimal Hospital Data (RHM – MZG) restricted to the inpatient stays for multiple significant trauma (Major Diagnostic Category (MDC) = 25).

The two databases could not be linked because a primary key containing crucial information on the patient identification was missing. In coming years, a compatible key such as the national number would be available and therefore, analyses using both databases could be envisaged; but for now, we used the two databases separately. Data on PIT and ambulance interventions for severe trauma cases could not be included in the analysis.

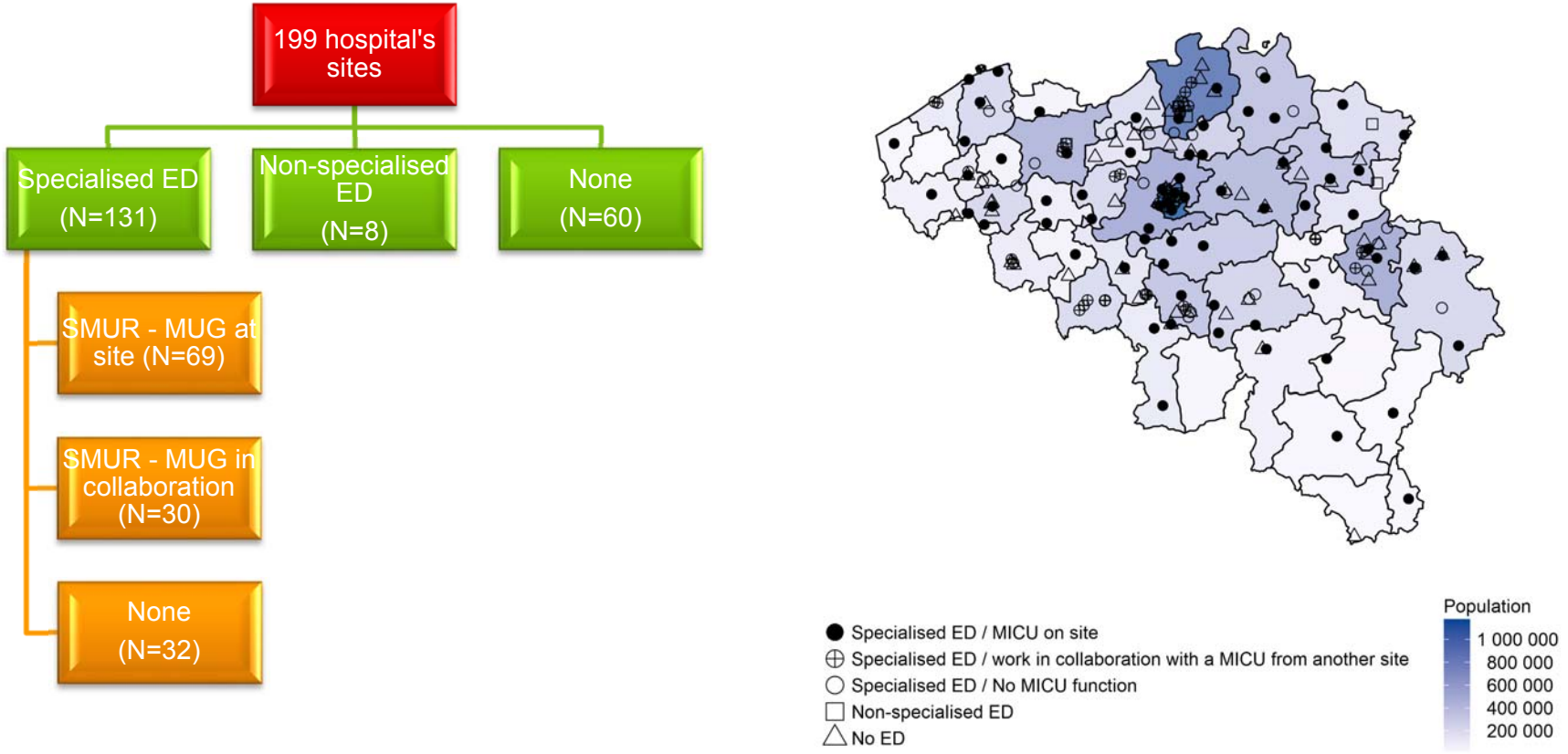
End 2016, the database with the PIT interventions was still experimental and could not be used to derive correct estimations of additional interventions for severe trauma that were not covered by a SMUR – MUG 'Service Mobile d'Urgence et de Réanimation' – 'Mobiele Urgentie Groep' intervention. A registry project dedicated to ambulance data (AMBUREG) is foreseen to start in December 2016. [70] In the future, this would be possible to complete the picture of the mobile emergency services. However, it should be taken into account that all EMS functions could intervene on the same scene.

The reference table with the characteristics of the hospital sites (e.g. number of beds, region, with or without some care services) comes from Federal Public Service (FPS) Health, Food Chain Safety and Environment. The region attributed to each site corresponds to the localisation of the site (UZ Jette is allocated to Brussel because the municipality code is Brussel).

2.3.3 The Belgian Situation

In 2015, Belgium had a high hospital density with 102 acute hospitals composed of 199 different sites (one site closed in June 2015). Most acute hospitals had a specialised emergency department (101 out of the 102 acute hospitals – the exception is Institute Bordet specialised in oncology which had a non-specialised ED) and a SMUR – MUG function (84 out of the 102 acute hospital). On the 199 sites, 131 sites had a specialised emergency department (ED) and 8 sites a non-specialised ED. Other sites (60) did not have ED. On the 131 sites with specialised EDs, 99 sites (76%) had a SMUR – MUG function attached to the site or working in collaboration with other sites. Eighty percent of the sites had at least a CT scan and 43% had at least a MRI. The supply of the emergency care is therefore quite large and as shown on Figure 1. However a lower number of sites covered the south-east of the territory. The supply catches the majority of the population.

Figure 1 – Number of hospital sites and number of beds by site for general/university hospitals – Year 2015



Source : Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015. Note: ED stands for Emergency department; MICU stands for Mobile Intensive Care Unit. In very densely served areas, some drawings (round, triangles, squares) overlap and are not all visible. In June 2015 one out of the 199 hospital sites closed.

2.3.4 SMUReg – MUGReg database description

SMUReg-MUGReg is a compulsory registration of SMUR – MUG interventions data for all authorised SMUR – MUG functions in Belgium. This data collection was introduced as a paper-based registration. From April 2008 onwards the registration is submitted via an electronic portal (i.e. via SMUReg-MUGReg web application) which is regulated by the Royal Decree of 27 April 2007.[71]

The time between the SMUR – MUG intervention and the recording of the data is maximum seven days. The file contains SMUR – MUG data about[39]

- emergency call and intervention of SMUR – MUG;
- patient data and clinical status;
- data on clinical interventions.

Box 6 – Limitations of the SMUReg – MUGReg

- Missing fields and possible mistake in some fields despite internal checks included at the level of the SMUR – MUG form;
- The flag for severe trauma is not an automatic field and is ticked by the physician on the SMUR – MUG form. Preliminary analysis showed that there is not a good correspondence between the flag for severe trauma and the definition included in the SMUR variable (i.e. a patient with an RTS of less or equal to five and whose International Classification of Diseases (ICD) code is between 800 and 959.9) (see Table 2).
- The flag of severity is ticked according to the physician's perception of the situation at the time of intervention. At the moment, there are no established protocols at a national or provincial level allowing to ensure that the flag is filled in the same way by all SMUR – MUG teams;
- The interventions made by a PIT or an ambulance without a SMUR – MUG are not included in the database and this could under-estimate the number of severe trauma interventions;
- No information on the quality of appropriateness of the care is available in the registry.

The initial database contains all **primary** interventions included in the SMUReg – MUGReg database from 2009 to 2015 (N=843 946 interventions). The secondary interventions (possible transfer from one hospital to another) were discarded. For the purpose of the analysis of the severe trauma cases, restrictions on the data were made (Box 7).

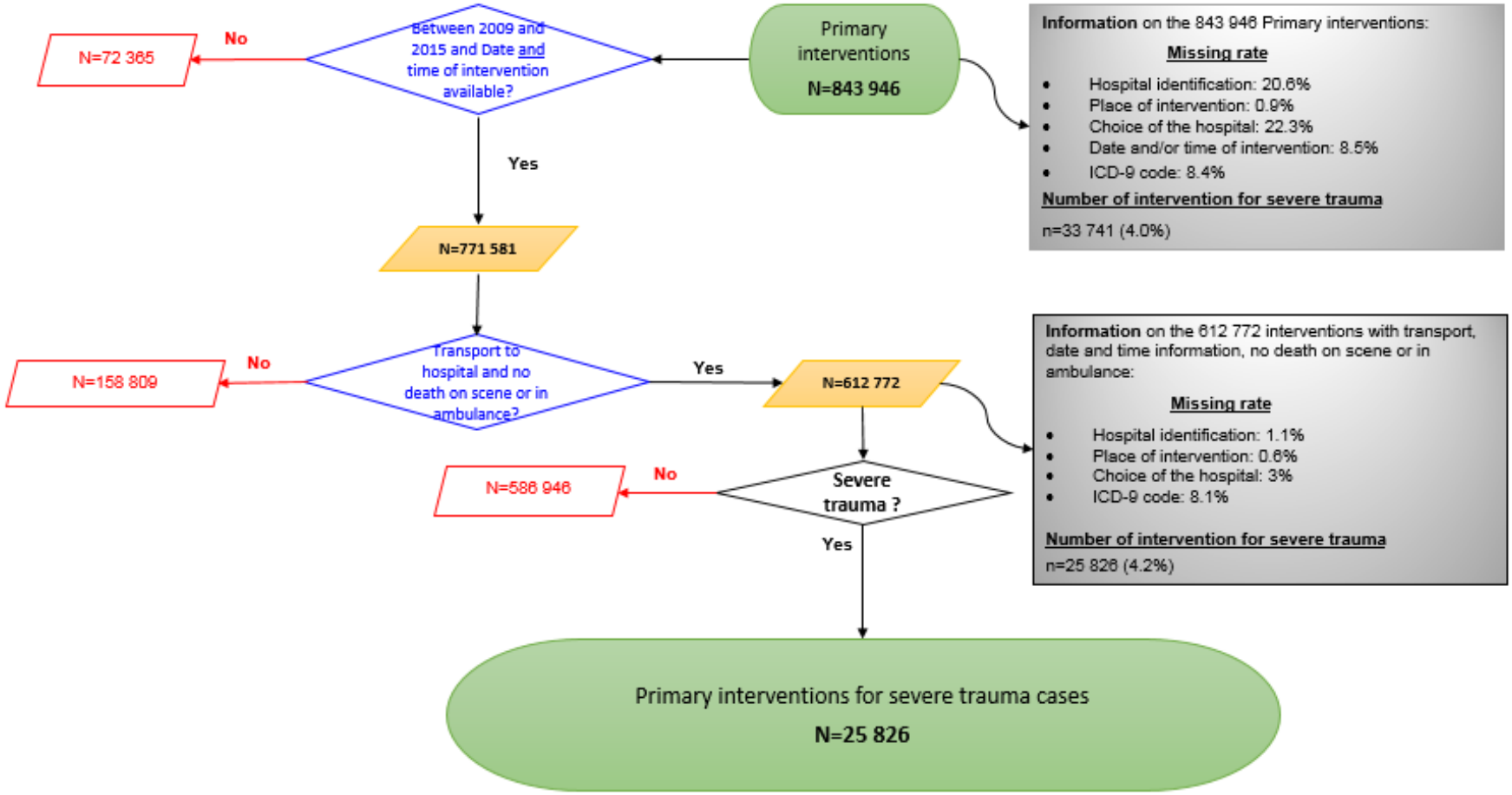
Box 7 – Restrictions on the data analysed

Primary SMUR – MUG interventions

- Including a transfer to an hospital (80% of all the primary SMUR – MUG interventions);
- Excluding patients dying on scene or in the ambulance (8% of all the primary SMUR – MUG interventions);
- A severe trauma was identified using the variable filled by the SMUR – MUG teams. This choice was made giving the coding issues for the RTS and the missing values in the International Classification of Diseases (ICD) code. Experts from the field validated this choice at the beginning of the project;
- Cases requiring a SMUR – MUR but without transport to a hospital site or without contact with the patient are discarded from all analyses below (around 20% of the primary SMUR – MUG interventions → without hospital site identification in the registry);
- Exclusion of the cases before 2009 (n=72 352) or without date and/or time of intervention (n=13) of primary interventions.

Between 2009 and 2015, a total of 612 772 interventions (all severity levels confounded – including a transfer to an hospital and excluding death on scene or in the ambulance) were considered for the analyses with a total of **25 826 interventions for severe trauma cases** (Figure 2).

Figure 2 – Flowchart of number of SMUR – MUG interventions included in the study (2009 to 2015)



2.3.5 *Analyses of mobile intensive care unit data (SMUReg – MUGReg)*

General information on pre-hospital emergency care interventions data

As described in Table 2, around 4% to 7% of the primary interventions from the SMUR – MUG (i.e. with transport to the hospital, no death on scene or in ambulance and with intervention date and time) are considered as ***severe trauma*** (i.e. flagged as severe trauma in the SMUReg – MUGReg database).

For severe trauma cases, the following missing data problems could be observed (Table 2):

- Around 3% of records lacked information on the choice for the hospital destination (adequate nearest hospital or other hospital campus/site);
- Between 4% to 7% lacked information about the place of intervention (i.e. ZIP-code);
- Less than 1% lacked information about the identification of the hospital campus/site where the patient was transported to.

Table 2 – Description of data included in analyses (2009-2015)

	2009	2010	2011	2012	2013	2014	2015	ALL
Number of interventions with transport and no death on scene or in ambulance	N= 80 639	N= 82 056	N= 79 693	N= 85 990	N= 91 895	N= 95 262	N= 97 237	N= 612 772
Number of interventions for severe trauma	3 547	3 959	3 728	3 792	3 295	3 649	3 856	25 826
% of severe trauma interventions	**4.4%**	**4.8%**	**4.7%**	**4.4%**	**3.6%**	**3.8%**	**4.0%**	**4.2%**
				Severe trauma interventions				
Severe trauma interventions	N=3 547	N=3 959	N=3 728	N=3 792	N=3 295	N=3 649	N=3 856	N=25 826
% of ICD-9 codes not between (800 – 959.9) or missing	**9.4%**	**8.7%**	**9.1%**	**9.3%**	**10.3%**	**11.9%**	**10.9%**	**9.9%**
% of RTS above 5 or missing	**44.8%**	**46.2%**	**46.3%**	**52.7%**	**77.3%**	**79.2%**	**79.3%**	**60.5%**
% Missing age	**4.4%**	**5.8%**	**5.5%**	**6.3%**	**6.8%**	**6.6%**	**6.5%**	**6.0%**
% Missing choice of hospital (adequate nearest hospital or other hospital)	**2.8%**	**3.5%**	**3.4%**	**3.0%**	**2.8%**	**2.5%**	**2.9%**	**3.0%**
% Missing ZIP code of intervention place	**6.6%**	**6.0%**	**6.1%**	**5.7%**	**4.8%**	**4.3%**	**4.9%**	**5.5%**
% Missing Campus/Site ID of destination	**1.5%**	**1.1%**	**1.0%**	**1.1%**	**0.9%**	**1.1%**	**1.1%**	**1.1%**
% Missing vital status (alive or dead)	**2.1%**	**0.0%**	**0.1%**	**0.4%**	**2.4%**	**3.1%**	**4.2%**	1.7%

Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2009-2015.

Proportion of hospitalisations for severe trauma patient: no clear evolution but increase for elderly patients

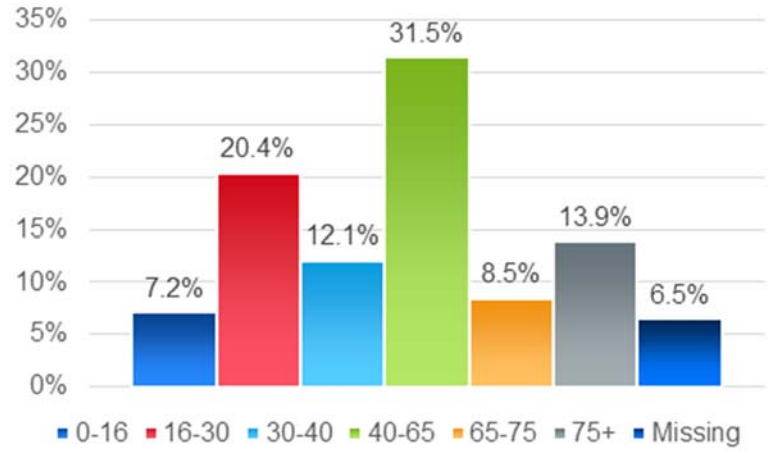
The percentage of 'severe trauma' interventions on the total number of primary interventions with a patient being transported to the hospital and not dying on scene or in the ambulance was comprised between 3.6% and 4.8% in the period 2009-2015. During this period, the number of interventions for severe trauma varies from 3 295 to 3 959 cases depending on the year without a clear time trend. The proportion of severe trauma interventions was around 7% for children younger than 16 years while that for older patients (75+ years) increased over the years from 11% to 14%.

Severe trauma pre-hospital emergency care interventions in 2015

In 2015, there were 3 856 interventions for severe trauma recorded in the SMUReg-MUGReg database.

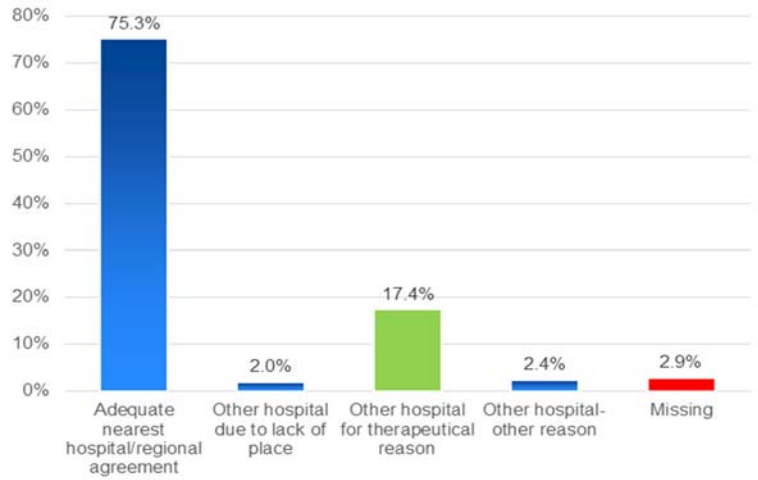
More than half of patients with severe trauma belong to the age categories of 40-65 years (31%) and 16-30 years (20%). Elderly patients (more than 75 years) represent 14% of the patients with severe trauma (Figure 3). Two-third of the cases were males. In 75% of the interventions, the hospital site where the patient was transported to was the adequate nearest one (or with regional agreement) ('Hôpital adéquat le plus proche/Accord regional'; 'adequaat dichtstbijzijnde / conform afspraken region'). For 17% of them, the choice was taken for **therapeutic reasons** (Figure 4). This category of interventions requires special attention and will be mentioned whenever it is pertinent. In 2015, the distribution of the age for the victims sent to another hospital for therapeutic reasons was similar to what was observed for all severe trauma interventions.

Figure 3 – Age of patients – Severe Trauma interventions 2015



Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.

Figure 4 – Choice of hospital site – Severe Trauma interventions 2015



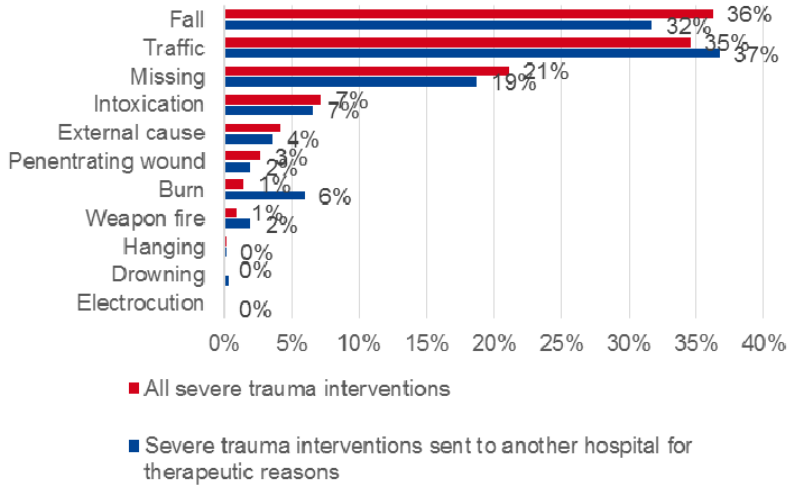
Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.

The most frequent causes for severe trauma interventions were, in descending order and over the period 2015 (Figure 5):

- Falls (36%);
- Traffic accidents (35%);
- Missing (21%);
- Intoxications (7%);
- Burns (1%);
- Other causes (< 5%).

For the subgroup of cases ***sent to another hospital for therapeutic reasons***, percentages were similar EXCEPT for burned patients which represent 6% of total interventions in this subgroup. It means that in case of burns, patients are more likely transported to a specific site for therapeutic reasons. For 2015, on the 56 severe trauma interventions for burns, 40 (71%) were sent to a hospital site for specific therapeutic reason. The majority of those cases were sent to one of the 6 designated burn care centres of Belgium which are reference centres for severe burns (see KCE report 209[72]).

Figure 5 – Cause of the severe trauma (2015)



Note: There might be several causes for the same intervention.
Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.

For 2015, the percentage of interventions varies slightly between months but we see that there are more cases on Thursdays and week-end days. For the cases sent to another hospital for therapeutic reasons, there are more cases during the week-end days, on Mondays and Thursdays. This is in line with the findings of Senterre et al. (2014).[33]

Figure 6 – Number of severe trauma interventions per month and day of the week (Data 2015)

All severe trauma intervention

	MON	TUE	WED	THU	FRI	SAT	SUN	All
JAN	49	31	40	48	37	45	27	7%
FEB	48	35	53	36	39	56	41	8%
MAR	43	38	49	25	33	36	67	8%
APR	37	36	46	51	45	48	49	8%
MAY	40	44	43	48	47	59	55	9%
JUN	60	64	29	61	42	58	57	10%
JUL	45	46	47	54	54	49	43	9%
AUG	42	38	63	51	73	56	55	10%
SEP	30	51	48	56	46	49	48	9%
OCT	51	36	40	44	50	62	50	9%
NOV	45	35	35	34	25	45	58	7%
DEC	34	34	42	56	52	45	44	8%
All	14%	13%	14%	15%	14%	16%	15%	

Severe trauma sent to another hospital for therapeutic reasons

	MON	TUE	WED	THU	FRI	SAT	SUN	All
JAN	6	6	5	8	6	9	4	7%
FEB	12	3	6	6	8	15	3	8%
MAR	13	4	4	9	5	12	10	8%
APR	6	7	9	9	4	11	7	8%
MAY	5	9	3	4	14	14	11	9%
JUN	17	11	3	12	5	12	9	10%
JUL	9	8	4	11	6	13	8	9%
AUG	7	9	12	7	9	8	10	9%
SEP	4	8	6	12	7	9	12	9%
OCT	9	5	6	6	5	11	9	8%
NOV	12	3	7	10	5	6	8	8%
DEC	7	3	10	11	2	13	9	8%
All	16%	11%	11%	16%	11%	20%	15%	

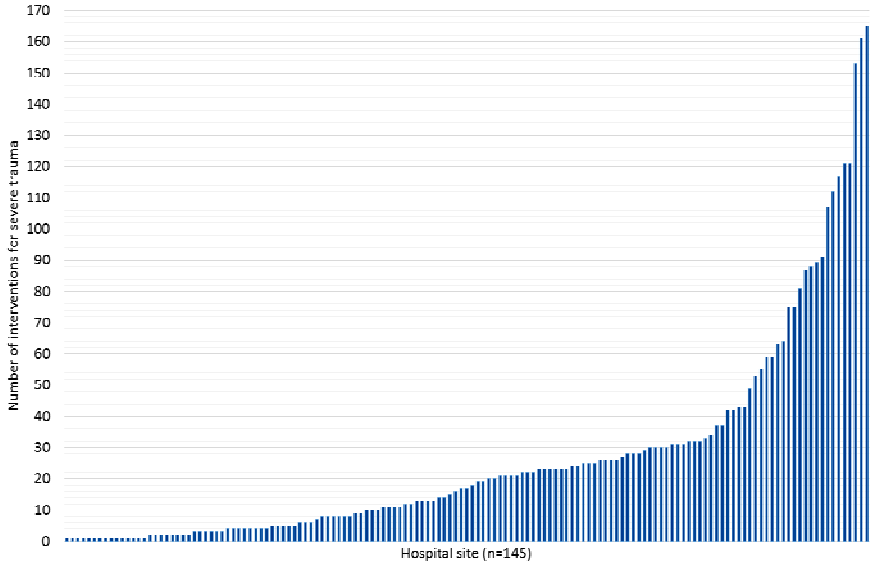
Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.

Figure 8 shows the number of severe trauma cases in function of the place of intervention (left side of the figure) and by hospital site (right side) where the patient was sent to (data 2015). There is a concentration of cases on some sites situated mainly in cities with higher population density like Brussels, Antwerpen, Gent, Liège, Leuven but also in south-west area (Mons, Ath, Tournai, Kortrijk).

For 2015, there is a total of 145 hospital sites that admit patients after a SMUR – MUG intervention for severe trauma. The number of severe trauma varies from 1 intervention to a maximum of 165 interventions per hospital site (Figure 7). Whereas 25% of the sites treated 30 severe cases or more, half of the sites treated less than 17 cases (Median (Q1-Q3): 17 (4-30) interventions).

If we focus on the severe trauma interventions ***sent to another hospital site than the nearest one for therapeutic reasons*** (Figure 9) we see that there are some specific hospital sites where the patients were sent to for therapeutic reason. Mainly in high density cities. For 2015, a total of 76 sites welcome those cases (672 interventions) and for those sites, the median (Q1 – Q3) number of severe trauma (all choice of destination confounded) was of 27 (13 – 51) interventions and the proportion of the cases sent for therapeutic reasons represents about 20% of all the severe trauma interventions arriving on their site (median [Q1 – Q3]: 22% [8% - 38%]).

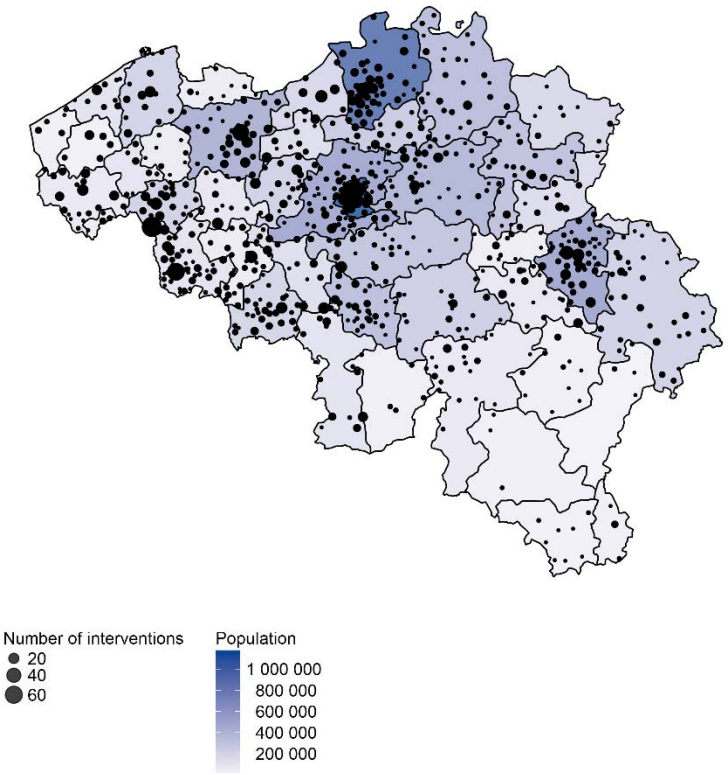
Figure 7 – Number of interventions for Severe Trauma by hospital site – Data 2015

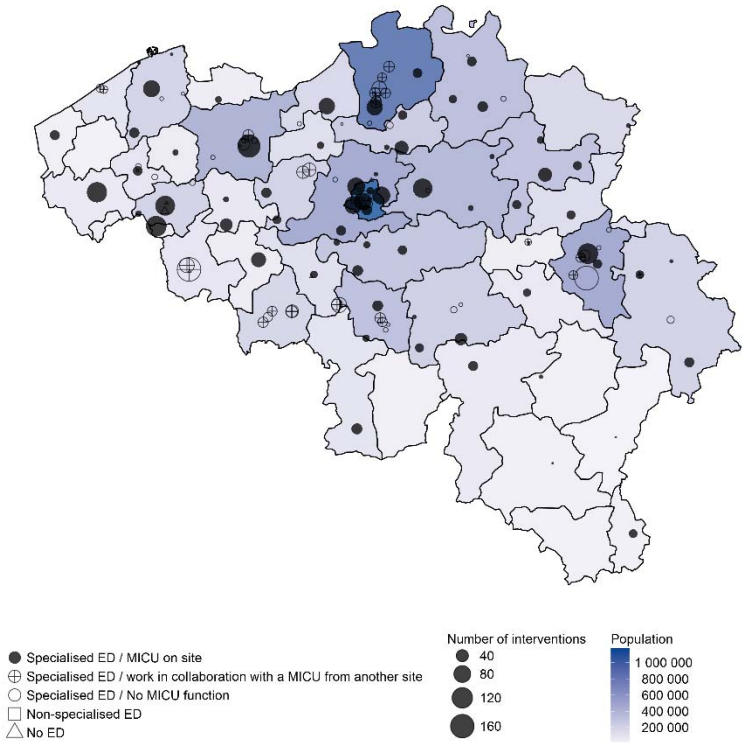


Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.

Figure 8 – Number of interventions for Severe Trauma – Data 2015

Place of the intervention (2015)	Hospital site the patient was sent to (2015)

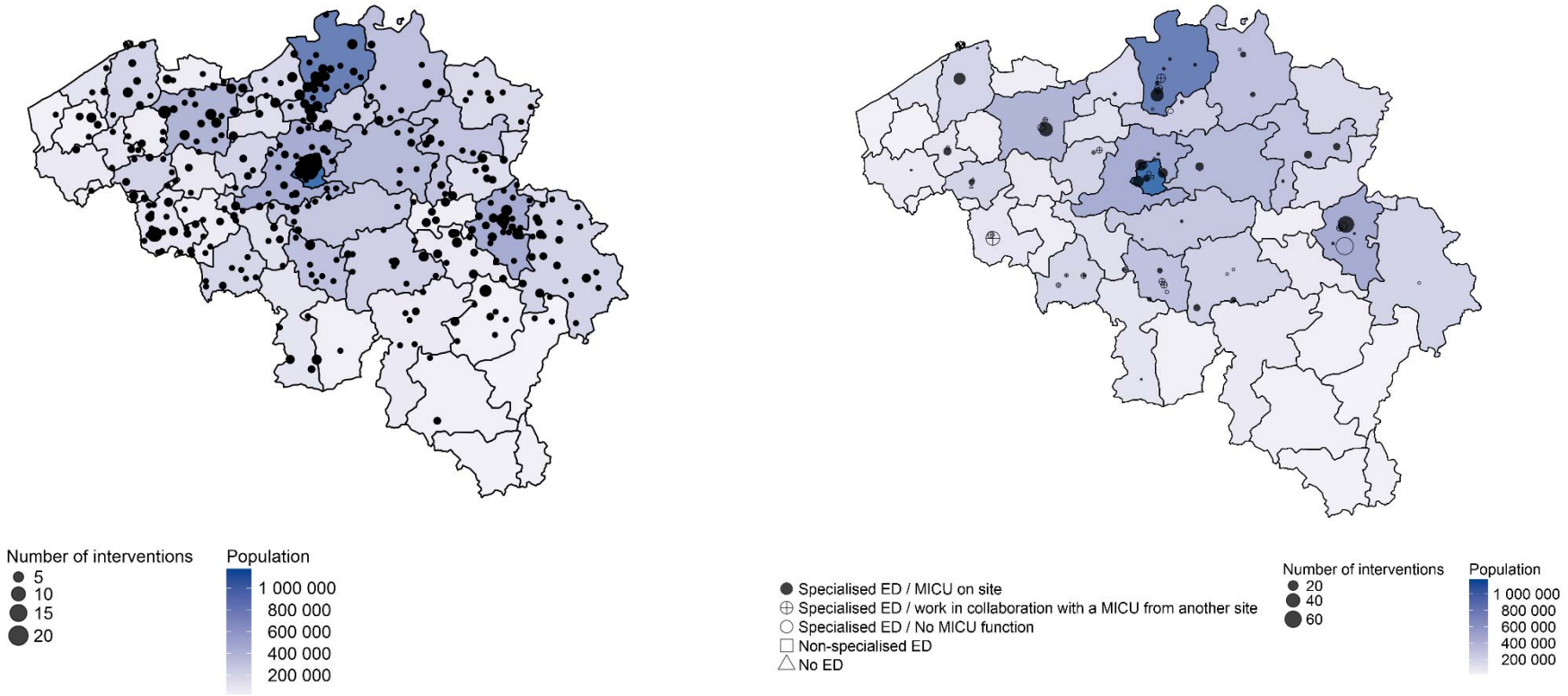




Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.

Figure 9 – Number of interventions for Severe Trauma sent to another hospital for therapeutic reasons – Data 2015

Place of the intervention (2015)	Hospital site the patient was sent to (2015)

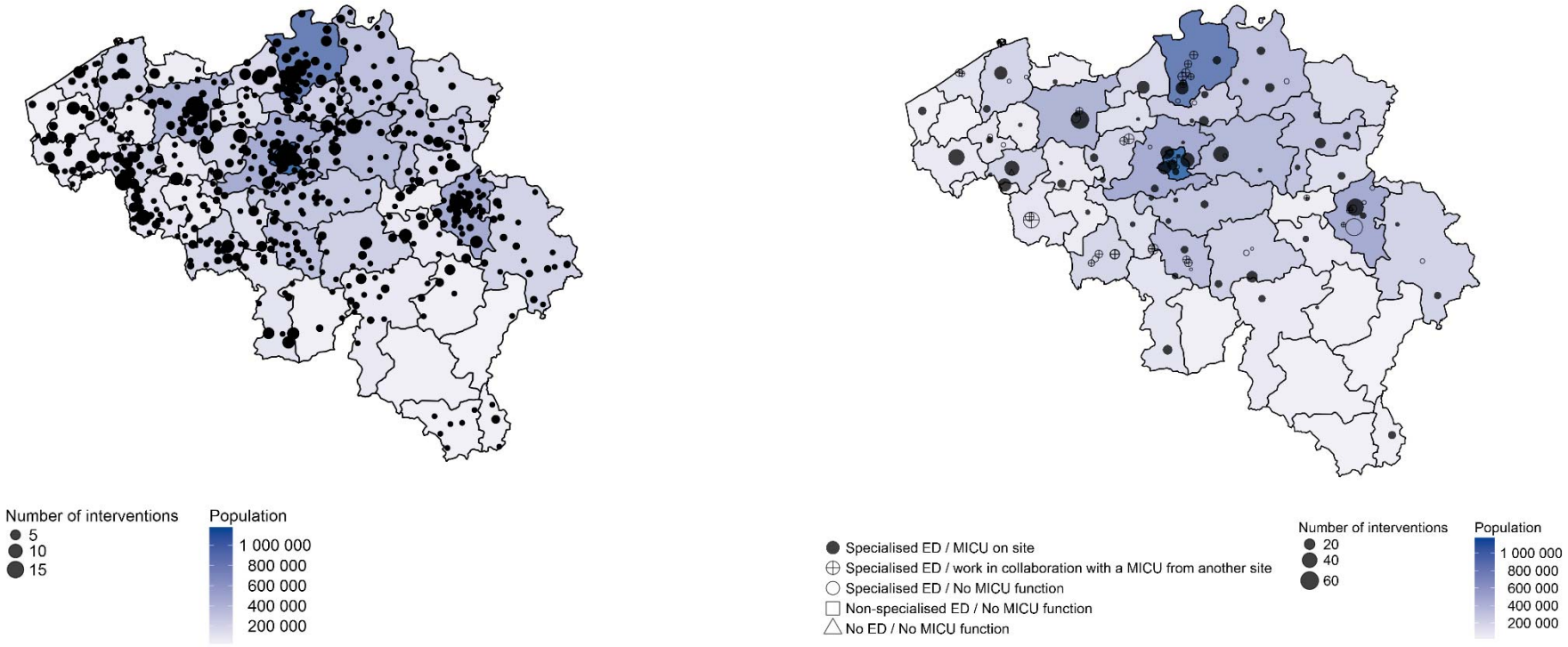


Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.

From Figure 10 (traffic accidents with severe cases) we see that there are more cases on the North of Belgium with higher frequencies in or near the densely populated cities cited before. On the left side we have the place of the interventions of SMUR – MUG for traffic accidents and on the right side the place where they were sent to (1 332 cases in 2015 – this number doesn't include the death on site or in ambulance). On Figure 11, the data come from Federal Public Service (FPS) Economy and includes the traffic accidents registered by the Police and necessitating an ambulance (all severity levels confounded) or death on site according to the accident's place (4 201 cases in 2015).

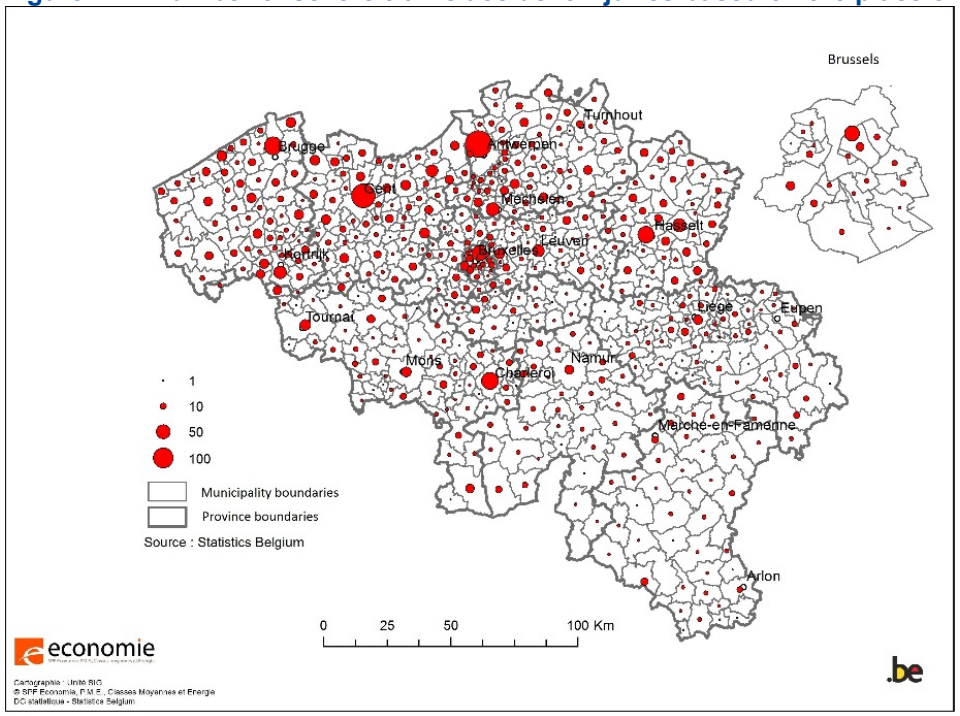
Figure 10 – Number of interventions for Severe Trauma due to traffic accident – Data 2015

Place of the intervention (2015)	Hospital site the patient was sent to (2015)



Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.

Figure 11 – Number of severe traffic accident injuries based on the place of the accident



Source: Federal Public Service (FPS) Economy (data 2015).

The sites are differentiated between those including an emergency department (ED) – specialised[e] and non-specialised[f] EDs – or without ED. The sites might have a SMUR – MUG function directly attached to their site or might work in collaboration with a SMUR – MUG function from another hospital/site. We see from Table 3 that, as expected, the number of severe trauma interventions is higher for the sites with a SMUR – MUG function (directly or with conventions between hospitals) than for the sites without a SMUR – MUG function. The median number of interventions is 24 for the hospital sites with a SMUR – MUG function (or in collaboration with a SMUR – MUG function from another hospital) compared to 4 for the hospital sites without a SMUR – MUG function. For the emergency department, the median (Q1 – Q3) number of interventions for the sites with a specialised ED welcoming patients from a SMUR – MUG function for severe trauma is of 21 (7 – 32) interventions on the year 2015 versus only 1 or 2 patients with severe trauma for the sites without specialised ED.

Table 3 – Number of interventions per site per sites' characteristics (2015)

Sites Characteristics	All	Regions*			Emergency service			Mobile intensive care unit		
		Wallonia	Flanders	Brussels Capital	Specialised	Non-specialised	None	With a unit on site	Alternating with other hospital	None
Number of sites	145	54	71	19	129	5	10	67	27	50
Median (Q1 - Q3)	17 (4 – 30)	20.5 (4 – 31)	17 (6 – 31)	8 (2 – 29)	21 (7 – 32)	1 (1 – 2)	1 (1 – 2)	23 (11 – 43)	30 (21 – 42)	4 (2 – 8)
Min – Max	1 - 165	1 - 165	1 – 153	1 - 91	1 - 165	1 - 6	1 - 30	1 – 153	1 – 161	1 - 165

*Source : Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015.*The region reflects the location of the hospital site.*

[e] 'Gespecialiseerde spoedgevallenzorg'/'soins urgents spécialisés'

[f] 'Eerste opvang van spoedgevallen'/'première prise en charge des urgences'

From Table 4, we see that the time spent by the SMUR – MUG service on the accident scene (from arrival on scene to departure from scene) is of 23 minutes in median and for 3 interventions on 4, the time on scene is lower than 34 minutes. For the interventions sent to another hospital for therapeutic reasons, this time is, in median (Q1 – Q3), of 30 minutes (21 – 40 minutes). For the travel time: median travel time of 10 minutes for all severe trauma (whatever the choice of site the patient was sent to) and 14.5 minutes for the interventions where the choice of the hospital site was made for therapeutic reasons.

If we compute the time from the call of SMUR – MUG service by the emergency 112 call centre to the arrival on the hospital site, we have a median time of 46 and 58 minutes, for respectively all interventions and interventions sent to a specific site for therapeutic reasons. In general, for 3 cases on 4, the full SMUR – MUG intervention lasts less than 1 hour. For interventions sent to another hospital for therapeutic reasons this time is stretched to 73 minutes.

Table 4 – Interval of time between some specific actions (in minutes) – Severe trauma intervention (2015) and severe trauma intervention sent to a site for therapeutic choice (Data 2015)

	All severe trauma interventions				Severe trauma interventions sent to another hospital site for therapeutic reasons			
	On scene (1)	Travel time (2)	From scene to hosp. site (1 + 2)	From the SMUR call to hosp. site (3)	On scene (1)	Travel time (2)	From scene to hosp. site (1 + 2)	From the SMUR call to hosp. site (3)
Number of interventions	3 423*	3 443*	3 473*	3 522*	625*	630*	632*	638*
Median (Q1 - Q3)	23 (16 - 33)	10 (6 – 16)	35 (25 – 48)	46 (35 – 60)	30 (21 – 40.6)	14.5 (10 – 22)	47 (35 – 61)	58 (45 – 73)
Min – Max	0.01 - 146	0.01 - 607	0.01 – 631	0.03 - 642	0.01 - 139	0.03 - 145	0.05 – 213	1 - 237

*Source : Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015. Notes: 1) from arrival on scene to departure from scene ; 2) From departure from scene to arrival to hospital site; 3) from call to arrival to hospital site. Records with an overall interval of time > 20h were deleted from the analyses and considered as coding error.*Each interval of time is calculated on available time in our database. Difference between the number of interventions are due to missing time information for some of the records.*

Table 5 – Number (%) of interventions according to hospital site characteristics – Data 2015

	All severe trauma	Below 16 y	Choice site = Therapeutic	Burns	Fall	Traffic
Number of interventions N=	3 856	527	672	56	1 396	1 332
(Number of sites)	(145)	(98)	(76)	(17)	(122)	(117)
Characteristics						
Missing	11 (0.3%)	4 (0.8%)	9 (1.3%)	10 (17.8%)	1 (0.1%)	0
Region						
Brussels Capital	487 (12.6%)	125 (23.7%)	100 (14.9%)	4 (7.1%)	182 (13.0%)	153 (11.5%)
Flanders	1 822 (47.3%)	194 (36.8%)	275 (40.9%)	30 (53.6%)	696 (49.9%)	682 (51.2%)
Wallonia	1 536 (39.8%)	204 (38.7%)	288 (42.9%)	12 (21.4%)	517 (37.0%)	497 (37.3%)
Site capacity						
<200 beds	518 (13.4%)	79 (15.0%)	95 (14.1%)	16 (28.6%)	164 (11.7%)	147 (11.0%)
200-299 beds	529 (13.7%)	68 (12.9%)	34 (5.1%)	1 (1.8%)	167 (12.0%)	171 (12.8%)
300-449 beds	1 105 (28.7%)	138 (26.2%)	113 (16.8%)	18 (32.1%)	454 (32.5%)	374 (28.1%)
450+ beds	913 (23.7%)	113 (21.4%)	194 (28.9%)	2 (3.6%)	340 (24.4%)	336 (25.2%)
University	791 (20.5%)	129 (24.5%)	236 (35.1%)	19 (33.9%)	271 (19.4%)	304 (22.8%)
Burn Care program						
Yes	486 (12.6%)	48 (9.1%)	139 (20.7%)	31 (55.4%)	157 (11.2%)	177 (13.3%)
No	3 359 (87.1%)	475 (90.1%)	524 (78.0%)	15 (26.8%)	1 238 (88.7%)	1 155 (86.7%)
Child care program						
Yes	3 005 (77.9%)	457 (86.7%)	466 (69.3%)	22 (39.3%)	1 134 (81.2%)	1 057 (79.4%)
In collaboration with	60 (1.6%)	3 (0.6%)	8 (1.2%)		21 (1.5%)	31 (2.3%)
No	780 (20.2%)	63 (12.0%)	189 (28.1%)	24 (42.9%)	240 (17.2%)	244 (18.3%)
Intensive Care						
Yes	3 746 (97.1%)	511 (97.0%)	639 (95.1%)	41 (73.2%)	1 367 (97.9%)	1 305 (98.0%)
No	99 (2.6%)	12 (2.3%)	24 (3.6%)	5 (8.9%)	28 (2.0%)	27 (2.0%)
Type of Emergency service						
Specialised	3 785 (98.2%)	513 (97.3%)	639 (95.1%)	44 (78.6%)	1 376 (98.6%)	1 321 (99.2%)
Non-specialised	11 (0.3%)	1 (0.2%)	2 (0.3%)		5 (0.4%)	1 (0.1%)
None	49 (1.3%)	9 (1.7%)	22 (3.3%)	2 (3.6%)	14 (1.0%)	10 (0.8%)
SMUR - MUG function						
Yes	2 382 (61.8%)	325 (61.7%)	378 (56.3%)	19 (33.9%)	870 (62.3%)	889 (66.7%)
In collaboration	947 (24.6%)	128 (24.3%)	144 (21.4%)	13 (23.2%)	365 (26.1%)	285 (21.4%)
None	516 (13.4%)	70 (13.3%)	141 (21.0%)	14 (25.0%)	160 (11.5%)	158 (11.9%)
Number of CT scan						
0	93 (2.4%)	24 (4.6%)	30 (4.5%)	4 (7.1%)	29 (2.1%)	25 (1.9%)
1	3 457 (89.7%)	460 (87.3%)	574 (85.4%)	40 (71.4%)	1 260 (90.3%)	1 202 (90.2%)

2	295 (7.7%)	39 (7.4%)	59 (8.8%)	2 (3.6%)	106 (7.6%)	105 (7.9%)
Number of MRI						
0	940 (24.4%)	119 (22.6%)	102 (15.2%)	9 (16.1%)	358 (25.6%)	300 (22.5%)
1	1 468 (38.1%)	210 (39.8%)	130 (19.3%)	16 (28.6%)	529 (37.9%)	486 (36.5%)
2	834 (21.6%)	79 (15.0%)	262 (39.0%)	9 (16.1%)	280 (20.1%)	304 (22.8%)
3	496 (12.9%)	98 (18.6%)	154 (22.9%)	7 (12.5%)	185 (13.3%)	196 (14.7%)
4	107 (2.8%)	17 (3.2%)	15 (2.2%)	5 (8.9%)	43 (3.1%)	46 (3.5%)

Source : Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015 ; Characteristics of the hospital site come from FOD-SPF Public health.

Table 6 − Cause / Other variables interaction for severe trauma interventions – Data 2015

	Age categories						Choice of Hospital site*		Total number of severe interventions
	0-16	**16-30**	**30-40**	**40-65**	**65-<75**	**75+**	**Other**	**Therapeutic**	
Burn	10 (17.9%)	10 (17.9%)	7 (12.5%)	18 (32.1%)	3 (5.4%)	4 (7.1%)	16 (28.6%)	**40 (71.4%)**	56 (100%)
Drowning	1 (50.0%)	1 (50.0%)	(0.0%)	(0.0%)	(0.0%)	(0.0%)	0 (0.0%)	2 (100.0%)	2 (100%)
Electrocution	(0.0%)	1 (100.0%)	(0.0%)	(0.0%)	(0.0%)	(0.0%)	1 (100.0%)	0 (0.0%)	1 (100%)
External cause	5 (3.1%)	34 (21.1%)	24 (14.9%)	68 (42.2%)	9 (5.6%)	16 (9.9%)	137 (85.1%)	24 (14.9%)	161 (100%)
Fall	127 (9.1%)	175 (12.5%)	131 (9.4%)	449 (32.2%)	153 (11.0%)	304 (21.8%)	1 183 (84.7%)	213 (15.3%)	1 396 (100%)
Hanging	(0.0%)	1 (20.0%)	1 (20.0%)	1 (20.0%)	(0.0%)	2 (40.0%)	4 (80.0%)	1 (20.0%)	5 (100%)
Intoxication	2 (0.7%)	49 (17.8%)	45 (16.3%)	125 (45.3%)	27 (9.8%)	13 (4.7%)	232 (84.1%)	44 (15.9%)	276 (100%)
Missing	58 (7.1%)	143 (17.5%)	86 (10.6%)	229 (28.1%)	67 (8.2%)	128 (15.7%)	689 (84.5%)	126 (15.5%)	815 (100%)
Penetrating wound	3 (2.9%)	26 (25.2%)	20 (19.4%)	40 (38.8%)	4 (3.9%)	3 (2.9%)	90 (87.4%)	13 (12.6%)	103 (100%)
Traffic	76 (5.7%)	397 (29.8%)	201 (15.1%)	409 (30.7%)	94 (7.1%)	84 (6.3%)	1085 (81.5%)	247 (18.5%)	1332 (100%)
Weapon fire	(0.0%)	6 (17.1%)	6 (17.1%)	19 (54.3%)	2 (5.7%)	1 (2.9%)	22 (62.9%)	**13 (37.1%)**	35 (100%)

*Source : Federal Public Service (FPS) Health, Food Chain Safety and Environment: Mobile Intensive Care Units (MICU) data 2015 *Choice of destination site: **Other** = Most adequate/Other for financial reason/Other for place reason/ Other ; **Therapeutic**=Therapeutic reasons.*

Key points

- **There are indications that the care for severe trauma patients is dispersed. A total of 145 hospital sites admit patients after a SMUR – MUG with a median of 17 severe trauma cases per hospital site (ranging from 1-165);**
- **The main causes of interventions are falls (36%) and traffic accidents (35%);**
- **The transport times for the vast majority of severe trauma patients is below the internationally used targets;**
- **Most of the interventions performed by SMUR – MUG functions for severe trauma are:**
  - **sent to hospital sites with 450+ beds (24%) or to university hospital sites (20.5%);**
  - **sent to sites with specialised emergency department (98%);**
  - **with a SMUR – MUG function attached directly to the site (or in collaboration with) (85%);**
- **71% of the interventions for burns are sent to another hospital site for therapeutic reasons;**
- **Interventions sent to another hospital for therapeutic reasons are sent to university sites (35%) or sites with 450+ beds (29%).**

2.3.6 RHM – MZG database description

For each patient admitted in a Belgian hospital (inpatient and day care), hospitals have to send twice a year medical data (more precisely, Minimal Hospital Data (RHM – MZG[g]), defined in a Royal Decree[73] to the Federal Ministry of Health (FOD – SPF). The RHM – MZG are based on the International Classification of Diseases-9th Revision-Clinical Modification (ICD-9-CM[h]).

At the FOD – SPF, each inpatient and day-care stay is assigned an APR-DRG (All Patient Refined Diagnosis Related Group; Version 28, up to the end of 2014).

The original database includes all stays recorded in the RHM – MZG database from 2009 to 2014 (N=40 775 269 stays). For the purpose of this study, we restricted the database to the stays with:

- A Major Diagnostic Category (MDC version 28) = Multiple Significant Trauma (MDC = 25)
- An emergency admission (with or without ambulance but with an admission via the emergency department (ED)) or emergency hospitalisation without passing by the ED
- A planned admission in case of transfer between hospital sites: A hospital site might ask another hospital site to transfer a patient for a specific reason. Therefore, the second hospital site considers the admission as planned.

For all analyses on Belgian Data, all the stays fulfilling those criteria will be reported as "**Severe Multiple Trauma**".

g RHM – MZG: Hospital discharge dataset ("Minimale Ziekenhuis Gegevens"/"Résumé Hospitalier Minimum").

h International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) is based on the World Health Organization's Ninth Revision, International Classification of Diseases (ICD-9). ICD-9-CM is a system of assigning codes to diagnoses and procedures associated with hospital utilization.

We are aware that other Diagnostic Related Groups (DRG) group cases which could be defined or interpreted as “Severe Trauma” but in absence of a clear definition, the decision was taken to include unambiguous cases. This means that, following a restrictive definition, the number of severe trauma is an **underestimation** of the real number of severe trauma cases treated in the Belgian hospitals. The purpose of the analyses are here to show the dispersion of the cases and not to focus on the real number of cases.

The APR-DRG system

The APR-DRG system is a type of patient classification system which provides a means of relating the type of patients a hospital treats (i.e., its case mix) to the costs incurred by the hospital. APR-DRGs extend the basic DRG structure by adding two sets of subclasses to each base APR-DRG, i.e. severity of illness (SOI) and risk of mortality (ROM). Within each APR-DRG there are four grades of SOI: 1 = minor; 2 = moderate; 3 = major; 4 = extreme. Patients are allocated to an APR-DRG-SOI group on the basis of principal diagnosis, secondary diagnoses and procedures, age and sex of the patient and, for some APR-DRGs (e.g. burns), type of discharge.[74]

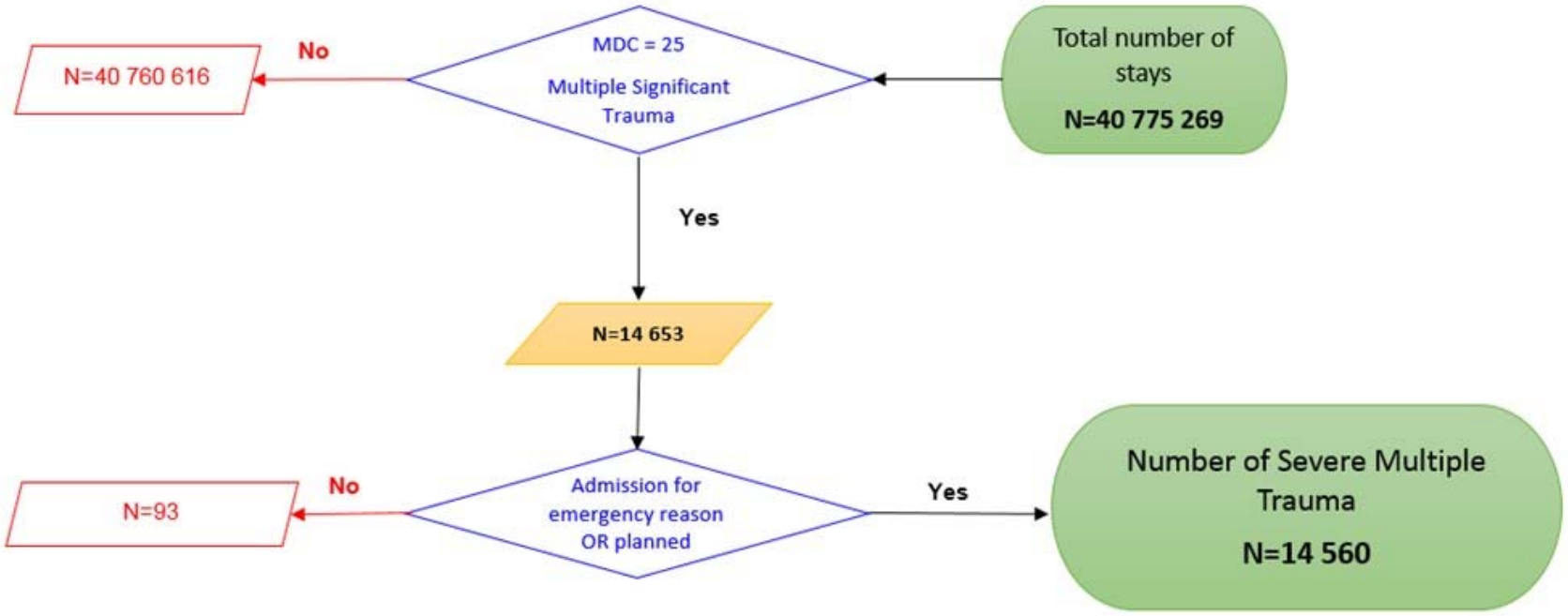
Based on the Minimal Hospital Data, the FOD – SPF classifies all stays in 1 282 possible APR-DRG-SOI combinations (which is done with APR-DRG-Grouper software). Each APR-DRG encompasses one or more procedures.

The principal diagnosis mentioned in the RHM – MZG determines in which Major Diagnostic Category (MDC) a stay can be classified. If the RHM – MZG database contain a procedure that is recognized by the grouper software as a surgical procedure, the respective stay will be labelled ‘surgical’. The surgical stays are then further classified in a surgical APR-DRG, mainly on the basis of the procedure code mentioned in the RHM – MZG. For medical stays, the principal diagnosis determines in which medical APR-DRG a stay is classified.

Box 8 – Limitations of the RHM – MZG data

- Restricton to the MDC 25 implies an underestimtaion of the real number of severe trauma cases;
- Severity of Illness is linked to the primary and secondary diagnosis/procedures;
- No information on the quality nor appropriateness of the care are included in the data.

Figure 12 – Flowchart of RHM – MZG data included in the study (2009 to 2014)



Severe multiple trauma *= MDC 25 stays with an admission via ED or emergency hospitalisation or planned admission.*

2.3.7 Analyses related to RHM – MZG data

There are around 2 400 hospital stays per year for Multiple Significant Trauma (MDC 25) – which represents less than 0.01% of all stays overall. Most (99%) of the stays for multiple significant trauma are stays with an admission via ED or emergency hospitalisation or planned admission (**severe multiple trauma**) (Table 7). The majority of those stays (around 70%) were categorized on the Severity of Illness scale (scale which refers to the extent of physiologic decompensation or organ system loss of function) as Major to Extreme.

Table 7 – Number of stays for Multiple Significant Trauma

	2009	2010	2011	2012	2013	2014	All
All stays for Multiple Significant Trauma (MDC 25)	2 456	2 425	2 542	2 450	2 365	2415	14 653
Stays with severe multiple trauma	2 447 (99.6%)	2 387 (98.4%)	2 529 (99.5%)	2 440 (99.6%)	2 349 (99.3%)	2408 (99.7%)	14 560 (99.4%)
Severe Multiple Trauma							
APR-DRG (version 28)	2 447	2 387	2 529	2 440	2 349	2408	14 560
Craniotomy For Multiple Significant Trauma	169 (6.9%)	164 (6.7%)	139 (5.7%)	192 (7.8%)	171 (7.0%)	163 (6.7%)	998 (6.9%)
Extensive Abdominal/Thoracic Proc. For Multiple Significant Trauma	255 (10.4%)	237 (9.7%)	263 (10.7%)	201 (8.2%)	201 (8.2%)	202 (8.3%)	1 359 (9.3%)
Multiple Significant Trauma W/O Surgical Procedure	996 (40.7%)	1 008 (41.2%)	1 085 (44.3%)	1 043 (42.6%)	996 (40.7%)	1 004 (41.0%)	6 132 (42.1%)
Musculo-Skeletal & Other Procedures For Multiple Significant Trauma	1 027 (42.0%)	978 (40.0%)	1 042 (42.6%)	1 004 (41.0%)	981 (40.1%)	1 039 (42.5%)	6 071 (41.7%)
Severity of illness (version 28)							
1 – Minor	28 (1.1%)	23 (0.9%)	25 (1.0%)	22 (0.9%)	29 (1.2%)	22 (0.9%)	149 (1.0%)
2 – Moderate	705 (28.8%)	661 (27.0%)	681 (27.8%)	676 (27.6%)	606 (24.8%)	571 (23.3%)	3 900 (26.8%)
3 – Major	1 077 (44.0%)	1 030 (42.1%)	1 105 (45.2%)	1 079 (44.1%)	1 067 (43.6%)	1 121 (45.8%)	6 479 (44.5%)
4 – Extreme	637 (26.0%)	673 (27.5%)	718 (29.3%)	663 (27.1%)	647 (26.4%)	694 (28.4%)	4 032 (27.7%)
Death							
	310 (12.7%)	272 (11.4%)	310 (12.3%)	294 (12.0%)	282 (12.0%)	271 (11.2%)	1739 (11.9%)

Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Minimum Hospital Discharge (MHD) data 2009-2014.

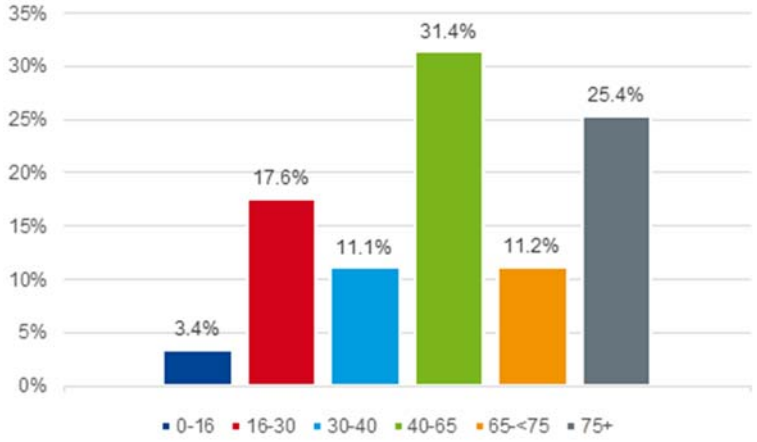
Multiple significant trauma patient's sable numbers except for elderly patients is increasing

The percentage of stays for multiple significant traumas varies over the years (from 2 447 stays in 2009 to 2408 stays in 2014) without time trends. During this period (2009 to 2014), the proportion of stays was around 3.5% for children younger than 16 years (regardless of the year) while that for older patients (75+years) increased from 19% to 25% over the years.

Characteristics of patients with severe multiple trauma (2014)

In 2014, more than half of the stays concerns patients between 16 and 65 years (Figure 13). The distribution is similar to the one observed in the SMUR – MUG interventions except for the 75+ (25% of the stays for severe multiple trauma). Sixty-three percent of the admissions for severe multiple trauma were for males (exactly the same as for the SMUR – MUG interventions for severe trauma).

Figure 13 – Distribution by age category – Stays for severe multiple trauma 2014

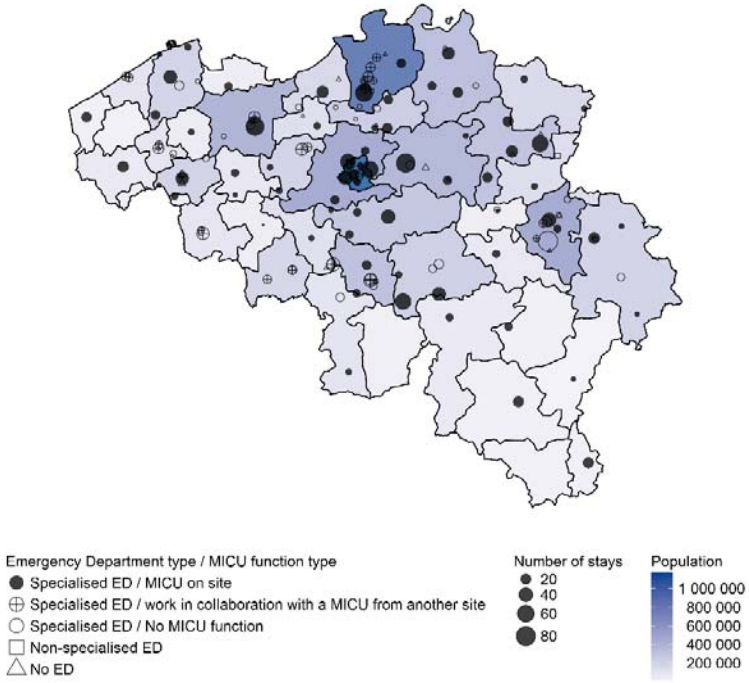


Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Minimum Hospital Discharge (MHD) data 2014.

Characteristics of the stays for severe multiple trauma (2014)

Figure 14 shows the number of stays for severe multiple trauma by hospital site (data 2014). There is a concentration of cases on some sites situated mainly in cities with higher population density like Brussels, Antwerpen, Gent, Liège and Leuven. Those sites are mainly the same as the ones with higher number of mobile intensive care unit interventions for severe trauma. This supports the concordance of the data from SMUR – MUG registration and RHM – MZG data.

Figure 14 – Dispersion of the number of stays for severe multiple trauma per hospital site – Data 2014



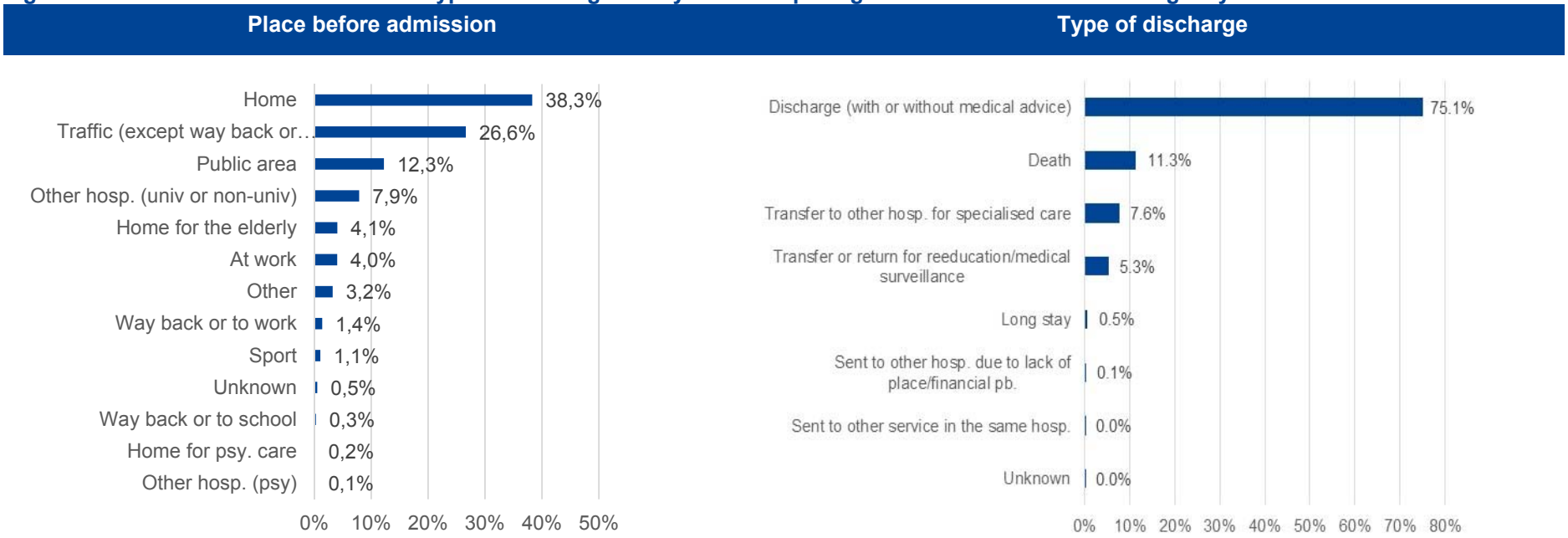
Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Minimum Hospital Discharge (MHD) data 2014.

For the majority (40%) of the stays for severe multiple trauma, the place before the admission was road traffic (26.6%) or a public area (12.3%) and 1.7% admissions for patients on the way back or to work/school. For 38.3% of the admissions, it was the home and around 7.9% of the admissions come from another hospital.

More than 80% of the patients admitted to hospital for multiple trauma were transported by an ambulance (51% were escorted by a mobile intensive care unit and an ambulance and for 31% of them only by an ambulance).

The majority of patients with a severe multiple trauma are discharged back home (with or without medical advice) (75%) and around 7.6% were transferred to another hospital site for specialised care (i.e. for a more accurate diagnostic, examination … but excluding the cases transferred for re-education hospital sites) (Figure 15). When comparing the length of stays for the ones transferred to another hospital for specialised care and the others we observe that the first ones have a shorter length of stay (median (Q1-Q3) = 10 (3.5 – 24) days) compared to the others (median (Q1-Q3) = 15 (7 – 33) days). For 9% of the cases transferred for specialised care, the transfer was performed within the day. The in-hospital mortality rate was around 11% to 12%. The in-hospital mortality rate per site over the period 2009 to 2014 was, in median, of 9.6% (Q1 – Q3 of [1.8% ; 13.5%]).

Figure 15 – Place before admission and type of discharge – Stays for multiple significant trauma with an emergency admission 2014



Source : Federal Public Service (FPS) Health, Food Chain Safety and Environment: Minimum Hospital Discharge (MHD) data 2014.

Characteristics of the hospital sites with stays for severe multiple trauma (2014)

Number of stays per site

The number of stays (for severe multiple trauma) per site depends on the characteristics of the sites. We should highlight here that the number of stays corresponds to the number of stays for MDC 25 only and not for other possible severe trauma cases which might be recorded under different DRGs. There are small differences between the Flemish and Walloon regions (median (Q1-Q3) number of stays varying from 10 (5 – 19) stays to 12 (6 – 19) stays, respectively) but for Brussels, half of the sites have less than or equal to 8 admissions per site (range Q1-Q3 = 3 – 11 stays). This might be explained by a higher density of hospital sites near to each other.

The sites with a specialised emergency service admit higher number of patients with severe multiple trauma (median (Q1-Q3) = 14 (8 – 23)) (Table 8). The presence of a mobile intensive care unit attached to the hospital or alternating with another hospital seems to influence a bit the number of stays (median (Q1 – Q3) : 15 (10 – 29) stays for sites with attached unit compared to 14 (10 – 22) stays for sites with a unit alternating with other hospitals) (Table 8).

Table 8 – Number of stays with severe multiple trauma (MDC 25) per site per hospital sites' characteristics

Sites Characteristics	All	Regions			Emergency service			Mobile intensive care unit		
		Walloon	Flemish	Brussels	Specialised	Non-specialised	None	With a unit on site	Alternating with other hospital	None
Number of sites	155	54	84	17	127	8	20	67	28	60
Median (Q1 - Q3)	11 (5 – 19)	12 (6 – 19)	10 (5 – 19)	8 (3 – 11)	14 (8 – 23)	3 (2 – 4)	1 (1 – 2.5)	15 (10 – 29)	14 (10.5 – 22.5)	4 (2 – 8)
Min – Max	1 - 85	1 - 85	1 – 84	1 – 66	1 - 85	1 - 11	1 - 7	1 – 84	1 – 36	1 - 85

Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Minimum Hospital Discharge (MHD) data 2014.

Number of stays per site's characteristics

Overall, the stays for severe multiple trauma were mostly in the sites (Table 9):

- University hospital (21%) or with 450+ beds (22%);
- Without burn care unit (89%);
- With child care unit (or in association with) (81%);
- With a specialised emergency department (97%);
- With a mobile intensive care unit attached to the hospital OR alternating with another hospital (83%);
- With at least one MRI on site (76%);

Patients below 16 years (54% of them) or patients coming from another hospital site (71% of them) are more likely to go to university sites. We can observe that for secondary stays (stays sent to the hospital from another hospital) the percentage of stays sent to a site with a burn care unit is higher (24.4%) than for all stays (11%). If most of the stays (78%) are sent to sites with a child care unit we observe that 95% of the stays for patients below 16 years and 83% of the stays from traffic/public area are well sent to this kind of sites.

Table 9 – Number (%) of stays according to hospital site characteristics – Data 2014

Sites Characteristics		All	Stays Transfer for spec. care	No transfer for spec. care	Patients below 16y	Traffic OR way back or to work/school	From another hosp.	Stays with SOI 1 - 2	Stays with SOI 3 - 4
Number of stays MDC 25 with emergency admission (Number of hospital sites)		2 408 (155 sites)	184 (77 sites)	2 224 (154 sites)	81 (40 sites)	680 (119 sites)	193 (53 sites)	593 (131 sites)	1 815 (149 sites)
Number of **Beds**									
	<200 beds	328 (13.6%)	29 (15.8%)	299 (13.4%)	14 (17.3%)	96 (14.1%)	13 (6.7%)	104 (17.5%)	224 (12.3%)
	200-299 beds	323 (13.4%)	27 (14.7%)	296 (13.3%)	6 (7.4%)	82 (12.1%)	12 (6.2%)	106 (17.9%)	217 (12.0%)
	300-449 beds	736 (30.6%)	54 (29.3%)	682 (30.7%)	13 (16.0%)	224 (32.9%)	28 (14.5%)	176 (29.7%)	560 (30.9%)
	450+ beds	521 (21.6%)	38 (20.7%)	483 (21.7%)	22 (27.2%)	148 (21.8%)	44 (22.8%)	111 (18.7%)	410 (22.6%)
	UNIVERSITY	500 (20.8%)	36 (19.6%)	464 (20.9%)	26 (32.1%)	130 (19.1%)	96 (49.7%)	96 (16.2%)	404 (22.3%)
Burn care program									
	No	2 137 (88.7%)	158 (85.9%)	1 979 (89.0%)	70 (86.4%)	620 (91.2%)	146 (75.6%)	535 (90.2%)	1 602 (88.3%)
	Yes	271 (11.3%)	26 (14.1%)	245 (11.0%)	11 (13.6%)	60 (8.8%)	47 (24.4%)	58 (9.8%)	213 (11.7%)
Child Care program									
	No	448 (18.6%)	35 (19.0%)	413 (18.6%)	2 (2.5%)	100 (14.7%)	33 (17.1%)	114 (19.2%)	334 (18.4%)

	via association	68 (2.8%)	9 (4.9%)	59 (2.7%)	2 (2.5%)	15 (2.2%)	8 (4.1%)	14 (2.4%)	54 (3.0%)
	Yes	1 892 (78.6%)	140 (76.1%)	1 752 (78.8%)	77 (95.1%)	565 (83.1%)	152 (78.8%)	465 (78.4%)	1 427 (78.6%)
Intensive care									
	No	78 (3.2%)	4 (2.2%)	245 (11.0%)	2 (2.5%)	16 (2.4%)	5 (2.6%)	22 (3.7%)	56 (3.1%)
	Yes	2 330 (96.8%)	180 (97.8%)	1 979 (89.0%)	79 (97.5%)	664 (97.6%)	188 (97.4%)	571 (96.3%)	1 759 (96.9%)
Type of Emergency service									
	non-specialised	29 (1.2%)	2 (1.1%)	27 (1.2%)	0 (0.0%)	4 (0.6%)	5 (2.6%)	2 (0.3%)	27 (1.5%)
	none	42 (1.7%)	1 (0.5%)	41 (1.8%)	2 (2.5%)	7 (1.0%)	5 (2.6%)	10 (1.7%)	32 (1.8%)
	specialised	2 337 (97.1%)	181 (98.4%)	2 156 (96.9%)	79 (97.5%)	669 (98.4%)	183 (94.8%)	581 (98.0%)	1 756 (96.7%)
SMUR – MUG function									
	No	406 (16.9%)	38 (20.7%)	368 (16.5%)	8 (9.9%)	78 (11.5%)	31 (16.1%)	116 (19.6%)	290 (16.0%)
	alternating with another hosp.	472 (19.6%)	43 (23.4%)	429 (19.3%)	26 (32.1%)	130 (19.1%)	34 (17.6%)	107 (18.0%)	365 (20.1%)
	Yes	1 530 (63.5%)	103 (56.0%)	1 427 (64.2%)	47 (58.0%)	472 (69.4%)	128 (66.3%)	370 (62.4%)	1 160 (63.9%)
Region									
	Brussels	259 (10.8%)	12 (6.5%)	247 (11.1%)	8 (9.9%)	54 (7.9%)	40 (20.7%)	52 (8.8%)	207 (11.4%)
	Flemish region	1 265 (52.5%)	75 (40.8%)	1 190 (53.5%)	39 (48.1%)	366 (53.8%)	96 (49.7%)	324 (54.6%)	941 (51.8%)
	Walloon region	884 (36.7%)	97 (52.7%)	787 (35.4%)	34 (42.0%)	260 (38.2%)	57 (29.5%)	217 (36.6%)	667 (36.7%)
Number of CT scan									
	None	59 (2.5%)	3 (1.6%)	56 (2.5%)	7 (8.6%)	11 (1.6%)	2 (1.0%)	18 (3.0%)	41 (2.3%)
	1	2 170 (90.1%)	173 (94.0%)	1 997 (89.8%)	72 (88.9%)	624 (91.8%)	184 (95.3%)	535 (90.2%)	1 635 (90.1%)
	2	179 (7.4%)	8 (4.3%)	171 (7.7%)	2 (2.5%)	45 (6.6%)	7 (3.6%)	40 (6.7%)	139 (7.7%)
Number of MRI									
	None	586 (24.3%)	50 (27.2%)	536 (24.1%)	20 (24.7%)	158 (23.2%)	21 (10.9%)	178 (30.0%)	408 (22.5%)
	1	935 (38.8%)	74 (40.2%)	861 (38.7%)	15 (18.5%)	282 (41.5%)	40 (20.7%)	232 (39.1%)	703 (38.7%)
	2	492 (20.4%)	44 (23.9%)	448 (20.1%)	21 (25.9%)	128 (18.8%)	52 (26.9%)	107 (18.0%)	385 (21.2%)
	3	311 (12.9%)	15 (8.2%)	296 (13.3%)	18 (22.2%)	82 (12.1%)	57 (29.5%)	62 (10.5%)	249 (13.7%)

	4	84 (3.5%)	1 (0.5%)	83 (3.7%)	7 (8.6%)	30 (4.4%)	23 (11.9%)	14 (2.4%)	70 (3.9%)
Pet scan									
	No	1 673 (69.5%)	133 (72.3%)	1 540 (69.2%)	48 (59.3%)	473 (69.6%)	72 (37.3%)	444 (74.9%)	1 229 (67.7%)
	Through association	165 (6.9%)	12 (6.5%)	153 (6.9%)	6 (7.4%)	57 (8.4%)	15 (7.8%)	36 (6.1%)	129 (7.1%)
	Yes	570 (23.7%)	39 (21.2%)	531 (23.9%)	27 (33.3%)	150 (22.1%)	106 (54.9%)	113 (19.1%)	457 (25.2%)
Type of hosp									
	General hospital	1 433 (59.5%)	101 (54.9%)	1 332 (59.9%)	37 (45.7%)	419 (61.6%)	56 (29.0%)	387 (65.3%)	1 046 (57.6%)
	General hospital university like	475 (19.7%)	47 (25.5%)	428 (19.2%)	18 (22.2%)	131 (19.3%)	41 (21.2%)	110 (18.5%)	365 (20.1%)
	University hospital	500 (20.8%)	36 (19.6%)	464 (20.9%)	26 (32.1%)	130 (19.1%)	96 (49.7%)	96 (16.2%)	404 (22.3%)

Source: Federal Public Service (FPS) Health, Food Chain Safety and Environment: Minimum Hospital Discharge (MHD) data 2014.

Key points

- **There are indications that the care for patients with multiple significant trauma is dispersed. A total of 155 hospital sites admit patients with severe multiple trauma with a median of 11 cases per hospital site (ranging from 1 – 85).**
- **Around 7.6% patients with severe multiple trauma were transferred to another hospital site but only 10% of these transfers were performed within the day (Median length-of-stay before transfer: 10 days).**
- **Most of the stays for severe multiple trauma are in hospital sites:**
  - **hospital sites with more than 300 beds (52%) or in university hospital sites (21%)**
  - **with at least one CT-scan (97%)**
  - **with specialised emergency department (97%)**
  - **with a SMUR – MUG function attached directly to the site (or in collaboration with) (83%)**
  - **in high density cities**
- **72% of the stays are considered as Major or Extreme (Severity of Illness = 3 or 4)**
- **40% of the stays are from traffic / public area and 38% from home accident**
- **Secondary stays (patient comes from another hospital site) are mostly in university hospital sites (50%) or with 450+ beds (23%)**

PART 3: INTERNATIONAL COMPARISON

3 ORGANISATION OF MAJOR TRAUMA CENTRES IN A SELECTION OF COUNTRIES

3.1 Introduction

3.1.1 Research question and definitions

In this chapter, we aim to gather information on the organisation framework of major trauma centres in a selected number of European countries. For the sake of clarity, the Table 10 provides a description of some relevant terms that are used throughout the text. For each country, the corresponding term is included in the respective section.

Table 10 – Overview of working definitions in selected countries

Term	Working definition
Trauma centre	Specific entities (e.g. hospitals/departments) that encompass health care professionals' expertise as well as specific infrastructure required to provide care for severely injured patients.
Trauma centre specialisation level	According to their specific capabilities, trauma centres are classified into different "levels". The number of and the characteristics of the different levels vary between countries. For the sake of clarity, the most specialised entities in each country will be addressed as major trauma centres (MTC) or Level I centres. Lower levels of trauma care entities will be assigned to a higher number (e.g. Level II, Level III, etc.).
Trauma network	A trauma network encompasses all entities that provide care to the severely injured within a clearly defined geographical area. The type of entities involved in and the scope of the trauma network may vary between countries and regions within one country. For instance, trauma network may include prehospital, acute and rehabilitation services.
Recognition	Recognition is a process organised by legislative or regulatory authority that allows a care service to operate. In general, authorities establish a minimum set of requirements.
Accreditation	An accreditation is quality assurance scheme that demonstrates that entities meet a set of quality standards. These are initiatives that externally assess hospitals against pre-defined explicit published standards in order to encourage continuous improvement of the health care quality.[75]

3.1.2 Methodology

A scoping review was performed to identify European countries where the reorganisation of care provided to severely injured patients led to the creation of major trauma centres. With the exception of Luxembourg, all neighbouring countries were screened (i.e. France, Germany and the Netherlands). In addition, we gathered information for England, two Scandinavian countries (Denmark and Norway), Switzerland and Spain. Non-European countries with a large experience in trauma care (i.e. The United States, Canada and Australia) were not included in the analysis because of the differences in the organisation of the health care system. However, we reviewed the main characteristics of both systems in other to have a larger perspective on the organisation of trauma centres in these countries.

Information was gathered using the Health System in Transition (HiT) reviews, the KCE report 263[29] on the reorganization of emergency services and web-searches in national authorities' and scientific societies websites. Selection of countries was linked to the following criteria:

- Recognised or accredited major trauma centres were operational for at least 2 years;
- Minimum requirements for recognition/accreditation of major trauma centres were available;
- An accreditation (or formal evaluation) process of centres was in place. The accreditation process is performed by an independent evaluator;
- Availability of a trauma registry;
- Reports and evaluations on centres were available.

The information for a selected number countries was summarised using the same grid. The grid was discussed with KCE team members as well as with Belgian experts working in the field of trauma. We also contacted at least one national expert in order to verify the quality and the completeness of the information for each country. National experts were selected among persons working in trauma care (e.g. consultant in a trauma unit) or working as policy advisor in the trauma sector. The feedback provided by national experts and the evidence obtained from the scoping review was summarised into a single document.

3.1.3 Overview of the specialisation level, accreditation and designation of MTC

Table 11 summarises the information identified for screened countries and whether they were finally included in our study. For selected countries (i.e. England, the Netherlands and Germany), we proceeded to gather detailed information on the implementation of MTCs and on the characteristics of these centres. The countries description is presented in the following sections of this chapter. Countries not included for further screening lacked of an external accreditation process for all MTCs. However, in some cases, hospitals participate in accreditation programs from other countries.

Except for Switzerland, in all European countries, acute hospitals can be classified into either two or three specialisation levels and hospitals' collaboration is based on the "Inclusive Trauma Systems" model. Within this model all providers of trauma care, from pre-hospital care through to rehabilitation are included.

In the United States[18, 76] and Association of Canada Canada,[7] acute hospitals can be classified into five different categories. In Australia, The Model Resource Criteria divides acute hospitals into four categories.[28] In England, the United States and Canada, hospitals participating in trauma care may be further classified according to their capacity to treat paediatric patients: children only, adults and children and adults only (centres without a specific program for children).

Except for Germany, in all European countries, MTCs are designated by health care authorities. In the United States and Canada, designation of MTC depends on the states or other federated authorities. In most cases, designation criteria closely the requirements of the American College of Surgeons[18, 76] or of the Trauma Association of Canada.[7] However, federated authorities designating trauma centres may establish unique criteria for them.

3.1.4 Maturation of the system of MTC

Following a reform of the healthcare system there is usually a period of time during which the impact on patient's outcomes would be minimal. Implementation of a trauma system needs time to mature before effects can be seen and measured. In this section, we present evidence on the possible impact of the maturation of the trauma system on mortality for a selection of countries.

New South Wales (Australia)

The trauma system (TS) in New South Wales (Australia) was implemented in 1991. Since its implementation, several aspects of the system have went through deep reforms.[77, 78] In 2007 and 2009, comprehensive quality improvement programs for trauma centres were implemented. In addition, a new Trauma Plan formalising rural and regional referral networks was established in 2009.[78] The aim of the plan was to improve the transfer of patients living in sparsely populate and remote areas to MTCs in metropolitan areas.

Dinh et al (2014)[77] evaluated changes in in-hospital mortality in one MTC in a metropolitan area between 1992 and 2012. The authors compared two periods 1992-2006 and 2006-2012 in order to take into account the system's reforms. Compared to the initial period (1992-2006), crude and risk adjusted in-hospital mortality (adjusted for demographic characteristics, mechanism, type and severity of injury) decreased in 2006-2012.

Dinh et al. (2016)[78] evaluated the impact of the 2009 referral plan on inpatient mortality. Crude and adjusted mortality (adjusted for demographic characteristics, geographic location, and admission to the intensive care unit, mechanism, type and severity of injury) declined for rural patients. Inpatient mortality rates for rural patient decreased significantly from 12.1% in 2009 to 8.7% in 2014. The odds ratio for these group of patients for in-hospital mortality was 0.88 (CI 0.81-0.96). Lack of improvement in mortality outcomes, and even worst results, for patients in metropolitan areas were found by the authors.

Quebec (Canada)

The trauma system (TS) in Quebec was implemented in 1992 and was fully operational in 1996. Accreditation standards were published in 1993 and the accreditation procedure was initiated in 1995. The accreditation standards have been revised in 2003, 2007, and 2011. Three studies have evaluated the system at different points in time: 1992-2006,[79] 1992-2012[80] and 2006-2012.[81]

Ten years after implementation of the system in 1992, Moore at al.(2010)[79] found an average yearly decrease of 4.6% in risk-adjusted hospital mortality from 2002 to 2006. The authors point out that structures and clinical processes were successfully implemented and that the number of severely injured patients (with a score of equal or above four measured in the Abbreviated Injury Scale) referred on to MTCs considerably increased.

A second study by Moore et al. (2015)[80] found that between 1999 and 2012, risk-adjusted mortality decreased from 5.8 to 4.2% for all patients and from 14.9 to 13.1% for severely injured patients (ISS ≥16) ($p < 0.0001$).

The most recent study by Moore et al. (2016)[81] found that among 78 807 patients admitted for major injury (ISS ≥12) in the period 2006-2012, risk-adjusted mortality decreased over time from 12.1% (95% CI, 9%-16.1%) to 9.9% (95% CI, 7.4%-13.3%; $P < .001$) and the mean length of hospital stay decreased from 11.6% (95% CI, 9.9-13.6) to 10.6% (95% CI, 9.1-12.5) days ($P < .001$).

Israel

The TS in Israel was implemented in 1992. A first evaluation of the system that took place in 2000 and recommendations to improve identified deficiencies were provided. After this first evaluation, Siman et al. (2013)[82] evaluated in-hospital mortality over a 10 year period (2000-2010) for severely injured patients (injury severity score ≥16) brought to the six MTCs in Israel. Crude and adjusted mortality (adjusted for demographic characteristics, mechanism, type and severity of injury) declined over the ten year period. Inpatient mortality rates decreased significantly from 16% in 2000 to 11% in 2010. The odds ratio for mortality in 2010 vs. 2000, was 0.53, confirming a downward trend.

Goldman et al. (2014)[83] assessed the contribution of the TS on the survival of victims of road traffic accidents. They studied the period between 1998 and 2011. The crude mortality rates for severely injured patients (ISS ≥16) fell from 18.6% in 1998 to 11.0% in 2011. A reduction in mortality rates was also observed among all injured patients, i.e. from 3.6% in 1998 to 2.7% in 2011. The adjusted risk of mortality decreased by 56% (OR=0.44, CI: 0.33-0.59)

The United States

Dutton et al. (2010)[84] studied patient's outcomes at one Level I Centre in Maryland. In 1993, the centre was accredited as following the requirements of the American College of Surgeons. In 2011, the accreditation was successfully renewed. The authors found that crude mortality through in the period 1996-2008 increased from 3% to 3.7% (p = 0.04). However, survival improved significantly when comparing observed and expected mortality (using the baseline situation of the Major Trauma Outcome Study (MTOS)) among patients with an Injury Severity Score comprised between 17 and 25. The authors of the study highlighted that although gains in survival were limited for the period studied, the results concerned a population with higher risks than before, i.e. older and more severely injured.

In the study of Sarkar et al. (2011)[85] for the MTC in Michigan it was found that the mortality rate decreased significantly for severely injured patients (ISS >24), from 30.1% (2004) to 18.3% (2008), representing a 12% absolute reduction in mortality (p = 0.011). The authors point out that the implementation of performance improvement program initiatives may have driven this improvement, despite that the population referred on to the MTC is more fragile (older patients).

Table 11 – Screened European countries and selection

	Availability of trauma centre				Minimum requirements	Designation	External accreditation process	Trauma Registry	Report or evaluation	Selected
	Availability	Levels	Number MTC	Population covered per centre (in million)						
Denmark	Yes Recommendation to reorganise trauma care in 2007 (as part of a large structural reform of the healthcare system).[86]	Two	In 2015: Level I= 4	1.41	Yes	Yes	No Each MTC has a person in charge of performing the evaluation. One MTC underwent the accreditation procedure of the American College of Surgeons. Benchmarking between centres is not in place.	Yes	Yes Hospital reports	No
France	Partly Only in one region in France (Trauma system du Réseau Nord Alpin des Urgences (TRENAU)).[87, 88] In other regions, university hospitals are considered as playing the role of a MTC.[89]	Three in the Northern French Alps Trauma System.	In 2015: Level I= 1	1.74 (only in the Trenau region)	Yes	No	No An internal audit performed by network participants.	Yes	N Network yearly reports	No
England	Yes Reconfiguration of trauma care was initiated in 2009[90]	Three	In 2016: Level I= 27	2.03	Yes	Yes	Yes	Yes	Yes, Network yearly reports	Yes
Switzerland	Yes Reconfiguration of trauma care was initiated in 2011.[10, 91, 92]	One	In 2015: Level I =12	0.69	Yes	Yes	No A first qualitative evaluation (stakeholder consultation) was performed in 2015.	No	No	No
Norway	Yes Reconfiguration of trauma care initiated in 2007.[19-22]	Two	In 2015: Level I =4	1.29	Yes	Yes	No In some cases, hospitals may	Not clear.	Yes Hospital reports	No

	Availability of trauma centre				Minimum requirements	Designation	External accreditation process	Trauma Registry	Report or evaluation	Selected
	Availability	Levels	Number MTC	Population covered per centre (in million)						
							participate in accreditation programs from other countries.			
Spain	Incomplete information. Regional development seems unequal.[93]	–	–	-	No	No	No	No	No	No
The Netherlands	Yes. Designation of centres since 1999 [12, 13, 94]	Three	In 2015: Level I= 11	1.54	Yes	Yes	Yes	Yes	Yes, Yearly network reports	Yes
Germany	Yes Reconfiguration of trauma care was initiated in 2006[15, 17, 95]	Three	In 2016: Level I= 105	0.77	Yes	No	Yes	Yes	Yes Network yearly reports	Yes

3.2 England[i]

3.2.1 General context

3.2.1.1 Definitions

Table 12 provides a description of some relevant terms that are used in this chapter.

Table 12 – Overview of working definitions in England

	England
Trauma centre levels[a]	Level I: A Major Trauma Centre (MTC) is a multi-specialty hospital, on a single site, optimised for the provision of trauma care. It is the focus of the Trauma Network and manages all types of injuries, providing consultant-level care. Level II: A Trauma Unit (TU) is a hospital that is part of a Trauma Network (TN), providing care for all trauma patients except the most severe major trauma patients. The role of a trauma unit will depend on the agreements established within the TN. Level III: The Local Emergency Hospital (LEH) is a hospital in a Trauma Network that does not routinely receive acute trauma patients (excepting minor injuries that may be seen in a minor injury unit). Processes are in place to ensure that patients are appropriately transferred to an MTC or a TU.
Trauma network	A Trauma Network (TN) is the name given to the collaboration between the providers commissioned to deliver trauma care services in a geographical area. At its heart is the 'Major Trauma Centre'. A TN should include all providers of trauma care, particularly: pre-hospital services, other hospitals receiving acute trauma admissions (Trauma Units), and rehabilitation services.
Major trauma[b]	Major trauma patients have an injury severity score (ISS) >8
Recognition	Recognition is a process organised by legislative or regulatory authority that allows a care service to operate. The NHS England recognises and establishes minimum criteria for major trauma centres.
Accreditation	An accreditation is a quality assurance scheme that demonstrates that entities meet a set of quality standards. The National Peer Review Programme (NPRP) is in charge of the accreditation process for an MTC and TU. The Trauma Audit and Research Network (TARN) also provides data to set benchmarks in the peer review process.
Consultant	Senior hospital-based physician who has completed all of his or her specialist training.
Specialist	Physician who has completed all of his or her specialist training.
Specialty registrar	Physician who is in training (at least 3 years) for a specialism.

Source: [a]The definitions presented for the different trauma centre levels come from the pages 5 and 6 of the NHS Clinical Advisory Groups Report (2010)[27]. [b]NHS England (2013)[9].

[i] Professor Chris Moran provided comments on the English system. Professor Moran is the National Clinical Director for Trauma for NHS England and an Orthopaedic Trauma Surgeon at the Nottingham University Hospitals NHS Trust

3.2.1.2 Country context

England along with Scotland, Wales and Northern Ireland make up the United Kingdom of Great Britain. While the National Health Service (NHS) covers the four countries, organisation, monitoring and financing of health care services differs greatly across the four nations. The Department of Health is responsible for setting health care policy in England and allocates health funds to the NHS England. The National Health Service (NHS) is mainly financed through general taxation and national health insurance contributions. In 2013, the general government expenditure on health care amounted to 83.5% of total health care expenditure. The remaining 16.5% was paid by patients via their private health insurance and out-pocket-payments.[96] In England, there is a split between purchasers – providers for the health care sector.

On 1 April 2013, a new structure of health geographies in England came into force. The new structure consists of clinical commissioning groups (CCGs), NHS area teams (NHSATs) and NHS commissioning regions (NHSCRs). In the period 2014-2015, the structure was further modified. The NHS England's area teams were integrated into the four existing regional teams (previous NHSCRs): London, Midlands and East, North and South. A local presence in each region is ensured in 13 Local Offices (LOs).[97, 98] The NHS England distributes funds and supervises and supports the 209 general practitioner-led Clinical Commissioning Groups (CCGs).[96, 99] The CGS are responsible for the planning and purchasing of all hospital activity, including urgent and emergency care, and some community services (e.g. mental health services).[100]

The NHS England also directly procures "specialised services" that are provided in relatively few hospitals, accessed by comparatively small numbers of patients but covering populations of usually more than one million.[101] By directly commissioning those services, the NHS England aims to ensure that "patients have equal access to services regardless of their location".[101] Specialised services have been grouped into six National Programmes of Care (NPoC), more precisely internal medicine, cancer, mental health, women and children, blood infection and trauma. For the different NPoC programmes, a board is in charge of coordinating and prioritising the work and clinical Reference Groups (CRGs) are in charge of providing clinical advice and leadership. The NPoC for trauma has seven Clinical Reference Groups (CRGs), one of which concerns Major Trauma.[99, 100]

3.2.1.3 Hospital classification and planning

In general, hospitals in England fall into one of two categories: those run by the NHS and those that are independent (e.g. run by private companies). Hospitals can offer a large number of specialisms (general hospital) or be more specialised (specialist hospital). Most NHS services are delivered by public providers. Since 2013, most public hospitals are grouped into legal bodies called "NHS foundation trusts".[102] NHS foundation trusts are independent and self-governing organisations not subjected to performance-management by health authorities. The cap on income that foundation trusts can generate from private sources is currently set at 49% of all income.[96] In 2016, there were 137 acute non-specialist trusts and 17 acute specialist trusts. Compared to non-specialist trusts, specialist trusts focus on particular conditions (e.g. cancer) or in some cases provide services for specific groups of the population (e.g. children's hospitals).[103] In the same year, University Trusts amounted to 30 (of the 154 Trust). Certain services, such as ambulance and emergency care services remain grouped into state-owned bodies called 'trusts'.[103]

Highly Specialised services are often found in urban areas, and are often linked to medical schools or teaching hospitals (university hospitals). Across England (and overall in the United Kingdom) there has been a tendency to concentrate specialised care in fewer centres in order to improve quality and control costs.[96]

3.2.2 Policy development

3.2.2.1 What factors were used to determine which institutions were initially selected to become MTC

Recommendations of the physician associations based on the US experience

Concerns about the management of severely injured patients date back to the 1980s.[90] In 2007 the Royal College of Surgeons of England recommended to implement trauma networks.[104] They specified that trauma networks should be led by major trauma centres working in close collaboration with other hospitals within a clearly defined catchment area.[104] Based on the experience of the United States (see Box 9 for more detains),[105] the College initially recommended establishing 12 to 16 major trauma centres, each serving populations of between 3-4 million, depending on location and geography.[104] In this configuration, each centre would receive a minimum of 250 critically injured patients per year.[104]

Box 9 – Requirements for trauma centres in non-European countries

The **American College of Surgeons (ACS)**[18] defines a Level I trauma centre as 'a comprehensive regional resource that is a tertiary care facility central to the trauma system. A Level I Trauma Centre is capable of providing total care for every aspect of injury – from prevention through rehabilitation'. Level I trauma centre must admit at least 1,200 trauma patients yearly or have 240 admissions with an Injury Severity Score (ISS) of more than 15.

At present, not all regions in the US have interpreted this advice in the same way, resulting in significant differences in designation standards. Several states do not use mandatory requirements regarding trauma patient volume, while others use thresholds of 600 and lower.[106] The American Trauma Society suggest that in 2013 there were 213 Level I, 313 Level II, 470 Level III, and 916 Level IV or V centres in the United States.

According to the ACS, Level I Trauma Centre must have 24-hour in-house coverage by general surgeons, and prompt availability of care in specialties such as orthopaedic surgery, neurosurgery, anaesthesiology, emergency medicine, radiology, internal medicine, plastic surgery, oral and maxillofacial, paediatric and critical care. Level I Trauma Centres are in charge of providing to other hospitals with support, continuing education for trauma team members and to establish and to follow comprehensive quality assessment program.

The **Trauma Association of Canada**[7] recommends to have only one Level I or Level II Trauma Centre and one Level I or Level II Paediatric Trauma Centre (free-standing or contained within the adult trauma centre) for a population of 1 to 2 million with an anticipated caseload in the order of 500 to 1000 major trauma patients with an Injury Severity Score (ISS) of more than 12.

The **Royal Australasian College of Surgeons**[28] based the criteria used to evaluate the trauma centres on the requirements established from the of the American College of Surgeons Committee on Trauma. In Australia, the trauma networks and trauma care services remain the responsibility of state and territory governments. The number of designated MTC varies considerably between the states but a national quality program covers all care providers. Major trauma patients included in the trauma registry are those with an Injury Severity Score (ISS) of more than 12.[8]

Audit reports showing clearly a room for improvement

Also, the publication of the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report, showing clear room for improvement in the care for severely injured patients (e.g. lack of a formal trauma team), helped to place the reform of trauma services on the policy agenda.[90, 107-109]

A report by the acting Minister of Health triggered the reform

The report, however, that actually triggered the appointment of the first National Clinical Director for Trauma care (in 2009) and the reform of the system at end of the 2000s[27, 107, 108] was the report of the then Health Minister Lord Darzi's.[110, 111] In his report, Lord Darzy clearly supported the establishment of MTCs and TNs.

Blueprint for trauma care spanning the entire care pathway: from pre-hospital care to rehabilitation

After the appointment of the Director for Trauma Care, five Clinical Advisory Groups (CAGs) provided advice on the organisation of the trauma care pathway based on scientific evidence, the consultation of experts and of stakeholders. The members of the CAG were drawn from different healthcare professions, healthcare authorities and patient's representatives.[27]

The advice of the CAGs were used to build the blueprint for the regional trauma networks. The care pathway included:

- Pre-hospital and inter-hospital transfers
- Acute care and surgery
- Ongoing care & reconstruction
- Rehabilitation
- Network organisation and governance

Defining the target group as a part of setting up the system

During the process that led to the organisation of TNs, the involved parties agreed that the target group for MTCs encompassed patients with an Injury Severity Score (ISS) greater than eight. The threshold of eight and not of 15 was selected because the different stakeholders agreed that the system should provide care to injured patients with life-altering and not only life-threatening injuries.[112] The experts pointed out that an early identification of the injured with an ISS>8 could improve the quality of care and reduce the hospital's length of stay and readmissions.[112]

Setting minimal standards for the major trauma system at the national level

- The Clinical Advisory Groups (CAG) recommended to take into account the following aspects for the selection of MTC:[27]
- Clinical quality: measure based on clearly defined standards and assessed independently by a panel of experts that are not involved in the provision of services in the network catchment area
- Coverage of the area in relation to travel times: it involved mapping travel times for primary and secondary transfers within a region for 'candidate' MTCs and other hospitals
- Co-location with other services: it involved to assess whether key specialties are co-located in the hospital. Lack of co-location could result in the exclusion of some hospitals from taking up the role of MTC.
- Ease of implementation: Care delivery models are assess with respect to reconfiguration of services that required
- Capacity (e.g. does one model has greater capacity for severely injured patients?)
- Effectiveness in delivering a Network
- Affordability
- Effectiveness in delivering major incident capability

The number of hospitals considered for the care of the severely injured also depended on the expected number of major trauma patients per year.[90] It was recommended to evaluate the health needs of the population at the level of the regions in order to understand the 'potential' number or patients who would be referred to MTCs and TUs.[27] The sources of data that were recommended included:

- The registry for trauma managed by the Trauma Audit Research Network (TARN) (see section 3.3.5 for more details)
- Hospital Episode Statistics (HES) and Emergency Department attendance

- Ambulance service data

The CAG proposed to combine the three sources of data because a single source could not provide a complete picture of the situation. Each data source had important advantages and disadvantages. The TARN data included information on the severity of injury but was not homogenously filled between the regions. The HES and the Emergency Department attendance lacked information on the severity of injury but could give a raw view of the number of attendances to the different hospitals. Ambulance service data lacked information on the exact severity of injury but could indicate a raw view of the number of patients treated following an urgent call (see section 3.2.3.2 for more details.)

Selection of MTCs at a local level: the trade-off between pragmatic and ideal objectives

The selection of MTCs and TUs was considered as one of the most challenging areas within the implementation process of the trauma networks.[27] The Department of Health (DoH) delegated the task of organizing the networks to the ten Strategic Health Authorities (SHAs). The SHA process started by analysing the travel times within their catchment area and by allowing all hospitals to propose their candidature as a MTC or TU. In order to be considered as MTC candidate, the hospitals had to fulfil the requirements included in the blueprint of the CAGs. At the moment of the launch of the Trauma Networks, the number of MTC and TU reflected the hospital's capacity to comply with the CAGs requirements as well as the level of competition between different healthcare providers. Within the regions, competition between hospitals arose when more than one provider wished to be designated as a MTC. In order to deal with multiple MTCs candidates, the CAG established the possibility to have a bid process.[27] The process of bidding was not applied and a negotiation process between the authorities and hospitals was established. The negotiation process resulted in the implementation of more MTC than initially foreseen by the Royal College of Surgeons of England.[112]

3.2.2.2 What were the main challenges faced during the implementation of MTC? Which solutions were found to overcome these challenges?

According to the Royal College of Surgeons of England "the lack of political will and central direction to take decisions on the location of major trauma centres has meant that local issues (such as the service configuration of A&E departments) impeded the development of defined trauma systems".[104] For instance, some stakeholders were of the opinion that building a trauma network could reduce the volume of patients attending an A&E departments and then leads to its closure.[112]

Trauma networks were first introduced in the London and East Midlands regions and were afterwards expanded over the entire English territory. Between 2008 and 2012 all trauma networks in England have succeeded in establishing a new organisation for the care provided to the severely injured.

When the discussions on establishing the system took place, a point of concern was the availability of resources to fund the services.[113] The mechanism that was established to fund MTCs was attached to the individual patient via a best practice tariff (BPT).[113, 114]

Box 10 – Best practice tariff (BPT) components

A best practice tariff (BPT) is composed of two parts: a base price and a conditional payment. The base price is payable to all activities irrespective of whether the characteristics of best practice are met. The conditional component is payable if the treatment meets several characteristics of evidence-based best practice.[115]

In the case of trauma patients, the conditional component aimed to support "the enhanced specifications for MTC which include immediate consultant input, immediate access to imaging and surgery, combined multispecialty input, and planned complex rehabilitation".[116] The BPT is made up of two levels of payment differentiated by the Injury Severity Score (ISS) of the patient and conditional on achieving the criteria included in Table 13.[117] Resources for the BPT were secured by pooling funds from the hospitals'

budgets following a re-distribution of means towards major trauma patients (the general per case payment for major trauma patients increased in comparison to other trauma patients). The latter was combined with an additional £37 million provided by the NHS.[113]

Table 13 – Specifications for the best practice tariff for major trauma patients 2014/15

Patients with an ISS of more than height	Patients with an ISS of more than 15
• The patient is treated in an MTC; • Trauma Audit and Research Network (TARN) data is completed and submitted within 25[a] days of discharge; • A rehabilitation prescription is completed for each patient and recorded on TARN; • Any 'coroners' cases are flagged within TARN as being subject to delay to allow later payment; • Tranexamic acid must be administered for those patients receiving blood products within three hours of injury;[b] • If the patient is transferred as a non-emergency, they must be admitted to the MTC within two calendar days of referral from the Trauma Unit (TU).[b]	• Level 1 criteria must be met; • If the patient is admitted directly to the MTC or transferred as an emergency, the patient must be received by a trauma team led by a consultant in the MTC. The consultant can be from any specialty, but must be present within five minutes;[c] • If the patient is transferred as a non-emergency they must be admitted to the major trauma centre within two calendar days of referral from the TU; • Patients directly admitted to an MTC with a head injury with an Abbreviated Injury Scale (AIS)=1+ and a Glasgow Coma Scale<13 (or intubated pre-hospital), and who do not require emergency surgery or interventional radiology within one hour of admission, receive a head CT scan within 60 minutes of arrival[d].

Source: NHS England (2015)116 a. In the specification for 2012/13 it was 40 days. b, d In the specification for 2012/13 this was not included. C In the specification for 2012/13 the criteria was 30 minutes. A patient cannot attract payments for both Level 1 and 2. The BPT applies to adults and children. Organisations will need to use the TARN database to support the payment.

3.2.3 System Integration

3.2.3.1 Categorization of hospital infrastructure

Organisation for MTC in a mature system: towards higher concentration of patients

In April 2012, regional trauma networks were implemented according to the "Inclusive Trauma Systems" model. Within this model all providers of trauma care, from pre-hospital care through rehabilitation are included.[9] There are three types of MTC according the population they treat: adults and children, adults only and children only.[118] MTCs have a key role in the Trauma Network and manage all types of injuries, providing consultant-level care.

In general, one MTC corresponds to one hospital (or trust). However, there were two collaborative MTCs in Manchester (3 partners) and Liverpool (two partners for adult care and one for children). Both collaborative MTCs served urban areas. The collaborative MTCs were organised in a way that allows each hospital to provide care according to the specialties available in the different hospitals.[113, 119]

The number of TNs, MTCs and TUs has evolved since the launch of the networks. In 2012, there were 26 Major Trauma Networks, each with a Major Trauma Centre. In 2015, there were 22 Major Trauma Networks, with 22 Major Trauma Centres for adults or adults and children or which five provide care to children only. In 2016, the number of networks will also be reduced and a process of concentrating the severely injured in fewer centres seems to be taking place. The reorganization of the collaborative MTCs is a good example of this concentration process. The National Peer Review Programme recommended in 2013 and 2014 to reduce the number of receiving hospitals in the collaborative MTCs (see 3.2.4.2).[120, 121] The collaborative MTC in Liverpool is already functioning with only one receiving hospital[122] and the collaborative MTC in Manchester is expected to complete the new reconfiguration by March 2017.[121]

Box 11 − Case study: The reconfiguration of the MTC in Liverpool

The MTC in the Liverpool area originally received severely injured patients (adults) in the Aintree University Hospital NHS Foundation Trust and in the Royal Liverpool and Broadgreen University Hospitals NHS Trust. The National Peer Review Programme (NPRP) pointed out in the reviews of 2013 and 2014 that the MTC should be moved to a single receiving hospital (only the Aintree University Hospital). The reviews pointed out that:

i) The Royal Liverpool Hospital treated a low number of severely injured patients (between 90 and 100 patients with an Injury Severity Score (ISS) greater than 15 per year). This volume was considered too low to fulfil the recognition criteria, to maintain in the long term a skilled base team and to be financially viable.[120]

ii) The regional neurosciences centre (i.e. The Walton Centre NHS Foundation Trust) was co-located with the Aintree University hospital. For this reason all patients with a Glasgow Coma Scale lower than 13 were directly referred to the Aintree University hospital.[123]

iii) In mid- 2015, the Aintree hospital opened a new emergency department with a co-located computed tomography facility (CT). Before that date, only the Royal Liverpool hospital had a co-located CT with the ED.[123]

The passage from two to one receiving hospital was facilitated by the close collaboration between the NHS commissioners and the clinicians of both hospitals. The collaboration between the NHS commissioners and the clinicians was essential to ensure that the hospitals' managers accepted to work towards establishing a single receiving hospital in their network.[112]

Collaboration between levels: an essential aspect of the trauma system

Hospitals designated as a major trauma centre must work in collaboration with all hospitals having an accident and emergency department that are located within their catchment area. These hospitals are classified into two groups: Trauma Units (TUs) and Local Emergency Hospitals (LEHs). TU provide care to less seriously injured patients (i.e. simple fractures of one limb, lacerations and minor head injuries) and if the travel time to a MTC exceeds 45 minutes, severely injured patients can be treated in TU to stabilise the patient before being referred on to a MTC. The role of a trauma unit depends on the characteristics of the TU, the configuration of the network, more precisely on the geographical accessibility of the hospitals participating in the network and on the triage protocols established for the transfer of patients.[6]

Box 12 − Case study: Variation in the coverage of MTC

In England, there are large variations in the population covered by the networks. For instance, the East of England trauma network and the South Yorkshire trauma network cover a population of 5.9 and 1.6 million, respectively.[118] The former network is composed by one major trauma centre and twelve Level II while the latter encompasses two separate major trauma centres (one for adults and one for children) and four Level II centres.

Local Emergency Hospital (LEHs) do not routinely receive acute trauma patients. LEHs are consistently bypassed when the patient is identified as being severely injured.[9, 113] LEHs must, however, be, in case of self-referred trauma patients, capable of identifying severely injured patients and ensuring their transfer to an MTC or TU. Trauma Units (TUs) and Local Emergency Hospitals (LEHs) located in the borders between trauma networks can collaborate with more than one MTC. For these hospitals, the decision to transfer a patient may depend on the travel time to the closest MTC (e.g. impact of the traffic at the arrival of the patient) or on the distance between the MTCs and the patient's place of residence.[112]

Table 14 – Number of trauma centres and trauma networks in 2015

England	
Number of acute Trust[a]	• 137 non-specialist • 17 specialist • 30 university trust
Number of acute Trust with a major accident and emergency department	139
Number of trauma networks[b]	22
Number of MTC and other lower level centres in each trauma network[b]	
Level I	*22*
Level II	120
Level III	27*
Paediatric centre	*5 (out of the 27 Level 1)*
Range of Level II & III centres per network	
Level I	1
Level II	2-12
Level III	0-5

Source: [a] NHS Confederation (2016)[118]. [b] *The information was extracted from the individual reports on the Network Governance Measures included The National Peer Review Trauma Programme in 2015. The range for the number of centres does not include the paediatric network. In general, one MTC corresponds to one hospital (or trust). However, there were two collaborative MTCs. The reference to the individual reports can be found on the page 25 of the National Peer Review Report: Major Trauma 2015.*[118]

Table 15 – Statistics of the Trauma Networks in England in 2015

	Networks	MTC (Adults only or adults and children)	Children only	TU	LEH	Population (Million)
1	South East London and Kent and Medway	1		7	3	4.5
2	East Midlands	1		6	1	4.6
3	Cheshire and Mersey (Collaborative)	1	[a]	6		2.3
4	East of England	1		12		5.9
5	North Yorkshire and Humberside	1	[a]	4		1.6
6	Thames Valley Trauma	1		5		3
7	Central England	1	[a]	2	2	1.9
8	North West Midlands and North Wales	1	[a]	5	3	2.1
9	Wessex	1		7		3.3
10	South Yorkshire	1	1	4		1.6
11	North East London and Essex	1		11		2.5-3
12	Northern	2		9	[e]	3.6
13	Birmingham. Black Country. Hereford and Worcester	1	1	9	2	3.13
14	Peninsula	1	[a]	4		1.67
15	Sussex	1		3		1.6
16	North West London	1		6		12[b]
17	Lancs and South Cumbria Trauma Network	1	[a]	4		1.6
18	Severn	1	1	6		2.3
19	South West London and Surrey	1		7		2.6
20	West Yorkshire	1		5		2.3
21	Greater Manchester Major Trauma Network (Collaborative)	1	[a]	3	5	2.8
22	North West Children's Major Trauma Network		2	16	11	1.4
	Total	22	5	[c]	27	

Source: [a] These networks refer children to one of the paediatric MTC. [b] Includes all of London's population. However London is served by other MTC. [c] A trauma unit can belong to more than one network, therefore a total is not provided. [e] Number not provided. The information on the table was extracted from the individual reports on the Network Governance Measures from The National Peer Review Trauma Programme in 2014[124] and in 2015[118].

3.2.3.2 Emergency Medical Services (EMS)

General overview of EMS

The organisation of EMS is the responsibility of ten ambulance Trusts.[122] The ambulance services are comprised of five NHS Trusts and five Foundation Trusts. The different ambulance trusts provide services within a specific area via their own ground fleet and purchase air ambulance services (Helicopter Medical Service (HEMS) and air ambulance missions) from 19 charity organizations.[125-127] The Trusts are responsible for responding to emergency calls via the 999 number, for providing on-scene care and for transporting patients to a hospital (see Table 16).

Emergency medical dispatchers triage calls into three categories: category A. immediately life-threatening; category B. serious but not immediately life-threatening; and, category C. not serious or life-threatening.[125, 126] The response time for the three categories is established by the Department of Health. The emergency medical dispatcher may send a rapid-response vehicle crewed by a paramedic and/or an emergency care assistant and an ambulance equipped with the resources required to provide treatment at the scene of an incident.[122]

From 1st June 2012, category A was subdivided into two-parts (Red 1 and Red 2) in order to reflect the response times for immediately life-threatening situations. Red 1 calls are the most time critical (e.g. airway obstruction) and red 2 calls are serious but less immediately time critical (e.g. stroke).[126]

Ambulances are required to reach immediately life-threatening patients as follows:

- Category A Red 1: within 8 minutes
- Category A Red 2: within 8 minutes. The clock starts the earliest of: i) The point at which the chief complaint of the call has been identified; ii) A vehicle has been assigned to the call or iii) A 60 second cap from the call connect time.[126]

If the first response is not a fully-crewed ambulance then an ambulance should arrive within 19 minutes.

EMS and MTC: a collaboration based on clearly defined agreements

In the different trauma networks, it is possible that more than one ambulance Trust transports patients to a MTC. At the same time, an ambulance trust may have agreements to transport patients to different MTC. In both cases, the transfer of patients to MTC or TU is performed according to the protocols established between all the participants of the trauma network (see section 3.2.3.2 for more information). For HEMS there are no definitive guidelines for call selection and tasking.[127] The ambulance service must inform the MTC that a patient is being transferred in.[9]

Table 16 – Emergency medical services

	England
Responsibility for organisation	• Ground fleet NHS Trusts and Foundation Trusts (total of 11) • Air fleets Charity organizations
Minimum requirements in terms of availability and accessibility of ground ambulances and aeromedical services?	An ambulance must be onsite after the emergency call within : • within 8 min for a life-threatening situation (must urgent category A Red 1) • within 8 minutes for a life-threatening situation (less urgent category A Red 2) with the clock starting upon the earliest of three situations. • If the first response is not a fully-crewed ambulance then an ambulance should arrive within 19 minutes.
Dispatching system	• 999 for life-threatening situation • NHS111 for non-life-threatening situations • Emergency Medical Dispatcher attends 999 calls for potentially life-threatening conditions or situations. • Triage Nurses or paramedics attend non-life-threatening conditions and decide on an appropriate care referral (e.g. GP)
Location	• Ground fleet Ambulance stations and fire services
Staff	• Ambulance service Paramedic or emergency care assistant. In some cases, HEMS employ a doctor-paramedic team.
Activity	• The paramedic or emergency care assistant can provide medical treatment independently at Advanced Life Support (ALS) level.
Are there predefined activation criteria for a "trauma call" before patient arrival to a MTC?	Yes, mandatory The emergency medical dispatcher usually pre-notifies the emergency department for the arrival of a trauma patient.

Source: National Audit Office (2010)[90], NHS Choices(2016) [125]; Health & Social Care Information Centre (HSCIC) (2014) [126] and Association of Air Ambulances (2013) [127]

3.2.4 Planning of trauma centres (Designation and accreditation of trauma centres)

3.2.4.1 Designation

The NHS directly commissions services from the hospitals that are designated as major trauma centres. The service specification for an MTC are included in the NHS standard contract.[9] The specifications for the MTCs (as for all commissioned services) are developed by specialised clinicians, commissioners, expert patients and public health representatives. MTCs must fulfil the minimum core standards and be able to adapt certain practices (i.e. developmental standards) over certain periods of time.[9] The catchment area of an MTC is defined at the moment of its designation and is determined by the configuration of the trauma network.[6] The NHS does not directly designate TUs and LEHs. TUs and LEHs are designated by the Trauma Networks.[112]

3.2.4.2 Quality monitoring and accreditation

Quality monitoring is performed via two audits, more precisely the National Peer Review Programme (NPRP) and the Trauma Audit and Research Network (TARN). Details on the latter will be provided in section 3.2.6. The NPRP for trauma uses quality indicators to measure the compliance with the requirements included in the NHS standard contract for Major Trauma and in the NHS clinical advisory group report on Major Trauma Workforce.[128] Figure 16 presents stages of the NPRP.[129] Since 1st April 2013, the National Peer Review Programme is an integral part of NHS Improving Quality hosted by NHS England.

Since the launch of the Trauma Networks, three rounds of peer-review have taken place. The latest round (2015) assessed the quality of trauma networks, MTCs, TUs and ambulance trusts. Among the 120 TUs existing in 2015, 15 were subjected to their network's review process but were not reviewed by the NPRP.[118] In 2016, TUs will have a formal peer review and the TNs and MTCs are advised to go through a self-assessment against the national peer review measures.[121]

Figure 16 – The Key Stages of the Peer Review Programme

Source: NHS England (2014)[129]

The NPRP measures the level of compliance of individual services using the same procedures for all the networks. The formal assessment is carried out by independent evaluators who do not participate in the activities of the network that is being reviewed. The following areas are assessed:

- Network governance: Network configuration of services, network governance structure, network protocols and guidelines and participation in the Trauma Audit and Research Network (TARN);
- Pre-Hospital: Clinical governance, triage tool, enhanced care teams, pain management, administration of tranexamic acid and pre-alert and patient handover;
- Reception and Resuscitation (in MTCs for adults and children as well as in TUs): Emergency Department (ED) staff (trauma team leader and training). Radiology (CT scanning, Radiology reporting and Interventional Radiology). Surgery (access to theatre and access to specialist consultants). Intensive care unit and Transfusion;
- Definitive Care (in MTCs for adults and children as well as in TUs): Major trauma leadership and staffing, major trauma pathways and specialist management pathways;
- Rehabilitation (in MTCs for adults and children as well as in TUs): Rehabilitation leadership and staffing, enhanced rehabilitation, specialist rehabilitation pathways, rehabilitation prescriptions and repatriation and psychological support.[130]

Table 17 – Organisation of the designation and/or accreditation process of trauma centres

	England
Is there a minimum threshold for the number of patients that should be admitted per year in an MTC?	No specific threshold was defined. The Royal College of Surgeons of England (2007)[104] suggested that a MTC should admit a minimum of 250 critically injured patients per year but this minimum threshold was not adopted in the designation process. Yet, from an analysis of reports of the peer review programme it appears that volume is taken into account as one of the elements that contributes to the final decision of the peer review committee (see example Box 11). Children MTCs are all below these thresholds.
Is the recognition of an MTC attributed to a hospital, a specific hospital ward (e.g. a separate entity from the emergency department) or other?	The recognition of an MTC is granted at the level of the hospital/Trust
How often are audits performed?	At the launch of the network • Yearly From 2016 onwards: • Variable frequency for the formal assessment of TNs, MTCs and TUs. A formal assessment can always be performed under the request of one of network's partners • Yearly self-assessment
Who performs the audit	The National Peer Review Trauma Programme
Is the participation in the audit voluntary or mandatory?	Mandatory
Depending on the audit results, what measures are taken to improve/reward the TC/Network performance?	There is a legal obligation to respond to any concerns after an audit. Failure to comply with the quality improvement programmes may have implications for health care providers (see Table 18 for more details)

Source: Royal College of Surgeons of England (2007)[104], NHS Clinical Advisory Groups (2010)[27] and NHS England (2014)[131]. After a formal review, three categories of concern requiring action were established: a) Immediate risk; b) Serious concerns and c) Concerns. Table 18 summarises the process relating to the response that needs to be provided in each case for MTCs.[131] The statutory process relating to the response in case of a concern does not apply to TUs. If an immediate or a serious concern is identified for a TU, the organisation's CEO is notified but he is not obliged to provide a formal answer to the health authorities.[112]

Table 18 – Identification and response of concerns for MTC

Risk Level	Definition of the risk	Persons informed	Formal response required	Follow-up process
Immediate risk	An "immediate risk" is an issue that is likely to result in significant harm to patients or staff or have a direct serious adverse impact on clinical outcomes and therefore requires immediate action	The quality Director immediately notifies the organisation's CEO. Key stakeholders are also contacted: • The National Programme Director for peer review • The Accountable Officer of the host Clinical commissioning groups (CCGs) • The Specialised Commissioners • The Medical and Nurse Directors of relevant Area Team (including specialised commissioners)	Yes • Within 10 working days of the notification • If an immediate action cannot be achieved, a plan for interim actions must be delivered with milestones dates	The Quality Director assesses whether an appropriate answer was provided. • Appropriate answer Response to all informed parsons (see column Persons informed) • Lack of or inappropriate answer Direct contact with the Area Team Director or appropriate Specialised Commissioner, and the Care Quality
Serious concern	A "serious concern" is an issue that, whilst not presenting an immediate risk to patient or staff safety, is likely to seriously compromise the quality of patient care, and therefore requires urgent action to resolve.		Yes • Within 20 working days of the notification • If an immediate action cannot be achieved, a plan for interim actions must be delivered with milestones dates	
Concern	A concern is an issue that is affecting the delivery or quality of the service that does not require immediate action, but can be addressed through the work programmes of the services.	N.S.	N.S.	N.S.

Source: NHS (2014)[129]. N.S. stands for not specified.

3.2.5 Characteristics of trauma centres

3.2.5.1 Admission criteria

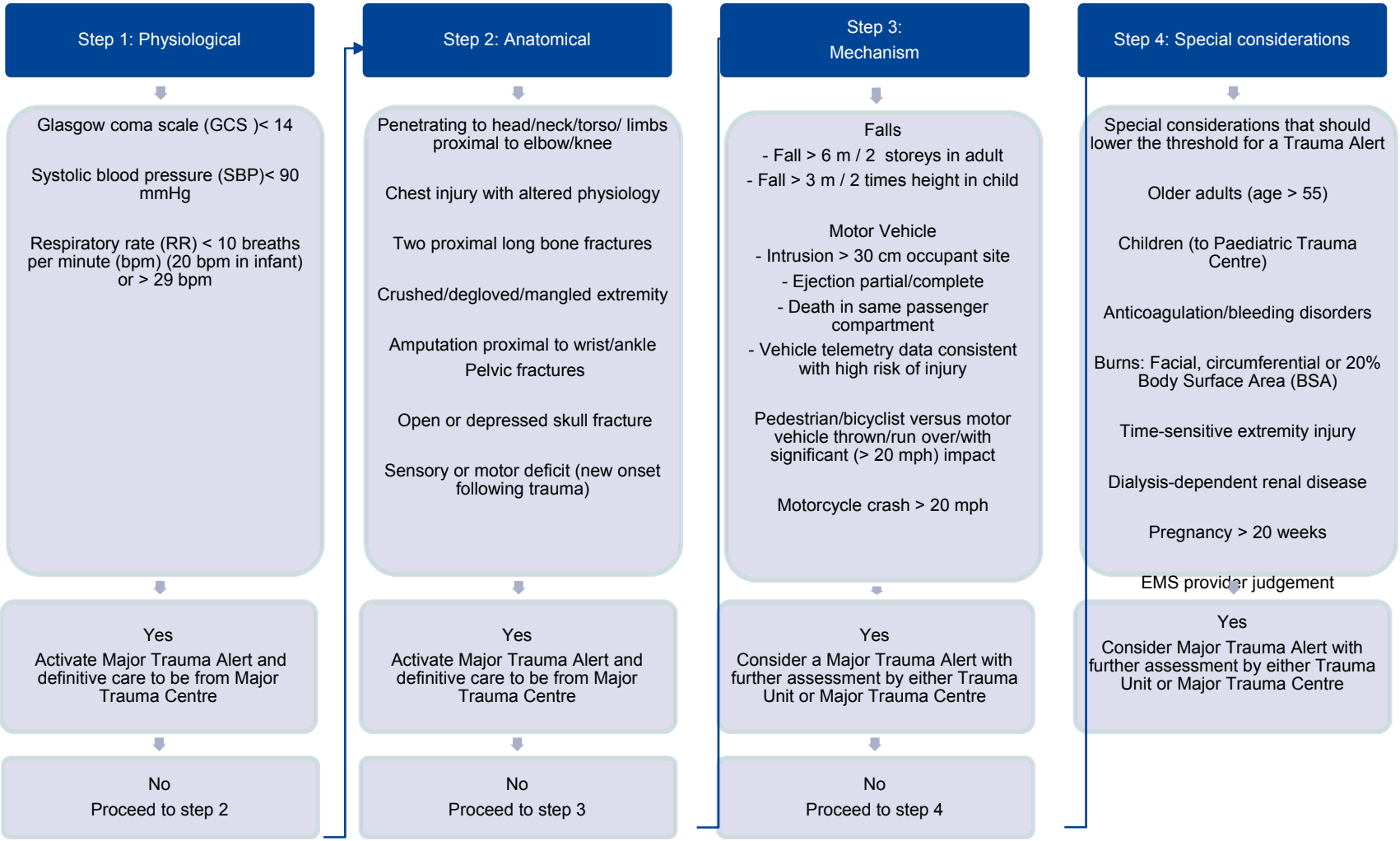
The Clinical Advisory Group (2010)[27] recommended that EMS providers use a Major Trauma Triage tool based on the 2006 American College of Surgeons Guidelines for Field Triage. The ambulance trusts along with other members of the trauma networks could adapt the recommended tool in order to add the specific elements of the network that may need to be taken into account in order to ensure that patients with an injury severity score (ISS) greater than eight are brought to and treated by Major Trauma Centres.[9] Figure 17 shows the protocol proposed by the Clinical Advisory Group (2010).[27] The triage tool proposed by the CAG is used by most TN.[112] However, the ambulance trusts working with the collaborative MTC used specific triage tools that allowed them to refer the patients to the hospital having the most relevant speciality to treat their injury. It is expected that a severely injured patient arrives to a MTC after being picked up by ambulance within 45 minutes.[9] If the patient is too unstable, he can be referred to a TU and upon stabilisation he will be transferred to an MTC. Transfer protocols between hospitals in the same network must also be developed. Severely injured patients can be treated in trauma units (TU) for up to 2 days but then they should be referred on to an MTC.[116] The transfer should take place within an hour of its request.[116]

Table 19 – Admission to trauma centres in England

	England
Are there specific criteria to transfer a patient between trauma centres of different levels?	Yes
Who has the authority to activate the trauma team (e.g. EMS)?	The Emergency Medical Dispatcher responding to the 999 call
Are there explicit criteria regarding the maximum transport time (e.g. minutes / KM) to arrive to an MTC?	Maximum of 45 minutes transport time from scene to a trauma centre. Changes in the travel time are subjected to current discussion (modification to up to one hour). When access to a Level I centre takes >45 minutes, the severely injured may be admitted to a Level II centre.
How the transport time is calculated (e.g. average time on regular transport tracking system)?	Transport time does not include the therapeutic treatment at the scene of the accident. Transport time is calculated based on the travel time of the ambulance (not regular traffic).
How is the time interval (starting point (e.g. upon call for an EMS) and end point calculated (e.g. arrival to an MTC)?	Start point: from the moment of departure with the ambulance from the scene of the incident End point: arrival to MTC
Do MTCs provide total care to all types of patients (e.g. cover the care needs of children (explicit age range). adults and elderly patients, type of trauma)?	Level I centres can provide care to adults and children, adults only or children only.

Source: NHS England (2013)[116] and Moran C (2016)[112].

Figure 17 – Pre-hospital Major Trauma Triage Tool recommended in the NHS Clinical Advisory Groups Report



Source: NHS Clinical Advisory Groups (2010)[27]

3.2.5.2 Infrastructure and medical equipment

Table 20 illustrates the infrastructure and medical requirements for hospitals participating in trauma networks. The information was extracted from the NHS standard contract for Major Trauma services[116] and from the Regional Networks for Major Trauma NHS Clinical Advisory Groups Report (2010).[27] The NHS contract for major trauma directly refers to other applicable national standards to ensure an appropriate provision of services to children and adults (e.g. standards include the requirements for intensive care units (ICUs)).[27]

The hospitals designated as MTCs must have specialist departments in the following areas: emergency medicine, vascular, orthopaedic, plastic, spinal, maxillofacial, cardiothoracic and neurological surgery, specialist in early/hyper acute rehabilitation and interventional radiology. Supporting services, intensive care units (ICUs) or high dependency units (HDUs) must also be available and adapted to provide care for critically ill children. The TNs should develop a protocol for major haemorrhage and for assessing whether the trauma patient has a spinal cord injury. If the patient has a spinal cord injury or a severe head injury, he should be cared for at a Neurosciences Centre or at a Spinal Cord Injury Centre.[9, 27] The co-location of highly specialised services such neurosciences centres was considered among the criteria used to select a MTC.[112, 121, 123, 124] A neurosurgical intervention should take place within two hours of the arrival in the MTC, depending on the patient's condition. In the MTC, operating rooms are usually not reserved for interventions of the severely injured. However, procedures within the hospital ensure that an operating room is available following a request of the trauma team.

Within the Trauma Network, it is required to elaborate protocols to ensure the appropriate transmission of information between all the members of the Network.

Table 20 – Summary of infrastructure and medical equipment criteria in hospitals participating in trauma networks

		Highest specialisation level Level I – MTC	Second highest specialisation Level II – TU[a]
Hospital infrastructure	Types of hospital	• Mostly University Hospital/Trusts • Children MTC are located in specialised children hospitals	N.S.
	Department for Neurosurgery	Yes • Patients with severe head or spinal cord injury should be managed in a specialised service (Neurosurgery and Neurosciences networks)	N.S.
	Operating room (OR)	Yes • 24/7 immediate availability (within 60 minutes)	Yes • According to minimum standards
	Access to critical care (3 types)[b]	Yes • 24/7 immediate availability	Yes
	Trauma ward	Yes	N.S.
Facilities required for trauma patients	Localisation	Emergency department	N.S.
	Trauma rooms (TR)	Yes • Availability 24/7 • Number and surface: Variable[c]	Yes • Number and surface: Variable[c]
	Helicopter landing pad	N.S.	N.S.
	Intervention radiology suites	Yes • Availability 24/7 • Ideally co-located with operating room and/or resuscitation areas	N.S.
	Computed tomography facility (CT)	Yes • In the emergency department • Availability after indication within maximum of 60 minutes, ideally within 30 minutes	Yes • Scanning and appropriate reporting within 60 minutes of referral
	MRI and an angiography unit	Yes • Availability 24/7	N.S.

Source: NHS England (2013)[9] and NHS Clinical Advisory Groups Report (2010)[27]. [a] Information for the TU was obtained from the NHS Clinical Advisory Groups Report [27]. N.S. stands for not specified. [b]Critical care units type 1–Ward based care including trauma wards[112], 2– high dependency unit (HDU) for patients needing single organ support (excluding mechanical ventilation) and 3–intensive care unit for patients requiring two or more organ supports (or needing mechanical ventilation alone). [c]Adapted to the characteristics of the hospital[112].

3.2.5.3 Healthcare professionals' expertise

Is trauma (management / surgery) recognised as a medical specialty?

In England, there is no recognised sub-specialty or qualification in the field of trauma surgery. According to Tai et al. (2014),[133] there is no agreement between surgical specialty organisations on the definition of what constitutes a 'Trauma Surgeon'.

What are the requirements regarding the availability of healthcare professionals 24/7 on duty and on-call in MTCs?

Table 21 illustrates the minimum requirements in terms of staffing in hospitals participating in trauma networks. The trauma team in MTCs and the TUs share the same characteristics, with the exception being the level of expertise.[112] In the MTC, the trauma team leader should be a consultant. In the trauma unit, there should be at least a specialist registrar (specialist training) in year four (ST4) who will be supported by a consultant within 30 minutes.

The trauma team is composed by specialists from different fields and should be present 24 hours per day, 7 days per week for the immediate reception of the patient. The Trauma Network must arrange that a neurosurgery consultant is available for consultation 24 hours per day, 7 days per week. The neurosurgery consultant should be involved in all decisions to operate for traumatic brain surgery. In the MTC, a clinical transfusion lead and a transfusion specialist should be available for advice 24 hours per day. In MTC, the operating room must be fully staffed and accessible 24 hours per day, 7 days per week.

The trauma education programmes for the team's members are organised according to the needs of the different MTCs. Tailored education programmes can include recognised trauma courses (e.g. Advanced Trauma Life Support-ATLS®, Trauma Nursing Core Course (TNCC)) as well as courses specifically designed and monitored by the Trauma Networks.[9] Staff working with children must be appropriately trained to care for them.

The major trauma case manager was introduced in MTCs and TUs during the implementation of the trauma system in 2012.[112, 134, 135] There is not a single profile for the trauma case manager and their tasks have not yet been homogeneously defined for MTCs and TUs.[135] They are involved in the full pathway for major trauma, from resuscitation in the ED, to rehabilitation and until the patient's discharge.[112, 134, 135] Major trauma case managers have a clinical background and are a point of contact for patients, relatives and the staff throughout inpatient episode and beyond.[112]

MTCs providing care to children must ensure that:

- Anaesthesiologists undergo specific advance training (Level 3 from the Royal College of Anaesthetists Continuing Professional Development Matrix)
- Two registered children' nurses are present 24 hours per day in the hospital/ward. A registered children' nurse in the hospital can provide advice to other departments
- All staff caring for children has to follow specific paediatric training
- Due to the low number of severely injured children, the trauma team is not required to be available for 24 hours per day. Availability for the members of the trauma team is required from 8AM to midnight. For other hours, the team must be on-site within 30 minutes of receiving the alert call.

Table 21 – Recommended minimum staffing in England

	Requirement	Highest specialisation level Level I	Second highest specialisation Level II
Medical management / head or coordinator of unit	Consultant	Yes	NA
Emergency trauma surgery	Consultant	Yes	NA
Physicians needed upon patient registration			
Availability	Round the clock 24/7	Yes	Yes
Team leader	Consultant	Yes	Level of seniority and training agreed in the TN (consultant or specialist registrar of ST4)
Trauma team		Yes, • Specialist in emergency medicine • Specialist in anaesthesiology • Specialist in intensive care • Specialist in general surgery • Specialist in trauma and orthopaedic surgery • Doctor able to deliver resuscitative thoracotomy	Yes • Airway doctor • Doctor able to deliver damage control surgery • Senior nursing staff
Physicians needed on-call			
Availability	Consultant	Yes, • On-site within 30 minutes • Specialist in general surgery • Specialist in anaesthesiology • Specialist in interventional radiology • Specialist in neurosurgery • Specialist in spinal and spinal cord surgery • Specialist in vascular surgery • Specialist in cardiothoracic surgery • Specialist in oral maxillofacial surgery	Yes, • On-call Round the clock 24/7 within 30 minutes

	Requirement	Highest specialisation level Level I	Second highest specialisation Level II
		• Specialist in plastic surgery • Specialist in trauma and orthopaedic surgery • Specialist in ear, nose and throat surgery • Specialist in intensive care	
Other requirements (training)	• Tailored trauma education programme (can include recognised trauma courses, e.g. Advanced Trauma Life Support (ATLS®) • Trauma surgeons with knowledge of damage control surgery • Paediatric training for staff providing care to children	Yes	Yes
MTC for children			
Availability 8AM to midnight	On-site	Yes	
Other hours	30 minutes of receiving the alert call	Yes	

Source: NHS England (2013)[9] and NHS Clinical Advisory Groups Report (2010)[27]. NA = not available

3.2.6 Trauma management information systems

In 1990, a group of emergency physicians started collecting data for trauma patients in the United Kingdom.[136] This initiative became the Trauma Audit Research Network (TARN) that collects today data on the most seriously injured patients. The participation in the TARN registry is mandatory and the completeness of the data introduced determines whether the best tariff practice is paid to hospitals. In 2016, all Major Trauma Centres use a live system to enter their data to the registry and most trauma units use their Trust coding system (International Classification of Diseases 10th edition (ICD10)) to identify severely injured patients.[137] MTCs and TUs must submit full data for the patients within 25 and 40 calendar days, respectively.[9]

Table 22 – Selected characteristics of the Trauma Audit & Research Network (TARN) registry

	England
Are there trauma registries at the level of the hospital/network/region?	Yes Individual hospitals complete their/the registries which are linked to a centralised database
What criteria are used to include patients in the registries?	Inclusion criteria • All trauma patients irrespective of age • Patients who fulfil one of the following length of stay criteria (LOS) • Direct admission Trauma admissions whose length of stay is 3 days or more or Trauma patients admitted to a High Dependency Area regardless of length of stay or Deaths of trauma patients occurring in the hospital including the Emergency Department (even if the cause of death is medical) or Trauma patients transferred to other hospital for specialist care or for an intensive care unit (ICU) or high dependency unit (HDU) bed. • Patients transferred in Trauma patients transferred to your hospital for specialist care or ICU/HDU bed whose combined hospital stay at both sites is 3 days or more or Trauma admissions to a ICU/HDU area regardless of length of stay or Trauma patients who die from their injuries (even if the cause of death is medical) Exclusion criteria • Exclusion criteria are set according to the body region or specific injury. For a detail description of the exclusion criteria we refer the interested reader to page 4 of the procedure manual from the TARN[137]
Is participation compulsory/mandatory?	Mandatory
Are transferred patients from one centre to another included?	Yes
Who is responsible for collecting and processing the data (in each hospital/network/national)?	MTCs submit their data into a live system via web-based application. The infrastructure for documentation, data management, and data analysis is provided by Trauma Audit & Research Network (TARN)
Are there protocols for monitoring data quality and completeness?	Yes Completeness of data is one of the requirements included to obtain payments based on the best practice tariff for major trauma patients
Is the data linked with other databases (e.g. to build quality indicators)?	Yes TARN data is used to measure quality indicators for the trauma networks
For how long are patients included in the registry (e.g. follow-up after hospital discharge)?	Until discharge

Source: Trauma Audit & Research Network (TARN) (2016)[137].

3.2.7 Trauma centres in numbers

3.2.7.1 General information on admitted patients

Before the implementation of the trauma system, there was a significant variation in the number of cases of major trauma treated in different hospitals. The number of cases ranged from 18 to 265 per hospital depending on hospital size, location and local demography.[138] Since the implementation of the trauma networks, there is sound evidence of an increase in patient volume.[139] Table 23 provides information on the patient flow at Major Trauma Centres and Trauma Units between April 2014 and March 2016. Data from TU may underestimate the number of cases treated. Data Completeness at Trauma Units varies between hospitals. In 2015-2016, 74% of all TARN eligible cases were submitted.

Table 23 – Number of patients admitted in trauma centres in between 2014 and 2016 by specialisation level and type of arrival

	Direct admission		Transfer in		Total
	Highest specialisation Level 1 – MTC[a]	Second specialisation Level 2 – TU	Highest specialisation Level 1 – MTC	Second specialisation Level 2 – TU	
Number of hospital	32	147	32	147	177
Admitted patients	38 419	2139	50 924	13 449	104 931
Injury Severity Score					
ISS 1 - 8	6685 (17.4%)	13274 (26.1%)	1609 (12%)	585 (27.3%)	22 153 (21.1%)
ISS 9 - 15	15 542 (40.5%)	26983 (53%)	3819 (28.4%)	987 (46.1%)	47 331 (45.1%)
ISS 16 - 24	7610 (19.8%)	6631 (13%)	3307 (24.6%)	326 (15.2%)	17 874 (17%)
ISS > 24	8582 (22.3%)	4036 (7.9%)	4714 (35.1%)	241 (11.3%)	17 573 (16.7%)
Head injury					
AIS = 4	4093 (10.7%)	4394 (8.6%)	1969 (14.6%)	191 (8.9%)	10 647 (10.1%)
AIS > 4	8688 (22.6%)	7449 (14.6%)	5439 (40.4%)	342 (16%)	21 918 (20.9%)

	Direct admission		Transfer in		Total
	Highest specialisation Level 1 – MTC[a]	Second specialisation Level 2 – TU	Highest specialisation Level 1 – MTC	Second specialisation Level 2 – TU	
Hospitalisation of severely injured patients (ISS>15)					
Total Number	16973	14597	8016	1351	40937
Median length of stay	11 (5 - 23)	6 (2 - 15)	10 (5 - 19)	13 (6 - 28)	-
Intensive Care Unit (ISS>15)					
Total Number	9978	4530	3735	351	18594
Median length of stay	3 (1 - 9)	3 (1 - 9)	2 (1 - 5)	4 (2 - 9)	-
Pre-hospital admitted directly from the scene (ISS>15)					
Total arrivals	14528	11392			25920
Ambulance	11830	11153			22983
Helicopter	2698	239			2937
Time from incident to hospital arrival					
Cases eligible for time from incident to hospital arrival	13136 (90.4%)	10302 (90.4%)			
Median (minutes)	88 (67 - 115)	90 (67 - 126)			
Time from ambulance arrival to hospital arrival (mins)					
Cases eligible for time from ambulance arrival to hospital arrival median	**12792 (86.8%)**	**9798 (86.0%)**			

Source: Edward A. (2016)[140]. [a] In general, one MTC corresponds to one hospital (or trust). However, there were two collaborative MTCs in this period. Information on the number of trauma centres in Table 14 and Table 15 differ from that on this table because they cover different periods (the first two 2015 and the last 2014-2016). N.A. stands for not applicable. MTC stands for Major Trauma Centre. TU stands for Trauma Unit.

3.2.7.2 Results from peer review publications

The implementation of major trauma systems in England consists of two stages. The major trauma systems was pioneered in the London area since 2010, with some hospitals already re-organising the care pathway in the mid-2000. In 2012, the major trauma network was expanded to the entire English territory.

Early evidence shows encouraging outcomes in the London area

Davenport et al. (2010)[141] analysed changes in the trauma care pathway in the Royal London Hospital that is a large urban multispecialty academic hospital with dedicated trauma resources since 1988. Based on external audits (1995) showing that there was little impact on outcomes major changes were made to the delivery of trauma care and to hospital's the supporting management, clinical governance and educational frameworks. In addition, in 2003 a multidisciplinary trauma service was formed with overall responsibility and in 2005 a dedicated trauma war was opened. To evaluate these changes TARN-data between 2000 and 2005 were analysed by comparing three groups of hospitals TARN-data: from the Royal London Hospital, from 13 multispecialty hospitals (full surgical capability and specialty surgical services including, for instance, at least neurosurgery) and other acute hospital without specialist services. The data were also compared with data for the US major trauma registry. In 2005, mortality for severe injury (ISS>15) was 20 per cent higher in England than in the USA (20.6% versus 17.2%). At Royal London hospital the mortality rates for severe injury patients dropped from 34.2% in 2000 to 17.9% in 2005 but with a sharp and significant ($p<0.001$) decrease only after the introduction of the multidisciplinary trauma service in 2003. The Royal London Hospital achieved in 2005 mortality rates comparable to the US where there is a long tradition of dedicated major trauma centres. Also at national levels improvement of mortality rates were observed but not to the same extent as at the Royal London Hospital: the national averaged dropped from 29.1 in 2000 to 20.6% in 2005($p<0.001$). Outcomes (e.g. improvement in survival rates severe trauma patients; mortality rates patients arriving in shock) were better in the Royal London Hospital but were also always worse when severe trauma patients were admitted to an acute non-specialty hospital versus a multi-specialty hospital. Also on process measures such as 'time from admission to CT' the Royal London Hospital (77 minutes) outperformed multispecialty hospitals (91 minutes) and non-specialty hospitals (91 minutes). The authors concluded this study demonstrated that the benefit of the trauma system lies not just in the simple presence of all trauma-related surgical specialties but that more is needed, more precisely specialist understanding of the trauma involved and the ability to provide complex and time-dependent multidisciplinary care.

The 2010 implementation of the inclusive trauma system in London (4 trauma networks organised around 4 major trauma centres covering 8.3 million people) was evaluated by means of a prospective data collection of all severely injured trauma patients (both admitted in trauma units as in major trauma centres) in the period dated from February to April 2013.[142] Independent external experts reviewed the case notes (from pre-hospital to 72h post admission) from 344 severely injured patients and compared this quality assessment with data from a national study using a similar methodology but performed in 2007. The data from the London system were compared with similar high volume multispecialty hospitals. Overall patients in the London Trauma System received significant better outcome scores with especially a reduction in organisational deficits. An evaluation of early mortality (within the first 72 hours) showed a significant reduction in mortality for all degrees of injury severity with the most benefits seen in the most critically injured patients (ISS>35) where crude mortality was 11% in the London Trauma system (Year 2013) compared to 31% in the Multispecialty hospitals (year 2007). The authors attributed these improvements in mortality to the observed improvements in the timely delivery of specialist multidisciplinary care (e.g. time to CT for patients with a head injury; consultant review within 30 minutes; trauma team response). The study also showed that quality assessments were substantially worse for severe trauma patients that were first admitted to a trauma unit compared to those directly admitted to a MTC.[142]

More evidence is needed to confirm an improvement in patient's outcomes for the National Trauma Network

The initial reports about the implementation of the 25 trauma networks have been encouraging. These reports were based on TARN-data including 16 000 major trauma victims in the first year after the implementation reporting significant improvements for all metrics.[113] McCullough et al. (2014) stated that it has been shown that the probability of survival after trauma (ISS>8) for the population of England increased with 19%. In addition the variation in mortality between centres dropped by 85%. The authors attribute these improvements to more standardization of care processes which is substantiated by improvements in key indicators. Examples are increases in: percentage of major trauma (ISS>15) patients that are received by senior consultant led trauma teams from 50% in 2011 to 75% in 2013; percentage of patients in coma receiving a definitive airway within 30 minutes from 50% in 2011 to 75% in 2013. Nevertheless, it should be stressed that the methods used to arrive to these figures are not reported.

These encouraging results that compared the introduction of MTC with TARN-data from a baseline in 2008 were, at least for mortality rates, not confirmed in a recent publication by Metcalfe et al. (2016).[143] The authors did a 270 days pre-post evaluation of all trauma patients admitted to hospitals that became a major trauma centres in 2012. The London hospital, where the system was implemented in 2010, were excluded from the analysis. The evaluation included TARN-data from 20 181 major trauma patients (Before: 7 705; Post: 12 476) of which 9 202 had an ISS>15 (Before: 3 469; Post: 5 733). The pre-post evaluation showed no difference in in-hospital mortality, neither for all major trauma patients (ISS>8) or for major trauma patients with an ISS >15. Also no significant changes for length-of-stay (in general and on critical care) were reported. For all other quality indicators significant improvement were reported following MTC designation. Examples are: a greater proportion of patients treated by a consultant-grade doctor (54.3% versus 30.4%); patients with suspected bleeding were more likely to receive tranexamic acid in the emergency department (58.5% versus 17.0%); median time to CT for patients with a head injury fell from 49.2 to 31.2 minutes; fewer patients required secondary transfer between hospitals (drop from 31.3% to 25.9%). This study shows some early improvements on evidence-based quality indicators associated with the reconfiguration of the trauma system but not yet on mortality. The authors stress that this evaluation was performed at a very early stage and that, as other authors suggest, a longer period (estimates vary between 2 and 10 years) might be needed to enable the maturation of the trauma system (e.g. development of pre-hospital triage protocols; refinement of hospital systems and accumulation of staff experience). The same study group reported comparable results on mortality and length-of-stay but were based on a smaller sample: a 200 day pre-post evaluation in one particular region (i.e. West Midlands).[143]

3.2.8 Future planning and challenges

3.2.8.1 Shortage in human resources

A recent report pointed out that a shortage in the workforce may affect trauma services. Healthcare professions that risk to experience shortages in manpower include interventional radiologists, nurses, emergency physicians and rehabilitation medicine.[128]

Opposite to this, the Centre for Workforce Intelligence (CfWI) (2014)[144] reviewed the balance of demand and supply for trauma and orthopaedic consultants. They found that under the current recruitment levels of trainees there is a risk of workforce oversupply until around 2022. The supply could still exceed the demand in 2028 if there is no intervention or cap on trainee recruitment.

The Royal College of Surgeons of England (2014)[133] considers that with the recently developed trauma networks there are two areas for improvement for the surgical workforce involved in the care of the severely injured. The RCS recommends the establishment of:

- Specific training paths for surgeons.
- Surgically-staffed MTCs

3.2.8.2 Rehabilitation

With the organisation of the Trauma Networks, the demand for rehabilitation services evolved and increased.[112] Currently there is not sufficient evidence on whether patients have an appropriate access to inpatient and outpatient rehabilitation services.[145] The challenge of organising specialised rehabilitation services may be linked to the complex fine-tuning that is required when aiming to match a demand for services that comes from a very centralised sector (acute trauma care) against a supply that is organised at a local level.[112]

3.2.8.3 Elderly population

The proportion of elderly patients among the severely injured population referred to and treated in a MTC exceeds earlier expectations.[146] This trend may be linked to the overall population aging but also to the changes implemented in MTCs that facilitate the early detection of the severely injured.[112, 146] Severely injured geriatric patients often have greater number of co-morbidities, require specific treatment that may lead to consume a large amount of hospital resources.

3.2.8.4 Patient triage

NICE (2016)[145] recently recommended to review the pre-hospital triage tools to identify patients who need to be taken to a major trauma centre, by passing the local emergency department. Currently used triage tools are based on physiological parameters with diagnostic cut-offs and categorical variables such as mechanism of injury. However, the parameters used, and the weighting given to each parameter, differ across the tools. It is expected, that the implementation of a national pre-hospital triage tool will lead to improved patient outcomes and reduced costs.

3.3 The Netherlands[j]

3.3.1 General context

3.3.1.1 Definitions

Table 24 provides a description of some relevant terms that are used throughout the text.

Table 24 – Overview of working definitions for The Netherlands

	The Netherlands
Trauma centre levels	Level I: Hospitals with the capacity to treat severely injured patients, with 24/7 availability of relevant facilities Level II: Hospitals with the capacity to treat severely injured patients, but where not all facilities are available (e.g. neurosurgery) Level III: Hospitals with the capacity to treat patients with isolated injuries only
Trauma network	Trauma networks are organised around one of the eleven existing major trauma centres and operate in clearly defined geographical areas.
Recognition	Recognition is a process organised by a legislative or regulatory authority that allows a care service to operate. The Ministry of Health, Welfare and Sport ('Ministerie van Volksgezondheid, Welzijn en Sport; VWS State governments) recognises major trauma centres.
Accreditation	An accreditation is quality assurance scheme that demonstrates that entities meet a set of quality standards. National Consultation Bureau ('Landelijke Beraadsgroep Traumatologie ('Landelijke Beraadsgroep Traumatologie (LBTC)) of the Dutch Network of Emergency Care (LNAZ) organises the accreditation process of trauma centres.
Specialist	Physician who successfully completed specialty training ('Specialist')
Specialty registrar	Physician undergoing a specialty rotation and training (Assistent in Opleiding tot Specialist (AIOS))
Hospital physician	A hospital physician not holding the title of medical specialist provides care in the hospital according to their specific skills and competencies. Two categories can be distinguished: Physician not in training to become a specialist ('Arts Niet in Opleiding tot Specialist' (ANIOS)) and Physician in training to become a specialist.

[j] Koen Lansink, Arold Reusken, Leontien Sturms and Christine Schepel provided comments on the Dutch system. Leontien Sturms and Arold Reusken reviewed a previous version of this chapter. Leontien Sturms is a project leader at the Dutch Network for Emergency Care (Landelijk Netwerk Acute Zorg (LNAZ). Arold Reusken is the chief officer of the Dutch Network for Emergency Care. Koen Lansink is a trauma surgeon at the Elisabeth Tweesteden hospital in Tildburg and Coordinator of the Netwerk Acute Zorg Brabant. Christine Schepel is the chief officer of the Network for Emergency Care of the Brabant (Netwerk Acute Zorg Brabant).

3.3.1.2 Country context

The Dutch health care system is divided into three compartments. The Health Insurance Act (Zvw) (in Dutch "Zorgverzekeringswet") regulates the first compartment and covers the basic health insurance for curative medical care (including hospital stays) and short-term care (e.g. care provided by general practitioners (GP), specialists, pharmaceuticals, etc.). The Zvw is financed through income-related contributions, community-rated premiums paid to the health insurer and tax revenues. Individuals are free to select the health insurer and insurers cannot refuse the application for the basic health insurance.[147] Since 1 January 2015, the long-term care insurance act ('Wet Langdurige Zorg (WLZ)') regulates the benefits for persons requiring dependency related care.[148] The WLZ is financed through income related contributions, supplemented by a general government revenue grant. Both compartments constitute the mandatory health insurance program and provide universal coverage for the population. The third compartment consists of the complementary voluntary health insurance (VHI) for services not covered by the two mandatory compartments.[147] Individuals participate in the cost of health care through different cost-sharing arrangements.

In the Netherlands, only recognised healthcare institutions can provide services that are reimbursed by the Health Insurance Act (Zvw) or the long-term care insurance act (WLZ).[149] The Care Institutions Act ('Wet toelating zorginstellingen (WTZi))[149] delineates the framework that must be respected by accredited institutions. The main requirements included in the WTZi include the minimal conditions on the access to acute care, the transparency in the governance structure of healthcare providers and their obligation to collaborate in care networks. The WTZi requires all professionals working in acute care to make agreements through the Regional Acute Care Consultations (Regionaal Overleg Acute Zorg (ROAZ)). ROAZ members include hospitals, ambulance services ('Regionale Ambulancevoorziening'), general practitioners physicians, midwives, mental health services ('geestelijke gezondheidszorg' (GGZ)), the Regional Medical Emergency Preparedness and Planning offices ('Geneeskundige Hulpverlening bij Ongevallen en Rampen Regional (GHOR)) and the municipal health authorities ('Geneeskundige en Gezondheidsdienst'(GGD)). Since 2006, major trauma centres have a directing and coordinating role as chair of the ROAZ.[149]

3.3.1.3 Hospital classification and planning

Inpatient and outpatient care is provided in general ('algemene'), categorical ('categorale') and university hospitals ('academische ziekenhuizen').[147] Policlinics associated to these care facilities can also deliver inpatient and outpatient care. General hospitals provide care within different departments and specialisms, varying from surgical wards to paediatric wards. The size of the hospital determines the number of specialisms that are available. Categorical hospitals specialise in certain forms of care or focus on certain categories of patients illnesses (e.g. dialysis). University hospitals have practically all types of specialisms and usually encompass reference centres where highly specialised care is provided ('topklinische zorg'). In the Netherlands, medical specialists are responsible for the organisation of care within the hospital. Physicians not holding a specialist title (Arts Niet in Opleiding tot Specialist' (ANIOS) or 'gemandateerd basisarts') are entitled to provide care to patients according to the level of their skills and competencies. In 2014, there were 85 hospitals encompassing 79 general hospitals, 8 university hospitals and 22 categorical hospitals.[150] In the same year, the total number of hospital sites and policlinics amounted to 131 and 106, respectively.

3.3.2 Policy development

3.3.2.1 What factors were used to determine which institutions were initially selected to become MTC (existing supply, population needs, others)?

Scientific societies recommend to have major trauma centres

At the end of the 1980s, the Dutch Trauma Society ('Nederlandse Vereniging voor Traumachirurgie' (NVT)) called to take rapid action regarding the lack of a standardised framework to provide care to severely injured patients in both pre-hospital and in-hospital settings.[151] The Dutch Trauma Society recommended to organise the care for severely injured patients around three or four major trauma centres.

A bottom-up initiative supported by the health care authorities

In 1998, the Ministry of Health, Welfare and Sport ('Ministerie van Volksgezondheid, Welzijn en Sport; VWS) recognised seven university hospitals and three major general hospitals with neurosurgical facilities as major trauma centres (Level I).[152] in 2008, a second MTC was designated in Amsterdam. The Ministry decision to designate university and general hospitals as major trauma centres reflected the need to include institutions that had practically all types of clinical departments and specialisms and that were located in the different Dutch provinces ('provincies', there are 12 provinces in the Netherlands). The catchment area of trauma centres were implemented by the trauma centres in consultation with the network partners. The catchment area were broadly delineated around the geographical boundaries of the provinces but were adjusted according to the population density of the provinces. For instance, less densely populated provinces like Friesland, Groningen and Drenthe, were pooled under the catchment area of one major trauma centre while the highly populated province of South Holland was set under the jurisdiction of two different two major trauma centres.[153]

3.3.2.2 What were the main challenges and solutions faced during the implementation of MTC?

Selection of MTCs at a local level: the trade-off between pragmatic and ideal objectives

The number of major trauma centres designated by the authorities was higher than the number initially recommended by the Dutch Trauma Society. The 11 centres reflects both the wish of the authorities to ensure an appropriate coverage of the areas delimited by the provinces boundaries and the need to deal and to provide a satisfactory solution to a large number of stakeholders.[151]

Improving coordination of emergency medical services (EMS) a necessary step for a successful trauma network

Before the implementation of the trauma system, there was little coordination between approximately 130 public and private ambulance services. The Ministry decided to reorganise the functioning of ambulance services and made it mandatory that services providers worked together under the guidance of the regional ambulance service ('Regionale Ambulancevoorziening'). Each major trauma centre was responsible to organise the triage of patients in collaboration with the regional ambulance service and with other regional hospitals in their catchment area (see section 3.3.4.1 details on triage protocol).The arrangements implemented by different trauma centres were put into question, as the efficacy of the assignation of injured patients seemed to vary between the different catchment areas.[152] In some regions, the different chain partners agreed to continue the existing policy of transporting trauma patients to the nearest hospital for stabilisation and, if necessary, further transferring to the trauma centre.[154] In addition, the heterogeneous capacity of hospitals to treat less severely injured patients implied that some patients had to be treated far away from their place of residence.[155]

Need for quality measures based on good data

The Dutch Trauma Society (NVT) (2010)[155] pointed out that while there had been many improvements in the care provided to severely injured patients in the eleven trauma regions, there was not sufficient evidence to assess whether the networks were providing optimal care to their patients. In order to improve the level of knowledge on the networks outcomes, the NVT pleaded to improve the quality of the registration of data for patients treated in the different networks.[155]

3.3.3 System Integration

3.3.3.1 Categorization of hospital infrastructure

In 2006, the Ministry of Health, Welfare and Sport (Ministerie van Volksgezondheid, Welzijn en Sport (VWS)) asked the National Association of Trauma Centres ((‘Landelijke Vereniging van Traumacentra’ (LVTC), today under Dutch Network for Emergency Care (‘Landelijk Netwerk Acute Zorg’ (LNAZ)) and the Dutch Trauma Society to define criteria to classify hospitals according to their capacity to treat severely injured patients.[156]

Major trauma centres are responsible for the organisation of local trauma networks and must work in collaboration with general hospitals located in their catchment areas. Categorical hospitals in the Netherlands are part of the trauma networks.[151] According to the Dutch Trauma Society (2016)[11] all general hospitals in the Netherlands (not recognised as a major trauma centre) have received an accreditation as a Level II or Level III centre. After the designation of the MTCs and determination of the trauma regions (catchment areas) the trauma networks were ‘operational’. The networks have evolved and are beyond the initial maturation phase.[94, 151] In 2015, eleven local trauma networks were operational in the Netherlands.

Table 25 – Number of trauma centres and trauma networks in the Netherlands (2015)

The Netherlands	
Number of general hospitals sites	131[a]
Number of trauma networks	11
Number of hospitals sites with an emergency department participating in the national trauma network [b]	101
Number of hospitals sites with an emergency department participating in the regional trauma networks	Ranging from 4 to 16
Average number of centres per network	8.5
Number of hospitals participating in the trauma care (organised in centres or networks)	*93 (96)*
Level I	11[c,d] *(14)*
Level II	36[d]
Level III	*46*[d]

Source: [a]Information on the number of hospitals was retrieved from Komer et al. (2015) [157]. [b]It is possible that a hospital with an emergency department (ER) has more than one hospital site.[151] [c] Usually, a single hospital is designated as a Level 1 centre. However, 3 hospitals (Leids Universitair Medisch Centrum (LUMC),Medisch Centrum Haaglanden (MCH) and het HagaZiekenhuis (HAGA)) work in a partnership as one major trauma centre. [d]Data for Level I, Level II and Level III was retrieved from the Nederlandse Vereniging voor Traumachirurgie (2016)[11].

The Ministry of Health, Welfare and Sport (VWS) attributed to major trauma centres in cooperation with the 25 safety regions an important role in the organisation of the response in case of a disaster. A safety region is a form of extended local government where different entities work in collaboration and according to clearly defined agreements in order to provide an appropriate response in case of a disaster or emergency.[158] The catchment area of the safety region defines the geographical boundaries for several organisations including fire and police departments, regional ambulance services ('Regionale Ambulancevoorziening') and the Regional Medical Emergency Preparedness and Planning offices ('Geneeskundige Hulpverlening bij Ongevallen en Rampen Regional (GHOR)'). The catchment area of major trauma centres (and of their respective networks) encompasses more than one safety region.

3.3.3.2 Emergency Medical Services (EMS)

General overview of EMS

In the Netherlands, there are two complementary forms of Emergency Medical Services (EMS). First, the regional ambulance service ('Regionale Ambulancevoorziening') organises ambulance care within a safety region.[158] An ambulance must reach any location within 15 min and 30 min for life-threatening situations and urgent but not life-threatening situations, respectively. The ambulance crew is composed of an ambulance nurse and a driver. The ambulance nurse can provide medical treatment independently at Advanced Life Support (ALS) level.

Second, four major trauma centres (Rotterdam, Amsterdam, Groningen and Nijmegen) have a Mobile Medical Team (Mobiel Medisch Team (MMT)). The four MMT have at their disposal a helicopter and constitute the nationwide air rescue system.[12] An MMT can be dispatched by the ambulance dispatch centres ("meldkamers ambulancezorg") according to clearly defined criteria.[159] The MMT crew is composed of a physician (usually an anaesthesiologist or a surgeon), a nurse and the pilot. The MMT crew is available 24 hours per day and seven days per week and works exclusively in the rescue missions that are assigned to them.

Table 26 – Emergency medical services

	The Netherlands
Responsibility for organisation	• Ground fleet Regional ambulance services (‘Regionale Ambulancevoorziening’) • Mobile Medical Teams (Mobiel Medisch Team(MMT)) Major Trauma centres: Amsterdam, Rotterdam, Nijmegem and Groningen
Minimum requirements in terms of availability and accessibility of ground ambulances and aeromedical services?	An ambulance must be onsite after the emergency call within : • within 15 min for a life-threatening situation • within 30 min for an urgent but not life-threatening situation
Dispatching system	• Universal access number 112 • Nurses that followed a training programme recognised by the sector are in charge of the response in dispatch centres (‘MeldKamer Ambulancezorg’)
Location	• Ground fleet Ambulance stations determined by the Reference Framework for Coverage & Availability (Landelijk Referentiekader Spreiding & Beschikbaarheid) • Mobile Medical Teams (Mobiel Medisch Team(MMT)) Four major trauma centres
Staff	• Regional ambulance service Ambulance nurse and driver • Mobile Medical Teams Physician (anaesthesiologist or surgeon) Specialised nurse
Activity	• The ambulance nurse can provide medical treatment independently at Advanced Life Support (ALS) level.
Are there predefined activation criteria for a “trauma call” before patient arrival to a MTC?	Yes. The emergency medical dispatcher pre-notifies the emergency department for the arrival of a trauma patient. A trauma alert is sent to Level I and Level II hospitals. Level III hospitals receive a resuscitation alert.

Source: Ambulancezorg Nederland (2013)[160], Dutch Trauma Society (NVT)(2013)[161] and Dutch Network for Emergency Care (2016)[151].

EMS and trauma centres: a collaboration based on clearly defined agreements

The deployment of emergency medical services (EMS) and the transfer of patients is performed according to national and regional protocols. The National Ambulance Institute ('Nederlands Ambulance Instituut') is responsible for the National Ambulance Care Protocol ('Landelijk Protocol Ambulancezorg, LPA'). Regional protocols are established according to the agreements between care providers in the different trauma networks. Regional protocols must be aligned to the national protocols in order to ensure the quality of the care provided.[160]

Activation and cancel criteria for the MMT were also developed by the Ambulance Institute and the Dutch Network for Emergency Care (LNAZ).[159] Triage protocols aim at providing guidance to EMS regarding the transport of the severely injured to trauma centres. Adherence to the protocol decision tree may vary between the EMS providers and include the possibility to transfer an unstable patient to the nearest hospital.[151] The discussion on how to improve the identification in the place of the accident and the triage of severely injured patients is ongoing.[151]

The Ambulance Dispatch Centre ('MeldKamer Ambulancezorg' (MKA)) is an integral part of the Regional Ambulance Service and determines the deployment of all Emergency Medical Services (ambulance and mobile medical teams). The Ambulance Dispatch Centre is responsible to pre-notify the emergency department of the arrival of a trauma patient. Level I and Level II centres receive a trauma alert. Level III hospitals receive a resuscitation alert.[161] The emergency nurse or the emergency physician decides whether the trauma team needs to be called to the trauma room. If needed, an extended trauma team can be alerted.[151]

3.3.4 Planning of trauma centres (Designation and accreditation of trauma centres)

The recognition of major trauma centres is performed by Ministry of Health, Welfare and Sport (VWS). The Ministry of Health, Welfare and Sport (VWS) does not provide a recognition to Level II and Level III centres. The process of the accreditation of hospitals as Level II or Level III is delegated to the trauma regions under the coordination of MTCs. Currently, the composition of the committees performing the visits, the visit's frequency and the questionnaires that are used vary between the different trauma networks.[11]

The Trauma National Consultation Bureau (LBTC) is the counselling body of the Dutch Network for Emergency Care (LNAZ) and is responsible for the regulations for the accreditation of MTCs. In 2016, a pilot project aiming to build an accreditation for major trauma centres is foreseeing. The pilot visit will review the centres characteristics and their work in ensuring:[11]

- The role of centre of expertise and of coordinator the registration of trauma data;
- The implementation of a quality system within the trauma network;
- The directing and coordinating role as chair of the Regional Acute Care Council (Regionaal Overleg Acute Zorgketen (ROAZ));
- The coordinating role for the education, training and practice programmes (Opleiden, Trainen en Oefenen OTO) to prepare for disasters and crises.

Table 27 – Organisation of the accreditation process of trauma centres (2014)

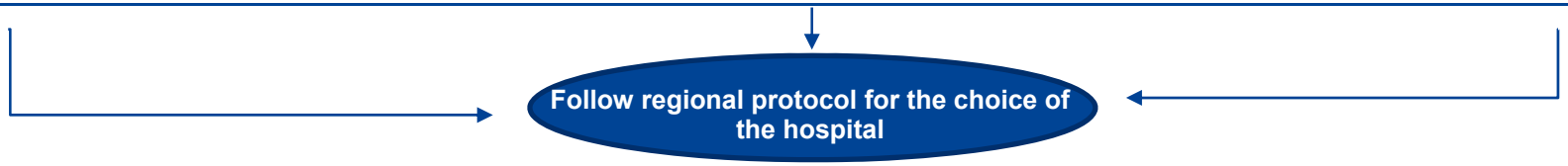
The Netherlands	
Is there a minimum threshold for the number of patients that should be admitted per year in TC?	The Dutch Trauma Society recommends that major trauma patients with an ISS>15 are treated in MTC • Level I = More than 100 patients • Level II & III = No threshold Admission via the trauma room • Level I = More than 300 patients • Level II = More than 50 patients • Level III= No threshold
Is the recognition of a MTC attributed to a hospital, a specific hospital ward (e.g. a separate entity from the emergency department) or other?	The recognition of a MTC is granted at the level of the hospital
How often are audits performed?	Variable
Who performs the audit?	Committees designated by trauma centres
Is the participation to the audit voluntary or mandatory?	Mandatory
Depending on the audit results, what measures are taken to improve/reward the TC (and networks) performance?	N.S.

Source: Dutch Trauma Society (2010) [155], Dutch Trauma Society (2013) [161] and Dutch Trauma Society (2016)[11]. MTC=Major trauma centre. N.S. stands for not specified. Characteristics of trauma centres.

3.3.4.1 Admission criteria

Each trauma network is responsible to organise regional triage protocols to ensure the transfer of patients from the scene of the accident to a trauma centre as well as between hospitals.[151] The protocols must be aligned to the national protocol that was established by the National Ambulance Institute ('Nederlands Ambulance Instituut') and the Dutch Trauma Society.[162] Table 28 shows the criteria included in the national protocol for the transfer of trauma patients to hospitals with and without a major trauma centre.[162] For more information on specific regional protocols, we refer the interested reader to the pages 186 to 200 of the National Ambulance Care Protocol.[162] The criteria for the triage to trauma centres includes a combination of physiological and anatomical parameters and the mechanism of injury.

Table 28 – Triage criteria used for the choice of a hospital for a trauma patient

Destination	Level I	Level I or II	Closest hospital with adequate reception facilities (Level I, II or III)
Criteria	• Airway, Breathing, Circulation (ABC) that cannot be stabilised • Disability (D) Glasgow Coma Scale (GCS) or Paediatric Glasgow Coma Scale (PGCS) < 9 or decreasing • Pupil differences • Neurological failure (≥ 1 extremity) • Exposure Hypothermia ≤ 32°C Revised Trauma Score (RTS) < 11 or Paediatric Trauma Scale (PTS)< 9 • Specific injures Head, thorax and/or abdominal/side penetrating injuries Fractures of more than two proximal bones, Flail chest Unstable pelvis ≥ fractures (femur, tibia and/or humerus) Amputation proximal to the wrist/ankle	• Revised Trauma Score (RTS) = 11 or Paediatric Trauma Scale (PTS) of 9 or 10 • Relevant mechanism of injury • Pregnancy > 13 weeks	• Revised Trauma Score (RTS) = 12 or Paediatric Trauma Scale > 10
			

Source: National Ambulance Care Protocol (2015) [162]. Note: Patients with unstable Airway, Breathing, Circulation or Disability (ABCD) and subjected to a large transport time may be transferred to the nearest hospital with a rendez-vous with a Mobile Medical Team (MMT).

Table 29 – Admission to MTC

	The Netherlands
Are there specific criteria to transfer a patient between trauma centres?	Yes. • Every region develops a protocol for the transfer of patients.
Who has the authority to activate the trauma team (e.g. EMS)?	The emergency nurse or the emergency physician, after receiving information from the dispatch centre
Are there explicit criteria regarding the maximum transport time (e.g. minutes / KM) to attain a MTC?	The Care Institutions Act ('Wet toelating zorginstellingen (WTZi)) stipulates that an emergency department must be reached within 45 minutes, including the time from first call.[149] This time applies to all hospitals in the Netherlands.
How is the transport time to a MTC calculated?	Ambulance time
How is the time interval calculated? (Starting point and end point; e.g. upon call for an EMS and arrival to TC)?	Start point : First call to 112 End point: arrival at the ED
Do TC provide total care to all types of patients (e.g. cover the care needs of children (explicit age range), adults and elderly patients, type of trauma)?	Level I centres ensure appropriate care for adult and paediatric patients within each local trauma network.

Source: National Ambulance Institute (2014) [162], Dutch Trauma Society (2015) [161]and Dutch Network for Emergency Care (2016)[151].

3.3.4.2 Infrastructure and medical equipment

Table 30 illustrates the infrastructure and medical requirements for hospitals participating in trauma networks. The Dutch Association Society (NVT) establishes and periodically reviews the minimum standards that trauma centres must fulfil.[161] In the most recent version, the NVT links the minimum requirements of certain facilities in the hospital, i.e. emergency departments[150, 163, 164] and intensive care units[165] to existing guidelines from healthcare authorities and other scientific societies.

The requirements for the different profiles of emergency departments were defined in 2009.[150, 163, 164]The profiles of emergency departments were built based on their capacity to provide: cardiac interventions, neurological interventions, surgical and orthopaedic interventions, paediatric care, obstetric care and acute psychiatry.[164] Healthcare authorities have not yet enforced the application of these requirements. However, the Dutch Trauma Society (NVT) decided to include the requirements for emergency departments among the minimum standards that must be respected by trauma centres.[151]

The profiles of intensive care units (ICUs) are based on the infrastructure and staffing that are required to ensure:[165] the coordination and the continuity of care (e.g. 24/7), the education and training of healthcare professionals, the management of the ICU regional network and the implementation of the quality policy.[165] In the trauma networks, operating rooms are usually not reserved for interventions of the severely injured. However, procedures within the hospital ensure that an operating room is available following a request of the trauma team requires it.[151]

Table 30 – Summary of infrastructure and medical equipment criteria in hospitals participating in trauma networks

		Highest specialisation level Level I –	Second highest specialisation Level II –	Third highest specialisation Level III –
Hospital infrastructure	Types of hospital	• University hospitals (N=8) • Major general hospitals with (neurosurgical) facilities (N=6)	• Major general hospitals without neurosurgical facilities	• General hospitals with a limited number of clinical departments
	Emergency department (3 profiles)	Availability 24/7 • Complete • 10 beds with monitoring • 10 rooms	Availability 24/7 • Profile • 5 beds with monitoring • 5 rooms	Consultation hours • Basic • 5 beds with monitoring • 5 rooms
	Department for Neurosurgery	Yes • Neurological surgery must be possible	No • Not required	No
	Operating room (OR)	Yes • C-arm operating table • Required emergency lift access • Availability after patient registration <15 min	Yes • C-arm operating table • Desirable emergency lift access • Availability after patient registration <30 min	Yes • C-arm operating table • No requirements expressed with respect to its availability
	Intensive care unit (3 levels) [165]	Highest level	Intermediate level	Basic level
	Other			
Facilities required for trauma patients	Localisation	Emergency department	Emergency department	Emergency department
	Treatment capacity in beds[a]	2 • Availability 24/7	1 • Availability 24/7	1 • Availability 24/7
	Helicopter landing pad	Yes	No	No
	X-ray facilities	In the emergency department	In the emergency department	No
	Computed tomography facility (CT)	Yes • In the emergency department • Availability after indication within 10 min	Yes • In the radiology department (access within 3 min) • Availability after indication within 30	Yes • In the radiology department (no specific requirement on time to access)
	MRI and angiography unit with intervention	Yes • In the radiology department • Availability after indication for angiography unit within 20 min	Yes • In the radiology department • Availability after indication for angiography unit within 30 min	No

Source: Based on the level criteria of the Dutch Trauma Society (2013)[161]. [a]A room usually has only one bed[151].

3.3.4.3 Healthcare professionals' expertise

Is trauma (management / surgery) recognised as a medical specialty?

A physician wishing to obtain a qualification as a specialist in the field of trauma surgery ('traumachirurg') must follow a surgical basic training of four years followed by a specific training in trauma surgery of two years ('Structuur Curriculum Heelkunde voor Reflectieve Professionals' (SHERP)). In the Netherlands, trauma surgeons are subjected to an accreditation procedure that is organised by the Dutch Trauma Society (NVT) and the Dutch Surgery Society ('Nederlandse Vereniging voor Heelkunde' (NVvH)). The accreditation is valid during a 5 year period.[166]

What are the requirements regarding the availability of healthcare professionals 24/7 on duty and on-call in MTC?

Table 31 and Table 32 illustrate the minimum requirements in terms of staffing in hospitals participating in trauma networks. The trauma team is composed by specialists from different fields that must be either present or able to reach the hospital within 15 to 30 minutes after that the patient reaches the emergency department. Team members that are in the hospital usually reach the trauma room in five to 10 minutes after being called-in.[151] Trauma teams must be available 24 hours per day, 7 days per week. The size of the trauma team depends on the patients' needs but also on the availability of specialists and other healthcare professionals in the hospital or on-call. Egberink et al. (2015) pointed out the number of members of the trauma team varies from three to 16.[167] Specialist registrar can provide care to the severely injured from the third year of their internship onwards and work under the surveillance of a fully trained trauma surgeon.

The Dutch Trauma society recommends that only specialists in the fields of trauma, vascular and gastrointestinal surgery supervise the interventions performed to trauma patients. In all trauma centres, the trauma surgeon holds the final responsibility of the care provided to trauma patients. It is required that all surgeons, anaesthesiologists and physicians in the emergency departments have an advanced qualification in Advanced Trauma Life Support-(ATLS®). The ATLS qualification is required for both specialist and specialist registrars. The Dutch Trauma Society recommends that emergency department nurses obtain the qualification in Trauma Nursing Core Course (TNCC) and in Trauma Nursing Paediatric Course (ENPC).

Table 31 – Recommended minimum staffing (2014 – 2018)

	Requirement	Highest specialisation level Level I	Second highest specialisation Level II	Third highest specialisation Level III
Medical management / head or coordinator of unit	• Specialist in trauma surgery	Yes	Yes	Yes
Availability of surgeons supervising trauma operations	• Trauma surgeon • Vascular surgeon • Gastrointestinal surgery	Yes	Yes	No
	• Surgeon with experience in thoracic surgery	Yes	No	No
Physicians needed upon patient registration				
1. Within consultation hours				
Specialist	Trauma surgeon	Present	N.S.	N.S.
	Surgery, anaesthesiology, neurosurgery and radiology	Available within 15 minutes	Available within 15 minutes	Available within 15 minutes
Specialist registrar ('Arts Niet in Opleiding tot Specialist (AIOS)')	Surgery, anaesthesiology, neurosurgery and radiology	Available within 15 minutes	N.S.	N.S.
Other physicians	Trained physician (not a specialist registrar – 'Arts Niet in Opleiding tot Specialist')	N.S.	Available within 15 minutes	N.S.
	Designated hospital physician ('gemandateerd basisarts')	N.S.	N.S.	Available within 15 minutes
Emergency department nurses		Two	Two	One
X-Ray technician		Two	One	One
Supervisor in emergency department	Specialist in trauma surgery	Yes	Yes	No, surgeon
2. Outside consultation				
Specialist	Trauma surgeon	Available within 15 minutes	Available within 15 minutes	Available within 30 minutes
	Surgery, anaesthesiology, Neurologist and radiologist	Available within 15 minutes	Available within 30 minutes	Available within 30 minutes
	Emergency physician	N.S.	Present	N.S.

	Requirement	Highest specialisation level Level I	Second highest specialisation Level II	Third highest specialisation Level III
Specialist registrar ('Arts Niet in Opleiding tot Specialist (AIOS)')	Surgery, anaesthesiology, neurosurgery, radiology, internist, cardiologist and vascular surgery	Available within 30 minutes	Surgeon in training required	N.S.
Other physicians	Designated hospital physician ('gemandateerd basisarts)'	N.S.	N.S.	Available within 30 minutes
Emergency nurses		Two	Two	One
X-Ray technician		Two	One	One
Supervisor	Trauma Surgeon	Available within 15 minutes	Available within 15 minutes	No
Surgeon in emergency department		Specialist registrar, 3rd year	Physician not in training to become a specialist	Yes
Other requirements (training)				
Surgeons, anaesthesiologists and physicians in the emergency departments	Advanced Trauma Life Support(ATLS®)	Yes	Yes	Yes
Emergency department nurses	Full emergency service training for nurses	Yes	Yes	Yes
	Trauma Nursing Core Course (TNCC)	Yes	Yes	Yes
	Trauma Nursing Pediatric Course (ENPC)	Yes	Yes	Yes

Source: Based on the level criteria of the Dutch Trauma Society (2013)[161] N.S. stands for not specified.

Table 32 – Healthcare professionals present in hospitals participating in trauma networks in the Netherlands (2014 – 2018)

	Requirement	Highest specialisation level Level I	Second highest specialisation Level II	Third highest specialisation Level III
24-hour availability of medical specialists	Anaesthesiology Internists Cardiology Surgery, Internal medicine, paediatrics Neurology Ophthalmology Orthopaedics Radiology Rehabilitation Ear, nose and throat (ENT)	Yes	Yes	Yes
	Other specialities	Oral maxillofacial surgery Neurosurgery Reconstructive surgery and microsurgery	Oral maxillofacial surgery	N.S.
Physicians in the ED				
• **Within consultation hours**				
Supervisor	Trauma Surgeon	Yes	Yes	A surgeon not necessarily specialised holding the title of trauma surgeon
Specialist registrar[a]		Yes	N.S.	N.S.
Other physicians	Trained physician[b]	N.S.	Yes	Yes
• **Outside consultation hours**				
Supervisor	Trauma Surgeon	Available within 15 minutes	Available within 15 minutes	No
Surgeon (specialist/specialist registrar)		Third year specialist registrar	Trained physician [b]	Yes
Other physicians	Trained physician[b]	N.S.	N.S.	N.S.

Source: Based on the level criteria of the Dutch Trauma Society (2013)[161] [a] 'Arts Niet in Opleiding tot Specialist (AIOS). [b]Not a specialist registrar – 'Arts Niet in Opleiding tot Specialist') ED stands for emergency department;.N.S. stands for not specified.

3.3.5 Trauma management information systems

Major trauma centres were responsible for coordinating the regional trauma registries. Since 2006, all hospitals participating in the trauma network are obliged to participate in the trauma registry.[156] The Dutch Trauma Registry (DTR) is composed of the data of the 11 regional trauma registries (RTCs). These regional trauma registries are coordinated by the bureaus of the RTCs. The regional registries collect data from trauma patients admitted to all acute care hospitals in the respective trauma region. For the data collection, the RTC registration bureaus closely collaborate with the regional ambulance services, HEMS and regional hospitals. The method of data collection varies and includes extracting data from the ambulance, HEMS and the hospital information systems. Manual data entry is performed, if required. The DTR is embedded in a web based relational database (SQL) in ProMISe (Project Manager Internet Server). The MTCs monitor the data quality.

Data are collected prospectively for the pre-hospital phase, in the emergency department and during the hospitalisation (including the phase in the intensive care unit). The template from the Major Trauma Outcome Study was initially used to collect data. In 2014, the data collection questionnaire was adapted based on the Utstein template in order to fulfil the current European standards.[12, 168] In addition to the participation in the national registry, three major trauma centres (University Medical Centres of Maastricht, Rotterdam and Groningen) participate in German Trauma Registry (TraumaRegister DGU®).[32]

Table 33 – Selected characteristics of the National Trauma Registry

	The Netherlands
Are there trauma registries at the level of the hospital/network/region ?	The National Trauma Registry regroups information from the 11 trauma network registries
What criteria are used to include patients in the registries?	Inclusion criteria • Injured patients treated at the emergency department and admitted to hospital/transferred to another hospital within 48 hours after their injury • Patients that reached the hospital with vital signs and deceased in the emergency department Exclusion criteria • Patients dead on arrival
Is participation compulsory/mandatory?	Mandatory
Are transferred patients from one centre to another included?	Yes
Who is responsible for collecting and processing?	Regional trauma registries bureaus and MTC
Are there protocols for monitoring data quality and completeness?	The Dutch Network for Emergency Care (LNAZ) transmits different quality checks that may be used by the different trauma networks. The LNAZ verifies the completeness of information for patients included in the registry.
Is the data linked with other databases (e.g. to build quality indicators)?	Quality of care in trauma centres and in trauma networks is partly evaluated on the basis of the data recorded and entered into the registry. The DTR is not directly linked to other databases.
For how long are patients included in the registry (e.g. follow-up after hospital discharge)?	From the incident until hospital discharge/30 day mortality.

Source: Dutch Network for Emergency Care (2015)[169], Dutch Network for Emergency Care (2016)[151] and Ringdal et al. (2008) [168]

3.3.6 Trauma centres in numbers

3.3.6.1 General information on admitted patients

The Dutch Network for Emergency Care ('Landelijk Netwerk Acute Zorg' (LNAZ)) publishes yearly reports about the activities of acute hospitals with emergency departments that participate in the Dutch Trauma Registry. The annual report of 2016 contains, for the first time, information for all acute hospitals in the country. Table 34 summarizes basic statistics on the activity of trauma centres in 2015. The introduction of changes in the coding of the Abbreviated Injury Scale (AIS) affected the definition for the severely injured.

Compared with the data of 2014, in 2015[170] data from the register showed that there were:[169]

- fewer severely injured patients (4 202 vs. 5 882);
- more activation of the MMT team (21% vs. 15%);
- more direct admissions to the theatre (12% vs. 7%);
- more ICU admissions (56% vs. 74%)
- and higher mortality (17% vs.12%)

Table 34 – Number of patients admitted in trauma centres in 2014 by specialisation level

	Highest specialisation level Level I	Second highest specialisation Level II and Level III	Total
Number of hospitals participating in the trauma registry	11	86	97
Total admitted patients (included in the register)	19 059	64 811	83 870
Patients with an ISS≥1	19 024	64 039	83 063
Patients with an Injury severity score 1≤ISS≤15 (number and (%))	16 226 (85.3%)	62 635 (97.8%)	78 861 (94.9%)
Patients with an Injury severity score ISS>15 (number and (%))	2 798 (14.7%)	1 404 (2.2%)	4 202 (5.1%)
Patients with head injury (AIS≥ 4) (number and (%))	1 357 (7.1%)	545 (0.9%)	1 902 (2.3%)
Patients with an isolated hip fracture 9≤ISS≤15	2 266 (11.9%)	14 789 (23.1%)	17 055 (20.5%)
Pre-hospital (patients with an ISS > 15 admitted directly from the scene)			
Transported patients (ambulance and helicopter)	2312	1210	3522
Time from accident to hospital for primary admissions in minutes (total time)	NDA	NDA	NDA
Time to CT scan (patients with an ISS > 15			
30 minutes or less	1197	211	1408
More than 30 minutes and less than 60	632	216	848
More than 60	402	333	735
Unknown	567	644	1211

Source: The Dutch Network for Emergency Care (LNAZ) (2016)[170]. NDA: no data available.

Cause of injury

In 2015, patients with a blunt trauma amounted to 97% of all cases that were registered and for which a cause of injury was known. The main causes of injury among admitted patients were falls (64%), followed by bicycle (12%) and motor vehicle (4%) accidents. Among severely injured patients (with an ISS≥15), the causes of injury follow the same order but with different proportions: 44%, 18% and 11% respectively for falls, bicycle and motor vehicle accidents.[171]

In-hospital mortality in 2014 and 2015

The percentage of severely injured patients (ISS≥16) that died in-hospital decreased from 15% to 12% between 2011 and 2014.[170] Data for 2015 cannot be compared with that of the previous years because a new version of the Abbreviated Injury Scale (AIS) was integrated in the registry. In 2015, the percentage of severely injured patients (ISS≥16) that died in-hospital amounted to 17%. The percentage of patients that died following a severe injury was higher among those who suffered a severe head injury (23%). Data on mortality according to the specialisation level of the hospitals was not available in the annual report.

Table 35 – In-hospital mortality for severely injured patients (ISS≥16) admitted in acute hospitals participating in the Dutch Trauma Registry (DTR)

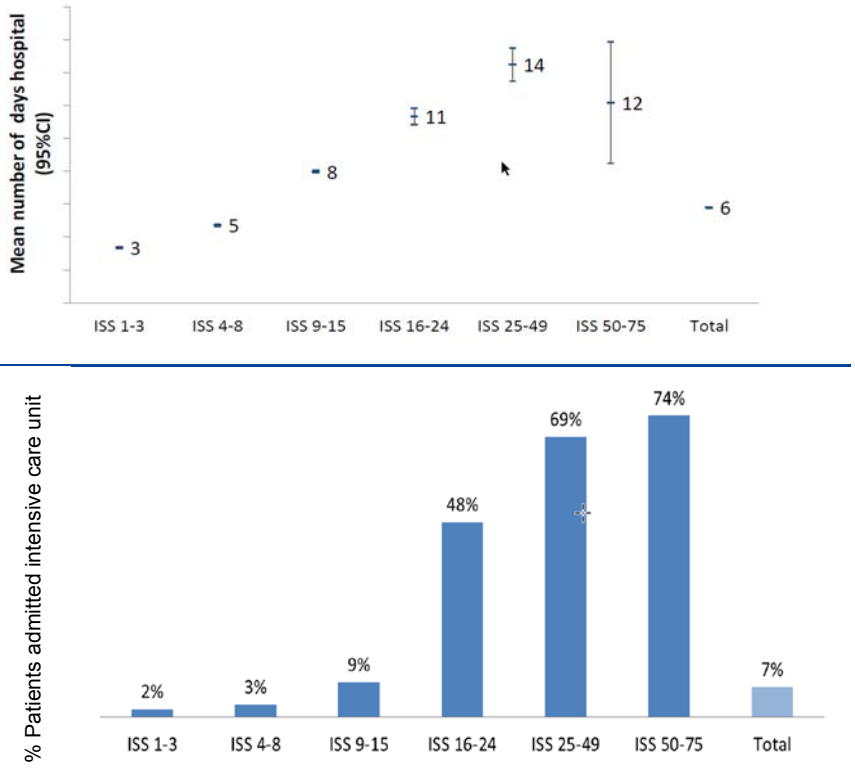
	2011 (AIS98)	2012 (AIS98)	2013 (AIS98)	2014 (AIS98)	2015 (AIS08)
All patients (N and %)	638 (15%)	653 (13%)	604 (11%)	714 (12%)	730 (17%)
With a severe head injury (AIS≥3) (N and %)	NDA	NDA	NDA	NDA	565 (23%)
Without a severe head injury (AIS≥ 3) (N and %)	NDA	NDA	NDA	NDA	165 (9%)

Source: The Dutch Network for Emergency Care (LNAZ) (2016)[170]. NDA: no data available.

Length-of-stay (2015)

Figure 18 shows the relation between the mean patient's length-of-stay and the injury severity (measured using the Injury severity score). In 2015, the mean length of stay for all trauma patients amounted to 6 days. The mean length of stay for patients with an ISS≥ 9 was above that of all trauma patients. For the same year, the percentage of patients admitted to an ICU was higher for those with a greater ISS score.

Figure 18 – Stay in hospital (length) and % patients admitted to an ICU



Source: Sturms L (2016)[171]

3.3.6.2 Results from peer review publications

Cause of death

Two recent studies provide information on the cause of death of injured patients in two major trauma centres in the Netherlands.[14, 172] Results in both studies showed that the first cause of death is a central nervous system injury followed by exsanguination. Respiratory failure and major organ failure (MOF) are the third and fourth causes of death among the injured, respectively. El Mestoui et al. (2015)[172] point out that mortality rate following a severe trauma in a major trauma centre is comparable with that observed in other European countries (19.1%) and that the mortality rate resulting from complications is very low.

Impact of the trauma system on mortality

The implementation of major trauma centres in the Netherlands started in 1999. In 2006, criteria were defined to classify all acute hospitals according to their capacity to treat severely injured patients.[156] The development of a full 'Inclusive trauma system' varied between the regions, in particular concerning the triage tools used to refer patients on to MTCs.[154] Most of the retrieved literature on the outcomes of the implementation of the trauma network concern the central part of the Netherlands, led by the MTC in the University of Utrecht (UMCU).

Before 2010, studies on the Dutch trauma networks lacked a comparative group and therefore the effect of the system could not be assessed.[173-175] Twinjstra et al. (2010)[176] studied the impact of the implementation of the trauma system in the central region of the Netherlands on in-hospital mortality for all trauma patients (including children) and on the concentration of severely injured patients (ISS>15) in a major trauma centre. The authors used data from one major trauma centre and 12 regional hospitals before the implementation (1996 –1998) and after the implementation of the trauma system (2003-2005). Logistic regression analysis was used to assess the association between the regionalisation of care and patient's outcomes. After adjusting for potential differences in the index and control group, the authors found an overall decrease in mortality of 16% for all trauma patients. A relative decrease in mortality of 21% was also found among patients with an ISS>15. The authors point out that the decrease in mortality was only statistically significant for regional hospitals and that the effect of the major trauma centre was smaller than anticipated. Twinjstra et al. (2010)[176] showed that after the implementation of the system, multiple trauma patients were more often admitted to the major trauma centre (adjusted OR: 1.19; 95% CI:1.01–1.39) while the proportion of injured patients admitted to the major trauma centre decreased (adjusted OR: 0.89; 95% CI: 0.84–0.93). A shorter length-of-stay (in general and on critical care) was also observed in their study.[176] The authors concluded that the gains in overall mortality are associated with a more efficient triage system that led to a more efficient distribution of patients in all the hospitals included in the regional trauma system.

Spijkers et al. (2010)[177] and Lansink et al. (2013)[14] focused on the following outcomes for adults (aged 18 years and older): mortality, hospital and ICU length of stay in a major trauma centre (UMCU) before and after its designation. The years of analysis included in both studies differed. Spijkers et al. (2010)[177] used data for the pre- and post-designation periods corresponding to 1996 – 1998 and 2003 – 2005, respectively. Lansink et al. (2013)[94] used data for the recent post-designation period (2003 – 2006) and for subsequent years (2007 – 2010). The latter was considered to correspond to a period when the major trauma centre attained its maturity. In both papers, logistic regression analysis was used to assess the impact of the major trauma centre on the patient's risk of death. Compared with the pre-designation period, Spijkers et al. (2010)[177] found that during the post-designation period mortality decreased after adjusting for age and for the severity of injury (Odds ratio =0.606 (p-value<0.001)). Compared with the post-designation period (2003-2006), Lansink et al. (2013)[14] found a reduction in adjusted mortality (Odds ratio =0.736 (p-value<0.01) between 2007 and 2010.

The authors[14, 176, 177] pointed out that the centre's designation may not be the only contributing factors that could explain the reduction in in-hospital mortality; during the same period, several quality improvement programs that may have enhanced the quality of care provided (e.g. all staff in the emergency department followed ATLS courses, expansion of the trauma staff (from three to six full-time dedicated trauma surgeons) and the implementation of massive transfusion protocol was introduced in our

hospital, increase in the percentage of total-body CT scans, massive transfusion protocols). Joosse et al. (2012)[178] studied outcomes in patients with severe traumatic injury who were transferred a Level I trauma (Academic Medical Center's (AMC)) compared with those who were primarily presented to the same centre. The authors used a small sample (80 patient) and statistically significant differences in the outcomes (30 day-mortality and the Glasgow Coma Scale on-scene) were not found. However, the authors point out that differences between the two groups would appear clinically relevant and that patients would benefit from a direct transfer to a MTC.

One study addressed the impact of the implementation of the trauma system in the central region of the Netherlands on mortality for paediatric trauma patients (aged 18 years old or younger) and on the concentration of these patients in Level I or Level II trauma centre.[179] Janssens et al. (2012)[179] used data before (1996-1998) and after (2001-2006) the regionalisation of trauma care. After adjusting for the injury severity (using the ISS score), a significant decrease of the mortality rate was found for patients aged 13 to 18 years (standardised mortality ratio of 0.64 (95% CI, 0.34-0.93)). No differences in the concentration of severely injured paediatric patients referred on to trauma centres were found.

Twinjstra et al. (2010)[176] and Spijkers et al. (2010)[177] analyse data for the same period for the central region in the Netherlands. Differences in the results concerning the impact of the MTC on mortality may be explained by the population included in their analysis. Spijkers et al. (2010)[177] included adults only while Twinjstra et al. (2010) included adults and children.

Similar to Lansink et al. (2013), Harmsen et al. (2016)[180] aimed to assess how the outcomes of severely injured patients treated in a major trauma centre were influenced by the maturation of the trauma system in both the pre- and in-hospital settings. The authors performed an observational cohort comparison study for adult trauma patients with an injury severity score (ISS) above 15 and who were admitted to a major trauma centre. Data for 219 patients for 2004-2005 were compared with that for 282 patients for 2014. The authors found that, for the most recent cohort, the mortality significantly declined (7.0% decreased in the cumulative mortality proportion, (p-value = 0.043)). Compared to the 2004–2005 and after adjusting for ISS and age, the 2014 cohort had an odds ratio of 1.9 for survival (95 % CI 1.14–3.3, p = 0.014). The authors pointed out that during the studied periods, there were changes in the number of processes and clinical interventions used in pre and in-hospital settings (e.g. a decline in the total number of trauma surgical interventions and an increase in the number of acute angio interventions).

Gunning et al. (2015)[181] compared the impact of three major trauma centres in different countries on mortality in adults, including the MTC in the central region of the Netherlands (UMCU). The authors used multivariable logistic regression models to calculate odds ratio (OR). Confounders included in the logistic regression included: age, Injury Severity Score (ISS), Revised Trauma Score (RTS), and presence of a severe neurological trauma. Compared with the MTC in Australia and the United Stated, the crude mortality and the adjusted odds for death were higher for patients admitted in the trauma centre in the Netherlands. The authors showed that the performance of the Dutch major trauma centre was equal to the international standards using the Trauma and Injury Severity Score (TRISS) methodology. The other two centres included in their comparison performed better than the international standard. The authors hypothesise that these results may be explained by the fact that the two centres in Australia and the United States benefit from having a higher volume of patients. According to the authors, higher volume may lead a care-oriented process targeting the specific needs of the injured and enhance individual experience among health care professionals (trauma surgeons, in particular).[181]

Hospital and ICU length of stay

Spijkers et al. (2010)[177] and Lansink et al. (2013)[14] used Cox regression models to assess the impact of the major trauma centre on the length-of-stay (in general and on critical care). Compared with the pre-designation period, Spijkers et al. (2010)[177] found that during the post-designation period the in-hospital length of stay decreased while the ICU length of stay increased (relative risk of 1.20 (p-value<0.001) and 0.868 (p-value<0.055), respectively). During the post-implementation period, the number of admitted patients in the ICU decreased (relative risk of 0.416 (p-value<0.001). Compared with the post-designation period (2003-2006), Lansink et al. (2013)[14] reported a significant reduction for length-of-stay (in general and on critical care) between 2007 and 2010 (relative risk of 1.068 (p-value<0.018) and 1.188 (p-value<0.007), respectively).

3.3.7 Future planning and challenges

3.3.7.1 Enlarging quality indicators and evaluation Trauma centre performance

After attaining 100% participation in the trauma registry, a challenge in the coming years is to improve the quality and completeness of the data. The NVT has pleaded in favour of improving the quality of the registration of data and to develop quality indicators to assess the overall well-being of patients.[7] The Dutch Network for Emergency Care (2015) set missing information to the highest values in order to avoid to underestimate negative outcomes. Missing data is present in the overall data collection process, in particular in pre-hospital settings. The Dutch Network for Emergency Care publishes the standardised mortality ratio and it is expected that hospitals with results beyond the 95% confidence interval review the quality of their clinical practices. Recently, the Trauma National Consultation Bureau (LBTC) has recommended to include patient reported outcome measures (PROMs) next to mortality as outcome measurement for the Dutch Trauma Network.[182]

3.3.7.2 Shortage in human resources

More surgeons with a specific expertise will be required to cover all the care needs of patients treated in trauma centres. However, it is likely that the number of patients referred to some centres will be too low compared to the actual capacity of surgeons to treat injured patients. In order to attain a better balance between the demand and the supply of specialised care, the Dutch Trauma Society recommends to create groups of surgeons that can work in several hospitals from the same network. In addition, enhancing the collaboration between trauma surgeons and other specialism, i.e. orthopaedists and emergency physicians, may not only reduce the workload for these specialism but may also improve the quality of the care provided.[11]

3.3.7.3 Centralisation of severely injured patients

In 2015, the percentage of patients with an ISS≥16 that were treated in Level I centres amounted to 66.6% (2798 over 4202), with a variability between hospitals ranging from 36% to 87%.[170] It is expected that this percentage increases up to at least 90% in the coming years.[183] Health insurers pleaded in favour of raising the number of patients in each centre to 450 poly-trauma patients per year. The Dutch Society for Trauma Surgery (NTV) recommended to maintain the current threshold of 100 patients per year (with an Injury Severity Score>15) given the recent changes in the coding of the Abbreviated Injury Scale (AIS). Indeed, the changes in the coding of the Abbreviated Injury Scale (AIS) will affect the definition for the severely injured and will lower the number of patients that will be registered as having an ISS>15. Overall, more concentration of treatment at the MTCs is necessary to meet the volume norms. By 2018, the National Health Care Institute ('Zorginstituut Nederland') recommends that the number of severely injured patients admitted to major trauma centres increases to a minimum of 240 per year.[183] Further concentration of patients, may have an impact on the number of trauma centres or in the activity of existing centres. Healthcare authorities may choose between reducing the number of major trauma centres,[14, 152] concentrating patients with the most severe injuries in one centre[14] or to create reference centres for specific injuries.[11]

3.3.7.4 Financing

Financial resources for the implementation of the networks were limited and this was identify as a challenge among the countries stakeholders. In the Netherlands a structural payment is provided to MTC's to take up the leadership role within the trauma network (data registration, training, etc.)

Payment for injured patients in the Netherlands is included in the 'regular' activity-based payment system for hospitals. In the Netherlands, trauma patients can be classified into different homogenous groups of patients (DOTs Diagnose Behandel Combinatie (DBC) Opweg naar Transparantie) according to their Injury Severity Score (ISS≥ 16).[184]

Three issues of concern regarding the payment system for the medical costs for severely injured patients were identified. First, the healthcare authorities only provided additional funding to cover the costs related to the organization of the trauma networks.[152] This was seen as problematic because major trauma centres were confronted with a considerably increase in the volume of severely injured patients that required to use additional unfunded hospital resources. Second, medical costs for severely injured patients were initially only reimbursed when the patients was treated in a major trauma centre. This policy is no longer applied and all hospitals treating a severely injured patient are reimbursed via the hospital payment system (DOTs or 'DBC's Op weg naar Transparantie'). The latter is considered as not providing sufficient incentives that will lead to concentrate the severely injured in specialised centres.[151] Finally, some stakeholders have also pointed out that funding for research in trauma care is lacking.[11]

3.4 Germany[k]

3.4.1 General context

3.4.1.1 Definitions

Table 36 provides a description of some relevant terms that are used throughout the text.

Table 36 – Overview of working definitions in Germany

	Germany
Trauma centre levels[a]	Level I: Supraregional trauma centre (STC) ('Uberregional Traumazentrum – ÜTZ). Level I centres will be also addressed in the text as Major Trauma Centres (MTCs) Level II: Regional trauma centre (RTC) ('Regionale Traumazentrum' – RTZ) Level III: Local trauma centre (LTC) ('Lokal Traumazentrum – LTZ)
Trauma network	Trauma networks can be organised into two different configurations. Networks should include at least the minimum number of hospitals required in one of the two configurations: • One supraregional trauma centre (Level I), two regional trauma centres (Level II) and three local trauma centres (Level III); • Two regional trauma centres (Level II) and three local trauma centres (Level III) in collaboration with a 'supraregional trauma centre' (Level I) belonging to another network. Arrangements for patients with specific injuries (e.g. spinal cord injuries, burns, etc.) must be clearly established with other competent hospitals.
Recognition	Recognition is a process organised by legislative or regulatory authority that allows a care service to operate. State governments are in charge of the recognition process.
Accreditation	The term certification ('Zertifizierung') is most often used in documents describing the German Trauma system
Registration	Hospitals participating in the care of severely injured patients can be registered in the national TraumaNetwork DGU ® – Project but not necessarily hold an accreditation.
Consultant	Physician who successfully completed specialty training and who has a leading position in a hospital or hospital department ('Oberarzt').
Specialist	Physician who successfully completed specialty training ('Facharzt')
Specialty registrar	Physician undergoing a specialty rotation and training ('Weiterbildungsassistent')

Source: [a]German Trauma Society for Trauma Surgery(2012) [15]

[k] Pol Maria Rommens and Sebastien Kuhn provided comments and read a previous version of the chapter on the German system. Pal Maria Rommens is a senior trauma surgeon and the director of the Department of Orthopaedics and Traumatology of the Johannes Gutenberg-Universität. Sebastien Kuhn is a senior trauma surgeon at the Johannes Gutenberg-Universität.

3.4.1.2 Country context

In Germany, the federal government, the states ('Landër) and self-governing bodies (representatives of payer and provider associations) share decisions related to the Social Health Insurance system ('Gesetzliche Krankenversicherung', SHI). Since 2009, every German is required by law to hold health insurance. There are two types of insurance types of health insurance systems, i.e. the Statutory Health Insurance system, covering around 86% of the population and the private health insurance (PHI) system covering around 10% of the population. The remainder 4% fall under special provision (e.g. military, police, social welfare, assistance for immigrants seeking asylum).[185, 186]

Under the SHI system, Germans are free to choose their SHI fund and SHI funds must accept any applicant. The main SHI fund in Germany is the general regional fund ('Allgemeine Ortskrankenkassen', AOK). SHI funds are mainly financed by contributions set as a uniform percentage of income, supplemented by tax funds. The premiums are deducted from pay packets with employers and employees paying about half each.[185, 186]

3.4.1.3 Hospital classification and planning

Planning, resource allocation, and financing for outpatient and inpatient services are completely separated. Each of the 16 state governments is responsible for maintaining hospital infrastructure. The main instruments used to do so are the so-called 'hospital requirement plans', which are set by the state governments after input by the respective hospital federation and the sickness funds. The 'hospital requirement plans' specify hospital capacity and the range of services to be delivered across all hospitals within a state, as well as within individual hospitals.[185] Operating costs are reimbursed by sickness funds and private health insurance. The state governments are fully in charge of planning and promotion of any alteration in hospitals capacity sizes.[185, 186]

Hospitals can be classified according to the intensity of care provided to patients.[187, 188] Maximum care hospitals ('Maximalversorgung') usually correspond to university hospitals with comprehensive spectrum of medical specialities and having responsibilities for research and training. Central care hospitals ('Schwerpunktversorgung' also have a wide spectrum of different medical specialty departments. Basic and regular care hospitals ('Grund-und Regelversorgung') have few medical specialty departments and a limited number of hospital beds. This classification may vary between the regions.[189]

In 2015, there were 1 916 hospitals encompassing 1 619 general hospitals and 337 hospitals specialised in different areas (e.g. psychiatric hospitals). The number of hospitals with four or less, five to ten and eleven or more specialism amounted to 778, 568 and 273, respectively.[190]

3.4.2 Policy development

3.4.2.1 What factors were used to determine which institutions were initially selected to become MTC?

Experience with the management of the severely injured: the role of the mandatory accident insurance

Before 2006, the mandatory accident insurance, state-specific political regulations and strategies for the professional development of all specialisms and professional groups determined the structures and processes for the care of the severely injured.[15, 191] The mandatory accident insurance ('Berufsgenossenschaft') demanded that only physicians holding the title of 'trauma surgeon' and working in specially a certified trauma department were entitled to care for workers who suffered a work-related accident.[191] The hospitals from the mandatory accident insurance enjoyed a good reputation for the high quality of care. Often, patients who had a severe traumatic injury asked themselves to be transferred to such a hospital. Also surgeons of smaller hospitals had the tendency to transfer such patients in order to avoid complications and law suits.[192] The most specialised and larger trauma departments were located in maximum care hospitals ('Maximalversorgung') while less specialised trauma departments were located in central care hospitals ('Schwerpunktversorgung') and in basic and regular care hospitals ('Grund-und Regelversorgung').[193, 194]

A successful bottom-up initiative: TraumaNetwork DGU project

In 2006, the German Society of Trauma Surgery ('Deutsche Gesellschaft für Unfallchirurgie" (DGU)) created a blueprint for the organisation of trauma centres and local trauma networks (TN). The white paper 'Treatment of the severely injured'('Weißbuch Schwerverletztenversorgung')[15] defines the requirements that need to be fulfilled by hospitals that wish to participate.[15, 17] The participation in the TraumaNetzwerk DGU® initiative is voluntary and all hospitals participating are obliged to participate in an accreditation process (see section more information 3.4.4.2).[95] In 2009, the trauma networks in Germany went live in many regions of the country.

Improving a mature system: aligning the recommendations from the white paper with the German Evidence-Based Guidelines

In 2012, the white paper was revised in order to integrate the German Evidence-Based Guidelines for the Treatment of the Severely Injured.[195] The guidelines were developed by the medical societies involved in the treatment of severely injured patients and included recommendations for prehospital and clinical treatment for these patients.[95] While the guidelines core concerns clinical aspects, there are also some relevant recommendations for the organisation of the system: i) the transport and hospital designation, ii) The emergency room - personnel and equipment resources and iii) criteria for emergency room activation.

3.4.2.2 What were the main challenges faced during the implementation of MTC? Which solutions were found to overcome these challenges?

Challenge within the hospital: making an effective collaboration between departments in the hospital

The health care authorities provide no specific guidance, additional reimbursement, investment budgets or compliance rules for hospitals participating in the trauma system. The implementation of a major trauma centre (MTC) has major implications for many other clinical departments and institutes of the hospital (e.g. operation theatre capacity, infrastructure, availability of specialists during day and night, high demand patients in post-operative care). As a consequence, different actors and medical speciality departments must collaborate and fully support the implementation of a major trauma centre. The latter cannot be achieved without the support of the direction of the hospital. The trauma department along with the direction of hospital must provide clear mentoring and counselling to all partners of the MTC.[192]

Challenge outside the hospital: making an effective collaboration between multiple partners

According to Ruchholtz et al. (2014)[95] the success of the system is in part due to the collaboration between medical societies that established 'the personnel and structure requirements for the system and agreed to work in line with the treatment guidelines'.

3.4.3 System Integration

3.4.3.1 Categorization of hospital infrastructure

Trauma care is organized in local trauma networks and facilities receive an accreditation corresponding to three different levels (see 3.4.4.2 for more details on the classification process): Level I (MTC) – supraregional trauma centre (STC), Level II – regional trauma centre (RTC) and Level III – local trauma centres (LTC). Severely injured patients can be referred to MTCs and Level II centres. MTCs can provide care to all types of patients. In all trauma networks a paediatric trauma referral centre must be assigned among MTCs that fulfil specific requirements (see section 3.4.5). If none of the MTCs fulfils these requirements, agreements with a MTC from another network must be implemented.[15]

Creation of the trauma networks based on existing collaborations

The creation of local trauma networks heavily relied on the existing collaboration between hospitals. The participation in the accreditation process required to be a part of the TraumaNetzwerk DGU® initiative is voluntary.[17] The audit results determine the classification of the hospital. The most specialised centres (Major Trauma Centre (MTCs)) are generally located in university or general hospitals located in large urban areas (major cities).[95] In areas where there is a high density of large hospitals with multiple specialist departments, it is recommended to work together and to create one single MTC.

The role of Level II and Level III centres is based on the requirements of the white paper. However, each trauma network must clearly define their definitive role in the care provided to severely injured patients. Level II centres are usually located in urban areas.[95] Compared with MTCs, Level II centres most often have a lower treatment capacity and different requirements for level of expertise of health care professionals (e.g. not always consultant level or limited specialists for extremely complex injuries) (see 3.4.5).[15]

The difference between being accredited as a Level II or Level III centre often depends on whether acute neurosurgical care is available. Level III centres are located in smaller urban or rural hospitals.[95] Level III centres are often the first point of contact for patients, in particular when the travel time to a Level II or MTC exceeds the established recommendations. Level III centres must be capable of providing acute stabilisation of a bleeding patient and play a major role at a national level in the treatment of the most frequent isolated injuries.[15]

In Germany, MTCs not only are responsible to provide care to the most severely injured patients but also have a prominent role in ensuring system coordination, evaluation of outcomes and to adapt service provision according to the evolving local care needs. Level I and Level II centres must participate in clinical studies and ensure specialist training and development.[15] Level I centres must participate in disaster control and to be prepared to cope with heavy casualty admissions as a result of mass casualty events and catastrophes.

Table 37 – Responsibilities beyond care provision

	Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
Teaching and advanced training	• Provision of teaching and training is required in particular for Level I centres located in University hospitals (e.g. not only training but lectures) • Inter-hospital training	• Participation in specialist professional development and advanced training	• Participation in basic and advanced specialist courses,
Clinical studies	Yes, special obligation	Yes	Optional
Participation in quality procedures	Yes	Yes	Yes
Hospitals in the same geographical area	Recommended to work together and create one Level I STC	N.S.	N.S.

Source: German Trauma Society for Trauma Surgery(2012)[15]. N.S. stands for not specified.

Defining boundaries for catchment areas at a national level requires fine tuning

The catchment area of the Trauma Networks and the inclusion of hospitals in the network were determined to take into account:

- Regional characteristics: This includes geographical and political divisions (e.g. federal state borders) as well as the hospitals accessibility
- Coverage of the geographical area and overlap between adjacent networks. Hospitals located in the borders between trauma networks should belong to only one trauma network
- Size of the network: The minimum requirement for each network is to have one MTC, two Level II and three Level III centres. In the absence of a MTC, it is expected that the networks has at least two Level II centres and to establish collaboration with other networks.

Not all hospitals within a geographical area are part of a local trauma network. For instance, in large urban areas some hospitals may not be a part of the local trauma network. The dispatch centre will not direct patients to hospitals that do not participate in the network.[192] Patients who are not transported by emergency medical services (e.g. family) may still go to these hospitals.[192]

Box 13 – Trauma Networks beyond national borders: Case study of the "Boundless Trauma Care Central Europe" (BTCCE)

The Boundless Trauma Care Central Europe (BTCCE)[196] is an initiative that encompasses the cooperation between dispatch centres, ambulance services, hospitals and rehabilitation services located the western border region of Germany and its neighbouring countries (i.e. Netherlands, Belgium, Luxembourg and France). The BTCCE project was preceded by two earlier collaborations (Meuse-Rhine Euroregion (EMR) and Meuse-Rhine in crisis (Emric+)) on cross border care in the region. The collaboration between BTCCE partners is based on non-contractual agreements and is driven by individual leadership from field actors. Most often encountered barriers encompass lack of involvement of political authorities and insurance companies as well as differences in financial arrangements to cover the costs associated with trauma care. The differences in clinical work practices, equipment used and the education background of healthcare professional were also cited as among the hindering factors that affect an efficient provision of cross border trauma care.

Trauma networks must collaborate other with networks

Networking between the trauma centres and centres from other specialised networks is considered to be an essential activity of the TraumaNetzwerk DGU® initiative. Trauma centres, in particular MTCs, will provide medical treatment to patients with severe injuries (e.g. burns, spinal lesions). It is expected that these patients will receive primary care at a MTC and then will be transferred to an appropriate specialist facilities.[15] According to Debus et al. (2015), the regional trauma networks covered geographical areas that range from 892 km2 to 16 820 km^2 in Belin and East Bavaria, respectively. The population density in same regions varies from 3 785 per km^2 in Berlin to 177 per km^2 in East Bavaria.[197]

Table 38 – Number of hospitals and trauma centres before and after the accreditation process a by the TraumaNetzwerk DGU® in Germany

	2000[a]	2016[b]
Number of acute hospitals	2 222	1 619[c]
Number of hospitals with a department of trauma surgery or trauma surgery and orthopaedics	N.A.	900[16]
Number of trauma networks	N.A.	51 regional and cross-border networks
Average number of centres per network		12.17
Range of participating centres[d]		5 – 26
Level I		0-6
Level II		1-9
Level III		2-14
Number of accredited trauma centres in the networks	N.A.	
Number of accredited hospitals participating in the trauma care (organised in centres or networks)		621
Level I	*108*	105
Level II		202
Level III	*209*	314
Level IV	*403[a]*	N.A.

Source: NA stands for not applicable. [a]Before the creation of the TraumaNetzwerk DGU®, Kühne et al. (2006)[194] analysed the characteristics of German hospitals and classified them according to their capacity to provide care to severely injured patients. In 2000, hospitals having the most specialised trauma departments amounted to 108. In the same year, less specialised trauma centres of Level III and Level IV amounted to 209 and 403, respectively. [b]Krause, U. (2016)[198]. [c]Statistics Germany (2016)[190]. [d]The range in the number of participating centres in Germany dates from 2012. [17]

3.4.3.2 Emergency Medical Services (EMS)

General overview of EMS

Germany has a long-history of physician-staffed emergency medical services.[199] A physician who received special training and is qualified as a primary care physician is transported to the scene by helicopter emergency services (HEMS) or ground vehicle. Municipalities (“Gemeinden”) and cities (“Städte”) are responsible for ground emergency medical services (GEMS) and states (‘länder’) are responsible for helicopter emergency medical services (HEMS).[188, 200] EMS services may be provided directly by the local authorities, non-profit organisations or private companies. Ground EMS physicians are stationed in a network of hospitals or fire and rescue stations. Primary care physicians are dispatched as a primary response when an impairment of vital functions is probable or as secondary response after a request from an ambulance crew. The HEMS in Germany consists of a dense network of helicopter bases each covering a radius of about 50 km^2.

Most local authorities have implemented a ‘rendez-vous system’ where a small vehicle transports the physician and the emergency medical technician (EMT) trained in Advanced-Life-Support (ALS). On scene they meet with an ambulance crew consisting of one EMT capable of ALS and a driver trained in Basic Life Support (BLS) hence the name ‘‘rendez-vous’’. This second vehicle transports medical equipment and may be used to transport the patient to the hospital.[201] Physicians on duty can also be directly transported by an ambulance.[199] German EMTs are allowed to perform a strictly limited set of therapeutic measures without the presence of a physician under special circumstances and only according to fixed protocols set by the regional Medical Director of Emergency Services. What these measures may include is defined by the German Board of Physicians: vein cannulation, application of crystalloid infusion, early defibrillation, endotracheal intubation without relaxation and administration of defined medication.

The states determine the maximum time between the moment that the dispatch centre receives the call and the arrival of an ambulance or physician staffed vehicle to the scene of the accident. In general, this time delay varies between 10 and 15 minutes.

The physician on scene decides where to transport the patient and a patient requiring special treatment can be referred to a specialised centre instead of to the nearest hospital.[188, 200] HEMS are sent if they are the fastest way of getting a medical team to the scene.[188] Structures for rapid communication between pre-hospital services and the receiving hospital are in place and in order to ensure that preliminary information is provided (as much as possible) before the patient's arrival.

EMS and trauma centres: a collaboration based on clearly defined agreements

During the implementation of each trauma network specific agreements between the participating hospitals for primary admission and inter-hospital transfer are developed. Each Trauma Network creates a list of competences and discusses them with the EMS.[15, 192] The decision to transport a patient to a MTC instead of to the nearest hospital depends on the severity of trauma, the injury pattern and distances to the respective hospitals (see Table 39 for more details).[192]

Table 39 – Emergency medical services in Germany

	Germany
Responsibility for organisation	Ground fleet[200] • Municipalities ('Gemeinden') and the cities ('Städte') Air fleet • State ('Länd')[188]
Minimum requirements in terms of availability and accessibility of ground ambulances and aeromedical services?	In general, an ambulance or physician staffed vehicle must be able to reach all areas in a region by 10 (in some states 15) min after that the dispatch centre receives the call.[188]
Dispatching system	• Universal access number 112 • Emergency medical technician (EMT) with ambulance dispatch training are in charge of response at dispatch centres ('Leitstelle')
Location	Ground fleet[200] • Hospitals (all types of hospitals) • Fire departments • Rescue (ambulance) stations Air fleet[202] • Hospitals (in general MTC) • Airports
Staff	• Physician • Emergency medical technician (EMT) (three different recognised levels ''Rettungshelfer'', ''Rettungssanit¨ater' and ''Rettungsassistent'')[188]

	Germany
Activity	• Medical treatment: Basic Life Support (BLS) and Advanced-Life-Support (ALS). • Emergency medical technician (EMT) performs a limited set of therapeutic measures • The physician on scene decides where to transport the patient[203]
What pre-hospital triage protocols are used?	Triage protocols are implemented according to the states regulations The German Interdisciplinary Association for Intensive and Emergency Medicine Care issued in 2000 a protocol for EMS that includes information on the patient's condition.[204]
Are there predefined activation criteria for a "trauma call" before patient arrival to a TC?	Yes[192] • Dispatch centre • IT based patient admission availability system (in some regions/states) • Contact between the doctor on scene (or the EMS team if the doctor is not present) and the trauma coordinator at the trauma centre

3.4.4 Planning of trauma centres (Designation and accreditation of trauma centres)

3.4.4.1 Designation

The health care authorities do not designate trauma centres.[192] In most states, investment funds for the organisation were not provided. Only in the state of Schleswig-Holstein a lump sum for the TraumaNetwork was provided.[192]

3.4.4.2 Quality monitoring and accreditation

The accreditation process reviews the compliance of the trauma centres with the criteria in the white book. Trauma networks are also subjected to an accreditation process. The accreditation process for trauma networks starts when all individual participating hospitals obtained their accreditation.[15, 17] Hospitals wishing to maintain their accreditation are obliged to participate in a new audit every three years.[192] Fully trained auditors working in independent commercial companies perform the audits (DIOcert and Cert iQ).[205]

The number of patients included in the trauma registry is considered as an indicator of the status of a hospital in the trauma network.[15, 17] The minimum number of patients that must be treated according to the level of the hospital (see Table 40) is not strictly regulated (or mandatory). In each audit, the number of treated injured patients with an ISS ≥16 patients is assessed. Hospitals not complying with this number are not automatically downgraded or do not necessarily lose their accreditation.

If the audit results in a negative evaluation for the centre, the hospital can lose the accreditation or be assigned to another level. In the case that the hospital does not agree with the results from the audit, the state representative (Bundeslandmoderator), the delegate of the steering committee for the implementation of the TNW ('AKUT Arbeitskreis Umsetzung TraumaNetzwerk DGU®) and members from the hospital (and from the trauma network of the hospital) meet to discuss any disagreements. When a solution is not found, the hospital can fill a claim to the company that carried out the audit.[206]

Table 40 – Organisation of the accreditation process of trauma centres

	Germany
Is there a minimum threshold for the number of patients that should be admitted per year in TC?	The German Society for Trauma Surgery[15, 17] recommends that centres treat a minimum number patients with an ISS≥16: • Level I = Minimum 40 • Level II = Minimum 20 • Level III = N.S.
Is the accreditation of a TC attributed to a hospital, a specific hospital ward (e.g. a separate entity from the emergency department) or other?	Accreditation is granted at the level of the hospital (Level I to III). [15, 17]
How often are audits performed?	Every three years
Who performs the audit	Two independent commercial companies perform the audits (DIOcert and Cert iQ)[205]
Is the participation to the audit voluntary or mandatory?	Mandatory after receiving the first accreditation. Before the audit, hospitals must perform a self-assessment indicating whether the requirements in the white book are fulfilled. Hospitals not fulfilling important personnel or structural requirements are not audited. When minor requirements are not fulfilled, hospitals can proceed to set changes before the audit. All changes must be documented.[17]
Depending on the audit results, what measures are taken to improve/reward the TC (and networks) performance?	• Downgraded to a lower specialised level • Losing accreditation[192]

3.4.5 Characteristics of trauma centres

3.4.5.1 Admission criteria

Admission criteria from scene to a trauma centre are based on physiological and anatomical parameters and on the mechanism of injury. The criteria are included in the interdisciplinary guidelines on the care of the severely injured.[15, 195] Table 41 presents the criteria used to determine whether a patient must be transported to a trauma centre (all levels confounded). Hospitals participating in local trauma networks must also establish transfer criteria for severely injured patients. Trauma networks establish according to the criteria in the white book agreements between the participating hospitals for primary admission and inter-hospital transfer.[15]

If a patient fulfils one criterion defined in the following table, a physician is sent to the site of the accident and in general the patient is referred to a MTC. However, if a physician is unavailable (e.g. to multiple emergencies with limited resources) then the EMS can activate the trauma team.[192]

Table 41 – Criteria for the treatment in a trauma centre of German Society of Trauma Surgery

Grade of recommendation A Physiological parameters	Grade of recommendation A Anatomical parameters	Grade of recommendation B Cause of accident or injury	Criteria for transfer of a paediatric patient to a Level I centre
• Systolic blood pressure below 90 mmHg after trauma, • Glasgow coma scale (GCS)<9 • Respiratory failure or intubation	• Penetrating injuries to the trunk or neck region, • Gunshot wounds to the trunk/neck region, • Fractures of more than two proximal bones, • Unstable thorax, • Unstable pelvic fracture, • Amputation injury proximal to the hands/feet, • Injuries with neurological signs of spinal cord transection, • Open cranial trauma • Burn > 20% of ≥ 2b degrees.	• Fall higher from 3 metres, • Road traffic accident (RTA), • Head-on collision with indentation of more than 50–75 cm, • Change of speed of delta > 30 km/h • Pedestrian / two-wheeled vehicle collision, • Death of a passenger, • Ejection of a passenger.	• Glasgow coma scale < 13 (moderate to severe CCT), impression fracture, neurological symptoms, • Thoracic trauma with pulmonary contusion (Abbreviated Injury Scale (AIS)> 2), • Abdominal trauma with organ injury (AIS) > 2), • Pelvic fracture or fracture of 2 long bones of the lower extremities, • Intensive care > 24 h • Injury Severity Score (ISS) ≥ 15

Source: German Society for Trauma Surgery (2012) [15, 195] If none of the criterion from a) or b) applies, the cause of accident c) determines the type of emergency care.

Table 42 – Admission to trauma centres

	Germany
Are there specific criteria used to determine whether a patient must be transferred to a Level I/II?	Yes
Are there specific criteria to transfer a patient from scene to a TC?	Yes
Who has the authority to activate the trauma team	• The physician at the scene of the incident[192] • The EMS team if the physician is not present
Are there explicit criteria regarding the maximum transport time (e.g. minutes / KM) to attain a TC?	Maximum of 30 minutes[163] When access to a Level I or II centre exceeds 30 minutes, the severely injured should be admitted to a Level III centre.
How is the transport time to a MTC calculated?	Ambulance time
How is the time interval calculated?	Start point : Departure from the scene of the accident End point: arrival at the trauma centre
Do TC provide total care to all types of patients?	Level I centres ensure appropriate care for adult and paediatric patients within each local trauma network. Level I centres receiving paediatric patients must fulfil additional requirements (see Table 46) Elderly patients In collaboration with gerontolist. Since 2014, trauma centres can be certified as "orthogeriatric reference centre" (AltersTrauma-Zentrum DGU®). The idea behind this initiative is to improve the care provided to elderly patients in different TC. These trauma centres have an expertise in geriatric patients.

Source: German Society for Trauma Surgery (2012) [15, 195].

3.4.5.2 Infrastructure and medical equipment

Table 43 and Table 44 illustrate the infrastructure and medical requirements for hospitals that participate in accredited trauma networks in Germany. Trauma rooms ('Schockroom') in all centres must be available 24/7. Compared with Level II centres, MTCs must have a higher treatment capacity (at least two patients) and additional specific equipment (e.g. angiography unit with intervention) in the trauma room. Intensive care units in Level I and Level II centres must comply with the recommendations of the German Interdisciplinary Association for Intensive and Emergency Medicine Care (Deutsche Interdisziplinäre Vereinigung für Intensiv- und Notfallmedizin – DIVI)[207] and with the operations and procedure code (Der Operationen- und Prozedurenschlüssel (OPS)) for complex intensive medicine.[208]

All trauma centres are required to have an available operating room for emergency surgery. The operative room can be used for elective surgery but the hospital are required to have procedures that allow its availability for an emergency surgery.[192] For MTCs, it is expected that the operating room capacity allows to receive and treat two severely injured patients. Operating rooms can be used for elective surgery but procedures within the hospital must ensure that they are available upon a request from the trauma team. In Germany, there is not a tradition of having a centralised emergency department. Decentralised ED are co-located within specialist departments, most often in the department of internal medicine and/or in the surgical department.[192]

Table 43 – Summary of infrastructure and medical equipment criteria in hospitals participating in trauma networks

		Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
Hospital infrastructure	Types of hospital	• University hospitals • Major city hospitals (Trade Association clinics)	• Hospitals in urban areas	• Smaller urban or rural hospitals
	Centralised emergency department	N.S.	N.S.	N.S.
	Department for trauma surgery or Department for trauma surgery orthopaedics and trauma surgery	Yes	Yes	Yes A department of surgery with an expert having expertise in orthopaedics/trauma is also a possibility
	Department for Neurosurgery	Yes	Yes/No Neuro-traumatological emergency care must be ensure either directly by the hospital or in collaboration with other centres	No
	Operating room (OR)	Adjacent to the trauma room[b] with a capacity for two patients	Adjacent to the trauma room with a capacity for one patients	Available in the hospital
	Intensive care unit	Permanent care	Permanent care	Provisional care
Trauma room (TR) ('Schockraum')	Required TR	Yes	Yes	Yes
	Localisation	Close to the transport bay (ambulance/ helicopter), radiological and surgical department	Close to the transport bay (ambulance/ helicopter), radiological and surgical department	NDA
	Treatment capacity	At least two simultaneous patients	One patient	One patient[c]
	Availability 24/7	Yes	Yes	Yes
	Number	One or two	One	One
	Surface	50 m^2 or two separate rooms	25m2 (40m2 recommended)	-
	Helicopter landing pad	Yes	Yes, but derogation possible	
	Imaging equipment (X-ray or Computed tomography facility (CT) or MRI)	Yes New buildings: Computed tomography facility (CT) in the immediate vicinity of the TR	Yes New buildings: Computed tomography facility (CT) in the immediate vicinity of the TR	Yes
	Angiography unit with intervention	Yes	No	No

Source: German Trauma Society for Trauma Surgery (2012) [15]. [b]Available in the room separate anaesthetic apparatus, operating room instrument sets for emergency trauma, visceral, neural, thoracic and maxillofacial surgery. Instruments for children surgery must also be available. [c]This is not explicitly mentioned in the guidelines but was confirmed by field experts. [192] N.S. stands for not specified.

Table 44 – Infrastructure and medical equipment required in emergency departments and in operating rooms in hospitals accredited as a trauma centre

		Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
Emergency admissions	Blood donor service /blood bank	E	E	E
	Laboratory[a]	E	E	E
	Microbiology	E	E	D
	Helicopter landing pad , operation 24 h	E	E	D
	Artificial respiration		E	E
	Pulsoxymetry	E	E	E
	Secretion suction unit	E	E	E
	Capnography	E	E	E
	Blood gas analyser (BGA unit)	E	E	E
	Rapid infusion system	E	E	E
	ECG monitor	E	E	E
	Defibrillator	E	E	E
	Invasive tonometry	E	E	E
	Equipment in the emergency operation room • Laparotomy • external pelvic stabiliser • craniotomy • thoracotomy • Bülau drainage • Pericardial puncture • suprapubic urinary drainage • Bronchoscopy	E	E	E

		Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
	• Emergency care for maximum severity burns			
	Emergency medication	E	E	E
	Diagnostic imaging			
	Ultrasound scanner, Doppler sonography Conventional radiography CT	E	E	E
	Angiography unit with intervention	E	D	–
	MRI	E	E	-
	Splinting and traction systems	E	E	E
	Constant temperature circulators	E	E	E
	Patients	E	E	E
	Infusion and blood	E	E	E
Operating Room				
OR installations	Constant temperature circulators			
	Patients	E	E	E
	Infusion and blood	E	E	E
	Cell saver	E	E	E
	Image intensifier	E	E	E

Source: German Trauma Society for Trauma Surgery(2012)[15]. E: essential; D:desirable [a] Recommendation: A unit should be available for blood gas analysis to facilitate documentation and transmission of findings more reliably.

3.4.5.3 *Healthcare professionals' expertise*

Is trauma (management / surgery) recognised as a medical specialty?

A physician wishing to obtain a qualification as a specialist ('Facharzt') in the field of trauma surgery ('Orthopädie und Unfallchirurgie') must follow a basic continuing training in surgery of two years followed by a specialist continuing training of four years. The specialty in orthopaedics and trauma surgery is one of the eight specialist qualification branches of surgery. In addition to this training, specialist in the field of trauma surgery can obtain extra qualifications (also called supraspecialisation) ('Zusatzweiterbildung') in special trauma surgery ('Spezielle Unfallchirurgie').[15] The training pathway that is previously mentioned corresponds to the current education standards in the field of trauma surgery. Previously, the specialisation in the field of trauma surgery consisted of a qualification as surgeon ('Chirurg') followed by a continuing training as a trauma surgeon ('Unfallchirurg').[192]

What are the requirements regarding the availability of healthcare professionals 24/7 on duty and on-call in trauma centres?

A key feature of the German trauma system is that treatment of the severely injured is led by highly trained specialists that are either present or able to reach the hospital within 20 to 30 minutes. Team members that are in the hospital work in their specific departments are required to come immediately in the trauma room when a patient is announced. They need to be there before the arrival of the patient himself.[192] Each severely injured patient is treated by one fully staffed trauma team.

It is required that half of the trauma specialists have an advanced qualification in emergency room management and a standard course in Advanced Trauma Life Support-(ATLS®) or other equivalent courses (e.g. ETC®). The trauma team leader responsible for stabilising and treating the patient must be a consultant with specific training in trauma surgery (see Table 45).

Table 45 – Health care professionals participating in the most specialised trauma centres in selected countries

	Requirement	Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
Medical management / head of unit	• Specialist in orthopaedics and trauma surgery with extra qualifications in special trauma surgery • Specialist in general surgery specialised in trauma surgery	Yes, additional requirements: • Full teaching experience in special trauma surgery is required • Associate professorship or comparable qualification	Yes, additional requirements: • 18 month teaching experience in special trauma surgery is required	Yes
Basic team in the trauma room ('Schockraum')				
Availability	Round the clock 24h /7d	Yes	Yes	Yes
Healthcare professionals	One specialist or specialty registrar in orthopaedics and trauma surgery	Yes	Yes	N.S.

	Requirement	Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
	One specialty registrar in one the following fields: 1) orthopaedics and trauma surgery 2) visceral surgery 3) general surgery	Yes A specialty registrar on the extra qualification on special trauma surgery can fill this position in the team	Yes	Yes A specialist in orthopaedics and trauma surgery can fill this position in the team
	One specialist and/or specialty registrar for anaesthesiology	Yes	Yes	Yes
	One specialist and/or specialty registrar for radiology	Yes	Yes	N.S.
	Two nurses for surgery	Yes	Yes	Yes
	One nurse for anaesthesiology	Yes	Yes	Yes
	One medical and technical radiology specialist	Yes	Yes	Yes
Other requirements	Transport staff (Paramedics EMS or in hospital transport team)	Yes	N.S.	N.S.
	Half of the trauma specialists must have an advanced qualification in emergency room management and a standard course in Advanced Trauma Life Support-(ATLS®) or equivalent courses (e.g. ETC®).	Yes	Yes	Yes
On-call healthcare professionals				
Time after being alerted after activation by the		20-30 minutes	20-30 minutes	20 minutes

	Requirement	Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
Trauma coordinator[a]				
Physicians	Specialist in orthopaedics and trauma surgery with extra qualifications in special trauma surgery	Yes, consultant A specialist (consultant) in general surgery specialised in trauma surgery can fill this position in the team	Yes, consultant	Yes, consultant
	Specialist in visceral or general surgery	Yes, consultant	Yes, consultant	Yes, consultant
	Specialist in anaesthesiology	Yes, consultant	Yes, consultant	Yes, consultant
	Specialist in radiology	Yes, the radiologists is a consultant with expertise in interventional radiology	Yes, consultant	Yes, consultant
	Specialist in neurosurgery	Yes, consultant	Yes	N.S.
	Specialist in vascular surgery	Yes	Yes	N.S.
	Two operating room nurses	Yes	Yes	Yes
	Specialist in cardiac and/or thoracic surgery	Yes	Optional	N.S.
	Specialist in oral maxillofacial surgery	Yes	Optional	N.S.
	Specialist in ear, nose and throat surgery	Yes	Optional	N.S.
	Specialist in ophthalmology	Yes	Optional	N.S.
	Specialist in urology	Yes	Optional	N.S.
	Specialist in gynaecology	Optional	Optional	N.S.
	Specialist with extra qualification in hand surgery	Optional	Optional	N.S.
	Specialist in paediatric surgery or paediatric	Optional	Optional	N.S.
	Specialist in plastic surgery	N.S.	Optional	N.S.

Source: German Trauma Society for Trauma Surgery(2012) [15].[a]This is not explicitly mentioned in the guidelines but was confirmed by field experts. [192] N.S. stands for not specified.

Table 46 – Requirements for paediatric trauma referral centre

	Germany
Level I centre	Yes
Infrastructure	• Department for paediatric surgery or department for orthopaedics and traumatology with special competence in paediatric trauma • Department of paediatrics and adolescent • Paediatric Intensive Care Unit • Trauma room in the emergency department with child-specific protocol
Medical management / head of unit	• Specialist for paediatric surgery ('Kinderchirurgie') with specific competence in paediatric trauma or, specialist in orthopaedics and trauma surgery with extra qualifications in special trauma surgery and competence in paediatric trauma
Basic team in the trauma room ('Schockraum')	• Specialist for paediatric surgery with experience in trauma care or specialist in trauma surgery with experience in paediatric care • Specialist in anaesthesiology with experience in paediatric care
On-call healthcare professionals	• Specialist in neurosurgery with experience in paediatric care or Specialist for paediatric surgery with experience in neurosurgery • Paediatric intensive care specialist or intensive care specialist with experience in paediatric • Specialist in radiology with experience in paediatrics

Source: German Trauma Society for Trauma Surgery(2012)[15].

3.4.6 Trauma management information systems

In 1993, the German Trauma registry was founded by the German Society of Trauma Surgery (Deutsche Gesellschaft für Unfallchirurgie, DGU). Data are collected prospectively in four consecutive time phases from the site of the accident until discharge from hospital: A) Pre-hospital phase, B) Trauma room and initial surgery, C) Intensive care unit and D) Outcome and Discharge.[16, 209] The documentation includes detailed information on demographics, injury pattern, comorbidities, pre- and in-hospital management, course on intensive care unit, relevant laboratory findings including data on transfusion and outcome of each individual.

About 90% of all hospitals submitting their data are located in Germany. The remaining 10% come from hospitals located in Austria, Belgium, China, Finland, Luxembourg, Slovenia, Switzerland, The Netherlands, and the United Arab Emirates. In 2015, four Belgian hospitals participated in the German Trauma Registry: AZ Groeninge Kortrijk, Centre Hospitalier Régional de la Citadelle Liège, H.-Hartziekenhuis Menen and AZ Delta Roeselare.[32]

Table 47 – Selected characteristics of the German Trauma Registry – TraumaRegister DGU®

	Germany
Are there trauma registries at the level of the hospital/network/region?	National trauma registry
What criteria are used to include patients in the registries?	Inclusion criteria • Admission to hospital via the trauma room with subsequent admission to the intensive care unit • Reaching the hospital with vital signs and deceased before admission to the intensive care unit Exclusion criteria • Patients dead on arrival, burns, hangings, drowning, and poisonings.
Are transferred patients from one centre to another included?	Yes
Who is responsible for collecting and processing?	The participating hospitals submit their data into a central database via a web-based application. Specialised documentation staff or physicians enter data into the system. Data are validated after their submission by physician. The infrastructure for documentation, data management, and data analysis is provided by AUC – Academy for Trauma Surgery (AUC – Akademie der Unfallchirurgie GmbH), a company affiliated to the German Trauma Society
Are there protocols for monitoring data quality and completeness?	The web-based application includes more than 130 high number of checks that are performed during the electronically import of the patient data. In addition, a randomised control of the health records is performed during the re-auditing process for the hospitals participating in the TraumaNetzwerk DGU. For hospitals associated with TraumaNetzwerk DGU®, the entry of at least a basic data set is obligatory for reasons of quality assurance.
Is the data linked with other databases (e.g. to build quality indicators)?	Quality of care in TC and in TNW is partly evaluated partly on the basis of the data recorded and entered into the registry.
For how long are patients included in the registry?	Until patients discharge

Source: German Trauma Registry (2014)[16, 209]

3.4.7 Trauma centres in numbers

3.4.7.1 General information on admitted patients

Each year, German Trauma registry published an annual report offering to all hospitals a benchmark of their own results with results obtained by all other hospitals. The annual report 2016 contains all trauma patients admitted until end of 2015, and completely documented until end of March 2016. From 2015, the report concerns 'a basic patient group' considered as severely injured. This group excludes patients with minor injuries and thus improved the comparability of the results. This basic patient group consists of 82% of all documented patients. In 2015, the median number of severely injured patients treated in MTC was 130 (min. 100 – max. 180), in Level II 40 (min. 25 – max. 55) and in Level III 9 (min. 4 – max. 16). In 2015, patients with blunt trauma amounted to 96% of all reported cases and the traffic accidents were the leading cause of injury with 50.4%.

Table 48 summarises basic statistics on the activity of trauma centres participating in the trauma registry in 2015. In order to reduce the statistical uncertainty, all patients from the last three years (2012 – 2015) were pooled together.[210]

Table 48 – Number of patients[a] admitted treated in trauma centres in Germany pooled data from 2012-2015

	Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
Number of hospitals participating in the trauma registry	124	233	279
Average per centre per year	147	43	13
Admitted patients over a three year period	53571	29588	9412
Admitted and treated over total (%)	86	84	75
Admitted and early transferred out over total (%)	1	11	23
Transferred in over total (%)	13	5	2
Injury			

	Highest specialisation level Level I – Supraregional TC	Second highest specialisation Level II – Supraregional TC	Third highest specialisation Level III – Local Trauma Centre
Percentage of patients with an Injury severity score ISS≥16 (%)	59	50	39
Patients with head injury (AIS≥ 3) (%)	43	31	23
Patients with thoracic injury (AIS≥ 3) (%)	37	37	34
Patients with abdominal injury (AIS≥ 3) (%)	10	9	8
Pre-hospital			
Transported patients for primary admissions	N=46 574	N=28 211	N=9 232
Time from accident to hospital for primary admissions in minutes	64	59	55
Length-of-stay (without early transfer)			
Intensive care unit	7.9	5.5	3.8
In hospital	18	14.8	12.5

Source: [a] Statistics based on all centres participating in the register and for patients having a Maximum Abbreviated Injury Score (MAIS) equal to three or a MAIS score equal to two if they died or were treated on the intensive care unit. German Trauma Society for Trauma Surgery(2016)[210].

In-hospital mortality in 2015

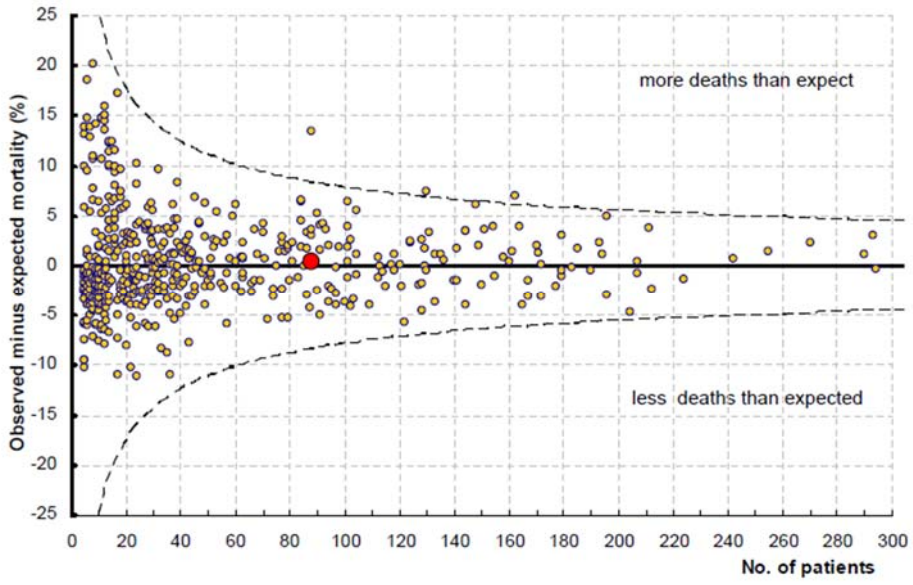
The TraumaRegister DGU® assesess the performance of the trauma centres by comparing the observed mortality of severely injured trauma patients with their expected mortality (prognosis). The prognosis is derived from the Revised Injury Severity Classification II (RISC II). The score is calculated for all primary admitted patients. The median mortality rate of all 563 hospitals in 2015 (with at least 3 cases) was 8.0%.

For severely injured patients, the in-hospital mortality was 11.3% (95% CI: 10.9 – 11.7) for a risk of death prognosis based on RISC II 10.8%. The figure compares each hospital's observed mortality rate with the respective RISC II prognosis in 2015. The deviation of observed mortality rate from the expected prognosis is plotted against the number of patients on the horizontal axis. Negative values correspond to mortality rates which are lower than expected. The dotted lines represent the 95% confidence interval. Hospitals with less than five patients were not included in this figure,

due to the large statistical uncertainty. The variation clearly diminishes with a higher number of patients treated annually.

For this analysis, all severely injured patients from the last three years (2013-2015) were pooled together. While the hospital mortality equalled 11.0%, this rate was different according to the level of care: 6.9% for Level III, 12.6% for Leve II and 12.6% for MTC. No explanation was provided in the annual report.

Figure 19 − Comparison of in-hospital and expected mortality in 2015



Source: German Trauma Society for Trauma Surgery(2016)[210].

3.4.7.2 Results from peer review publications

Two relevant peer-reviewed publications aimed to explain the potential relationship between level of care, volume of patients and mortality for the Trauma Network in Germany.[95, 211]

Process outcomes

The time interval between an accident and arrival to the hospital was longest in MTCs for patients admitted directly from the scene. More than one third of those patients required air rescue. The time for basic diagnostics, such as ultrasound of the abdomen/thorax (Focused Assessment with Sonography in Trauma [FAST]) and x-ray of the thorax/pelvis, in patients with an ISS of 16 or greater was significantly shorter in MTCs (5-12 minutes) than in Level II centres (6-16 minutes) or Level III centres (9-27 minutes). The length of time until cerebral computed tomographic scan (cCT) in sTBI (20 minutes vs. 25 minutes vs. 30 minutes, respectively) differed in the same manner. The incidence of the use of a whole-body multislice CT was 85% in MTCs, 76% in Level II, and 52% in Level III. The length of time until whole-body CT scan showed the same TC differences as those for isolated cCT.

In-hospital mortality: better prognosis at all levels

In 2014, Ruchholtz et al. (2014)[95] used 2012 data from 504 trauma centres (92 MTC, 210 Level II and 202 Level III) in order to assess the performance of the German trauma initiative. The patients in MTCs had more severe injuries and more often had disturbed physiologic parameters, including GCS score and systolic blood pressure (e.g. mean (SD) ISS were 21 (13) in MTC, 18(12) in Level II and 16 (10) in Level III); p<0.001). In agreement with these findings, the in-hospital mortality rate was higher in this group of patients (13.3% vs. 10.2% vs. 5.9%; p<0.001); both the ICU stay (mean (SD): 7.9 (11) vs. 5.9 (9) vs. 4.0 (7); p<0.001) and the total hospital stay (mean (SD): 19.2 (20) vs. 15.7 (17) vs. 11.7 (13); p<0.001) were significantly longer for patients treated in MTCs. Moreover, MTCs had higher rates of patients referred from other hospitals with higher severity scores than reported for patients without referrals who were treated in Level II or III centres. Although the initial times for diagnostics were longer in Level III centres (a maximum of 15 minutes longer), the quality of treatment with

regard to mortality was not worse than that of the Level II or MTC, as demonstrated by the RISC score. Based on the RISC methodology, the observed mortality rates were significantly lower than predicted in all of the centres categories in 2012. The authors concluded that it is possible to successfully structure and standardize the care of severely injured patients in a nationwide trauma system.

In-hospital mortality and volume

Zacher et al. (2015)[211] aimed to study the association between volume of severely injured patients and mortality in German trauma hospitals. In this retrospective multicentre cohort study, hospital mortality was analysed according to the mean number of patients treated in one hospital per year (patient volume). The analysis included German severely injured patients who were admitted to hospital between 2009 and 2013 (ISS ≥ 16). A total of 39 289 patients were included. Of 587 hospitals, 98 were level I (MTC), 235 level II (RTC) and 254 level III trauma centres (LTC).

Most of the level III hospitals (LTC) did not treat more than 20 of these injured patients per year, whereas most level II hospitals (RTC) did not treat more than 40 patients per year. Level I hospitals (MTC) usually treated more than 40 patients with major trauma injuries per year.There was no significant difference between observed and expected mortality in volume subgroups with 40–59, 60–79 or 80–99 patients treated per year. In the subgroups with 1–19 and 20–39 patients per year, the observed mortality was significantly greater than the predicted mortality ($p < 0.050$).

In this study, an increasing hospital volume of severely injured patients was an independent, significant and positive predictor of survival. Although a clear cut-off value could not be established, it appears that at least 40 patients per year per hospital might be enough to improve survival. High-volume hospitals had an absolute difference between observed and predicted mortality, suggesting a survival benefit of about 1 per cent compared with low-volume hospitals. In rural districts, local level III trauma centres provide primarily life-saving trauma care. This study demonstrated appropriate outcomes achieved by such hospitals.

3.4.8 Future planning and challenges

3.4.8.1 Centralisation of severely injured patients

Not all severely injured patients may be included in the trauma registry. TraumaRegister DGU® (2014)[212] pointed out that about 900 hospitals in Germany have a trauma surgery or orthopaedic department while the number of hospitals that participate in the registry amounts to about 550. It is possible that hospitals not participating in the trauma registry focus more on orthopaedic disorders than on trauma. It is estimated that the registry covers about 90% of all severe trauma cases.[212] However, the exact number is not yet available.[197, 212]

3.4.8.2 Relying on highly specialised centres for less severely injured patients

Modification or restructuring of in- and outpatient emergency care, especially outside normal working hours, leads to a tangible accumulation of emergency care needs at specialist centres. In return these reduces the centres capacity to provide care for the severely injured.[15, 210]

In Germany, a variable volume of severely injured patient per major trauma centre has been observed. According to Debus et al. (2015), the average number of severely injured patients treated in 2012 in a major trauma centre amounted to 85 with a standard deviation of 42.9.[197]

3.4.8.3 Financing

Classification of the severely injured into the appropriate homogenous German Diagnosis-Related Groups System (G-DRG) is challenging.[213-215] On the one hand, there seems to be a trade-off between developing an appropriate case allocation for these patients and increasing the system complexity.[214, 216-218] On the other hand, lack of appropriate case allocation seems to lead to systematic underfunding by German reimbursement system.[219]

Several modifications have tried to improve case allocation and its corresponding reimbursement for the severely injured.[217,220] These modifications have resulted in improvements for in both aspects, with appropriate funding being allocated to patients who were appropriately identified as severely injured in the G-DRG system.[219]

Key points

In the analysed countries the provision of care for trauma patients always concerns collaboration initiatives, via so-called "Inclusive Trauma System" and is not limited to stand-alone institutions (England, NL & DE).

- **Within a clear national framework the operationalisation of the trauma network can be tailored to local circumstances in each country.**
- **The trauma networks aim to encompass the entire care-pathway: from pre-hospital care through to rehabilitation. The participation of acute hospitals in the trauma network is mandatory (England & NL) or voluntary (DE).**
- **In all countries, the inclusion of rehabilitation services into the networks is ongoing:**
  - **The challenge of organising specialised rehabilitation services may be linked to the complex fine-tuning that is required when aiming to match a demand for services that comes from a very centralised sector (acute trauma care) against a supply that is organised at a local level.**
- **The catchment area for the local trauma networks is established according to two different but interrelated criteria.**
  - **First, existing catchment areas determining the access to healthcare services are taken into account.**
  - **Second, a 'reasonable' and 'safe' time span for the patient's transport is established. The target times differ per country both in terms of time as well as calculation method:**
    - **The time span is calculated from the moment that the emergency medical services (EMS) departs from the accident scene until it arrives to the hospital in England and Germany and amounts to 45 and 30 minutes, respectively.**
    - **In the Netherlands, there is not a specific time span for the transport of severely injured patients. However, the law establishes that the time span between the moment of the call to the dispatch centre and until the arrival to an emergency department should be less than 45 minutes.**
- **The trauma network reform was characterised by five steps (England, NL & DE):**
  - **First, concerns about the management of severely injured patients were raised by scientific societies and healthcare professionals. The latter created the sense of 'urgency' that was required to initiate the reform.**
  - **Second, scientific organisations established a "blueprint" of the trauma network based on a set of minimal standards in terms of the availability of healthcare professionals and medical infrastructure:**
    - **This blueprint was in based on a combination of best-available evidence and expert opinion.**
    - **In two countries (England and the Netherlands) the reform process was endorsed by national healthcare authorities.**
  - **Third, based on these minimal standards, healthcare providers along with local authorities proposed a possible configuration of the local network. The first configuration of the network heavily relied on the existing collaborations between local healthcare providers.**
  - **Fourth, the group of stakeholders that established the minimal standards for the trauma networks reviewed the proposed local network configuration in order to ensure that the minimum standards were met.**
  - **Fifth, the network's performance is evaluated via a peer review process. The results of the peer review/accreditation process allow healthcare authorities to establish or to recommend modifications in the network configuration.**

- Financial resources for the implementation of the networks included:
  - In the Netherlands a structural payment is provided to MTC's to take up the leadership role within the trauma network (data registration, training, etc.)
  - In England, the 'best practice tariff (BPT)' includes a conditional component that depends on the compliance with different factors:
    - treatment in a MTC
    - data registration
    - rules for secondary transfer
    - administration of specific treatments
- In all countries strong and dedicated leadership as well as high commitment from all stakeholders were identified as key factors for successful and rapid implementation of a new model of care for severely injured patients.
- The categorisation of acute hospital into trauma centres (of different levels) is one of the most challenging implementation issues.
  - The trauma centre "levels" correspond with a different capacity to provide care to injured patients.
  - Hospitals can 'candidate' for a specific trauma centre level which is latter confirmed via an accreditation process (e.g. by a third-party) or authorised by public authorities.
  - The number of established trauma centres corresponds with the number of hospitals that comply with the minimal standards. The number is heavily influenced by competition between hospitals since being an accredited or authorised major trauma centre is assessed as important for the hospital's reputation (both to attract physicians and patients). Consequently, in England and the Netherlands the number of authorised major trauma centres was higher than the number initially recommended by the scientific societies.
- The target group of patients treated in the different "levels" is discussed at a national level during the implementation phase.
  - Target groups can be defined using multiple criteria including:
    - injury severity (e.g. a threshold for the Injury Severity Score)
    - the type of injury (e.g. spinal cord injury); and
    - the patient's characteristics (e.g. children in the England)
    - expected outcomes of the system that may vary from targeting improvement of mortality and/or of functional outcomes (life-saving versus limb-saving).
  - The choice of the target group has important implications on the required capacity and on the interventions provided in trauma centres of different levels
  - Challenges for the provisions of care to specific target groups include the effective management of the elderly population. The proportion of elderly patients among the severely injured population referred to and treated in a MTC exceeds earlier expectations. This requires the involvement of specific expertise (e.g. collaboration with geriatricians) since geriatric patients are characterised by multi-morbidity and frailty.

Emergency medical services (EMS) are a key player in the local trauma networks.

- Improving the coordination between different emergency medical services (EMS) is a necessary step for the implementation of a new model of care for severely injured patients
- Stakeholder groups led by scientific organisations proposed 'uniform triage protocols' that can be adapted to the local context. All protocols include the mechanism of injury and physiological and anatomical parameters.
- The emergency medical dispatcher pre-notifies the hospital of the arrival of a trauma patient. The EMS team may also directly contact the hospital.

- Transfer of information between the EMS and the trauma team is performed via a structured process. Pre-hospital information is recorded and is used in the trauma registry.

The highest specialisation entities, i.e. major trauma centres (MTC) are the "centre of gravity" of the trauma network (England, NL & DE).

- MTCs provide care to the most severely injured patients and are also are in charge of providing to other hospitals with support, continuing education for trauma team members and to establish and to follow comprehensive quality assessment programs.
- The catchment area of the MTC depends on the travel time of emergency medical services (EMS).
- Healthcare authorities or accreditation entities recommended that within small geographical areas hospitals work together towards the implementation of a collaborative MTC.
- The implementation of a MTC has an impact on the hospital's infrastructure and human resources. Therefore, both hospital managers and healthcare professionals in the hospital must adhere to the decision of establishing a MTC.
- Infrastructure and medical equipment
  - Hospitals categorised as MTCs must have highly specialised neurosurgery departments, intensive care units and ensure a rapid (or even direct) access from the trauma room to a computed tomography facility (CT), magnetic resonance imaging (MRI) and interventional radiology unit. Protocols to ensure immediate access to operating rooms for emergency surgery are also established.
  - Additional equipment for the treatment of specific groups of patients (i.e. children) or specific severe injures must also be available.
- Healthcare professionals
  - A key feature in all countries is that treatment of the severely injured is led by highly trained senior specialists that are either present or able to reach the hospital (trauma room) within 15 to 30 minutes, on a 24/7 basis.
  - Healthcare professionals within the trauma team must follow training programs in emergency room management and trauma related life support courses (e.g. A Advanced Trauma Life Support (ATLS ®), Basic Endovascular Skills for Trauma (BEST))
  - A designated trauma team leader is responsible for stabilising and treating the patient. In all countries, the team leader must be a senior physician. The specialism of the team leader varies cording to the tradition of each country.
- Volume requirements vary substantially between the countries (England, NL & DE).
  - In England, The Netherlands and Germany it is expected that MTCs treat a yearly minimum number of severely injured patients of 250, 100 and 40, respectively.
  - The volume thresholds are recommended but are not legally binding. During the accreditation (or peer review) process, the volume of severely injured patients treated in MTCs is assessed. Not complying with the volume requirement alone does not lead to losing the designation or accreditation as a MTC.
  - Healthcare authorities plead in favour of increasing the volume of severely injured patients that are treated in MTCs (England & NL). The latter is based on the hypothesis that high volumes are required to enhance the skills and experience of multidisciplinary teams. Options to increase the volume threshold include to:
    - improve the triage of the most severely injured patient and their immediate transport to a MTC;
    - reducing the number of MTCs; and
    - create centres of references for specific injuries.
  - Issues regarding how to improve the centralisation of severely injured patients are also affected by:

- Lack of clear rules for the referral of patients and limits to existing triage protocols in the pre-hospital phase lead to a tangible accumulation of emergency care needs for less severely injured patients in highly specialised centres.
- This reduces the centres capacity to provide care for the severely injured and may be a barrier to have more concentration of treatment at the MTCs in order to meet the higher volume norms.

The role of lower level centres vary between the countries and within the local trauma networks (England, NL & DE).

- Local networks must clearly define the role of the lower trauma centres in the care provided to injured patients.
  - The latter requires to define which group of patients can be referred on to these hospitals.
  - MTC and other trauma centres are required to sign cooperation agreements for the secondary transfer of severely injured patients.
- Compared with MTCs, Level II centres most often have a lower treatment capacity and lower requirements for level of expertise of health care professionals. Equipment for the treatment of extremely complex injuries is often not required.
- Level III centres are often the first point of contact for patients, in particular in less densely populated geographical areas when the travel time to a Level II or MTC exceeds the established recommendations.
- Level II and /or Level III centres may play a major role at a local level in the treatment of the most frequent isolated injuries.

Appropriate collection of data on severely patients is needed to evaluate the needs of the population as well as to evaluate the performance of the trauma network and of MTCs. A trauma register was established in the three countries. The level of the data included in the trauma registry and the inclusion criteria varies between the countries.

- All registries include data on the pre-hospital phase, the initial treatment in the emergency department and the complete hospitalisation phase (including the phase in the intensive care unit), and on patients' outcome and discharge.
- Data from the registries is essential to evaluate that actors in the trauma network meet the minimal standards that were established.
- Data registration is mandatory and lack of compliance may lead to financial penalties or possible sanctions (including accreditation loss in Germany and a reduction of case payment in England).
- Challenges for the data registry in the coming years include:
  - MTCs have reached a high quality registration of data in the trauma registry that needs to be met by Level II and III centres.
  - Collecting new data will be required in the following years in order to move away from an evaluation of the network's performance based on mortality. New outcome measures will encompassed disability and patient's quality of life.

PART 4: LITERATURE REVIEW

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4 LITERATURE REVIEW ON MTC

4.1 Aim

The most recent systematic reviews on the association of the availability of a system of trauma care with short-term patient outcomes included articles up to 2011.[106, 221] New evidence is available on the topic as the developing of the organisation of trauma care continues.

The aim of this study was to review the recent (from 2012 onwards) level of scientific evidence regarding whether improvement of mortality and length of hospital stay following a major trauma are associated with the existence of major trauma centres and to the characteristics of major trauma centres.

4.2 Research question

The main research question was: what is the level of evidence available on the effect of a major trauma centre (MTC) on mortality (up to 30 days after discharge), length of hospital stay and length of stay at an intensive care unit (ICU)? The sub-questions formulated to answer the main question are:

- Are trauma centres associated with better severely injured patient outcomes compared to non-trauma centres? What is the association between level of trauma centre and patient outcomes?
- What is the association of the severity of the injuries of the patient and the outcomes if treated in a trauma centre?
- Are high patient volume centres associated with better short-term patient outcomes? Is there a volume threshold below which patient outcomes are worse?

4.2.1 Hypothesis

The published literature will demonstrate that mortality (up to 30 days after discharge), length of hospital stay, and length of ICU stay are better for patients treated at a major trauma centre (MTC).

4.3 Methods

4.3.1 Design of the study

We conducted a systematic review, following, as far as possible the PRISMA-statement (Preferred reporting items for systematic review and meta-analysis)[222] and MOOSE (Meta-analysis Of Observational Studies in Epidemiology) guidelines.[223]

4.3.2 Search

4.3.2.1 Search strategy

We searched for primary studies dating from 2012 and younger. Besides, we searched for systematic reviews without date limit to compare our results with evidence from older systematic reviews.

The search strategy is reported in Appendix 1 in the report supplement. The search strategy was developed in consultation with an expert librarian/information specialist at the VU University Medical Centre in Amsterdam, the Netherlands, and in collaboration with KCE. The search strategy included terms identifying patients (major trauma patients / severely injured patients) and the intervention (trauma centres / trauma system).

Appropriate truncation and wildcards were used in the search to account for plurals and/or variations in the spelling of search terms. Language restrictions were not applied. The date of the last search was June 7th, 2016.

Identifying Primary Studies

The search took place in two main steps. To find the most recent primary studies, in the first step we searched for all relevant primary studies according to the search strategy, but with a date limit from 2012 onwards. The search results were deduplicated before screening. All positively screened primary studies were full text searched for inclusion and exclusion criteria.

Identifying Systematic Reviews

We searched for all relevant systematic reviews according to the search strategy with a “systematic review filter”. We used a search filter developed by the librarian experts of VU University Medical Centre to find the reviews. The search filters are shown in the Appendix 1 of the search strategies.

The search results of this second step were deduplicated before screening. All positively screened systematic reviews were full text searched for inclusion and exclusion criteria. The selected systematic reviews were used to compare our findings (with the most recent evidence) with the evidence and conclusions in selected systematic reviews.

4.3.2.2 Search sources

Electronic searches

We searched the following databases:

- Cochrane Database of Systematic Reviews
- Cochrane Central Register of Controlled Trials (CENTRAL)
- Pubmed
- Embase
- CINAHL

The search strategy was modified to the structure of each database, based on the initial PubMed search. In addition we asked the clinical experts of the KCE expert committee from the Belgian field of trauma care about any studies they know of.

4.3.3 Inclusion process

The stepped search process resulted in two sets of studies:

1. Primary studies
2. Systematic reviews

4.3.3.1 Inclusion criteria for primary studies and systematic reviews

Included studies needed to be comparative studies (for example a trial or a study with a before/after study design). The publication addressed the organisation of trauma care within the geographical context of at least one Western European or Anglo-Saxon country. Since the definition of Western Europe is complex and carries economic and cultural connotations, we adopted the definition of the Statistics Norway. They define the "West" as EU28/EEA, USA, Canada, Australia and New Zealand (see the report supplement).[224]

4.3.3.2 Types of participants for primary studies and systematic reviews

The studies to be included had to contain data on patients with major trauma, i.e. severely/critically injured. Several instruments were used for defining severely/critically injured trauma patients. The instruments and thresholds we used are: ISS≥15, International Classification of Diseases (ICD-9) Injury Severity Score (ICISS)<0.85 or AIS≥3.

4.3.3.3 Types of interventions for primary studies and systematic reviews

The studies to be included had to focus on the organization of trauma care, i.e. trauma centres, trauma system, trauma model, trauma network or trauma organizations. Almost all trauma systems follow at least to a certain extent the level criteria for trauma centres outlined by the American College of Surgeons Committee on Trauma (ACS-COT).[225] The different levels, from I to V, refer to the kind of resources available in a trauma centre and the patient volume. If a study did not contain the level of the included trauma centres, we classified the centres according to the ACS-COT criteria, if possible.

4.3.3.4 Types of outcomes for primary studies and systematic reviews

The following primary outcomes were selected to identify the effect of the organization of trauma care: in-hospital mortality OR mortality up to 30 days after discharge OR length of hospital stay OR length of stay at ICU. Secondary short-term outcomes of patients (up to 30 days after discharge) were collected.

4.3.3.5 Types of study design

We included primary studies that were of a comparative design in which there was a comparison between before and after the introduction of a trauma care system or a significant part of it (without changing the level of trauma care), or there was a comparison between different levels of trauma care.

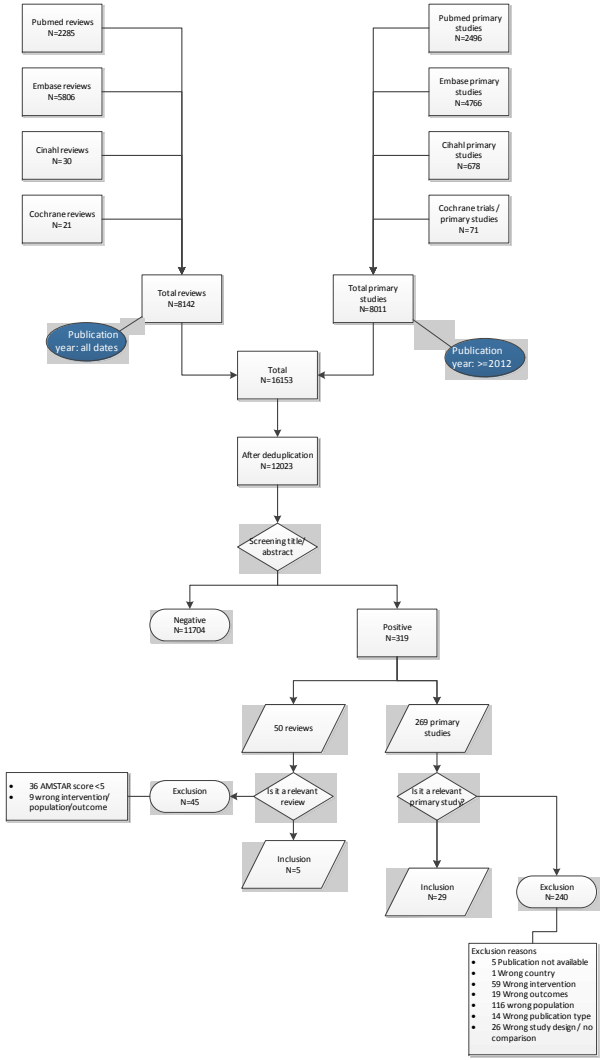
To be included, systematic reviews had to concern specifically the effect of trauma systems for major trauma patients (see paragraph 4.3.3.1). We used the AMSTAR checklist to assess the quality of the systematic reviews. [226] The checklist contains the following points: establishing the research question and inclusion criteria before the conduct of the review, data extraction and inclusion by at least two independent data extractors, comprehensive literature review with searching of at least two databases, key word identification, expert consultation and limits applied, detailed list of included/excluded studies and study characteristics, quality assessment of included studies and consideration of quality assessments in analysis and conclusions, appropriate assessment of homogeneity, assessment of publication bias and a statement of any conflict of interest.

The range of the AMSTAR score is between 0 and 11. The total score was used to classify the overall quality of each review as high (total score 9 to 11), moderate (score 5 to 8), or low (score 0 to 4).[227] Systematic reviews were included for the comparison if AMSTAR score was 5 or higher.

4.3.3.6 *Exclusion criteria for primary studies and systematic reviews*

Studies regarding only trauma patients with burns, disaster trauma patients or terrorism/war trauma patients were excluded.

Figure 20 – Flowchart of stepwise search strategy



4.3.4 Data collection

4.3.4.1 Selection of studies

Bibliographic records were exported to a "Covidence" database for screening and data collection (http://www.covidence.org). Three review authors (ML, JH and NB) screened titles and abstracts for eligibility for all eligibility criteria, so that each title/abstract was screened once. About 10% of all titles were screened twice to obtain an interobserver agreement (kappa, K). The K value is an indication of the strength of the agreement and can be interpreted as follows:[228]

< 0.20 Poor
0.21 - 0.40 Fair
0.41 - 0.60 Moderate
0.61 - 0.80 Good
0.81 - 1.00 Very good

We resolved disagreements through discussion with the third review author.

All full text articles were reviewed independently by different combinations of two authors.

Data extraction and management

One review author (ML, JH or NB) reviewed selected studies and extracted data on the following, using a specifically developed and piloted data extraction file:

1. General information about the study
   a) Aim of the study
   b) Study design
   c) Duration of the study
   d) Inclusion and exclusion criteria
   e) Details of the control and intervention group
   f) Duration of follow-up (if applicable)
   g) Quality of the study
2. Characteristics of trauma patients
   h) Number, age, gender and co-morbidities of participants
   i) Severity of trauma
3. Intervention characteristics
   j) Organisational characteristics of trauma centre, accreditation and designation of the trauma centres, the level of trauma centre (level 1 to 5, or non-trauma centre (NTC) and participation in a trauma network
   k) Country
   l) Patient volume of the trauma centre (per centre)
4. Outcome measures
   m) In-hospital crude mortality, 30-day crude mortality, crude mortality in emergency room
      i) Definition
      ii) Unit of measurement
      iii) How it was measured
      iv) Data
   n) Adjusted mortality, if crude mortality rates were not available
      i) Definition
      ii) Unit of measurement

iii) How it was measured

iv) Data

o) Length of hospital stay and length of ICU stay

i) Definition

ii) Unit of measurement

iii) How it was measured

iv) Data

p) Secondary outcomes

i) Definition

ii) Unit of measurement

iii) How it was measured

iv) Data

5. Authors' conclusions

We used as much as possible the unadjusted crude data to estimate a population average effect. We expected that all included studies used different variables to adjust for confounding, so comparison of the effect estimated would be difficult.

In case, a publication presented only adjusted results, we contacted the study authors to obtain unadjusted data and when not possible we used adjusted data but separately from the unadjusted data.

One other review author (ML, JH, NB, Maria Isabel Farfan (MIF) or Sabine Stordeur (SS)) checked the extracted data. In case of any disagreements, it was resolved through discussion within the team of researchers. Where information was unclear or data were missing, we contacted corresponding authors of the publication. Seven of the fifteen authors provided requested additional information.

For the systematic reviews, two reviewers independently evaluated the quality of included reviews based on the AMSTAR scale, rating each of the 11 items on a binary scale (i.e., 'yes' (score 1), 'no' (score 0), 'not applicable' (score 0) or 'can't answer' (score 0)). Disagreements in the ratings between the two reviewers were discussed and, if a consensus decision was not reached, a third reviewer was called into make a final determination. The range of the overall quality score for each review was between 0 and 11. The total score was used to classify the overall quality of each review as high (total score 9 to 11), moderate (score 5 to 8), or low (score 0 to 4).[227] Systematic reviews were included for the comparison if AMSTAR score was 5 or higher.

4.3.4.2 Assessment of risk of bias in included studies

Cohort studies and uncontrolled before-after studies were included in this review. No randomised controlled trials were included, only a secondary data analysis of two randomised controlled trials. Cohort studies are observational studies in which the starting point is the selection of a study population or cohort. Information is obtained to determine which members of this cohort are exposed to the factor of interest.[229] Most studies in this review are based on registries of routine-data. Data on the patients' characteristics (demographics, admission characteristics and injury characteristics and the outcome(s) of interest are obtained from routine data-collection systems (e.g., hospital registries and national trauma registries).

Uncontrolled before and after studies measure performance before and after the introduction of an intervention in the same study site(s) and observed differences in performance.[230]

Two review authors independently assessed the risks of bias of included studies. Table 49 shows the domains we used for cohort studies and before-after studies according to the Cochrane guidelines and KCE-templates to assess the risk of bias for observational studies.

Table 49 – Domains for assessing risks of bias

Secondary data analysis of two randomised controlled trials [231]	Cohort study, uncontrolled before-after study [232]
Sequence generation	Selection bias
Allocation concealment	Detection bias
Blinding of outcome assessment	Attrition bias
Incomplete outcome data	
Selective outcome reporting	
Other bias	

4.3.5 Analysis

The primary analyses were partly narrative. When possible, studies and outcomes were pooled and further analyses were performed. Studies were included in a meta-analysis if they were: 1) of the same type, and have 2) the same population, 3) the same trauma care system, 4) the same comparison, 5) the same outcomes, and 6) the same statistical methods.

The included studies were explored on methodological and statistical heterogeneity. The latter were quantified by the I^2 statistic. An I^2 value >50% is considered to indicate substantial heterogeneity.[231, 233] It was expected that the data would carry a certain amount of heterogeneity and a random-effects model will be used. If the data turned out to be too heterogeneous for pooling based on methodological heterogeneity and statistical heterogeneity, we would perform a more descriptive review and summarise the available evidence for this intervention.

Evaluation of included studies for meta-analysis were conducted by two review authors (Maaike Langelaan (ML) and Nanne Bos (NB)) and in case of disagreement, the authors consulted a third reviewer (Julie Heeren (JH)). If possible, we conducted sub-analyses for paediatric and elderly trauma patients and for severity of injuries.

To synthesize the evidence, “best-evidence synthesis” was performed. As proposed by the Cochrane Back Review Group, the levels of evidence were ‘strong,’ ‘moderate,’ ‘limited,’ ‘conflicting’, or ‘unknown’.[234] Only RCTs could have the status of an excellent study (low risk of bias). Cohort studies and other observational studies could have the status of fair quality (low to moderate risk of bias) if:

- Use of reliable data in a retrospective study
- Follow up rate of 80%+ and <10% difference in follow-up between groups
- Controlling for possible confounding

The cohort studies and observational studies that did not meet these criteria were qualified as poor quality (high risk of bias).

Table 50 – Levels of Evidence for the Quality of the Measurement Property

Levels	Description
Strong	Consistent findings in multiple studies of good methodological quality OR in one study of excellent methodological quality
Moderate	Consistent findings in multiple studies of fair methodological quality OR in one study of good methodological quality
Limited	One study of fair methodological quality
Conflicting	Conflicting findings
Unknown	Only studies of poor methodological quality

Source: van Tulder et al. (2003) [234]

If appropriate, statistical analyses were carried out using Stata 14.2.[235] For dichotomous outcomes including patient mortality, presence of a complication, and readmission, risk ratios with 95% confidence interval (CI) were used to assess differences in short-term patient outcomes in trauma centres and usual trauma care. For continuous outcomes, including length of hospital stay and length of stay at the ICU, standardized mean differences with 95% CI were calculated with the random effects model.

All outcomes are presented in a “Summary of main findings” table.

4.4 Results

In the search 12,023 references were identified and screened for relevance on title and abstract. 1076 titles were screened twice on title/abstract by the three reviewers. The inter-reviewer agreement was indicated as very good (Kappa 0.82, 95%CI 0.72 - 0.92).

All positive screened primary studies (N=269) and reviews (N=50) were full text searched for inclusion and exclusion criteria). Seven full-texts of primary studies could not be obtained. Finally, this resulted in 29 primary studies and 5 systematic reviews that fulfilled the inclusion criteria. Experts did not suggest any new studies.

4.4.1 Final sample of primary studies

A total of 29 primary studies were selected for data extraction (see section on the included studies in the report supplement).[139, 142, 178, 211, 236-260] Seventeen of the 26 cohort studies were based on registries of routine-collected data. Most studies (N=25) were single country studies and based on data from the USA. Four studies reported on differences between two countries (Table 51). Nine studies [236, 242, 244, 250, 252, 255, 258-260] compared care specific for paediatric patients and six for adults only.[178, 247-249, 254, 259] There were differences in the definitions of severely injured patients between the different studies, but most studies used the ISS as instrument to define the severity. The most frequently used threshold was an ISS score of 16 or higher. Excluded references and reason for the exclusion can be found in the report supplement.

Table 51 – Summary of study characteristics of included primary studies

Characteristic	Number of studies (N)
Type of study	
Cohort study	26
Uncontrolled before-after study	2
Secondary data analysis based on data of two RCTs	1
Country of origin	
Single country	
USA	17
France	1
Germany	1
The United Kingdom	2
Australia	1
Italy	1
The Netherlands	1
Canada	1
Two countries	
Germany and Finland	2
USA and The United Kingdom	1
USA and Canada	1
Specific study population	
Only paediatric patients	9
Only patients with a specific diagnosis	4
Only adults	6
Only geriatric patients	1
No specific study population	9

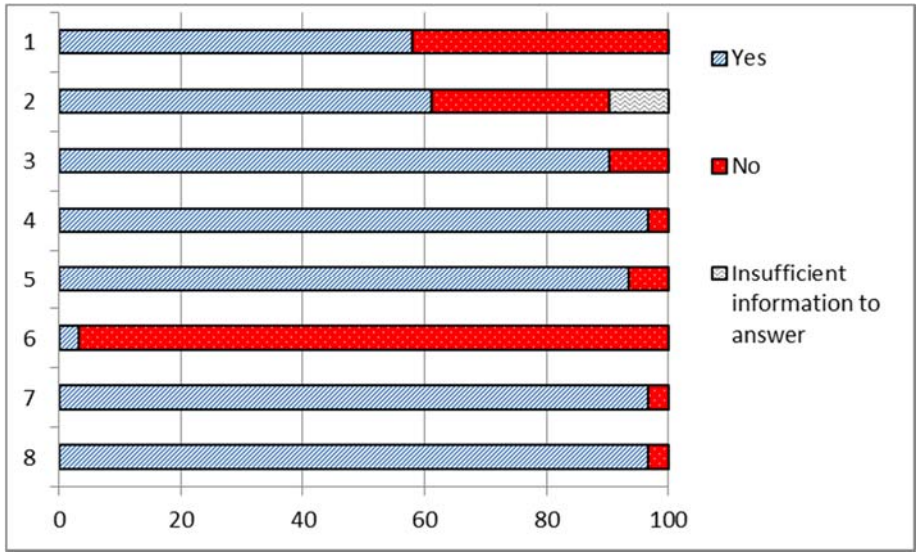
Characteristic	Number of studies (N)
Injury severity	
ISS≥15	2
ISS≥16	14
ISS>16	1
ISS≥25	2
Modified ISS≥25	1
ISS unclear	2
AIS≥3	4
ICISS<0.85	2
Unclear	1
Sample size of included studies (median, IQ-range)	
Median	4540
IQ-range	1054 – 21 360
Min-Max	65 – 414 074
Duration of data collection (years: median, IQ range)	4.1 (2.0 – 5.5)

4.4.2 *Risk of bias in included primary studies*

The most prevalent shortcomings were found in the items relating to selection bias and blinding to the exposure status (Figure 21). The methodological qualities of the individual studies are shown in the report supplement.

In none of the studies, the design could be rated as “high quality of evidence” as we found no randomised controlled trials.

Figure 21 – Proportion of primary studies presenting a risk of bias per item



1. Can selection bias sufficiently be excluded?
2. Are the most important confounding factors identified, are they adequately measured and are they adequately taken into account in the study design and/or analysis?
3. Is the exposure clearly defined and is the method for assessment of exposure adequate and similar in study groups?
4. Are the outcomes clearly defined and is the method for assessment of the outcomes adequate and similar in study groups?
5. Is the likelihood that some eligible subjects might have the outcome at the time of enrolment assessed and taken into account in the analysis?
6. Is the assessment of outcome made blind to exposure status?
7. Is the follow-up sufficiently long to measure all relevant outcomes?
8. Can selective loss-to-follow-up be sufficiently excluded?

4.4.3 Are trauma centres associated with better severely injured patient outcomes compared to non-trauma centres? What is the association between level of trauma centre and patient outcomes?

Twenty-two included studies had extractable data for severely injured patients on unadjusted in-hospital mortality and/or up-to-30 day mortality and/or emergency department mortality.

Five studies contained data on hospital length of stay and 4 on ICU length of stay.

We separated the analyses for three different intervention comparisons:

- High level (level 1 and/or level 2) trauma centres (TC) versus Non-trauma centres (NTC) (4.4.3.1)
- Higher level versus lower level trauma centres (4.4.3.2)
- Special features of a trauma system (3.8.3.3)

4.4.3.1 High level (level 1 and/or level 2) trauma centres (TC) versus Non-trauma centres (NTC)

Mortality

Five studies compared care for severely injured patients between a high level of trauma care (level 1 and 2) and non-trauma centres (Table 52 and Figure 22).[236, 244, 248, 253, 254] The study of Afifi 2015 reported on two comparisons between TCs and NTCs, for a mandated as well as a non-mandated trauma system. Afifi 2015 found a benefit for paediatric patients admitted to a NTCs and compared to TC in a mandated system; (presumably in-hospital) mortality rates were 19% (NTC) versus 30% (TC).[236] They also found a similar result for paediatric patients admitted to NTCs compared to TCs in a non-designated trauma system; mortality rates were 22.5% versus 33.3%.

In the study of Narayan 2015, severely injured trauma patients were more likely to survive in NTCs compared to higher level TCs.[254] This unexpected finding could be explained by a high proportion of transfers of extreme severely injured patients from NTCs and level 2 and 3 centres to level 1 centres. The crude mortality rate was 7.2% in the intervention group (TC) versus 6.1% in the comparison group (NTC). Morrissey 2015 found a survival benefit for severely injured patients admitted to a high level TC. In two studies no difference for in-hospital mortality was found.[244, 248]. Deasy 2012 and Kuimi 2015 found no significant differences for in-hospital mortality rates between level 1 or 2 TC and NTC.[244, 248] Because of clinical heterogeneity, no meta-analysis was performed.

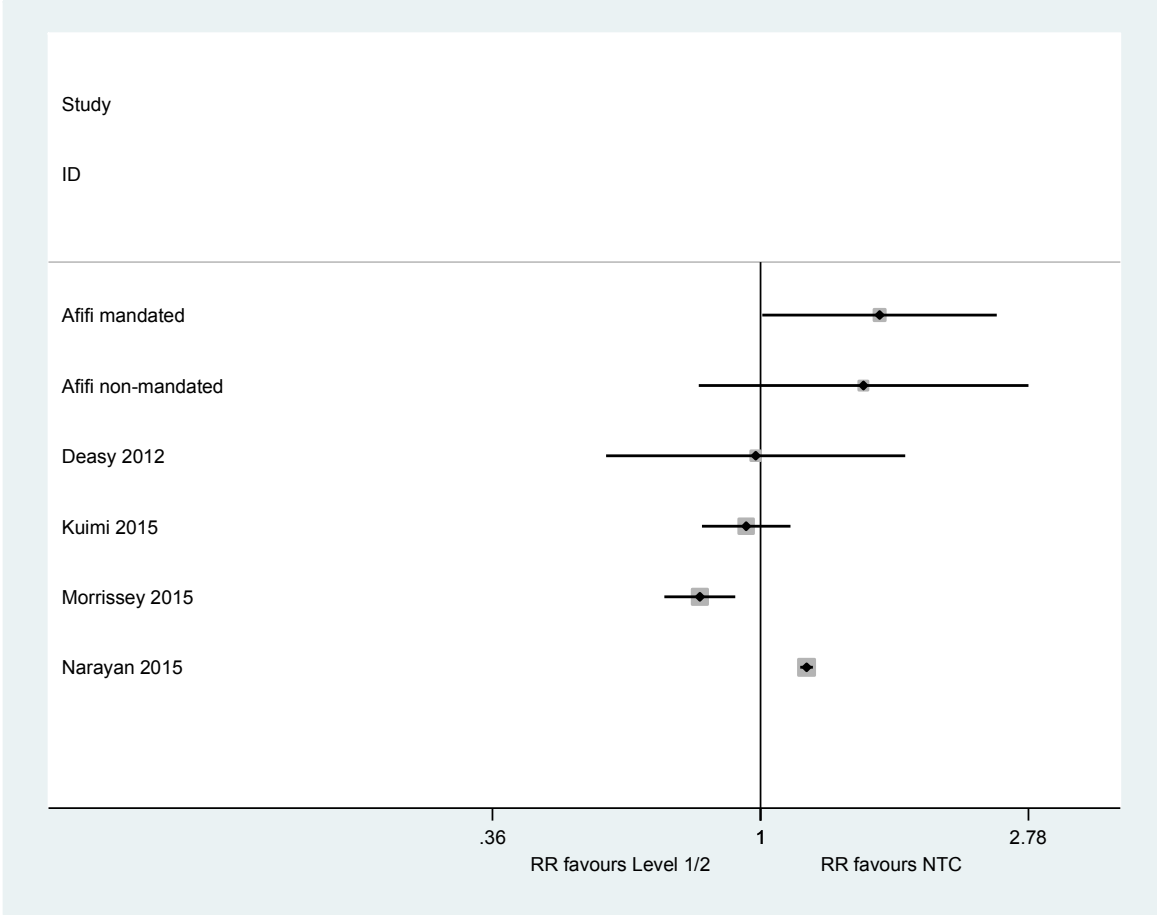
We noticed one article relevant for this comparison, but provided no data to extract [255].

The risk of bias in the five studies was moderate to high. The evidence for a difference between TCs compared to NTCs in unadjusted hospital mortality is conflicting.

Table 52 – Comparison "designated level 1 and/or level 2 TC" vs "NTC", outcome: unadjusted in-hospital mortality for all severely injured patients

Study	Study design	Study population	Country	Level of intervention group	Comparison group	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Afifi 2015	Cohort study	Paediatric	USA, Florida	Level 1+2 in mandated system	NTC in mandated system	103/349	18/96	1.57 (1.01-2.46)
			USA, Indiana	Level 1+2 in non-mandated system	NTC in non-mandated system	40/120	9/40	1.48 (0.79 -2.78)
Deasy 2012	Cohort study	Paediatric	Australia	Level 1 paediatric and adult	NTC	72/1077	13/191	0.98 (0.56 – 1.74)
Kuimi 2015	Cohort study	Only adults, no children	Canada	Level 1+2	NTC	1 454/20 885	137/1 864	0.95 (0.80 – 1.12)
Morrissey 2015	Cohort study	No special group	USA and UK	Level 1	NTC	733/3 588	202/785	0.79 (0.69 – 0.91)
Narayan 2015	Cohort study	Only adults, no children	USA	Level 1+2	NTC	8 301/114 481	21 497/353 443	1.19 (1.16 – 1.22)

Figure 22 – Comparison "designated level 1 and/or level 2 TC" vs "NTC", outcome: unadjusted in-hospital mortality for all severely injured patients



RR=relative risk

One study reported on the comparison between level 1 and NTC for 30 day (presumably after event) mortality (Table 53). The study of Di Bartolomeo 2014 found a significant difference for 30 day mortality rates in patients in favor of patients admitted to a NTC compared with patients admitted to a level 1 TC.[245]

However, in a subgroup patients with particularly severe injuries mortality was significantly lower when they were treated in TCs as compared to NTCs.

Based on one study, there is limited evidence for a negative effect of higher level TCs compared to NTCs on the 30-day in-hospital mortality rate for all severely injured patients combined.

Table 53 – Comparison "designated level 1 and/or level 2 TC" vs "NTC": unadjusted 30-day in-hospital mortality for all severe injured patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Outcome	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Di Bartelomeo 2014	Cohort study	No special group	Italy	Level 1	NTC	30 day in-hospital mortality	345/2419	183/1640	1.28 (1.08 – 1.51)

Vickers 2015 reported on ER mortality. Mortality in the emergency room was significantly lower for adult patients in level 1 or 2 trauma centres, compared to non-trauma centres (see following table).[259]

Based on one low quality study, there is limited evidence for the effect of higher level TCs compared to NTCs on the emergency room mortality rates.

Table 54 – Comparison "designated level 1 or 2 TC" vs "NTC", outcome: unadjusted mortality at emergency department for all severely injured adult patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Vickers 2015	Cohort study	Only adults	USA	Level 1+2	NTC	951/61358	1018/31335	0.48 (0.44 – 0.52)

Ashley 2015 compared 126 NTCs versus a combination of 6 level 1, 10 level 2, 2 level 3 and 1 level 4 trauma centres that were designated (DTC); the unadjusted in-hospital mortality rate at DTCs (15.1%) was higher compared with the rate at NTCs (12.1%). However, after adjusting for injury type and severity, patient demographics, the presence of comorbidities, insurance status and type, and selection bias, a 10% survival advantage on average for severely injured patients treated at a designated trauma centre (DTC) was observed.[237]

Hospital length of stay

Only one study reported the mean hospital length of stay in comparing higher level TCs to NTCs. Afifi 2015 concluded that there is no significant difference in hospital length of stay for severely injured paediatric patients.[236]

Based on one study, there is no evidence of effect with regard to hospital length of stay when level 1 or 2 TCs are compared to NTCs

Table 55 – Comparison Level 1+2 vs NTC, outcome: mean hospital length of stay

Study	Study design	Special group	Country	Level of intervention group	Level of comparison group	Intervention (mean/sd)	Comparison (mean/sd)	SMD (95% CI)
Afifi 2015	Cohort study	Paediatric	USA	Level 1+2	NTC	11.06 (12.7)	9.8 (14.6)	0.10 (-0.13 – 0.32)

Intensive care unit (ICU) length of stay

No studies were found in which ICU length of stay was compared between level 1 or 2 TCs versus NTCs.

4.4.3.2 *Higher level versus lower level trauma centres*

Mortality

For this comparison we found only studies with some type of mortality as outcome and none with regard to hospital or ICU length of stay.

Five studies compared the effect of a higher level TC with a lower level TC on in-hospital mortality, up-to-30 day mortality and ER-mortality.[238, 247, 250-252]

Two studies reported in-hospital mortality (Table 56 and Figure 23). Gomez 2015 states there was no significant difference in crude in-hospital mortality rate in patients admitted to a level 3 TC compared to patients that were transferred to a level 1 or 2 TC; however, Gomez adds that after adjusting for case-mix, patients who were admitted at level 3 centres had a 24% higher likelihood of death (OR1.24, 95% CI 1.08–1.43) when compared to those transferred to level 1–2 centres.[247] In our RR calculation the crude mortality rate appeared to be significant in favour of level 3 TC. Miyata 2015 found that, based on the crude in-hospital mortality rate, severely injured paediatric patients benefited from a level 1 TC compared to a level 2 TC.[252] Mortality rates were 12% versus 15% (Table 56 and Figure 23). However, when adjusted for injury severity, analyses showed no difference in mortality between centre types.

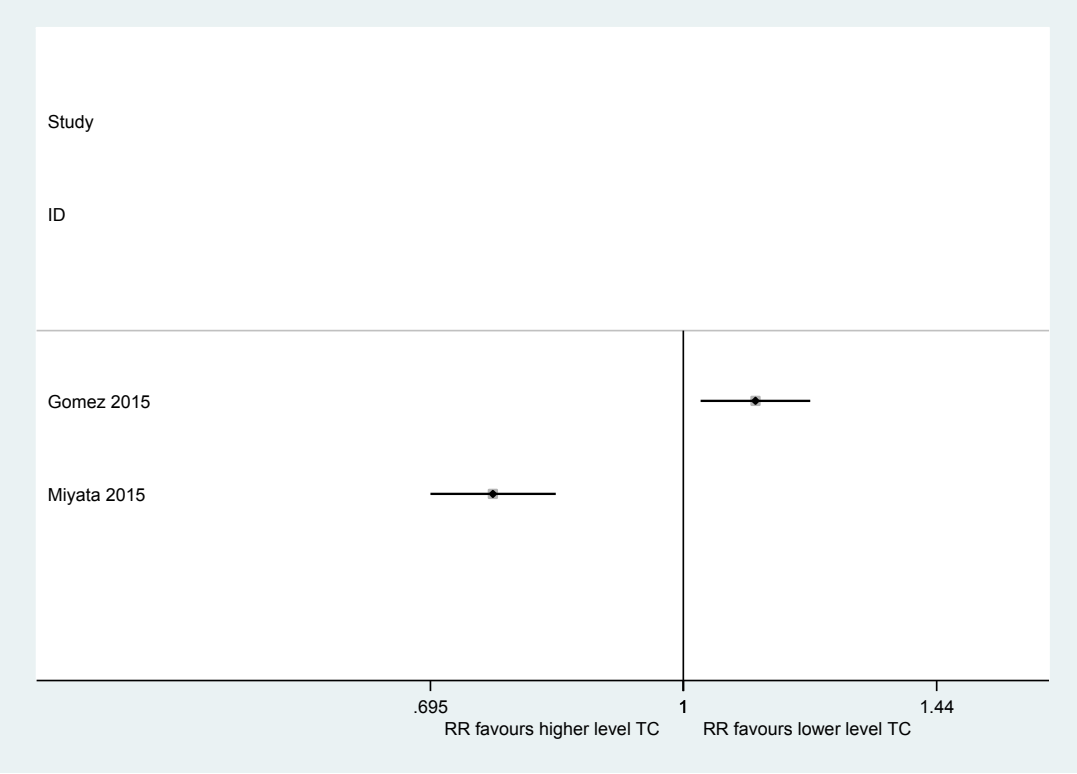
We noticed one article relevant for this comparison, but provided no data to extract [241].

The low quality studies reported conflicting evidence for a difference between higher level TCs compared to lower level TCs in unadjusted hospital mortality rates.

Table 56 – Comparison "higher level TC" vs "lower level TCs", outcome: unadjusted in-hospital mortality for all severely injured patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Outcome	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Gomez 2015	Cohort study	Only adults	USA	Level 1+2	Level 3	In-hospital mortality	4568/41165	632/6318	1.11 (1.03 – 1.20)
Miyata 2015	Cohort study	Paediatric	USA	Level 1 paediatric	Level 2 paediatric	In-hospital mortality	1132/9690	632/4113	0.76 (0.69 – 0.83)

Figure 23 – Comparison “higher level TC” vs “lower level TCs”, outcome: unadjusted mortality for all severely injured patients



RR=relative risk

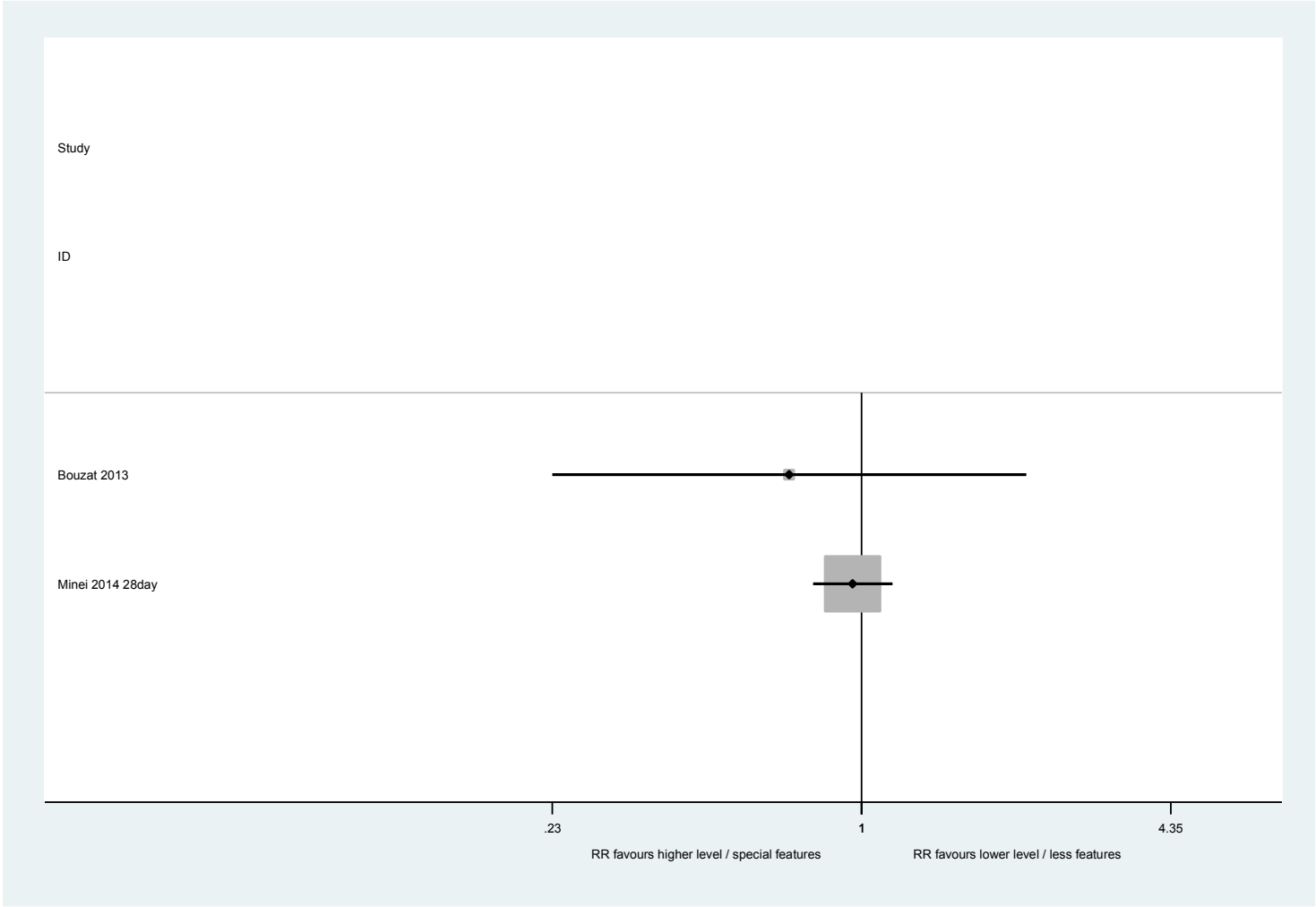
Three studies compared the higher level TCs with lower level TCs or NTCs for up-to-30 day in-hospital mortality (Table 57, Table 58, Figure 24 and Figure 25).[238, 251] The small study of Bouzat 2013 found a non-significant RR in the comparison between level I TC and level 2 TC.[238] Minei 2014 found no significant difference in both 24h mortality and 28 day mortality if level 1 TCs was compared to level 2 TCs.[251] Mills 2015 found no significant association between level of TC (level 1 versus level 2) and adjusted in-hospital 30-day mortality (no exact data was provided).[250]

Based on 3 studies, there is no evidence of effect that admission to a higher level TC is beneficial for severely injured patients on up-to-30 day in-hospital mortality.

Table 57 – Comparison "higher level TC" vs "lower level TCs": unadjusted 30-day in-hospital mortality for all severe injured patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Outcome	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Bouzat 2013	Cohort study	No special group	France	Level 1	Level 2	mortality at day 28 post trauma	4/29	7/36	0.71 (0.23 – 2.19)
Minei 2014	Secondary data analysis	Only patients with severe TBI or patients in shock	USA and Canada	Level 1	Level 2	28 day mortality	397/1649	102/406	0.96 (0.79 – 1.16)

Figure 24 – Comparison "higher level TC" vs "lower level TCs": unadjusted 30-day in-hospital mortality for all severe injured patients

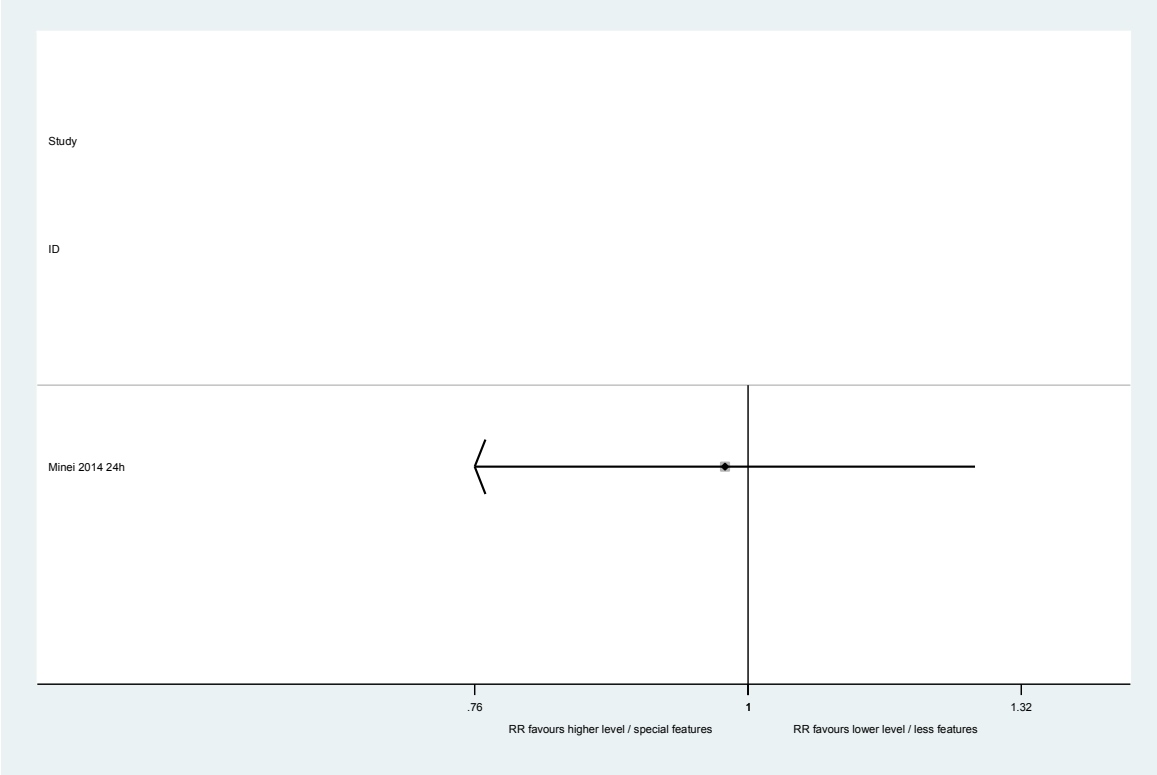


RR=relative risk

Table 58 – Comparison “higher level TC” vs “lower level TCs”: unadjusted 24h mortality for all severe injured patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Outcome	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Minei 2014	Secondary data analysis	Only patients with severe TBI or patients in shock	USA and Canada	Level 1	Level 2	24h mortality	254/1649	64/406	0.98 (0.76 – 1.26)

Figure 25 – Comparison “higher level TC” vs “lower level TCs”: unadjusted 24h mortality for all severe injured patients



RR=relative risk

Gomez 2015 reported the crude ER mortality in patients admitted to a level 3 TC compared to patients that were transferred to a level 1 or 2 TC as a subanalysis of the total in-hospital mortality rate. Mortality in the emergency room was significantly lower for adult patients in level 1 or 2 trauma centres compared to the level 3 TCs (Table 59).[247]

Based on one low quality study, there is limited evidence for the effect of higher level TCs compared to lower level on the emergency room mortality rates.

Table 59 – Comparison "designated level 1 or 2 TC" vs "lower level", outcome: unadjusted mortality at emergency department for all severely injured adult patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Gomez 2015	Cohort study	Only adults	USA	Level 1+2	Level 3	19/41165	23/6318	0.13 (0.07 – 0.23)

4.4.3.3 *Special features of a trauma system*

Mortality

Three articles focused on a change in care within the same TCs (Table 60). Afifi 2015 found no statistical differences in (presumably in-hospital) mortality for paediatric patients admitted to a designated TC in a mandated system versus a designated TC in a non-mandated system.[236] The same applied for the comparisons between admissions in a NTC in a mandated system versus a non-mandated system. Choi 2016 compared in-hospital mortality before and after ACS- of the paediatric TC.[242] According to Choi 2016, severely injured paediatric patients did not have a survival benefit from ACS-verification. Metcalfe 2014 showed that the launch of a trauma network in The United Kingdom resulted in a lower in-hospital mortality rate, but the difference was not significant (10% versus 13%).[139]

Cole 2016 evaluated the impact of the implementation of an inclusive pan-regional trauma system on quality of care (Table 61).[142] They found lower 72h mortality in the inclusive trauma system compared to a non-inclusive trauma system. Mortality rates were 7% versus 15%.

Table 60 – Comparison special features of a trauma centre versus less special features of a trauma centre in designated level 1 and/or level 2 TC", outcome: unadjusted in-hospital mortality for all severely injured patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Outcome	Intervention (n/N)	comparison (n/N)	RR (95% CI)
Afifi 2015	Cohort study	Paediatric	USA, Florida and Indiana	Level 1+2 in mandated system	Level 1+2 in non-mandated system	In-hospital mortality	103/349	40/120	0.89 (0.66 – 1.21)
				NTC in mandated system	NTC in non-mandated system	In-hospital mortality	18/96	9/40	0.83 (0.41 – 1.70)
Choi 2016	Before-after study	Paediatric	USA	Level 1 paediatric with ACS verification	Level 1 paediatric no ACS verification	In-hospital mortality	32/208	30/208	1.07 (0.67 – 1.69)
Metcalfe 2014	Before-after study	No special group	UK	Hospitals after launch of trauma network and designation to MTC	NTC (hospitals before designation as MTC)	In-hospital mortality	65/639	29/230	0.81 (0.53 – 1.22)

Table 61 – Different comparisons for outcome: unadjusted up to 72-hours mortality for all severe injured patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Outcome	Intervention (n/N)	comparison(n/N)	RR (95% CI)
Cole 2016	Cohort study	No special group	UK	Inclusive trauma system	Non inclusive trauma system	72h mortality	22/321	119/795	0.46 (0.30 – 0.71)

In this analysis three studies were included reporting the up-to-30 day mortality on meaningful changes in the organisation of trauma systems, without changing the level of trauma centre (Table 62). [178, 239, 240] Brinck 2015 and Brinck 2016 focused on the 30 day mortality in two different countries/trauma systems.[239 , 240] Severely injured patients in the German trauma system had higher risk to die within 30 days than severely injured patients in Finland. Joosse 2012 performed a small study on patients with severe traumatic brain injury.[178] They found no significant difference for unadjusted 30 day mortality between patients directly or indirectly transferred to a level 1 TC.

The variety of the interventions is too large to draw an overall conclusion about the effect of special features of TCs on mortality (all definitions confounded).

Table 62 – Special features in level 1 centres: unadjusted up-to-30-day in-hospital mortality for all severe injured patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Outcome	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Brinck 2015	Cohort study	No special group	Germany and Finland	German level 1 TCs	Helsinki Trauma Unit	30 day mortality	2847/19398	197/1624	1.21 (1.06 – 1.39)
Brinck 2016	Cohort study	Only unconscious patients	Germany and Finland	German level 1 TCs	Helsinki trauma unit	30 day mortality	2123/5243	139/398	1.16 (1.01 -1.33)
Joosse 2012	Cohort study	Only patients with severe TBI	The Netherlands	Direct transfer to level 1 TC	Indirect transfer to Level 1 TC	30 day mortality	15/56	8/24	0.80 (0.39 – 1.64)

Hospital length of stay

Metcalfe 2014 evaluated the effect of the establishment of the launch of a trauma network.139 Patients had a longer hospital stay after the launch of the trauma network. Brinck 2015 found that severely injured patients stayed longer in German hospitals than in the higher volume Helsinki trauma unit. Length of stay was significantly shorter for a TC with ACS than without this verification according to the study of Choi 2016. Ovalle 2014 found a significant difference in hospital length of stay in favour of adult trauma centre with a paediatric qualification (see table 63).

The variety of the interventions is too large to draw an overall conclusion about the effect of special features of TCs on hospital length of stay.

Table 63 – Comparison special features of a trauma centre versus less special features of a trauma centre in designated level 1 and/or level 2 TC", outcome: (median/mean) hospital length of stay for all severely injured patients

Study	Study design	Special group	Country	Level of intervention group	Level of comparison group	Intervention (mean/sd)	Comparison (mean/sd)	SMD (95% CI)
Brinck 2015	Cohort study	No special group	Germany and Finland	Level 1 TCs in Germany	Helsinki trauma unit in Finland	25 (22)	12 (12)	0.61 (0.56 – 0.66)
Choi 2016	Before-after study	Paediatric	USA	Level 1 with ACS verification	Level 1 no ACS verification	10.1 (1.2)	11.2 (1.4)	-0.84 (-1.04 – -0.64)
Ovalle 2014	Cohort study	Paediatric	USA	Adult TC with paediatric qualification	Adult TC no paediatric qualification	4.84 (0.16)	5.01 (0.17)	-1.03 (-1.09 – -0.97)

Study	Study design	Special group	Country	Level of intervention group	Level of comparison group	Intervention median	Comparison median	Mann–Whitney U test,
Metcalfe 2014	before- after study	No special group	United Kingdom	After launch of trauma network	Before launch of trauma network	14	12	0.599

Intensive care unit (ICU) length of stay

Four studies measured ICU length of stay to compare different aspects of the trauma system. Brinck 2015 found that severely injured patients in Germany had a higher mean ICU length of stay than the severely injured patients in the higher volume Helsinki trauma unit (respectively 12 versus 8 days). Zacher 2015 found the opposite; the severely injured patients in higher volume trauma centres had a longer mean length of stay at the ICU (respectively 10.7 versus 7.3 days). Choi 2016 concluded that ACS-verification of a level 1 TC significantly lowered the mean ICU length of stay. Metcalfe 2014 found no difference on ICU length of stay (median of 6 days) after the launch of a trauma network for severely injured patients (see following table).

The variety of the interventions is too large to draw an overall conclusion about the effect of special features of TCs on ICU length of stay.

Table 64 – Comparison special features of a trauma centre versus less special features of a trauma centre", outcome: (median/mean) ICU length of stay for all severely injured patients

Study	Study design	Special group	Country	Level of intervention group	Level of comparison group	Intervention (mean/sd)	Comparison (mean/sd)	SMD (95% CI)
Brinck 2015	Cohort study	No special group	Germany and Finland	Level 1 TCs in Germany	Helsinki trauma unit in Finland	12 (14)	8 (8)	0.29 (0.24 – 0.34)
Choi 2016	Before-after study	Paediatric	USA	Paediatric level 1 with ACS verification	Paediatric level 1 no ACS verification	4.1 (0.4)	4.8 (0.7)	-1.23 (-1.44 - -1.02)
Zacher 2015	Cohort study	No special group	Germany	High volume TC	Low volume TC	10.7 (14.4)	7.3 (9.4)	0.29 (0.25 – 0.32)

Study	Study design	Special group	Country	Level of intervention group	Level of comparison group	Intervention median	Comparison median	Mann–Whitney U test,
Metcalfe 2014	before- after study	No special group	United Kingdom	After launch of trauma network	Before launch of trauma network	6.0	6.0	0.181

4.4.3.4 *Secondary outcomes*

Metcalfe 2014 evaluated the patients with a good recovery according to the Glasgow outcome scale [261] at discharge. They found no significant difference for good recovery for severely injured patients after the launch of a trauma network.

Afifi 2015 found that significantly more severely injured paediatric patients were discharged home in TCs compared to NTCs. The difference between the patients discharged home from mandated versus non-mandated system was not significant.

Ovalle 2014 found significantly less hospital complications for severely injured paediatric patients admitted to a TC with a paediatric qualification compared to patients admitted to a TC without this qualification (Table 65).

Brinck 2015 compared the number of ventilation days between patients in a German trauma system compared to those in Finland; German patients were ventilated longer.

All evidence on the secondary outcomes is based on just one, low quality study per outcome. Therefore the evidence is limited.

Table 65 – Secondary outcomes for severely injured patients

Study	Secondary outcome	Special group	Country	Intervention group	Comparison group	Intervention (n/N)	Comparison (n/N)	Effect size
Metcalfe 2014	Glasgow outcome scale "good recovery" at discharge	No special group	UK	After launch of trauma network	Before launch of trauma network	254/639	90/230	1.02 (0.84 – 1.23)
Afifi 2015	Discharge home	Only paediatric patients	USA, Florida and Indiana	level 1+2 Mandated system	NTC Non-mandated system	138/349 55/120	58/96 20/40	0.65 (0.53 – 0.81) 0.92 (0.64 – 1.32)
Ovalle 2014	Hospital complications			adult trauma centres with paediatric qualification	adult trauma centres without paediatric qualification	333/2049	423/1871	0.72 (0.63 – 0.82)
Study	**Study design**	**Special group**	**Country**	**Intervention group**	**Comparison group**	**Intervention (median/IQ range)**	**Comparison (median/IQ range)**	
Brinck 2015	Ventilation days		Germany and Finland	Trauma system in Germany	Trauma system in Finland	10 (5-13) days	6 (5-7) days	

4.4.3.5 *Paediatric patients*

Five studies reported on unadjusted in-hospital mortality in severely injured paediatric patients (Table 66).[236, 242, 244, 252, 257] The studies report on trauma systems of different countries and compared different types of TCs. Therefore they are not comparable and an overall estimate could not be calculated. Afifi 2015 found that paediatric patients admitted to a NTC have lower in-hospital mortality rates compared to patients admitted to a higher level TC (mortality rates 19-22% versus 30-33%). Deasy 2012 found no differences in crude in-hospital mortality rate, but in adjusted analyses they found that being treated at a Level 1 trauma centre was associated with lower adjusted odds of in-hospital mortality [adjusted OR 95% CI: 0.27 (0.11, 0.68)] for Australian paediatric patients. Severely injured paediatric patients did not have a survival benefit from ACS-verification concluded Choi 2016. Ovalle 2014 evaluated the addition of a paediatric qualification to an adult TC. Ovalle 2014 reported that paediatric patients benefit from adults centres with a paediatric qualification compared to the usual adult TCs. Mortality rates were 13% versus 15%. Miyata 2015 showed that severely injured paediatric patients have better in-hospital mortality outcomes in a level 1 TC compared to a level 2 TC (mortality rate 12% versus 15%). However after using a matched –control cohort in level1 and level 2, benefits of being treated in a level 1 centre are no longer no statistically significant.

Sathya 2015, Mills 2015, Odetola 2016 and Wang 2013 also analysed in-hospital mortality rates in children treated in TC (compared to other settings) but data could not be extracted for the analysis included in Table 66.

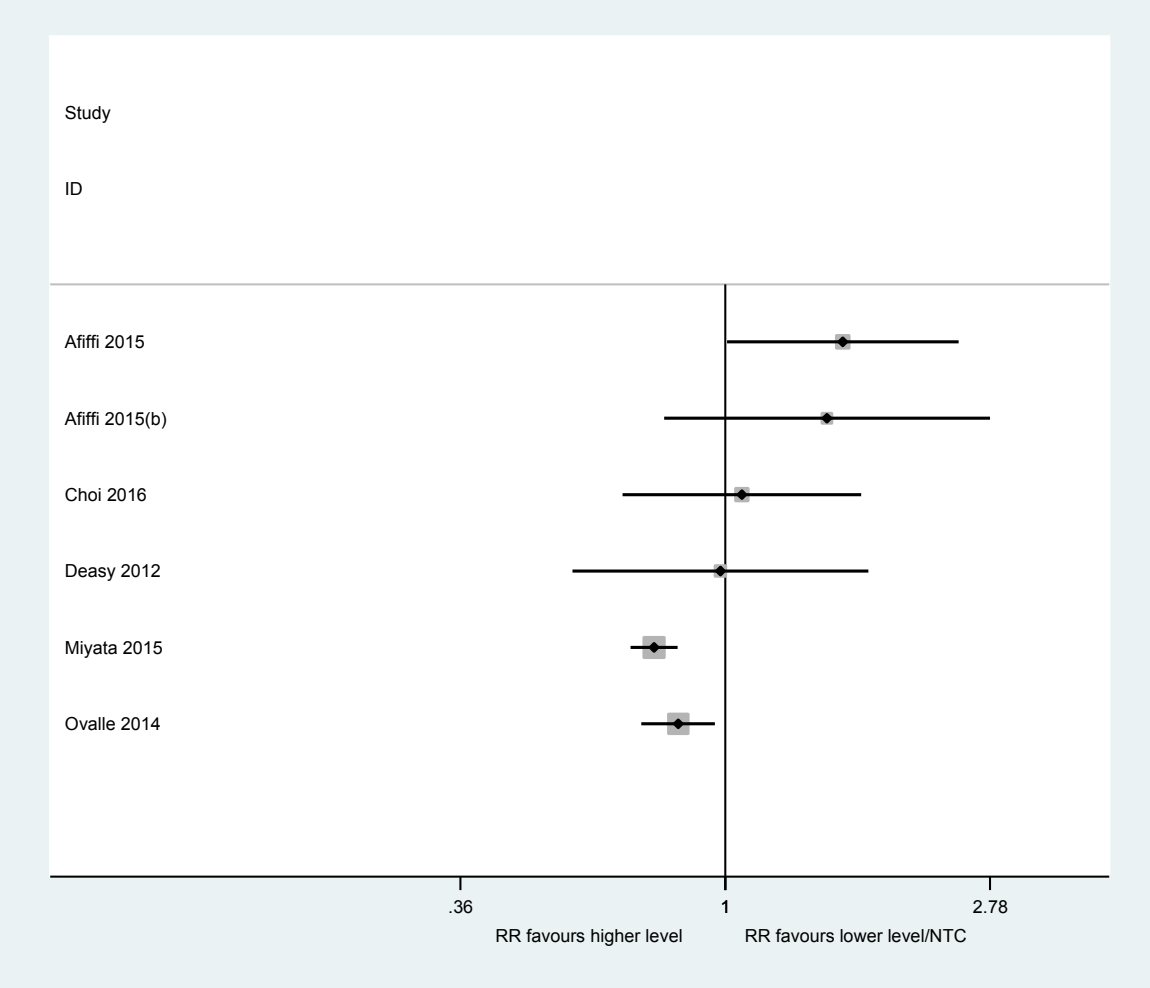
The low to moderate quality studies reported conflicting evidence for the effect of trauma care for paediatric patients.

Table 66 – Comparison "higher level" vs "lower level/NTC" or "special features" vs "less special features", outcome: unadjusted in-hospital mortality for all severely injured paediatric patients

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Intervention (n/N)	comparison (n/N)	RR (95% CI)
Afifi 2015	Cohort study	Paediatric	USA, Florida	Level 1+2 in mandated system	NTC in mandated system	103/349	18/96	1.57 (1.01-2.46)
			USA, Indiana	Level 1+2 in non-mandated system	NTC in non-mandated system	40/120	9/40	1.48 (0.79 -2.78)
Choi 2016	Before-after study	Paediatric	USA	Level 1 paediatric with ACS verification	Level 1 paediatric no ACS verification	32/208	30/208	1.07 (0.67 – 1.69)
Deasy 2012	Cohort study	Paediatric	Australia	Level 1 paediatric and adult	NTC	72/1077	13/191	0.98 (0.56 – 1.74)
Miyata 2015	Cohort study	Paediatric	USA	Level 1 paediatric	Level 2 paediatric	1132/9690	632/4113	0.76 (0.69 – 0.83)
Ovalle 2014	Cohort study	Paediatric	USA	Adult TC with paediatric qualification	Adult TC no paediatric qualification	299/2329	366/2378	0.83 (0.72 – 0.96)

RR=relative risk

Figure 26 – Comparison "higher level" vs "lower level/NTC" or "special features" vs "less special features", outcome: unadjusted in hospital mortality for all severely injured paediatric patients



RR=relative risk

Odetola 2016 compared outcomes for children with spinal cord injury treated in TC and non-TC. Odetola 2016 reported that despite the more severely injured receiving care at trauma centres, unadjusted mortality was not different in hospitalised children treated in TC vs. NTC (6.1 vs. 6.6%, p = 0.86).

Sathya compared in-hospital mortality for paediatric patients treated in adult TCs versus mixed TCs (adult and children), and paediatric TCs. Sathya 2015 found that severely injured children (ISS ≥25) treated at paediatric trauma centres (PTC) had lower odds of death compared to those treated at adult TCs and mixed TCs. These results hold for adjusted and unadjusted mortality rates.

Additionally, Wang 2013 demonstrated that, in California, seriously injured children cared for in TCs have decreased adjusted mortality compared to children cared for in non-trauma hospital settings.[260]

Mills 2015 compared 30-day in-hospital mortality after a severe traumatic brain injury in patients treated in Level I and II paediatric and adult TC. Mills 2015 found no significant association between level of TC (level 1 paediatric versus other TC) in adjusted in-hospital 30-day mortality (risk ratios presented in a figure).[250]

Table 67 – Comparison "higher level/ paediatric TCs" vs "NTC" or "lower level/paediatric TCs", outcome: overview of adjusted outcomes for mortality for all severely injured paediatric patients

Study	Special group	Country	Outcome description	Intervention group	Comparison group	Description effect size	Effect size
Sathya 2015	Only paediatric patients	USA	In-hospital mortality	Paediatric TC	Mixed TC	regression estimates (adjusted odds ratios)	1.62 (1.15-2.29)
				Paediatric TC	Adult TC	regression estimates (adjusted odds ratios)	1.75 (1.25-2.44)
Wang 2013	Only paediatric patients	USA	In-hospital mortality	TC	NTC	regression estimates (in percentage points)	-0.79 (-0.80 - -0.30)
				Paediatric TC	Adult TC	regression estimates (in percentage points)	0.64 (−0.26 - 1.54)

4.4.3.6 Geriatric patients

Olufajo 2016 concluded that major trauma geriatric patients mortality rate is significantly lower in level 2 versus level 1 trauma centres, and level 3/4 is not significantly better compared to level 1 trauma centres. [256]

Based on one low quality study, there is limited evidence for the effect of higher level TCs compared to lower level TCs on the in-hospital mortality rate for geriatric patients.

Table 68 – Comparison "higher level TCs" vs "NTC" or "lower level TCs", outcome: overview of adjusted outcomes for mortality for all severely injured geriatric patients

Study	Special group	Country	Outcome description	Intervention group	Comparison group	Description effect size	Effect size
Olufajo 2016	Only geriatric patients	USA	In-hospital mortality	Level 1 TC	Level 2 TC	Adjusted OR	0.73 (0.57-0.93)
				Level 1 TC	Level 3-4 TC	Adjusted OR	0.75 (0.43 –1.33)

4.4.4 What is the association of the severity of the injuries of the patient and the outcomes if treated in a trauma centre?

Six studies explored the relationship between severity of the injuries and mortality if treated in a trauma centre.[237, 245, 246, 248, 249, 259] Vickers 2015 compared patients with ISS 16-24 to ISS 25-75 and found that patients with ISS 25-75 have better outcomes (lower mortality) at the emergency department in level 1+2 TCs compared to treatment at the emergency departments of NTCs (see Table 69).

Ashley 2015 looked at differences in survival between MTC and NTC for severe injury patients in total and per severity category. They found a 9.6 % improvement in survival probability for all severe injury patients in favour of a MTC, but in this was 8.3% in the least critical, 22% in the intermediate critical and 16.5% in the most critical patients; they concluded that patients with more severe injuries have better outcomes (higher probability of survival) at DTC compared to NTCs (Table 70). Di Bartolomeo 2014, Glance 2012, Kuimi 2015 found that a benefit appeared in terms of lower mortality as the severity of injury increased (Table 70). Di Bartolomeo 2014 found that MTC care, compared to NTC provided no survival benefit when analyzed for all severe injury patients together. However, in subgroup analysis a significantly decreased mortality by 30% was found in the most injured patients (TMPM-ICD9 > 0.12). Glance 2012 found that patient with an ISS between 9 and 15 and with ISS between 15 and 25 had similar risks of adjusted mortality in Level I and Level II trauma centres, but very severely injured patients (ISS >25) admitted to Level I trauma centres had a significant 22% lower odds) of mortality.

Matsushima 2016 found that level 1 centres had lower odds compared to level 2 centres of in-hospital mortality for patients with a higher ISS but not for patients that were less severely injured (no exact data was provided).

The six studies were of low to moderate quality and all pointed out in the same direction. There is moderate evidence that patients with more severe injuries have better outcomes in higher level TCs compared to lower level TCs or NTCs.

Table 69 – Comparison of higher level TCs versus lower level TCs or NTCs for different categories of severity of injury for outcome: unadjusted mortality for all severe injured patients in emergency department

Study	Study design	Study population	Country	Level of intervention group	Level of comparison group	Outcome	Injury severity	Intervention (n/N)	NTC (n/N)	RR (95% CI)
Vickers 2015	Cohort study	Only adults, no children	USA	Level 1+2	NTC	mortality in emergency department	ISS 16-24	314/44817	258/26021	0.71 (0.60 – 0.83)
							ISS 25-75	637/16541	760/5314	0.27 (0.24 – 0.30)

Table 70 – Comparison "higher level" vs "lower level/NTC" or "special features" vs "less special features", outcome: overview of other outcomes for mortality for different categories of severely injured patients

Study	Type of study	Special group	Country	Outcome description	Intervention group	Comparison group	Description effect size	Injury severity	Effect size
Ashley 2015	Cohort study	No special group	USA	Improvement in probability of survival when treated at a DTC versus NTC	DTC	NTC	probability	Most critical trauma (ICISS<0.25)	16.5% (p<0.01)
								Intermediate critical (0.25=<ICISS<0.5)	22.0% (p<0.01)
								Least critical (0.5=<ICISS<0.85)	22.0% (p<0.01)
Di Bartolomeo 2014	Cohort study	No special group	Italy	Effect estimate of trauma-centre care on mortality	Level 1 TCs	NTCs	OR	TMPM-ICD9 >0.12	0.71 (0.52 – 0.97)
								TMPM-ICD9 >0.10 & <0.12	0.75 (0.56 – 1.01)
								TMPM-ICD9 >0.08 & <0.10	0.77 (0.58 – 1.02)
								TMPM-ICD9 >0.06 & <0.08	0.89 (0.69 – 1.18)
								TMPM-ICD9 >0.04 & <0.06	0.91 (0.70 – 1.18)
								TMPM-ICD9 >0.02 & <0.04	0.98 (0.77 – 1.25)
								TMPM-ICD9 >0.00 & <0.02	1.51 (0.68 – 3.33)
Glance 2012	Cohort study	No special group	USA	Adjusted odds ratio of in-hospital mortality for level I versus level II trauma centres	Level 1 TC	Level 2 TC	OR	ISS>=15 & ISS<25	0.84 (0.64 – 1.03)
								ISS>=25	0.78 (0.64 – 0.95)
Kuimi 2015	Cohort study	Only adults, no children	Canada	in-hospital mortality associate with access to trauma care	Access to trauma care	No access to trauma care	OR	ICISS<0.85	0.99 (0.81 – 1.22)
								ICISS<0.75	0.91 (0.73-1.15)
Matsushima 2016	Cohort study	Only adults, no children	USA	in-hospital mortality for patients without DNR-order	Level 1	Level 2	OR	ISS 20	1.03 (0.77 – 1.38)
								ISS 60	0.55 (0.33 – 0.92)

4.4.5 *Are high patient volume centres associated with better short-term patient outcomes? Is there a volume threshold below which patient outcomes are worse?*

Three studies reported on the association of annual patient volume and short-term patient outcomes (Table 71 and Table 72).[211, 243, 251] Minei 2014 found no significant difference of unadjusted 28-day or 24-hours mortality for patients admitted to lower volume TCs compared to high volume TCs; however, in adjusted multivariate analyses it was found that as trauma centre admission volume increased there were reduced odds in both all-patient 24-hour and 28-day mortality of 7% for every 500 trauma patient admission increase to a trauma centre.[251]

Zacher 2015 concluded that the hospital volume of severely injured patients was identified as an independent predictor of survival. A clear cut-off value for volume could not be established, but at least 40 patients per year per hospital appeared beneficial for survival (Table 71).[211] Clement 2013 included patients with subdural, subarachnoid, and extradural haemorrhage following injury.[243] For patients admitted to higher volume TCs (≥6 admissions per year) there was a significantly reduced risk of in-hospital mortality as compared with the group with fewer than 6 annual patients (Table 72). However this conclusion must be interpreted with care as lower volume hospitals are more often lower level TCs that treat not only less patients but also less severe injured patients. These patients have obviously more chances to survive the injuries.

- There is limited evidence that patients admitted to higher volume TCs have a reduced risk of in-hospital mortality.
- Two thresholds were found: 6 and 40 patients per year per TC. For both thresholds the evidence for the effect of hospital volume on in-hospital mortality is limited as both thresholds are based on one lower quality study.

Table 71 – Comparison high volume TCs" vs "low volume TCs", outcome: unadjusted mortality for all severely injured patients

Study	Study type	Special group	Country	Outcome	Level of intervention group	Level of comparison group	Intervention (n/N)	Comparison (n/N)	RR (95% CI)
Minei 2014				28-day mortality	>= 3000	<= 1000	149/635	69/284	0.97 (0.75 – 1.24)
					>= 3000	1001 – 1999	149/635	116/504	1.02 (0.82 – 1.26)
					>= 3000	2000 – 2999	149/635	105/438	0.98 (0.79 – 1.22)
				24-hours mortality	>= 3000	<= 1000	96/635	41/284	1.05 (0.75 – 1.47)
					>= 3000	1001 – 1999	96/635	74/504	1.03 (0.78 – 1.36)
					>= 3000	2000 – 2999	96/635	71/438	0.93 (0.70 – 1.24)
Zacher 2015	Cohort study	No special group	Germany	In-hospital mortality	>=100 admissions per year	1-19 admissions per year	1195/5955	1235/7654	1.24 (1.16 – 1.34)
					>=100 admissions per year	20-39 admissions per year	1195/5955	1544/8264	1.07 (1.00 – 1.15)
					>=100 admissions per year	40-59 admissions per year	1195/5955	1361/6961	1.03 (0.96 – 1.10)
					>=100 admissions per year	60-79 admissions per year	1195/5955	1159/5761	1.00 (0.93 - 1.07)
					>=100 admissions per year	80-99 admissions per year	1195/5955	951/4694	0.99 (0.92 – 1.07)

Table 72 – Comparison "lower volume level TCs" vs "higher volume TCs", outcome: adjusted odds ratios for in-hospital mortality for severely injured neuro trauma patients

Study	Special group	Country	Outcome description	Intervention group	Comparison group	Description effect size	Effect size
Clement 2013	severely neuro trauma patients	USA	adjusted odds ratio for in-hospital mortality	6-11 admissions per year	<6 admissions per year	adjusted OR	0.45 (0.29 – 0.68)
				12-23 admissions per year	<6 admissions per year		0.56 (0.38 – 0.81)
				24-59 admissions per year	<6 admissions per year		0.63 (0.44 – 0.90)
				>= 60 admissions per year	<6 admissions per year		0.59 (0.41 – 0.87)

4.4.6 Systematic reviews

The report supplement includes details on the systematic reviews that were included (N=5) [106, 221, 262-264] or excluded (N=45) [108, 124, 265-307] for comparison with our final results. Four of these systematic reviews report on the effect on mortality or length of stay related to different levels of trauma care or specialized trauma care versus non-specialized trauma care.[221, 262-264]

Mann 1999 based on 42 (USA & Canada) studies concluded that the evidence is 'suggestive' that hospital mortality is reduced in severely injured trauma patients with the implementation of trauma care system, but also that compelling evidence is lacking.[264] Biewener 2005 performed a review that focused on pre-hospital airway transport and to a smaller extent on the comparison of mortality between level 1 and lower levels of trauma centres. For this comparison they could include 6 studies, originating from USA (2), Canada (2), Australia (1) and Germany (1). In 5 of the 6 studies a significant lower mortality rate was found for level 1 trauma centres. However, the author warns that weak study designs and high heterogeneity prohibits definitive conclusions.[262] Celso 2006 found an improved odds of survival in 8 of the 14 included (13 USA & 1 Canada) studies after the implementation of a trauma system; they also performed a meta-analysis based on 6 studies that showed a 15% reduction in mortality in favour of the presence of a trauma system.[263] The most recent systematic review on this topic of Kim 2014; they included 50 studies (of which 47 originated from USA & Canada): 10 of 17 articles showed that level I trauma centres had better patient outcomes (mainly mortality) than level II centres; the achievement of trauma centre verification by American College of Surgeons or State was beneficial to decreasing mortality and length of stay in 9 of 11 studies; the relationship between volume of annual trauma patients and in-hospital mortality and hospital length of stay was not clear but high trauma admission volume was beneficial in 8 of 16 studies.[221]

Along with Kim (2014)[221], Caputo et al. (2014)[106] focused on the relationship between patient volume and mortality. Of the 16 articles on this topic included in each review, 10 are common to both them.

Caputo 2014 focused on the relationship between patient volume and mortality in level I trauma centres; they included 19 USA studies: Sixteen studies examined the relationship between institutional trauma centre volume and mortality. Of the 16 studies, 12 examined the volume of severely injured patients and 8 examined overall trauma patient volume. High institutional volume was associated with at least somewhat improved mortality in 10 of 16 studies (63%); however, nearly half of these studies found only some subpopulations experienced benefits. In the remaining six studies, volume was not associated with any benefits. Four studies (25%) analysed the impact of surgeon volume on mortality. High volume per surgeon was associated with improved mortality in only one of four studies (25%).

In line with Mann 1999 and Kim 2013 we found conflicting evidence about reduced mortality rates in higher level trauma centres based on 29 primary studies.

With regard to volume, the reviews of Kim 2014 and Caputo_2014 warn that the evidence base is not firm, due to weak (mainly retrospective) study designs and large heterogeneity (e.g. severity of injury, definitions used) between studies. Both reviews state that definitive conclusions cannot be drawn about the impact of higher level of trauma centres or higher volume of patients on mortality. We conclude that there is limited evidence that patients admitted to higher volume TCs have a reduced risk of in-hospital mortality. In accordance to both systematic reviews we found the quality of studies low.

Most reviews discussed the problem of the diversity among the included studies. Unclear and variations of definitions (trauma centres/levels, patients, injury severity scores) and incompleteness of data registries made it difficult for authors to formulate generalizable recommendations. Also the heterogeneity of data-analyses was discussed and made it difficult to perform meta-analyses. Mann 1999 addresses this issue by criticizing the study designs of the included studies resulting in a lack of evidence. Therefore most reviewers recommend further research on this topic, which takes into account the above mentioned limitations before sound conclusions and recommendations can be formulated. We agree to this conclusion.

4.5 Discussion

Our systematic review revealed 29 studies of variable methodological quality examining short term outcomes for the organisation of trauma care for severely injured patients. Short-term outcomes included in-hospital mortality (up to 30-day mortality after discharge), length of stay in hospital and in the ICU. Studies including mortality, however, only had information on in-hospital mortality. The studies were clinically and statistically heterogeneous and as a consequence we could not perform a meta-analysis.

4.5.1 Summary of main results

Table 73 shows a summary of the main findings. The effect of higher level TCs (for example level 1 or level 2 TCs) compared to lower level (e.g. level 3 TCs or NTCs) or TCs with more special features compared to TCs with less special features was analysed. We found conflicting evidence for the effect of higher level trauma centres compared to lower level trauma centres or non-trauma centres for all severely injured patients and for severely injured paediatric patients. There is limited evidence that patients benefit from admission to an emergency room in a higher level trauma centre compared to lower level care. We found some evidence that admission to a higher level trauma centre reduces the hospital length of stay compared to admissions at a non-trauma centre, but this evidence was not found for ICU length of stay. Some improvements in trauma care to achieve more special features, i.e. ACS verification, setting up an inclusive trauma system or having a paediatric qualification in an adult trauma centre, seem to be effective, but the evidence is limited.

Patients with the most severe injuries seems to benefit from admissions to higher level trauma centres compared to patients with less severe injuries. One explanation might be that patients with the most severe injuries admitted to a high level TC are younger than patients admitted to a lower level TC or NTC. Elderly patients with trauma are at high risk for complications and death from injuries that would not necessarily prove fatal to their younger counterparts.[26]

We could not find evidence that there is a positive relation between hospital volume and patient outcomes and no optimal threshold for hospital volume was found.

Table 73 – Summary of main findings

Research question	Sub analysis	Studies (N)	Best evidence synthesis	Comparing best evidence synthesis with systematic reviews
Are trauma centres associated with better severely injured patient outcomes compared to non-trauma centres? What is the association between level of trauma centre and patient outcomes?	unadjusted mortality for “designated level 1 and/or level 2 TC” vs “NTC”	5	The risk of bias in the five studies was moderate to high. The evidence for a difference between TCs compared to NTCs in unadjusted hospital mortality is conflicting.	Mortality rates can be lowered significantly through primary treatment at a level 1 TC
		1	Based on one study, there is limited evidence for a negative effect of higher level TCs compared to NTCs on the 30-day in-hospital mortality (presumably after event) mortality rate for all severely injured patients combined.	Reduction in mortality in favour of the presence of a trauma system Achieving ACS trauma centre verification is beneficial to patient outcomes.

Research question	Sub analysis	Studies (N)	Best evidence synthesis	Comparing best evidence synthesis with systematic reviews
		1	Based on one low quality study, there is limited evidence for the effect of higher level TCs compared to NTCs on the emergency room mortality rates.	The benefit of level 1 centres compared to level 2 centres is not clear
		1	Based on one study, there is no evidence of effect with regard to hospital length of stay when level 1 or 2 TCs are compared to NTCs	Weak evidence that organised systems of trauma care are an effective health care policy.
	unadjusted mortality for "higher level TC" vs "lower level TC"	2	The low quality studies reported conflicting evidence for a difference between higher level TCs compared to lower level TCs in unadjusted hospital mortality rates.	
		3	Based on 3 studies, there is no evidence of effect that admission to a higher level TC is beneficial for severely injured patients on up-to-30 day in hospital mortality.	
		1	Based on one low quality study, there is limited evidence for the effect of higher level TCs compared to lower level on the emergency room mortality rates.	
	special features of a trauma centre versus less special features	7	The variety of the interventions is too large to draw an overall conclusion about the effect of special features of TCs on mortality (all definitions confounded).	
		4	The variety of the interventions is too large to draw an overall conclusion about the effect of special features of TCs on hospital length of stay.	
		4	The variety of the interventions is too large to draw an overall conclusion about the effect	

Research question	Sub analysis	Studies (N)	Best evidence synthesis	Comparing best evidence synthesis with systematic reviews
			of special features of TCs on ICU length of stay.	
		4	All evidence on the secondary outcomes is based on just one, low quality study per outcome. Therefore the evidence is limited. Secondary outcomes • Glasgow outcome scale "good recovery" at discharge • Discharge home • Hospital complications • Ventilation days	
	unadjusted in-hospital mortality rates for trauma care for children	5	The low to moderate quality studies reported conflicting evidence for the effect of trauma care for paediatric patients.	
	unadjusted in-hospital mortality rates for trauma care for geriatric patients	1	Based on one low quality study, there is limited evidence for the effect of higher level TCs compared to lower level TCs on the in-hospital mortality rate for geriatric patients.	
What is the association of the severity of the injuries of the patient and the outcomes if treated in a trauma centre?	Hospital mortality for higher trauma care versus lower trauma care for different categories of injury severity	6	The six studies were of low to moderate quality and all pointed out in the same direction. There is moderate evidence that patients with more severe injuries have better outcomes in higher level TCs compared to lower level TCs or NTCs.	Not reported
Are high patient volume centres associated with better short-term patient outcomes? Is there a volume threshold below which patient outcomes are worse?	Unadjusted mortality for "higher volume TC" vs "lower volume TC"	3	There is limited evidence that patients admitted to higher volume TCs have a reduced risk of in-hospital mortality.	The relationship between volume of annual trauma patients and outcomes is not clear. It is unclear whether an optimal volume exists It has not been demonstrated that the ACS criteria improves survival
	Volume threshold below which patient outcomes are worse	2	Two thresholds were found: 6 and 40 patients per year per TC. For both thresholds the evidence for the effect of hospital volume on in-hospital mortality is limited as both thresholds are based on one lower quality study.	

4.5.2 Potential biases in the review process

The large number of studies not fulfilling our inclusion criteria demonstrates the degree of difficulty in constructing a concise search in this area. This is mainly caused by a huge variability in the definitions used for trauma centres and severely injured patients. For example, studies from Canada mainly use another threshold for severely injured trauma patients.[308, 309] Other studies reported on the longitudinal outcomes of trauma systems without or with a minor change in aspects of the trauma system.[14, 80, 310, 311,181] Surprisingly, the number of studies reporting on volume and effect of trauma systems on patient outcomes was low. As a result of our focus on comparison between different levels of TCs in trauma systems, articles about the relationship between volume and patient outcomes may have been excluded from the selection.

Some studies were excluded because they failed to provide enough information on the patient or hospital characteristics or on the outcome measures. It is possible that the studies which analysed data from the same registry resulted in patients being counted twice. There is time overlap between these studies and inclusion criteria are not equal. Furthermore, registry data may have been limited by incomplete registration of interventions and outcomes. Some studies did not provide data for calculation of unadjusted mortality, and this may have influenced the possibility of calculating an overall relative risk of unadjusted mortality.

On the other hand, reporting the unadjusted outcomes did not reflect on the differences between study populations and hospital characteristics, limiting the evidence for our findings. It was interesting to see that some conclusions were reversed depending of adjusted or non-adjusted outcomes were used; however, different authors used different variables to adjust their analyses, making it impossible to compare adjusted outcomes across studies.

Besides the analyses were limited by under powering of studies due to small sample sizes or mortality rates, and the lack of adjustment for possible confounders.

The risk of publication bias is a well-recognized limitation of systematic reviews.[312] This was minimized by including studies in all languages in order to avoid bias introduced by the tendency to publish very unique results in an English journal and otherwise in a journal of native language. However, the number of non-English articles published in electronic indexed journals is limited.

4.5.3 Quality of the evidence

We found no randomised controlled studies. Because this was suspected, we had chosen to include cohort studies, before-after-studies and routine-data-based studies a priori. This was done in order to pursue the best available evidence.[313]

The overall quality of the studies in this review was low as assessed by the risk of bias tools. All cohort studies had a high risk of bias across all domains. The low quality of the studies is supposed to lead to biased findings. Strong evidence can only be found in studies of high methodological quality. As our systematic review only retrieved studies of lower quality, the best evidence could not exceed a moderate level of evidence. Although the levels of evidence in this review were arbitrary, it seems unlikely that a different rating system would have resulted in different conclusions. A common study method was to use existing trauma registry data, but the registries use different definitions for inclusion. This makes comparison between the studies difficult. Generally, our conclusions are more conservative and therefore less convincing than the conclusions of the authors of the individual studies.

4.5.4 Implications for practice and research

Due to the weakness of the evidence and the clinical and statistical heterogeneity we were unable to determine an overall estimate for the benefit of trauma care for severely injured patients. Based on moderate or limited evidence the benefits of trauma care seems to be greatest for the most severely injured patients.

Further research is needed to evaluate the effect of the organisation of trauma care on short term patient outcomes like mortality and length of stay. In line with this, two systematic reviews are in progress and are expected to be published in 2017.[314, 315] At this moment, however, there is a lack of information and present studies lack quality. Ideally, a RCT would be used to test our hypothesis that mortality (up to 30 days after discharge), length

of hospital stay, and length of ICU stay are better for patients treated at a major trauma centre (MTC). However, it will be very difficult to perform because isolation of the interested trauma care component is difficult to realize in daily practice due to the complex organisation of hospitals.

Some studies report on the patient outcomes shortly after introduction of the trauma system or aspects of it. It is advisable to study the effect of the intervention both on short term (for example, 1 year after the introduction) as on long term (for example 3 years after the introduction). Also, not only in-hospital mortality rates provide information, but also 30-day mortality rates after discharge is relevant in the context of studying this topic. Including mortality after discharge could remove the bias introduced by in-hospital mortality in admissions with a shorter length of stay.[316]

Use of comprehensive nationwide trauma registries will be the most promising method to answer the research questions. The registries should include all data from prehospital care to hospital discharge and beyond. The registries should use the same definitions for all variables to make comparisons possible.

Key points

- **Based on moderate or limited evidence the benefits of trauma care seems to be greatest for the most severely injured patients presented to a higher level trauma centre.**
- **Establishing comprehensive National Trauma Registries can provide more solid answers the research questions.**
- **Further research is needed to evaluate the effect of the organisation of trauma care on short term patient outcomes like mortality and length of stay. At this moment there is a lack of information and present studies lack quality.**

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