KCE REPORT 281Cs

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

SHORT REPORT

TOWARDS AN INCLUSIVE TRAUMA SYSTEM FOR MAJOR TRAUMA

KCE REPORT 281CS
HEALTH SERVICES RESEARCH

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

TOWARDS AN INCLUSIVE TRAUMA SYSTEM FOR MAJOR TRAUMA

MARIA-ISABEL FARFAN, CECILE DUBOIS, PATRIEK MISTIAEN, AUDREY CORDON, SABINE STORDEUR, KOEN VAN DEN HEEDE

2017 www.kce.fgov.be

FOREWORD

Belgium, as is well known, is a ‘dense’ country: dense population, dense motorway network, dense traffic, etc., and also having a dense hospital network. Moreover, in the event of an accident, the time necessary to transport a casualty to the nearest hospital is remarkably short, on the order of ten minutes, while international standards generally recommend that 45 minutes not be exceeded. Can we be sure that everything is under control?

Let’s be clear, we are not speaking here of disaster situations, which our emergency services dealt with remarkably well during the tragic events of March 2016. We are speaking of the approximately 3000 deaths annually that plunge into mourning our roads, our worksites, our homes and our recreational areas on a daily basis.

A look beyond our borders teaches us that traumatology today is no longer the prerogative of an isolated hospital, however well-equipped it may be. In countries where the mortality statistics after a major trauma are low, victims are treated by highly qualified and smoothly functioning teams in highly specialised centres operating within integrated and structured geographical networks.

So here we are again at the heart of the dilemma – raised so many times by the KCE – between excellence and proximity. We have so many very well-equipped hospitals; it would be easy to multiply the number of ‘Major Trauma Centres’. But this would amount to diluting the essential experience, which would rapidly become counterproductive both in terms of chances of survival of the victims and in economic terms for society. In this report we have set up several benchmarks to delimit the ‘scope of the reasonable’ and avoid measures that are too ‘traumatising’.

So let us look at the positive side of things; we already have all the ingredients for putting in place an efficient system for treating major trauma. The issue is to distribute and coordinate them judiciously. This has been confirmed for us by the numerous field experts – Belgian and foreign – who have supported us in our work, and whom we warmly thank here.

The reform of the hospital landscape underway gives us a unique opportunity to go beyond the standard rivalries between hospitals to build efficient supraregional collaborations under the leadership of some reference centres. This appears to be the best solution for wresting additional lives from the statistics.

Christian LÉONARD
Deputy general director

Raf MERTENS
General director

SYNTHESIS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

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 ISS takes values from 0 until 75. 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 equal or higher to nine 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 severity 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 via the emergency department and undergo 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 acute 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 network).

Major trauma care in Belgium: lack of data and uniform approach for the territory

In Belgium, there is neither a formal 'trauma system' for the territory nor an official adopted definition for a 'major trauma patient[1]'' 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.

Rainer et al. (2003)[35] state that the perfect trauma system does not exist, but that it may be better to have a system rather than no system at all.

[1] 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.

2 OBJECTIVE OF THE REPORT

The current study provides a second analysis of the organisation of emergency departments[36], this time with a focus on major trauma. The previous Ministerial Cabinet (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?

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)[37] 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 in October 2016[38] (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.

Supraregional collaborations will 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 – Vision statement of Minister De Block[38]

- 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). Major trauma centres will be the focal node of the supraregional collaboration.

3 METHODS

This short report focuses on the main messages drawn from the scientific research. For interested readers, detailed methods along with exhaustive results are available in the scientific report. A summary of the methods used is presented hereafter:

Chapter 1 of the scientific report 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. For this analysis, we used two different databases with for each database a specific selection of 'major trauma' patients:

- **The Mobile Intensive Care unit (MICU)** (*'Service Mobile d'Urgence' (SMUR) – 'Mobiele Urgentie Groep' (MUG))* database includes data on the pre-hospital setting since data about interventions of the mobile intensive care units are registered. We used the variable including a 'severe trauma' as one pathology or condition;
- **The Minimum Hospital Discharge (MHD)** *('Résumé Hospitalier Mimum' (RHM) – 'Minimale Ziekenhuis Gegevens' (MZG))* database includes data about the in-hospital setting. We restricted the analysis to in-patient stays for multiple significant trauma (Major Diagnostic Category (MDC) = 25). This choice was made in order to unambiguously identify patients with severe trauma, with the knowledge that this only concerns a subgroup of major trauma patients.

The combination of these two databases gives an overview of trauma care in the pre-hospital and in-hospital setting.

Chapter 2 of the scientific report includes an in-depth analysis of the organization of trauma care in three neighbouring countries: England, The Netherlands and Germany. The three countries were selected because:

- Recognised or accredited major trauma centres were operational for at least 2 years and reports and evaluations on the centres activities were available;
- Minimum requirements for recognition/accreditation of major trauma centres were available;
- An accreditation process was piloted at national level and a national trauma registry was set up. The accreditation process is performed by an independent evaluator.

Information for other European and non-European countries on the main characteristics of the networks was gathered in order to have a larger perspective on the organisation of trauma care in developed countries.

Chapter 3 of the scientific report includes the evaluation of the evidence 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. Information was obtained via a systematic review of the literature for primary studies published since 2012. The results of the recent literature were compared with those published in other earlier relevant systematic reviews.

4 CARE FOR MAJOR TRAUMA PATIENTS IN BELGIUM

In this section we provide a description of:

- the organisation of the 'Urgent Medical Care' services *('Aide médicale urgente' – 'Dringende Geneeskundige Hulpverlening')* and the transport rules of medical emergencies;
- the degree of dispersion of 'major trauma' patients across Belgian hospitals.

For a detailed analysis of the Belgian situation, we refer the interested reader to first chapter of the scientific report.

4.1 The organization of 'Urgent Medical Care' services

The Law of 8 July 1964[39] dictates the main principles for the organisation of 'Urgent Medical Care' *('Aide médicale urgente' – 'Dringende Geneeskundige Hulpverlening')* in Belgium. The principles include to ensure:

- the immediate provision of help;
- the transport of the patient to an adequate hospital;
- the reception of the patient at an adequate hospital.

The Urgent Medical Care' encompasses pre-hospital emergency medical services, hospitals and advisory and consultative bodies:

- Dispatch centres ('centres d'appel unifiés' – 'eenvormige oproepcentra') where 'medical calls' are handled by non-clinical staff based on an initial standardized inquiry and a standardized 'process book';
- Emergency medical services are organised in a two-tier system (see Table 1) including ambulances ('112 ambulances) and mobile Intensive Care Units (MICU) ('Service Mobile d'Urgence' (SMUR) – 'Mobiele Urgentie Groep' (MUG). In addition, pilot initiatives projects for helicopter emergency medical services (HEMS) ('Services Médicaux d'Urgence Héliportés' (SMUH) – 'Medische Urgentie Groepen per Helikopter' (MUGH)) and for paramedical intervention teams (PITs) are also involved in pre-hospital care in Belgium;
- Hospital;

- The Commission for urgent medical help (COAMU – CoDGH);
- The Advisory and Consultative body for Emergency Medical Relief ('Conseil national des secours médicaux d'urgence' – 'Nationale raad voor dringende geneeskundige hulpverlening') and
- Strategic partners that can intervene in the case of a mass casualty incident.

4.1.1 Availability and organisation of emergency medical services

Differences between EMS services

The **MICU team** (an emergency physician specialised in emergency care and a nurse specialised emergency and intensive-care medicine) can provide all necessary medical and nursing care at the scene of the accident and provide supervision during the transport to the hospital.[40]

The MICU teams are a hospital function which is programmed based on the number of inhabitants (i.e. 140 000 inhabitants per MICU).[41] The MICU must be linked to a hospital with a specialised emergency department (see section 0). In case the intervention zone of a MICU includes more than one hospital with a specialised ED, agreements between hospitals about MICU have to be made (via so-called 'hospital associations').[40] In 2015, 84 out of 102 acute hospitals had a MICU function.

The **PIT team** (including a driver and a nurse specialised in emergency and intensive-care medicine) can intervene when the presence of a medical doctor is not required or to provide first aid assistance whenever the MICU is not available. The federal government started to finance PITs at the end of 2006 as pilot projects in order to increase the coverage of the Belgian territory with medically trained transport services. In 2014, 12 active PITs received a temporary 'pilot project' funding.[42]

There are also two **pilot projects for helicopter emergency medical services** (HEMS), staffed in a similar way as the MICU. They are located in Bruges and Bra-sur-Lienne. This type of transport can be used when it is required to[43]:

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

Ambulances are staffed by '2 rescuer – ambulance drivers' and receive a certification from the Federal Public Service (FPS) Health, Food Chain Safety and Environment[2] and must follow a basic training of a minimum of 160 hours. They participate in the transport of urgent medical transport for ill or injured persons to a specified hospital as is indicated by the dispatcher.

Choice of EMS transferred to the accident scene

After receiving an emergency call, the medical dispatcher assesses the patient's vital functions and decides which type of emergency medical services will be sent out as follows:

- 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) or when the MICU is not available (already deployed elsewhere). In the case where the PIT is not available (limited number of PITs) most often the dispatcher will upscale the severity and send a MICU;
- minor but urgent situation: 112 ambulance.
- If the most appropriate type of transport is not available within a reasonable timeframe, the dispatcher may sent the transport type that is available. It is estimated an EMS service can arrive within a 15 minute delay in more than 90% of the Belgian territory emergency care transport.[42]

---

2 Service public fédéral (SPF) Santé publique, Sécurité de la Chaîne alimentaire et Environnement – Overheidsdienst (FOD) Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu)

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

	Mobile intensive care units (MICU)[40]	Paramedic intervention teams PIT[44]	Ambulance[45, 46]
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 or equivalent • 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[47] • 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[47]
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)[48]	• Federal subsidies are dedicated to the implementation of PIT services [49]	• Federal subsidies are dedicated to ambulance services[50]

4.1.2 The acute hospital care landscape in Belgium

Two types of emergency departments

In Belgium, acute hospitals can have **specialised and non-specialised emergency departments (ED)**. **Specialised emergency** departments 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'.[36, 27, 51] 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.[36, 51] 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 equivalent) and one physician.[36, 51]

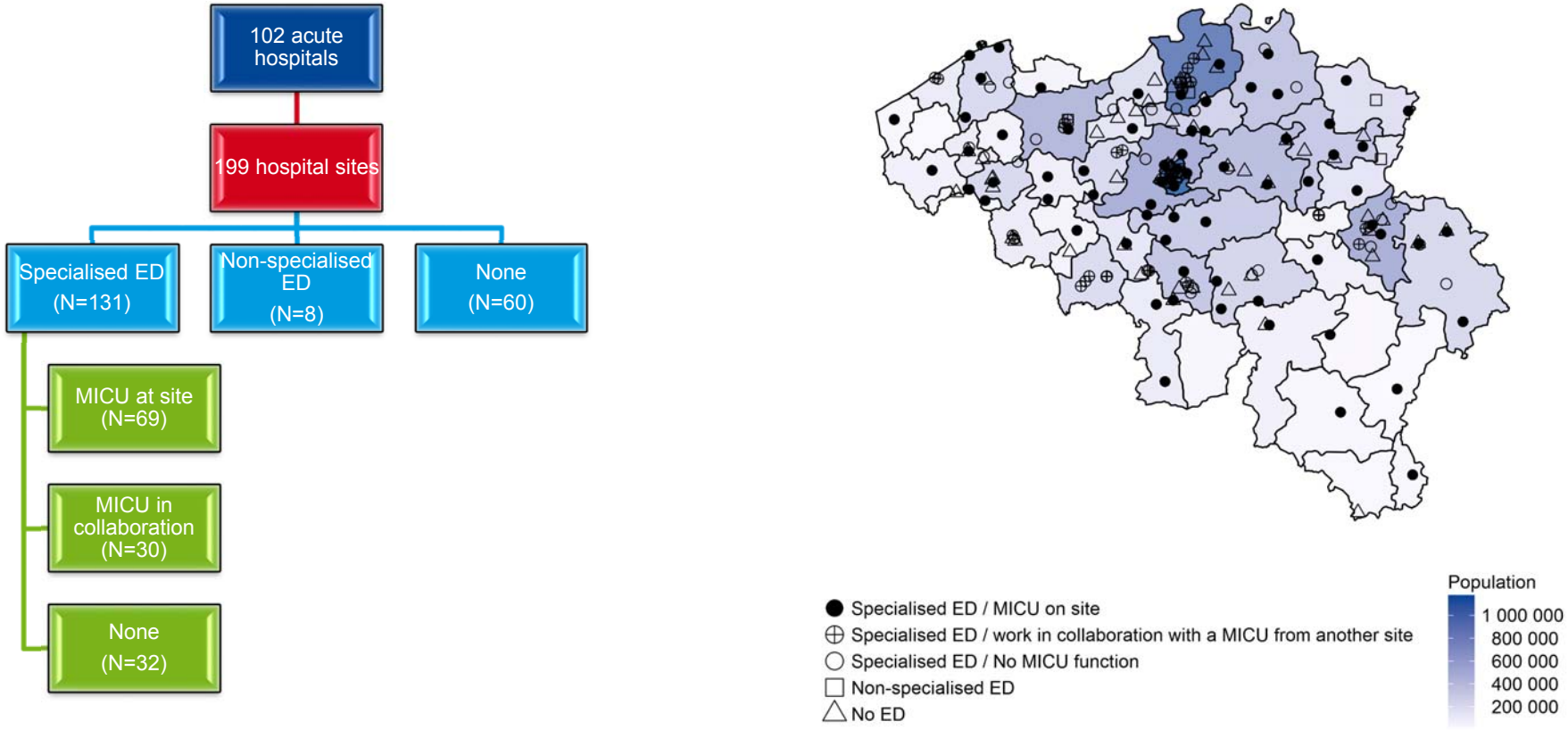
Acute hospitals without a 'specialised ED' are obliged to have a **non-specialised ED** that is capable to deal with the first care[52] and treatment of patients with an acute pathology. The recognition standards for non-specialised EDs are light compared to these of specialised EDs (e.g. nursing staff 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).[36] For a critical analysis of the supply and role of emergency departments, we refer the interested reader to the KCE report 263.[36]

Vast majority of acute hospital sites have specialised emergency departments

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. This results in 1.77 hospital sites per 100 000 habitants with an emergency department, which is high in the international context.[36] 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 function (see Figure 1).

It is well documented 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.[53] In theory, the infrastructure and medical equipment to provide care for major trauma patients is available. Yet, as described in a previous KCE report[36], this dense hospital landscape and more particularly the high density of emergency departments have an important downside. It results in a dispersion of budgets (i.e. to provide 24/7 availability) and expertise.

Figure 1 – Number of hospital's sites and number of beds by site of acute hospitals (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.

4.1.3 *Pre-hospital standards: refer patients to the closest and most adequate hospital*

As a general rule, the Royal Decree of 2 April 1965 on the organisation modalities for Urgent Medical Care[54] mandates that emergency medical services (EMS) transport the victim to **the nearest hospital with a specialised emergency department (ED).** However, under specific circumstances (see Box 2) the patient may be referred on to **closest and most adequate hospital's site**.

The Commission for urgent medical care of each province establishes a list of hospital specificities and protocols that are used by the dispatcher centres.[55] Based on these lists, the dispatcher can inform the emergency medical team about the location of the closest and most adequate hospital's site.[56]

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.[56]

Box 2 – What happens in case of an emergency?

1 – The European emergency number '112' is called;

2 – The emergency medical dispatchers handle 'medical calls' based on an initial standardised inquiry and a standardised 'process book'. The process book includes 40 specific protocols for the most common emergency situations (e.g. traffic accidents, falls from heights or head trauma) and helps the dispatcher to make a decision in terms of the means and medical personnel that need to be dispatched to the emergency scene.

3 – The 'emergency level' is established and the dispatcher decides which type of emergency medical services will be sent out:

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

4 – 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;

5 – The medical doctor of the mobile intensive care unit may indicate to the transport team to access another hospital if:

- The care capacity of the nearest hospital is overwhelmed after a collective emergency or disaster;
- The victim requires specific diagnostic or therapeutic procedures that are 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;
- The victims aged 14 years or younger are transported to a nearest hospital with specialised emergency department that also has a care program for children.

6 – If no doctor is present on the scene of the accident, the patient is transported to the hospital indicated to the EMS team

7 – The patient arrives in the hospital with a specialised Emergency Department (ED);

8 – Possible secondary transfer to another hospital for therapeutic reason;

9 – Patient is managed in the hospital site where he is finally admitted.

4.2 Analysis of the Belgian data

Due to the absence of a trauma registry in Belgium, it is currently not possible to fully assess the incidence of life-altering and life-threatening trauma related incidents in Belgium. Therefore, we used two data sources to assess the degree of dispersion of patients with major trauma: the MICU registries and the MHD data.

4.2.1 Pre-hospital data show timely access to acute hospitals but also a large degree of dispersion

The proportion of MICU interventions for severe trauma patients is relatively stable except among older patients

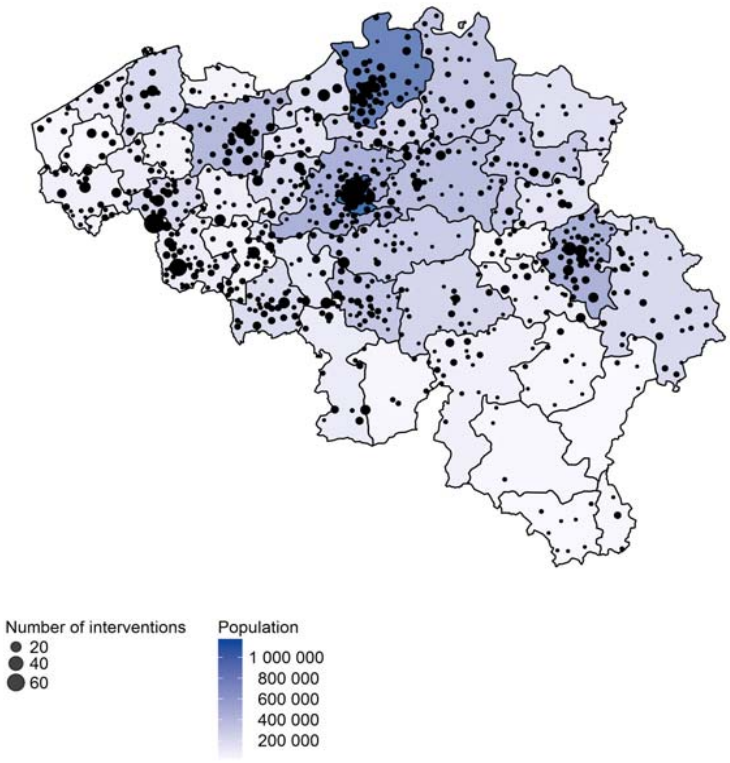
During the period 2009-2015, the number of interventions for severe trauma varies between 3 295 to 3 959 cases[3] per year without a clear time trend. 'Severe trauma interventions' represent between 3.6% and 4.8% of all MICU-interventions.

The proportion of severe trauma interventions for children (<16 years) was stable around 7%. The proportion of MICU interventions for older patients (≥75 years) increased over the years from 11% to 14%.

Severe trauma patients: falls and traffic accidents are the main causes

In 2015, there were 3 856 interventions for severe trauma cases of which falls (n=1 396; 36%) and traffic accidents (n=1 332; 35%) were the two most common causes. The MICU-interventions for severe trauma were spread over the territory with a higher frequency in very densely populated cities but also near the border in the south-west of the territory (Figure 2). Given the lack of standardisation in the coding of the severe trauma in the MICU registry, it is unclear if these regional differences represent reality or differences in coding practices. The observed differences should be interpreted with caution.

Figure 2 – Place of intervention for severe trauma (Data 2015)



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

[3] These data include only patients that are transported to the hospital. Patients who died on scene or in the ambulance were excluded from the figures.

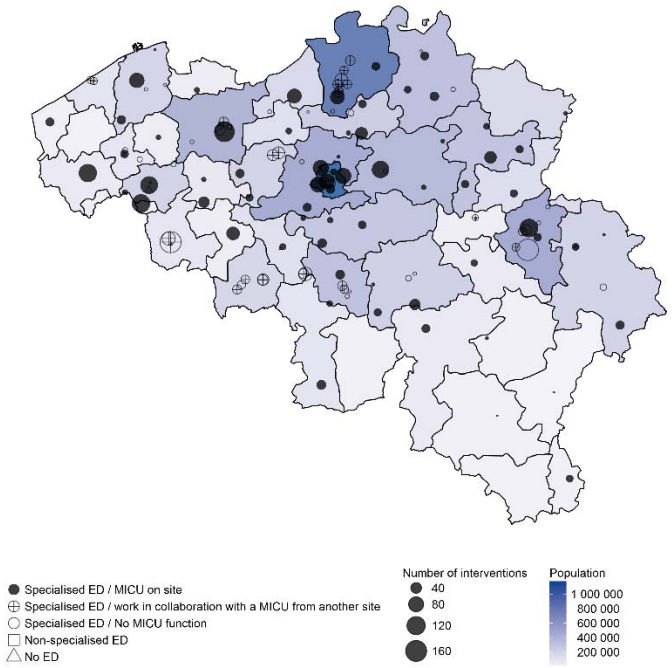
Patients with severe trauma are transported to a (too?) large number of hospital sites resulting in (too?) few cases per hospital site

In 2015, 3 856 severe trauma cases were transported to 145 different hospital sites (Figure 3) resulting in a median of 17 cases per hospital site (IQR4 4 – 30) and with a minimum of 1 and maximum of 165 interventions per site. The majority of the severe cases were transported to hospital sites with a specialised ED and with a mobile intensive care unit attached directly to (or in association with) hospital site. The majority of the sites admitting patients with severe trauma have at least one CT-scan (98% of the sites) and a MRI (76%). The dispersion of major trauma cases is obviously linked to the combination of the legal provisions (i.e. transport to the most adequate nearest hospital) and the high density of emergency departments [36] Taking into account these results, we may wonder whether, in the long-term, the dispersion of patients will allow to ensure the medical expertise of the teams while being financially viable.

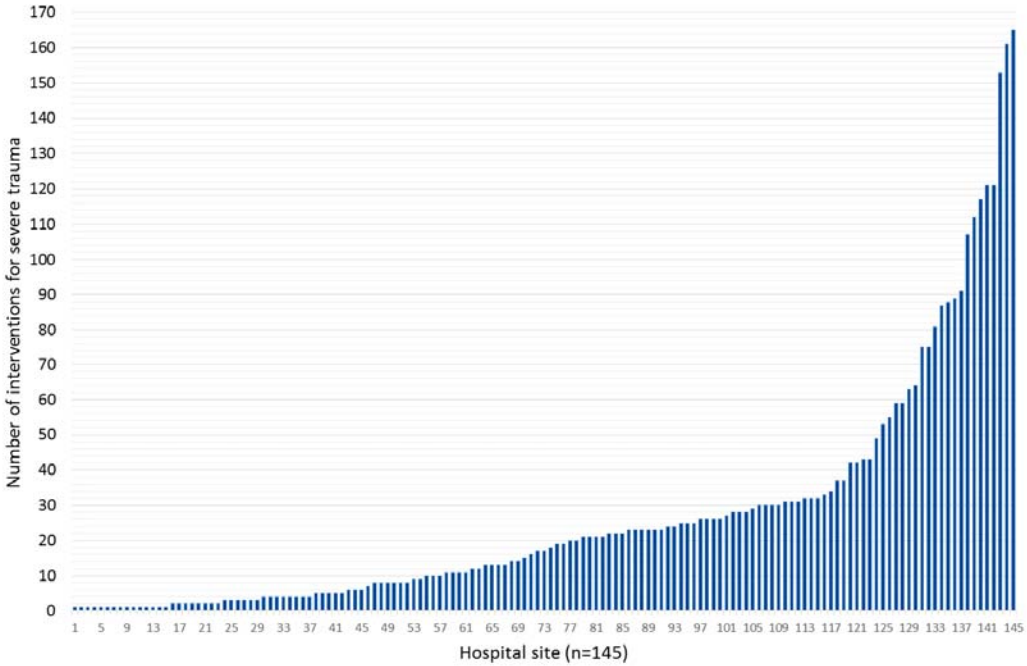
4 IQR : Interquartile range

Figure 3 – Dispersion of the number of interventions for severe trauma (Data 2015)

Hospital site where the patient was sent to (2015)



Number of cases per hospital site



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

Transport times for severe trauma are relatively short

An important factor in the managing of major trauma patients is the time interval/delay between the accident, the call to the mobile intensive unit and the arrival to the hospital site. From the moment when the mobile intensive care team receives the call until the arrival of the victim at hospital's site, the delay was less than 46 minutes in half of the cases (IQR 35 – 60 minutes). The time needed to provide basic care on the scene is counted in this result.

The median transport time (time from departure on the scene to the arrival to the ED) was 10 minutes (IQR 6 – 16 minutes). Those time intervals are far below to the international used targets (see Table 7) and are a result of the very dense acute hospital landscape on a small territory. Therefore, it is not surprising that the transport time is shorter than for other countries with more rural regions.

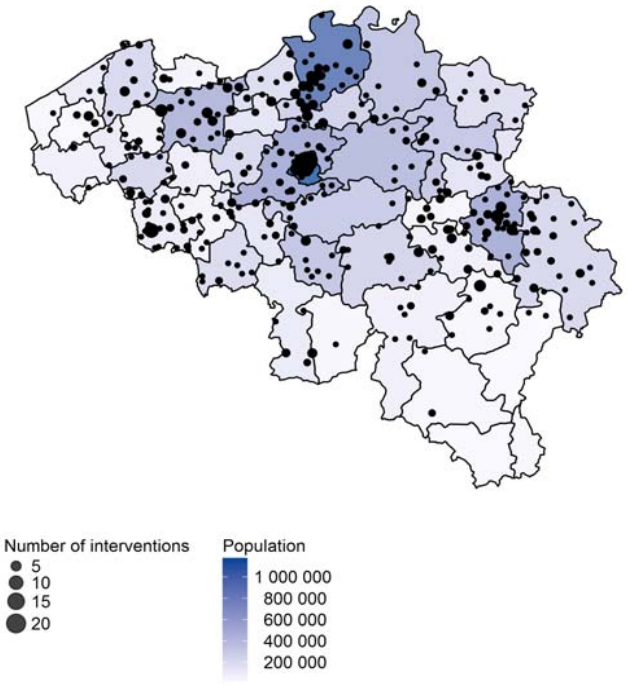
In a minority of severe trauma cases hospitals are bypassed for therapeutic reasons, except for burns

In 2015, for only 17% of the interventions (n=672) for a severe trauma (Figure 4) the closest hospital was bypassed for therapeutic reasons. Those trauma cases were mainly sent to university hospitals (35%) or to larger (>450 beds) hospitals (29%).

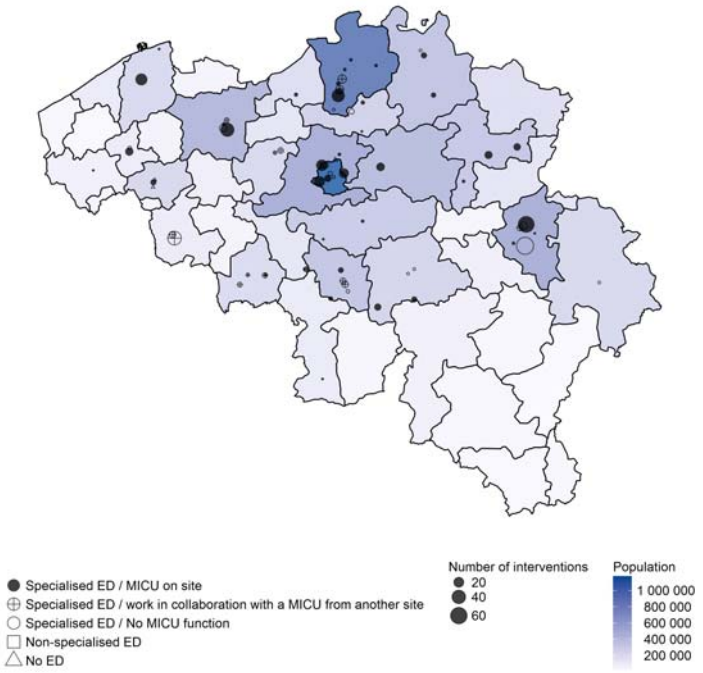
The main therapeutic indication to bypass a hospital is a burn injury. **In 71% of the burn-related severe trauma cases**, the closest hospital was bypassed. From those cases, 80% were sent to one of the five acute hospital sites with a burn care service or to the Military hospital. This shows that the transfer to a hospital site with a specialised designation works well in Belgium and could be probably enlarged to other specified pathologies when indicated.

Figure 4 – Dispersion of the number of interventions for severe trauma sent to another hospital for therapeutic reasons (Data 2015)

Place of the intervention (2015)



Hospital site where the patient was sent to (2015)



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

4.2.2 *In-hospital data for patients with multiple significant trauma: a large degree of dispersion and few between hospital transfers*

The number of multiple significant trauma patients is stable but with an increasing number of elderly

The number of stays for multiple significant traumas varies around 2 400 a year (from 2 447 stays in 2009 to 2 408 stays in 2014 without time trends). During this period (2009 to 2014), the proportion of stays was constant around 3.5% for children (< 16 years) while that for older patients (≥75 years) increased from 19% to 25% over the years.

A large number of hospital sites treat patients with multiple significant trauma

In 2014, 2 408 stays for multiple significant traumas (MDC25) were registered in 155 different hospital sites. For this specific category of severe pathology, the median number of cases was of 11 per site (IQR[5] 5 – 19) and with a minimum of 1 and maximum of 85 stays per site. As such, the dispersion of the in-hospital stays for MDC 25 shows a quite similar picture as that for the MICU interventions for severe trauma cases (see Figure 2).

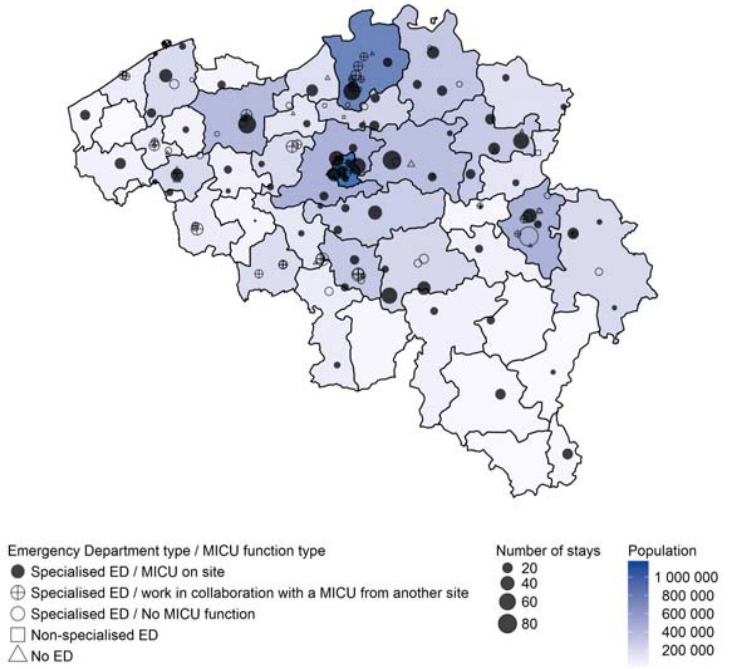
Patients with multiple significant trauma are mainly admitted from their home address or from traffic accident scene

The place before the hospitalisation was mainly the patient's home address (38%) and traffic accident scene (27%). Seventy-five per cent of the multiple significant trauma cases were classified as having a major or extreme severity of illness, according to the APR-DRG classification (All-Patient-Refined-Diagnostic-Related-Groups).

A minority of patients is transferred to another hospital and only after a relatively long period

Around 8% of the MDC 25 stays (n=184 cases) are transferred to 77 hospital sites for specialised care (other than rehabilitation or medical surveillance). Only for 9% of them, the transfer occurs within the day of arrival to the hospital site. The median length-of-stay in the hospital before transfer, is 10 days after admission.

Figure 5 – Number of stays for multiple significant trauma (MDC=25) per hospital site – MHD Data 2014



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

[5] IQR : Interquartile range

5 INTERNATIONAL COMPARISON

Differences between models for the care of trauma patients cover a large array of factors such as the criteria used to define the severely injured or major trauma patients, the organisation of pre-hospital emergency services and the provision of in-hospital services.[9, 12-17]

In England, The Netherlands and Germany, the trauma network reform was characterised by five steps. Minimal requirements were established at a national level and were latter adapted by local actors (healthcare providers and authorities) during the implementation of local trauma networks.

Box 3 – Five steps for the organisation of a trauma network

Step 1: Raising awareness that injury is a public health problem followed by a call for action (e.g. in England, The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report concludes that almost 60 per cent of trauma patients received a standard of care that was less than good practice). [15, 57-60]

Step 2: Creation of a 'blueprint'[11, 15, 27, 61] at a national level based on a set of minimal standards for the complete care pathway. Blueprints were based on a combination of best-available evidence and expert opinion

Step 3: The 'blueprint' is submitted to local healthcare providers along with local authorities in charge of proposing the configuration of local networks. The first configurations heavily relied on existed collaborations between care providers, and took into account the specificities of the areas (e.g. geography and the travel time).

Step 4: The proposed configuration of the local networks is reviewed in order to ensure that the minimum standards in the 'blueprint' are respected.

Step 5: A peer review process of the networks performance is implemented.

Strong and dedicated leaders at the national level, was identified as a key facilitator that could bring local actors to address complex issues such as:

- the categorisation of the hospital system;
- the role and requirements for the trauma centres;
- the establishment of a target population;
- the organisation of emergency medical providers and the establishment of catchment areas;
- the adoption of a single quality assurance process and data registry.

5.1 Categorization of the hospital infrastructure

5.1.1 The process of building trauma networks

Building a blueprint for the national system requires the participation of all stakeholders involved in the trauma care pathway

The development of the blueprint in the different countries was led by scientific societies and healthcare professionals from multiple fields. Blueprints were always based on a combination of best-available evidence and expert opinion.[15, 27, 62] In England and the Netherlands, healthcare authorities also participated in the process of providing support. At a later stage they also played a role in the designation of major trauma centres. The blueprints included at least the organization of:

- the regional network and governance;
- pre-hospital and inter-hospital transfers;
- acute care and surgery provided after accessing the hospital;
- ongoing care and rehabilitation.

Blueprints are to be reviewed on a regular basis in order to update evidence-based protocols leading to a continuous improvement in patient's outcomes. (e.g. In 2012, the German blueprint was reviewed to include the recommendation from the German Evidence-Based Guidelines for the Treatment of the Severely Injured).[63]

Acute hospitals are classified in three levels of trauma care

Differences in the number and the role assigned to each trauma level reflect differences in the hospital landscape between and within countries.

In England, The Netherlands and Germany, three levels are used while in non-European countries (i.e. Canada, the US and Australia) more levels are used.[7, 18, 28, 64]

Except for the highest specialisation level, (i.e. major trauma centres), the minimal requirements and the role for the other levels varies between the countries (see section see 5.2 for more details).

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).

Table 2 – Terminology used for the trauma centres in selected countries

	England	The Netherlands	Germany
Major trauma centre	Major trauma centre (MTC)	Level I	Supraregional trauma centre (STC) ('Uberregional Traumazentrum – ÜTZ).
Level II	Trauma unit (TU)	Level II	Regional trauma centre (RTC) ('Regionale Traumazentrum' – RTZ)
Level III	Local Emergency Hospital (LEH)	Level III	Local trauma centre (LTC) ('Lokal Traumazentrum – LTZ)

Regional systems adapted to the local context but within the guidelines of a national framework

Local actors were asked to propose a configuration for their local trauma network that respected the minimal standards for the complete care pathway established at a national level. The proposed configuration heavily relied on the pre-existing informal networks or hospital collaborations. One of the most challenging implementation issues for the final configuration of the networks was the categorisation of acute hospitals into trauma centres. Based on the minimal requirements of the 'blueprint', hospitals were categorised according to their capacity to treat trauma patients (see 5.2)

Accreditation process: voluntary or compulsory

In England and in Germany hospitals could 'candidate' for a specific trauma centre level which was later confirmed via an accreditation process by a third-party or authorised by public authorities. In the Netherlands, healthcare authorities initially designated major trauma centres that were later in charge of the categorisation of other acute hospitals.

5.1.2 Supply of major trauma centres

Recommended number of major trauma centres

Based on the experience of the United States, the Royal College of Surgeons of England recommended the creation of 12 to 16 major trauma centres for England, each serving populations of between 3-4 million, depending on location and geography.[65] The Dutch Trauma Society recommended to organise the care for major trauma patients in the Netherlands around three or four major trauma centres.[58]

The German Society of Trauma Surgery did not propose a maximum number of major trauma centres. The German Society of Trauma Surgery recommended, however, that each network should include one MTC, two Level II and three Level III centres. In the absence of a MTC, the networks should have at least two Level II centres and establish a collaboration with other networks.

For major trauma centres, healthcare authorities or accreditation entities in the three studied countries recommended that, within dense populated areas with a large number of acute hospitals (e.g. in large cities), hospitals could work together as a single MTC ('collaborative MTC'). The extent to which this recommendation is followed varies between and within the countries.

More trauma centres than initially recommended

The number of established trauma centres is heavily influenced by competition between hospitals since being an accredited or recognised major trauma centre is assessed as important for the hospital's reputation (both to attract physicians and patients).

During the initial implementation phase, the number of established trauma centres in each country was influenced by the number of hospitals that could comply with the minimal standards as well as by the need to ensure that the proposed regional networks were politically viable. Consequently, the number of recognised major trauma centres in England and the Netherlands was higher than the number initially recommended by the scientific societies (see Table 3).

5.1.3 Covered population

There is a considerable variation in the networks composition between the three countries studied (see Table 3).The average population covered by the networks is 2.49, 1.54 and 1.59 million inhabitants in England, the Netherlands and Germany, respectively. Large variations can also be observed in the average population covered by major trauma centres going from 2.03 million in England to 0.77 million in Germany.

Table 3 – Summary of number of trauma centres and trauma networks (2015)

	England [a]	The Netherlands	Germany [b]
Recommended number of major trauma centres	12-16	4	N.S.
Designation health authorities			
Major trauma centre	Yes	Yes	No
Level II/Level III	No	No	No
Number of centres			
Major trauma centre	27, (of which 5 for children)	11	105
Level II	120	36	202
Level III	27	46	314
Number of networks	22	11	51
Average number of centres per network	7.4	8.5	12.1
Range per network (Minimum - maximum)			
Major trauma centre	1-2	1	0-6
Level II	2-12 (16 for children)	4-16	1-9
Level III	0-5 (11 for children)		2-14
Average population covered (in millions)			
Network	2.49	1.54	1.59
Major trauma centre	2.03	1.54	0.77
Level II/III	0.37	0.67	0.11

Source: England[65, 66], The Netherlands[11, 67] and Germany[68]. Notes: [a]The maximum number of centres including the paediatric network are between brackets. Most networks in England have only one MTC. The city of London has 4 MTC that belong to different network. [b]The range in the number of participating centres in Germany dates from 2012.[17] Own calculations. N.S stand for not specified.

Within each country, variations in the geographical areas covered and the population are also striking. The Box 4 illustrates the existing variations in the countries studied.

Box 4 – Examples of variations in the coverage of trauma networks

In England, the population covered by the East of England trauma network and the South Yorkshire trauma network amounts to of 5.9 and 1.6 million inhabitants, respectively.[66, 69] The former network is composed by one major trauma centre and twelve Level II centres while the latter encompasses two separate major trauma centres (one for adults and one for children) and four Level II centres.

In Germany, the local trauma networks covered geographical areas that range from 892 km^2 to 16 820 km^2 in Berlin and East Bavaria, respectively. The population density in these regions varies from 3 785 inhabitants per km^2 in Berlin to 177 per km^2 in East Bavaria.[70]

5.1.4 Rehabilitation services are within the scope of a trauma system but integrating them remains challenging

The trauma networks aim to encompass the entire care-pathway: from pre-hospital care through rehabilitation. However, the inclusion of rehabilitation services into the networks is a challenging issue. 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 and that are financed via different arrangements (e.g. rehabilitation services are not directly financed by the NHS in England).

5.2 The role and requirements of major trauma centres

5.2.1 Role of major trauma centres

Care for the major trauma patients and knowledge platform

The major trauma centres (MTC) are the 'centre of gravity' of the trauma network. MTCs provide care to the patients with the most severe injuries and are also in charge of providing other hospitals with support, continuing education for trauma team members and to establish and to monitor comprehensive quality assessment programs.[11, 15, 27]

A key player in case of disasters and mass casualties

In the three countries, major trauma centres are also expected to actively participate in the organisation of the response in case of mass casualty events and catastrophes. They have a leadership role in developing major incident policy and establishing exercises to prepare partners of their network for large emergency situation.[11, 15, 27]

After designation, the patient flow of a MTC changes

The implementation of a MTC has not only an impact on the hospital's infrastructure (e.g. additional CT capacity), human resources (e.g. increased 24/7 availability of senior physicians) and in the establishment of multiple processes allowing for a rapid availability of these resources (e.g. trauma protocol at the ED). It will also have an impact on the patient flow of the hospital that becomes a MTC. After the implementation of the trauma system, the number of trauma patients referred on to a MTC will increase.[14, 15, 71-76]

The implementation of a MTC has, as a consequence, to include capacity (extra capacity or re-allocating capacity by referring other patient groups to other hospitals) to deal with these extra patients during the entire care pathway (from the reception in the emergency department, until the patients' discharge). Table 4 shows that the patient-flow in MTC and in Level II/III differs. Only in the Netherlands, MTC treat a higher proportion of less severely injured patients (9≤ISS≤15) than of those of the more severely injured. The Dutch system is designed in such a way that mono-trauma was almost exclusively seen in Level II and Level III hospitals.[77]

Table 4 – Patient's treated per year in trauma centres with an Injury Severity Score above eight[a]

	England[b]		The Netherlands[c]		Germany[d]	
	Major trauma centre	Level II	Major trauma centre	Level II/III	Major trauma centre	Level II/III
Total number of patients	21 759	19 607	8 428	23 897	17 857	13 000
Percentage of patients over total (%)						
ISS 9 – 15	44.5	71.3	66.8	94.12	41.0	52.7
ISS 16 – 24	25.0	17.7	18.7	4.2	N.S.	N.S.
ISS > 24	30.5	11.0	14.5	1.6	N.S.	N.S.
All ISS >15	55.5	28.7	33.2	5.8	59.0	47.3

Source: England[78], The Netherlands[67] and Germany[79]. Notes: Own calculations. [a]Concerns the number of patients included in the trauma registry of each country with an ISS above eight. [b]For England data were based on a yearly average using information for 2014-2016. [c]For the Netherlands data refers to patients treated in 2015.[67] Information for England and Netherlands concerns patients receiving the final treatment at each level (primary admissions and transferred in). [d]For Germany[79] data were based on a yearly average using information for 2012-2015. Data concerns all admitted patients before been referred on to another hospital for further treatment. Therefore, the number of patients that receive the final treatment in a MTC may be underestimated.

5.2.2 Medical equipment and protocols

Hospitals categorised as MTCs must have operating rooms for emergency surgery, neurosurgery departments, highly specialised 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. It is expected that MTC can treat at least two severely injured patients simultaneously.[11, 15, 27]

Protocols to ensure immediate access to operating rooms for emergency surgery are also established. In England, for instance a target is used, specifying that major trauma patients should receive a CT (when needed) within 30 minutes after arrival at the hospital.

In addition to general requirements, there are also specific requirements for the treatment of specific groups of patients (i.e. children).[11, 15, 27]

5.2.3 Healthcare professionals: senior staff and expertise in trauma care

A key feature in all countries is that treatment of the major trauma patients is led by highly trained senior specialists that are present in the hospitals on a 24/7 basis. Team members that are in the hospital usually reach the trauma room in five to 10 minutes after being called-in.[58, 80, 81]

On-call physicians must be able to reach the hospital (trauma room) within 15 to 30 minutes. These physicians include all relevant specialities including anaesthetist, neurosurgeon, radiologist, vascular surgeon, orthopaedic surgeon etc.[11, 15, 27] After the initial patient's reception and stabilisation, it is expected that their care remains at the hands of specialists in the relevant fields. The latter implies that specialists from the hospitals will be mobilised during the entire stay of the patient.

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 according to the tradition of each country.

Healthcare professionals within the trauma team should 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)). In Germany, it is expected that at least half of the trauma specialists follow these training programs.[15] For the other countries, a specific number for the number of healthcare professionals following the training programs was not identified.

5.2.4 Volume requirements

High variability in the recommended volume thresholds

In England, The Netherlands and Germany it is expected that MTCs treat a yearly minimum number of major trauma patients of 250, 100 and 40, respectively. These volume requirements seem to have been established based on a combination of best-available evidence and expert opinion.[15, 27, 65, 82] The volume thresholds are recommended but are not legally binding. During each accreditation (or peer review) process, the volume of major trauma 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. Currently, only in England the volume threshold for major trauma patients is aligned with that recommended by the American College of Surgeons (ACS).[18] The ACS recommends that a Major Trauma Centre admits at least 1 200 trauma patients per year or has at least 240 admissions with an ISS above 15.[18]

Most major trauma patients are referred to a MTC

Table 5 illustrates the average number of major trauma patients (ISS above 15) treated in trauma centres. In all three countries, about two thirds of all patients with and ISS above 15 are treated in MTC. The number of patients with an ISS above 24 treated in MTC in England and The Netherlands amounts to 76%.

Variability between major trauma centres in the number of admitted major trauma patients

At a national level, the indicated volume thresholds are attained for the three countries. There is, however, a high variability in the number of patients with an ISS>15 that are treated in major trauma centres in each country.

In the Netherlands, the volume treated per centre varied between in 2015 between 123 and 441 patient.[67] The National Health Care Institute ('Zorginstituut Nederland') recommends that this increases to 90% by 2018. [82] In 2015, the median number of severely injured patients treated in MTC in Germany was 130 (P25: 100; P75:180).[79]

Table 5 – Patients treated in trauma networks per year (2015)[a]

	England[a]	The Netherlands[b]	Germany[c]
Patients treated in major trauma centres (%)			
ISS 9 – 15	40.9	20.6	51.7
ISS>15	68.3	66.6	63.1
ISS>24	75.7	75.7	N.S.
Average volume per centre (ISS>15)			
Major trauma centre	448	254	85
Level II/Level III	38	16	12
Number of patients per 100 000 inhabitants (ISS>15)			
Major trauma centre	22.1	16.6	13.0
Level II/Level III	10.3	8.3	7.6

Source: England[66, 78], The Netherlands[67] and Germany[79] Notes: Own calculations. [a]For England data were based on a yearly average using information for 2014-2016. Information concerns only major trauma centres and Level II centres. [b]For the Netherlands data refers to patients treated in 2015. Information for England and Netherlands concerns patients receiving the final treatment at each level (primary admissions and transferred in) [c]For Germany data were based on a yearly average using information for 2012-2015. For Germany data concerns all admitted patients before been referred on to another hospital for further treatment. N.S. stands for not specified.

Adapting the number of centres and increasing volume as trauma networks mature

As previously mentioned, the number of recognised major trauma centres was higher than the number initially recommended by the scientific societies. A direct consequence of this higher number, is that volume of patients treated in MTC does not always correspond to that expected at the moment of the configuration of the networks.

In England and in the Netherlands, there are on-going discussions on whether fewer major trauma centres are needed to treat the major trauma patients.[77, 83-85]The main argument of the stakeholders in favour of the reform is that a higher volume of patients is needed in each centre in order to maintain sufficient expertise in rare life-treating or life changing injuries.[77, 83-85] However, the stakeholders recognise that such concentration must respect that pre-hospital times are maintained within acceptable time limits and that the volume of patients treated is aligned with the available resources of the hospital.[77, 86]

In order to increase the number of major trauma patients treated in MTCs and to improve patient outcomes, substantial modifications in pre-hospital and in-hospital settings have been proposed. In The Netherlands, currently proposed options for in-hospital settings include:[11, 59, 77]

- reducing the number of MTCs; and/or
- create reference centres for specific injuries (e.g. spinal cord injuries).

In England, reduction in the number of MTC seems to be a part of the maturation of the system. Box 5 shows an example of the on-going changes in the English system.

Box 5 – Case study for the reconfiguration of a MTC in England

In Liverpool, several general hospitals originally managed major trauma patients. After two rounds of the National Peer Review Programme (NPRP) it was recommended that the major trauma patients were referred to one single receiving hospital. The rationale behind this recommendation included that:

- One hospital treated a low volume of 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 on the long term a skilled base team and to be financially viable.[84]
- The regional neurosciences centre (i.e. The Walton Centre NHS Foundation Trust) was co-located with one hospital.[83] This hospital opened a new emergency department with a co-located computed tomography facility (CT).[83]

The transition 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 hospitals' managers accept to work towards establishing a single receiving hospital in their network.[80]

5.2.5 Financial incentives

Financial resources for the implementation of the networks were limited and this was identified as a challenge by the stakeholders in all countries. [11, 58, 87, 88] Payment for major trauma patients in the three countries is included in the 'regular' activity-based payment system for hospitals. [89-91]

Only in The Netherlands a structural payment was provided for MTCs to take up the leadership role within the trauma network (data registration, training, etc.)[59] In England, the payments have been adapted in order to incentive to treat the patient in 'appropriate settings' via a 'best practice tariff (BPT)'. 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.[92] In the case of trauma patients the conditional component depends on the compliance with different factors:

- treatment in a MTC;
- data registration;
- rules for secondary transfer;
- administration of specific treatments.

In Germany, the classification of the major trauma patients into the appropriate homogeneous German Diagnosis-Related Groups System (G-DRG) has been pointed out as a challenging issue. Recent modifications in the G-DRG have attained a better correspondence between case allocation and corresponding reimbursement for the major trauma patients.[87, 93, 94]

5.3 The role of other major trauma centres varies between and within countries

The minimal requirements in terms of hospital infrastructure and medical equipment for Level II and Level III centres vary between and within the countries. In each local trauma network cooperation agreements are made between the trauma centres of different levels. These agreements include specifications about which group of patients can be referred to what level of care.[11, 15, 27, 95]

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. Depending on the geographical area that is covered by Level II centres, they have two different roles. First, in isolated less populated areas Level II centres should ensure a rapid transfer of patients towards MTC and may serve as the lead facility for some of these patients. Second, in dense populated areas and having a large hospital supply, Level II centres work in close collaboration with the MTC. In this case, clear referral rules must be established between the institutions.[18]

Level III centres are not expected to receive major trauma patients. They are sometimes the first point of contact for patients (e.g. self-referrals at the emergency department). These centres must be able to identify a severely injured patient and to ensure a rapid transfer to an MTC. In England, Level III centres are consistently bypassed when the patient is identified as being severely injured. Level II and /or Level III centres may play an important role at a local level in the treatment of non-major trauma patients (e.g. common isolated injuries).

5.3.1 Target population adapted to the local supply of care

The target group of patients treated in the different 'levels' is discussed at a national level during the implementation phase[15, 27] and may be reviewed with the system maturation.[95]

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; head injury);
- the patient's characteristics (e.g. children in the England); and
- expected outcomes of the system (e.g. in England patients with an ISS≥9 are referred on to MTC).

The choice of the target group has important implications on the required capacity and on the interventions provided in trauma centres of different levels.

Provisions of care for children and the elderly

Challenges for the provisions of care to specific target groups include having appropriate resources for the treatment of severe injuries in children and the effective management of the elderly population.

For children two models are dominant. In a first model, only a number of general major trauma centres that meets additional requirements (e.g. paediatric intensive care) can accept children. In a second designated centres for 'children only' were implemented. In England, but also in other non-European countries, i.e. The Unites States, Canada and Australia both models are used.[7, 18, 28, 64]

The care for older patients with a major trauma requires the involvement of specific expertise (e.g. collaboration with geriatricians) to deal with the multi-morbidity and frailty concerns of this patient group. The proportion of elderly patients among the major trauma patients referred to and treated in a MTC exceeds earlier expectations in the different countries.[15, 63, 96, 97] This trend may be linked to the overall population ageing but also to the changes implemented in MTCs that facilitate the early detection of the major trauma patients.[80, 96]

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

5.4.1 Overview of EMS in different countries

Centralised organisation of ground services

The organisation and management of ground emergency medical services are delegated to local authorities in England, the Netherlands and Germany.[98-100] The latter ensures that the EMS teams use standardised processes upon its approval by the regional authority.

At the moment of the implementation of the trauma networks, the regional authorities in charge of the EMS facilitated the implementation of the triage tool allowing to identify the patients who must be referred on to a MTC. However, triage protocols aim at providing guidance to EMS and adherence to the protocol decision tree varied between the networks.

Different staffing models for EMS services

The staffing level in the different countries varies, with Germany having the most comprehensive physician-staffed emergency medical services of the three countries (see Table 6). In the Netherlands, only the helicopter emergency service has a permanent crew composed of a physician and a nurse. In England, the team is mostly staffed by paramedics.

Different models for Helicopter medical services

Only in Germany, regional authorities (the states) are directly responsible for the organisation of helicopter emergency medical services.[101, 102]. The HEMS in Germany consists of a dense network of helicopter bases each covering a radius of about 50 km^2. In England, Helicopter Medical Service (HEMS) area provided by 19 charity organisations.[103-105] In the Netherlands, helicopters stationed in four major trauma centres constitute the nationwide air rescue system.[12]

Table 6 – Summary of the characteristics of Emergency medical services and dispatch centres in 2015

	Belgium	England	The Netherlands	Germany
Dispatching centre				
Dispatching system	Universal access number 112 (previously 100)	999 for life-threatening situation and 111 for non-life-threatening situations	Universal access number 112	Universal access number 112
Training emergency medical dispatcher	Basic training (no clinical background)	Triage Nurses or paramedics	Nurses that followed a recognised training programme	Emergency medical technician with ambulance dispatch training
Emergency medical services				
Organisation Ground fleet	• Hospitals or hospital association for MICU & PIT • Public and private entities for ambulances (e.g. hospitals, fire brigades)	Regional ambulance service (Ambulance Trust)	Regional ambulance service	Decentralised authorities (municipalities)
Organisation air fleet	• Hospitals (two pilot projects)	Charity organizations	Major trauma centres	Decentralised authorities
EMS Team and their training	• Ambulance: rescuers – ambulance driver • MICU: Specialist and specialised nurse • PIT: driver and specialised nurse	• Ambulance: Paramedic or emergency care assistant. • In some cases, HEMS employ a doctor-paramedic team.	• Ambulance: Nurse and driver • MMT: Specialist and specialised nurse	• Specialist and emergency medical technician (EMT)

Source: Belgium (see section 4.1.1 for detailed references). England[57, 103-105]. The Netherlands[58, 61, 106]. Germany.[101, 107]

5.4.2 Uniform triage protocol

Improving the coordination between different emergency medical services (EMS) is a necessary step for the implementation of a new model of care for major trauma patients.[9, 11, 15, 27, 106, 108]

In the three countries studied, the 'blueprint for the national trauma system' included a 'uniform triage protocols' that was adapted to the local context. This process was facilitated in the different countries by the fact that regional ambulance services could rapidly implement the proposed triage tools among the emergency medical teams under their jurisdiction. All protocols include the mechanism of injury and physiological and anatomical parameters.[15, 27, 106]

5.4.3 High uptake of triage tools but there is still room for improvement

While the implementation of a triage tool within the trauma networks is certainly a success story in all countries, the discussion on how to improve the identification in the place of the accident and the triage of major trauma patients is ongoing. NICE (2015)[109], for instance, recently recommended to review the parameters used, and the weight given to each parameter. In the Netherlands, adherence to the protocol decision tree varies between the EMS providers. In addition, the possibility to transfer an unstable patient to the nearest hospital is foreseen but variably applied.[58, 110]

Poor performance of triage tools has been link failure to meet the envisaged concentration of care, patient outcomes and costs.[15, 74, 109]

5.4.4 Clear rules for a rapid secondary transfer

MTC and other trauma centres are required to sign cooperation agreements for the secondary transfer of major trauma patients. In England, the payment of the Best practice tariff (BPT) for trauma is linked to transferring the patient within two calendar days of referral from the Level II centre to a MTC.[15, 27, 106, 108]

5.4.5 Trauma alert: a necessary tool to insure better care

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.[15, 27, 106, 108]

5.4.6 Catchment area of MTC and of the trauma system

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. The latter implies that the frontiers for the trauma networks reflect the catchments that were previously assigned to pre-hospital and hospital services. Second, the boundaries within a regional network may be draw taking into account the travel time needed to reach the MTC.

Table 7 – Access to hospitals treating trauma patients

	Belgium	England	The Netherlands	Germany
Time for the presence of EMS for a life-threatening situation after the emergency call	• 10 minutes for a large section of the population[a] • 15 minutes for the non-covered population	• 8 minutes • Additional support within 19 minutes if the first response is not a fully-crewed ambulance	• 15 minutes	• 10/15 minutes depending on the choice of decentralised authorities
Rules for direct transport to major trauma centre				
Agreed protocols based	No. A list of hospital specificities is available at a provincial level	Yes, recommend national protocol adapted to the specificities of the trauma networks	Yes, recommend national protocol adapted to the specificities of the trauma networks	Yes, recommend national protocol adapted to the specificities of the trauma networks
Maximum time for referral to a MTC	N.S.	45 minutes	45 minutes	30 minutes
Start point	N.S.	Departure from the scene of the accident	Call to 112	Departure from the scene of the accident
End point	N.S.	Arrival at the hospital	Arrival at the hospital	Arrival at the hospital
Rules for secondary transport to major trauma centre	Agreements between hospitals depending on the patient's condition and hospital's availability	Trauma networks agreed on specific protocols	Trauma networks agreed on specific protocols	Trauma networks agreed on specific protocols
Is there a predefined 'trauma call'?	No, variable processes	Yes, usually performed by the emergency medical dispatcher	Yes, usually performed by the emergency medical dispatcher	Yes, emergency medical dispatcher or EMS team (usually doctor)
Population accepted	N.S.	• Adults and children • Adults only • Children only • ISS>8	• All patients irrespectively of age • As according to the triage tool (no ISS limitation)	• In general all patients irrespectively of age • Centres receiving paediatric patients must fulfil additional requirements • New certification (2014) for centres having an expertise in geriatric patients

Source: Belgium (see section 4.1.1 for detailed references). England[57, 103-105], The Netherlands[58, 61, 106] and Germany.[15, 63, 81, 101, 107]. N.S. stands for not specified.

5.5 Quality assurance process and data registry

5.5.1 Accreditation

The results of the peer review/accreditation process allow healthcare authorities to establish or to recommend modifications in the network configuration. Three different accreditation processes are established in the countries studied.

In England, the accreditation process measures in a standardised way, the level of compliance of individual services. The review process encompasses, pre-hospital services, trauma centres of all levels, the network governance and rehabilitation services.

In the Netherlands, the process of the accreditation of hospitals as Level II or Level III is delegated to the trauma networks 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] In 2016, a pilot project aiming to build an accreditation for major trauma centres is foreseen.[11]

In Germany, the construction and verification of the networks is directly linked to the accreditation process.[15] The accreditation process for trauma networks starts when all individual participating hospitals obtained their accreditation.[15, 17] Fully trained auditors working in independent commercial companies perform the audits (DIOcert and Cert iQ).[111]

5.5.2 Trauma registry

Compulsory registration of the entire trauma care pathway

Appropriate collection of data on major trauma patients is needed to evaluate the needs of the population as well as to evaluate the performance of the trauma network and of MTCs. The quality of the data registration is validated by a third-independent party in order to avoid unappropriated coding of the patients severity of injury.[12, 16, 62, 112-114]

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). MTCs have reached a high quality registration of data that needs to be met by Level II and III centres in the different countries.

While the level of the data included in the trauma registry and the inclusion criteria varies between the countries, they all include some information on:

- The pre-hospital phase;
- The initial treatment in the emergency department;
- The complete hospitalisation phase (including the phase in the intensive care unit); and
- Patients' outcome and discharge.

Focus: a shift from improved mortality to improved quality of life

Data collection for patients' outcomes is undergoing a major change in the different countries. Outcome measures in the coming years will not only include mortality but also disability and patient's quality of life.

Table 8 – Selected characteristics of the accreditation process and of the trauma registry

	England	The Netherlands	Germany
Audit/ peer review process			
How often are audits performed?	Every year at the launch of the trauma network. The frequency will be reduced in the coming years	Variable	Every three years
Who performs the audit	The National Peer Review Trauma Programme	Committees designated by trauma centres	Independent commercial companies perform the audits
Is the participation in the audit voluntary or mandatory?	Mandatory	Mandatory	Mandatory after receiving the first accreditation.
Do the audit results lead to penalties/rewards?	Losing designation	N.S.	Losing accreditation or downgraded to a lower specialised level
Trauma Registry			
Inclusion criteria			
Hospital stay	Yes, 3 days or more. For transferred patients, the combined hospital stay is taken into account	Yes, no minimum number of days	Not specified
Admission to intensive care unit/area	Yes	Yes	Yes
Reaching the hospital with vital signs	Yes	Yes	Yes
Transferred patients	Yes	Yes, trauma patients transferred within 48 hours	Yes
Exclusion criteria	Exclusion criteria are set according to the body region or specific injury	Patients dead on arrival	Patients dead on arrival, burns, hangings, drowning, and poisonings.
Is participation compulsory/mandatory?	Mandatory	Mandatory	Mandatory after receiving the first accreditation
Duration patient's follow-up?	Until patient's discharge	From the incident until hospital discharge/30 day mortality.	Until patient's discharge

Source: England [112, 115] The Netherlands[11, 12, 62, 113]. Germany [16, 17, 81, 111, 114].

5.5.3 Outcomes in selected countries

Too early to have a full assessment of the changes in patients' outcomes related to a new trauma care pathway

The implementation of fully operational inclusive trauma networks is a relatively recent phenomenon in European countries. Proof of the effectiveness of centres and networks in these countries is, therefore, still an ongoing issue.[116] As networks mature and better data are gathered, evidence is starting to be published in the peer-review literature. Yet data on the impact of the national networks are scarce and available literature is mostly available for only a limited number of MTCs or networks within the national network.

Box 6 – The impact of the trauma systems in more mature systems

Implementation of a trauma system needs time to mature before effects can be seen and measured. Conflicting results from systematic reviews on effectiveness of introducing a MTC, may be due, at least to some extent, to the fact that their impact on patient's outcomes was assessed at different time intervals after implementation. The latter not allowing to compare effects taking into account the maturation over time. Several studies [117-126] in countries in which MTCs were introduced a time ago clearly demonstrated that effectivity can only be shown after several years and that the impact of patients' outcomes changes over the years.

Reduction in mortality but only for systems that are implemented for sufficiently long period

After the implementation of the trauma networks, reductions in mortality at the level of the networks and, to some extent, for MTCs were reported for our selection of countries.

Evidence from The Netherlands showed that a reduction of mortality in the trauma networks, mostly concerned Level II and Level III centres[72, 121] with reductions in mortality at a MTC being reported at a later stage of the maturation of the network.[14, 71]

In Germany, mortality rates were significantly lower than the expected mortality rates for the different trauma centres levels.[73, 127]

Results on the implementation of the inclusive trauma network in London showed positive results with a significant reduction of early crude mortality (within the first 72 hours) for all degrees of injury severity.[128] Results on the National Trauma Network in England are less conclusive. An early study [88] observed an increase in the probability of survival after trauma for patients with an ISS above 8 (ISS>8). These encouraging results were not confirmed in a recent publication on the National Trauma Network[76] and on a specific regional network in England.[129] The authors suggest that the evaluation was performed at a very early stage and that, benefits are expected to be observed after a maturation period of 2 to 10 years.[76, 129] Differences between the results for the London network and the rest of the country may also be explained by the fact that London network is at a higher stage of the system maturity.

Compliance to evidence-based processes increases and might improve patient outcomes

The authors of the different studies supported the hypothesis that the reduction in mortality rates after the introduction of the trauma network can be attributed to the successful implementation of standardised clinical procedures (e.g. reduction in time to CT, introduction and expansion of trauma teams, massive transfusion protocols).[14, 71-73, 88, 121, 128-130] Cole et al. (2016) pointed out that better performance of the MTC in London compared to other multi-specialty hospitals (full surgical capability and specialty surgical services including, for instance, at least neurosurgery) may be explained by the fact that procedures to enhance trauma care were early implemented in the former and not in the latter.

One study[72] pointed out that overall gains in in-hospital mortality at the implementation of the network may be 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 network.

Little or insufficient evidence regarding volume and mortality

Evidence concerning the impact of volume on patient's outcomes in England, The Netherlands and Germany is very limited. After the implementation of the trauma network, the proportion of severely injured adults referred on to MTCs increased in the three countries.[14, 71-73, 128, 129] While higher concentration of the severely injured adults is observed in MTCs in all the countries, no direct assessment of a potential association between patient's volume and mortality was conducted in The Netherlands and in England.[14, 71, 72, 88, 128, 129]

A recent study from Germany points out that an increasing hospital volume of severely injured patients (ISS above 15) was an independent, significant and positive predictor of survival.[127] The latter holds for all trauma centres levels included in the study. Although a clear cut-off value could not be established, the authors mentioned that treating at least 40 patients per year per hospital might be enough to improve survival.

Less outstanding results for MTCs in selected European that required further discussion

Compared with major trauma centres in other countries (using different reference points; i.e. The United States, Australia and Finland), major trauma centres in The Netherlands[131], England[130] and Germany[132] report, to some extent, higher in-hospital or 30-day mortality rates (both crude and adjusted mortality).

Gunning et Al (2015)[131] compared in-hospital mortality in major trauma centres in three different countries (The Netherlands, Australia and the United States) and found that the centre in the Netherlands had a higher in-hospital mortality rate (both crude and adjusted mortality) compared to the centres in the other countries. The authors hypothesise that having higher volumes of patients in centres in Australia and the United States allows to develop process targeting the specific needs of the injured and to enhance individual experience among health care professionals (trauma surgeons, in particular).

Davenport et al. (2010)[130] reported that the survival rate at the Royal London hospital was initially lower than that of a centre in the USA. However, both centres attained equivalent survival rates following the implementation of evidence-based procedures in the trauma service in London.

Two studies.[132, 133] pointed out that severely injured patients treated in a MTC in Germany had higher 30-day mortality rates than severely injured patients treated in a MTC in Finland. However, differences between observed and expected mortality provided similar results in both countries[132, 133], with the exception of two specific sub-groups of Finish patients (i.e. patients with penetrating head injury and younger than 60 years with isolated head injury).[132]

The authors of the different papers acknowledged that comparison between countries is difficult given differences in the inclusion criteria for the trauma registries, demographic patterns and type of injury of the victims (e.g. with penetrating trauma being more often reported in the US than in other countries). In addition, the comparison between registries may be flawed by the level of correspondence between the calibration parameters used to estimate the probability of mortality with the trauma population referred to MTCs in the different countries.[131-134]

6 EFFECTIVENESS OF A MAJOR TRAUMA CENTRE (MTC)

In this section we discuss the analysis of the available literature on effectiveness of major trauma centres and trauma systems. The analysis of the scientific literature is hampered by the weak study designs, mainly using retrospective collected data from registries, and large heterogeneity of the definition of the characteristics of MTC and trauma networks, populations included, the definition of the injury severity and in the way outcomes are measured. The results provided in this section must be considered in the light of these limitations. Overall assessment of effectiveness trauma centres needs to be interpreted cautiously.

Systematic reviews suggest an impact of the pioneering North-American trauma systems on mortality

An early review[135] dating from 1999, based on 40 studies concluded that the evidence is 'suggestive' that in-hospital mortality is reduced among the most severely injured with the implementation of trauma systems; however, compelling evidence is still lacking. The authors point out that their conclusions on the overall impact of trauma systems effectiveness mostly concerns trauma centres and that other components of care delivery were not assessed.

Celso et al. (2006)[136] found an improved odds of survival in 8 of the 14 included 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 a trauma system.

Major trauma centres seem to have the highest impact on mortality among the most severely injured patients

Biewener et al. (2005)[137] performed a review that focused on pre-hospital airway transport and to a smaller extent on the comparison of mortality between major trauma centres and lower levels trauma centres. For this comparison they included 6 studies, originating from the USA (2), Canada (2), Australia (1) and Germany (1). In 5 of the 6 studies a significant lower mortality rate was found for major trauma centres. However, the authors warn that weak study designs and high heterogeneity hamper to draw definitive conclusions.

Kim (2014)[138] identified 17 articles that compared mortality between major trauma centres and Level II centres. The authors found that major trauma centres had better (10 studies) or similar (7 studies) mortality rates than Level II centres. The ten studies showing a better performance of MTC focus on very severely patients.

Recent studies on the impact of different levels of care on patient outcomes provided a similar picture. Mortality rates for severely injured patients were sometimes better, sometimes worse in higher level trauma care centres compared to lower level trauma care centres[139-143] or non-designated trauma centres.[144-150] MTCs, however, seem to be the most beneficial for higher risk groups including the most severely injured (e.g. ISS>24).[146, 149-153]

Indications for a volume-outcome relationship in the majority of studies, but evidence base not entirely straightforward

Kim (2014)[138] and Caputo et al. (2014)[154] focused on the relationship between patient volume and mortality. Each review included 16 articles, out of which 10 are common to both reviews. High volume was associated with at least somewhat improved mortality in about half of the studies; however, benefits were mostly found only for some subpopulations (i.e. the most severely injured, older persons, etc.)[138, 154] In Caputo (2014), 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%).

Both reviews stated that given the methodological shortcomings in the studies, definite conclusions cannot be drawn with respect to the impact of patient-volume on mortality. The authors also point out that it was not possible to determine an optimal volume-threshold above which better patient's outcomes are attained. Recent studies[127, 142, 155] provide limited evidence that major trauma patients admitted to higher volume trauma centres have a reduced risk of in-hospital mortality

Evidence of the impact of trauma systems for other outcomes is limited

The evidence on the implementation of trauma centres and of patient-volume on the length of stay in the hospital or in the intensive care unit (ICU) was not clear-cut. This result was present in one recent review[138] as well as in more recent studies.[129, 133, 144, 156, 157]

Quality assurance programme may enhance the performance of the major trauma system

Kim (2014)[138] pointed out accredited or designated trauma centres (via the American College of Surgeons or state verification programs) had better patient outcomes (mortality and length-of-stay) in nine out of eleven studies. Recent studies [128, 129, 133, 144, 156, 157] do not provide further elements to clarify the impact of accreditation or designation of centres on patient's outcomes.

7 CONCLUSION

The purpose of this study was to evaluate, in light of the recent scientific evidence and the experience of other European countries, the need to reform the organisation of care for major trauma patients in Belgium. Based on this study it is clear that there are compelling arguments to implement an 'Inclusive System for Major Trauma' in Belgium.

7.1 Lessons for the implementation process

An international consensus to organise care for major trauma patients via inclusive trauma networks

Since the 1990s, some European countries started after the example of the US to implement major trauma centres that from the mid-2000 evolved towards trauma networks. Although major trauma centres remain a cornerstone in a trauma network the emphasis moved from isolated institutions towards a collaboration between all relevant actors in the care process of major trauma patients. The most important characteristic of these networks is that they are 'inclusive'. This means that within a defined geographical area, all key actors, from prehospital emergency care services towards rehabilitation, have a clear role in trauma care.

Evidence about effectiveness is not clear-cut …

Despite the international support for the trauma networks and the belief that they contribute to better patient outcomes (e.g. improved survival or reduced disabilities) the evidence base is less clear-cut. Although many studies show some beneficial effects after implementation of a trauma system, the overall picture is not entirely clear with some studies showing no effect or even a few contra-intuitive results. One of the main reasons behind this conflicting evidence is that the quality of the available studies and the used study designs are not optimal. Frequent problems are the heterogeneity in the studied population (e.g. different levels or types of severity injury), outcome measurement (e.g. in-hospital mortality versus 30-day mortality) and insufficient risk-adjustment (i.e. mortality decreased in lower levels of trauma care since the most severely injured are directly transported to or

secondarily referred to a MTC). Comparability between studies is also hampered by the heterogeneous definitions of the trauma centre characteristics, including volume thresholds and the level of maturation of trauma networks. The latter may lead to evaluate newly implemented systems before reaching processes improvements or to fail to take into account that boundaries between trauma levels over time tend to dilute in mature systems.

…. But strong indications for effectiveness among the most severely injured

In the scientific literature, the most omnipresent definition of a 'major trauma' is a patient with an Injury Severity Score (ISS) above fifteen. However, behind this homogeneous definition lies a complex reality. Compared to lower-levels of care, admission to a MTC has been often, but not always, found to be beneficial for 'major trauma patients'. A more in-depth analysis of studies with outcome measures reported for different subgroups of major trauma patients suggests that effects are most prominent for the most severely injured patients (e.g. ISS >24).
Likewise, there are indications that special provisions should be undertaken for specific subgroups such paediatric and older patients and specific injuries (e.g. burns, spinal cord injury). A key success factor for a trauma network is thus getting the patients with a major trauma, especially those with very severe or specific injuries, to the MTC.

… and it takes time before trauma networks achieve the expected benefits

The evidence suggests that trauma networks need time to mature and that improvement in patient's outcomes may be visible for different levels of care at different moments during the maturation of the system. Longitudinal studies evaluating networks after different points in time (e.g. the Netherlands, Israel and Canada) showed that a significant and consistent decrease in mortality is reached after a period of 10 years.

Furthermore, improvements in patient outcomes can be observed in mature systems after the introduction of evidence-based processes. This makes sense since the crux of a trauma network is not just to provide staff and equipment but also to streamline the processes (e.g. shared knowledge between different levels of trauma care and implementation of standardised protocols) which requires time. Experts confirmed that indeed, it is not sufficient to provide the necessary staff and equipment, but that continuous investments in improved care processes (e.g. standardised protocols to accept and stabilise the patient at the Emergency Department, rapid access and interpretation of CT-imaging) make the real difference.

Concentration of care: a critical mass of major trauma patients to gain and maintain expertise

A trauma system, per definition, aims to enhance the concentration of patients into the centres that are better adapted to respond to the complex care needs major trauma patients require.

Achieving a critical mass of patients per centre is considered 'a must' to allow the multidisciplinary teams to acquire and maintain the required expertise. Yet the available literature does not allow to set an optimal volume-threshold above which there is an indisputable improvement in patient's survival. Despite the lack of consensus on the overall impact of high-volume, the latter seems to be associated with improvement on patients' outcomes for some subpopulations, including the most severely injured.

Countries that use volume-thresholds rely on the best available evidence as well as on expert opinion. The most often cited volume-threshold (i.e. at least 240 major trauma patients (ISS>15) or 1 200 injured patients per year per centre) is that of the American College of Surgeons (ACS).[18] While this norm is widely used all over the world, it should be noted that, even in the United States, some states require higher or lower volume of patients to be treated in designated MTCs.

During the conceptualisation phase of the networks in European countries, professional organisations tend to align the volume thresholds to this international standard. Yet, it should be noted that these thresholds may be adapted to lower or higher norms because of political compromises or to the available resources when the actual implementation takes place. Nevertheless, it was observed that after some time, the volume thresholds tend to be aligned (e.g. as planned in by 2018 in the Netherlands) to the standards of the American College of Surgeons (ACS).

7.2 Towards a new care pathway for major trauma patients in Belgium

All ingredients for trauma networks are available… but need to be brought together

While Belgium has no formal 'trauma network' many of the elements that were identified in other European countries are already available.

The future supraregional collaborations can rely on MICU teams that cover most of the country within short spans of time. The MICU teams are staffed by an emergency physician and a nurse. This is a different starting point compared to other European systems that re-designed their trauma system (e.g. in England ambulances are staffed by paramedics). MICU teams have the advantage that they can assess the severity of the injury at the scene of the accident and stabilise the patient when needed.

In addition, Belgian hospitals have a large capacity and a modern infrastructure. Both elements provide a solid basis for the implementation of the system. There is, however, substantial room for improvement: limited coordination between prehospital providers, very large number of hospitals treating major trauma patients and therefore a very low caseloads, limited or late inter-hospital transfers and lack of good data and quality insurance programs

Room for improvement: building a coordinated approach between prehospital providers

Available data for prehospital settings show that patients are being referred to a too large number of hospital's sites. The median volume of patients treated per hospital's site is far below the lowest internationally established threshold (i.e. Germany's threshold of 40 patients). In addition, unlike in countries with a trauma system in place, in Belgium it is not standard practice to transfer severe trauma cases immediately (e.g. after initial stabilisation in an acute hospital) towards a limited number of reference centres.

Major trauma patients with burns seem to be an exception to this rule since most of these patients are immediately transported to one of the six Belgian major burn centres. As such, the case of burns shows that bypassing the closest hospital to centres that are better equipped and resourced to treat these severely injured trauma patients is not unthinkable.

Yet, changing the triage of major trauma patients will require to:

- Implement **a common definition for 'major trauma'** and **a common triage tool** to identify these patients. The most often used tools take into account the mechanism of injury and physiological and anatomical parameters.
- Implement common rules to ensure a rapid **inter-hospital transfer**.
- Impement **common criteria** to define the capacity ('adequacy') of hospitals to treat these patients in the list of **hospital specificities** of the Commissions for urgent medical care of each province. The criteria are currenlty based on a broad and heterogeneous desciption of the services (departments) available in the hospital.

In other words, at the moment of the implementation of the inclusive trauma system clear triage tools and rules should be implemented.

Room for improvement: categorisation of hospitals

There is currently no formal categorisation of hospitals leaving each hospital to decide how and which resources are devoted to the treatment of major trauma patients. If an inclusive trauma system us implemented in Belgium, it is of utmost importance that the role of each acute hospital is clearly defined. In line with this, designating MTCs and the role played by other acute hospitals within the supraregional collaboration need to be established.

After the implementation of the supraregional collaborations, the patient's flow will change. The most severely injured patients will be referred to a MTC. MTCs will work with other acute hospitals in the supraregional collaboration to deliver care for less complex cases. The role of 'non-MTC hospitals', however, can differ according to their location. In areas at remote distance from a MTC, 'non-MTC hospitals' may have an important role in stabilising the patient before transferring them to a MTC as well as in the after-care and rehabilitation. The latter to ensure that patients with a long rehabilitation can be managed closer to their home. Acute hospitals at close

distance of a MTC, should be bypassed, except in the case that the MTC is overloaded.

MTCs will need to accommodate a higher number of severely injured patients and in order to do so, other patients need to be referred to non-MTCs. For these patients, clear agreements should be established in the network in order to determine which groups of patients will be brought to which hospital.

Fostering a successful transfer of knowledge and expertise between healthcare professionals working in MTCs and non-MTCs is essential. A successful collaboration between MTCs and non-MTCs should enhance the expertise of healthcare professionals at all acute hospitals, leading to improvements in the quality of care provided to all injured patients.

Room for improvement: improved data collection

Evaluation and research on trauma care requires appropriate collection of data. At the moment, high quality data on the incidence of major trauma is lacking in Belgium. A trauma registry is not available and linking prehospital and hospital data is not possible. The latter was already addressed by healthcare authorities and it is expected that a unique patient identifier will be available in both databases in the near future.

The implementation of the 'inclusive trauma system' provides a good opportunity to reassess the scope and content of the prehospital registry. The definition of major trauma patients in the prehospital registry should be aligned with the prehospital triage tool that will be selected at the moment of the implementation of the inclusive trauma system.

Room for improvement: evaluation of the quality of care provided

Except from some isolated initiatives, hospitals do not participate in programs allowing them to measure the performance of the care provided to major trauma patients.

The implementation of an inclusive trauma system should be simultaneously be accompanied by **a planned evaluation of predefined end-points for short-and long-term outcomes including quality of life indicators**. Coupling data from the pre- and in-hospital settings with mortality data from the national registry could be used to evaluate process selected end-points for the networks before and after their implementation. While this approach has several shortcomings (e.g. mapping codes from the International classification of diseases clinical modification with (ICD-9) into codes of the Abbreviated Injury Scale (AIS)), it provides a short-term solution until these data can be retrieved from a trauma registry.

In addition to this, the establishment of a formal **quality assurance program** needs to be foreseen. This is necessary to verify the compliance with the requirements that will be established for the supraregional collaborations. Given the time and costs required to establish an audit/accreditation process, an international established auditing institution could initially assess the compliance with the established requirements. Ideally, all structures should follow the same accreditation process in order to ensure that the supraregional collaborations are homogeneously implemented throughout the country.

7.2.1 Policy levers for a successful implementation

Opportunities within the overall reform of the Belgian hospital landscape

As the Belgian hospital landscape is undergoing a large reform on its organisation and financing, there is a momentum that can be used to install 'inclusive trauma system'. The supraregional collaborations for major trauma can be aligned to the new hospital landscape with loco-regional networks and to the policy levers used to realise them. Three main policy levers can be used to support the implementation of trauma centres:

- programming the maximum number of supraregional collaborations and MTCs and supraregional ;
- recognition of the supraregional collaborations and MTCs based on clearly defined recognition criteria (and;
- payment mechanism.

Evidence from abroad shows that the participation of all stakeholders in the discussion of the 'blueprint' for the inclusive trauma system facilitates its implementation. The latter requires that healthcare authorities propose clear and transparent programming and recognition requirements.

Programming the supraregional collaborations and MTCs based on internationally accepted criteria

Care for major trauma patients is a typical care assignment that requires, as pointed out in the principles of the current reform, a supraregional collaboration encompassing several loco-regional networks. The 'reference points' of these supraregional collaborations are the major trauma centres that will attract patients from the loco-regional networks encompassed in 'the suprearegional collaborations for major trauma'. In other words, there will be less supraregional collaborations and MTCs than there will be loco-regional networks. Consequently, the loco-regional networks will have to make arrangements for the referral of patients to the MTC (theoretically unique) of the supraregional collaboration.

The programming rules for the supraregional collaborations and MTCs can be based on best practices abroad and on the scientific literature. Minimum key parameters to model the supply of MTCs throughout the entire territory should include: **the transport time to the MTC** (i.e. allowing to reach the MTC within 45 minutes), the **population covered** by the supraregional collaborations (i.e. with variations between 1.5 and 2.5 million inhabitants as in the Netherlands and England, respectively), the **supply of EMS providers and acute hospitals** and **minimum volume thresholds** (e.g. 240 major trauma patients (ISS>15) as defined by the American College of Surgeons (ACS)). In addition, to avoid duplication of services and low volumes per centre, it seems appropriate that a supraregional collaboration is built around only one MTC.

The programming of MTCs should also take into account agreements with **international partners**. Indeed, cross-border collaborations between EMS teams and hospitals (e.g. with MTC abroad close to the Belgian boarder) may influence the patient's flow.

Defining and implementing recognition criteria

The translation of the Federal programmed supraregional collaborations and MTCs towards their actual designation is the responsibility of the federated entities**. Recognition standards will have to be developed based on internationally accepted standards** for infrastructure (e.g. operating room capacity for emergency surgery), staffing (e.g. 24/7 availability of experienced emergency physicians, nurses, etc.) and ideally, the **same recognition standards should be implemented throughout the entire territory.**

Since the programming will limit the number of MTCs and given that many Belgian hospitals have a modern and good infrastructure the number of eligible candidates will potentially be higher than the number of programmed MTCs. As such the federated entities will have to run simulations whereby the **transport times prevail** on the other criteria. Additional provisions should be undertaken in areas not in 45 minutes reach of a MTC (e.g. acute hospitals can play an important role in the initial stabilisation).

The recognition process should include a careful assessment of the **hospital's manpower**, the **processes in place** and the hospital's capacity to **create links with other hospitals** (e.g. 'informal networks' and the possibility of expanding them within delimited the supraregional collaboration).

Hospitals designated as MTCs should be ready and capable to be the centre of a **'knowledge network'** and to ensure the transfer of expertise to other hospitals in the supraregional collaboration. The latter implies the transfer of evidence-based protocols as well the support necessary to effectively implement them.

Payment mechanism taking into account the required resources and aligned to the overall reform of the Belgian hospital payment system

Payment mechanisms for the acute phase in MTCs should be designed as a mixed financing model, similar to that recommended for the financing of emergency departments (KCE report 263).[36] A large share of the financing should encompass a **fixed part** in order to guarantee the reception of patients on a 24/7 basis by highly qualified staff in the trauma centre.

The **variable part should** allow to take into account the large variability in the care process. After the most critical phase, the care provided to these patients becomes highly variable given that it depends on the type of injury and on the comorbidities. Therefore, the financing model should include a variable component in order to take into account these large variability.

A KCE study is currently addressing the advantages and short-comings of financing models for hospitals stays with a large variability in the care process. The results of this study are expected by the summer of 2017 and could provide a basis for the establishment of financing mechanisms for these specific categories of patients.

Healthcare authorities should also consider whether current payments for **primary and secondary transfers** will need to be adapted when trauma collaborations are implemented. The MICU teams are linked to individual (or associations of) hospitals and it will be necessary to assess whether increased transport times needed to reach a MTC (primary and secondary transfers) may lead to extra costs for these hospitals.

Finally, a budget to cover the cost related to the logistic organisation of the networks may be required to launch the networks.

Transitional phase

The inclusive trauma system will require time to implement changes. Therefore, it is recommended to make an **evaluation after five years** of the system's implementation, in particular to assess the modifications in the patient's flow: concentration of major trauma patients in MTCs, role of other hospitals and the performance of the supraregional networks to re-organise the patient's flow according to the hospitals' capacity.

Policymakers should be aware that saving lives is the first step of the system. While, *per se*, this is a great accomplishment, the next challenge will be to allow these victims to live, as much as possible, without disabilities. In order to do so, rehabilitation services should meet the specific needs of these patients. Therefore, we encourage policymakers to review this aspect at the launch of the new pathway for major trauma patients in Belgium.

Box 7 – Study limitations

Scope

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.

We did not evaluate the link between the care for burnt and major trauma patients. The latter was decided given that a detailed analysis of the organisation framework for burnt patients in Belgium was included in a previous KCE study.[158] An analysis of costs in selected foreign countries was not included as these depend on organisational and financing models that are not directly transferable to the Belgian situation. The payment for services in the different countries analysed is based on different activity-based payment system. This model of payment is currently not in place in Belgium making direct comparison impossible.

Belgian data

Five main limitations concerning the analysis of the Belgian data must be mentioned. First, the data analyses mainly rely on administrative data, i.e. the Mobile Intensive Care registry and the minimum hospital data. **First**, the most recent data were used for both sources which implied to have a certain time lag (2015 for the Mobile Intensive Care registry and 2014 for the minimum hospital data).

Second, we could not measure the performance of the system giving the lack of information of patients' outcomes.

Third, our definitions for 'major trauma' reflect an approximation of the true cases in Belgium. The definitions used were discussed with experts from the field. While they acknowledged that the data did not reflect the incidence of 'major trauma', the experts agreed that the choices made allow to have an appropriate view on the dispersion of patients throughout the country.

Fourth, each database had specific shortcomings. **In pre-hospital settings**, the number of 'severe trauma' is likely to be influenced by the coding practices of the MICU teams. In addition, there is not a good correspondence between the flag for 'severe trauma' and the definition included in the SMUR manual (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). Data on PIT (Paramedics Intervention Team) or ambulance interventions were not available for this study. For severe trauma, an ambulance or a PIT are likely to be sent to the scene of the accident if the MICU is not available. Overall, data shortcomings may lead to underestimations of the number of severe trauma interventions.

In in-hospital settings, we restricted the analysis to in-patient stays for multiple significant trauma (Major Diagnostic Category (MDC) = 25). This choice does not allow to calculate the total number of patients with a 'major trauma' as it focuses on poly-traumatised patients and does not encompass serious isolated injuries. In order to validate our choice, sensitivity analysis were performed for other groups (e.g. Craniotomy for trauma, Head trauma without coma > 1hr or Haemorrhage, Brain contusion/Laceration, Major chest & respiratory trauma). Compared with patients in the MDC25, a higher percentage of patients had a low severity of illness in the other groups and the number of cases largely exceeded the number of expected number of major trauma cases based on international comparisons. Both observations indicate that these trauma-related APR-DRG's outside MDC25 include a large portion of less severely injured patients.

Fifth, little data was available to analyse whether the hospital's resources were associated with the referral of patients to a specific site.

International comparison

Evidence gathering for the international comparison relies on a narrative review of available reports and ad-hoc searches for the volume-outcome analysis and the impact of the maturity of the system. This approach allowed us to have a global perspective of the situation in the different countries that was further completed and reviewed by experts working in the field of trauma in each country.

Systematic review

The systematic review had several limitations. The complex literature on this topic combined with the heterogeneous definitions of patients and trauma centre characteristics resulted in a large number of studies not being included. We focused on unadjusted outcomes that do not reflect differences between study populations and hospital characteristics, limiting the evidence for our findings. However, different authors used different variables to adjust their analyses, making it impossible to compare adjusted outcomes across studies. We focused on the most recent literature (i.e. published since 2012). To avoid missing relevant information from older studies we compared our findings with the evidence included in systematic reviews of high quality. Finally, the field of research on trauma care is continuously expanding. However, given the time constraints of the project evidence published after April 2016 was not included.

RECOMMENDATIONS

To the Federal Minister of Social Affairs and Public Health

In order to reduce the fragmentation in major trauma care, all structures involved in major trauma care should be integrated into one 'Inclusive Trauma System', divided into several supraregional collaborations. The 'reference point' of each supraregional collaboration is a Major Trauma Centre (MTC).

- **On the basis of international benchmarks and of estimates of major trauma incidence in our country, the maximum number of Major Trauma Centres (MTCs) in Belgium should be between four and seven. A further concretisation of this programming will have to take into account the following parameters:**
  - **The population covered by a supraregional collaboration varies between 1.5 million (as in the Netherlands and Germany) and 2.5 million inhabitants (as in England).**
  - **Transport times (from departure with the patient at the accident scene until arrival at a Major Trauma Centre) should not exceed 45 minutes.**
  - **A Major Trauma Centre should manage at least 240 patients per year with a major trauma (Injury Severity Score (ISS) above 15), and at least 80 patients with a very severe major trauma (ISS>24).**
  - **There is one Major Trauma Centre per supraregional collaboration.**
  - **All acute-care hospitals with a specialised emergency department are also part of a supraregional collaboration.**
- **To foresee financing mechanism that take into account the required resources and that are aligned to the reform of the financing of hospital: a fix part for availability and a variable part to take into account the large variability in the care process**

To the Federated and Federal entities in charge of programming and recognition

- **Recognition standards for supraregional collaborations and MTCs should be developed, on the basis of the federal defined programming rules.**
- **A distinction should be made between Major Trauma Centres for adult patients only and Major Trauma Centres that also can accept children.**
- **The recognition standards for a Major Trauma Centre for adults should be based upon the internationally accepted standards (i.e. the American College of Surgeons Committee on**

Trauma ACS-COT standards, upon which most European trauma systems are based) and should at least include the following requirements:

- **Infrastructure and medical equipment: highly specialised emergency departments with at least two trauma rooms, operating room capacity for emergency surgery, highly specialised neurosurgery departments and intensive care units, a blood bank with adequate supply to allow mass transfusions, computed tomography facility (CT), magnetic resonance imaging (MRI) and interventional radiology unit.**
- **Protocols to ensure:**
  - **a safe and rapid handover from pre-hospital team to the trauma team;**
  - **stabilisation of the patient in the trauma room;**
  - **direct access to diagnostic and surgical infrastructure and equipment within a predefined timing upon arrival. (e.g. within CT within 30 minutes)**
- **Healthcare professionals:**
  - **24/7 availability of a multispecialty trauma team including at least one emergency physician or equivalent and one specialist with experience in major trauma, present at the hospital;**
  - **other specialists with critical skills (anaesthetist, neurosurgeon, radiologist, vascular surgeon, etc.) should be able to reach the hospital within 15 to 30 minutes;**
  - **a sufficient number (to be defined) of the healthcare professionals within the trauma team must have followed a training in emergency room management and trauma related life support.**
- **Coordination functions of each Major Trauma Centre in its the supraregional collaboration include:**
  - **to provide and coordinate training and education programs for all healthcare professionals;**
  - **establish and run a comprehensive quality system;**

- **provide short-term specialised advice and/or care in the Major Trauma Centre, on an outpatient or day-care basis, for less severe patients admitted in other hospitals.**

- **MTCs that also admit children aged 16 years or younger should in addition fulfil the following conditions:**
  - **Infrastructure and medical equipment: Paediatric Intensive Care Unit, trauma room in the emergency department with child-specific protocol, paediatric resuscitation equipment;**
  - **Healthcare professionals: 24/7 availability of dedicated and specifically trained paediatric teams;**
  - **MTCs providing care for children may cover larger areas than those for adults, in order to increase the concentration of patients treated per centre.**
- **Recognition standards for supraregional collaborations;**
  - **The supraregional collaborations are responsible to establish clearly defined agreements between all participating actors (hospitals and emergency medical services), including:**
    - **the role of acute care hospitals not designated as a Major Trauma Centre (e.g. stabilisation of major trauma patients in case the 45 minutes transport times to a Major Trauma Centre cannot be met);**
    - **protocols for secondary transfer between acute care hospitals;**
    - **continuity of care in terms of post-acute care and rehabilitation in facilities in proximity of patient's place of residence;**
    - **monitoring of the compliance with established evidence-based protocols for the clinical management of trauma patients.**
- **The quality of care of the supraregional collaboration and MTC should be evaluated on a regular basis using internationally accepted accreditation standards.**

To the Federal Public Service Health, Food chain safety and Environment

- **A national pre-hospital triage tool for trauma should be introduced in Belgium. This tool should allow to identify major trauma patients and ensure that they are transported to the nearest major trauma centre.**
- **The registration of pre-hospital information in the Mobile Intensive Care Unit registry (MUGreg – SMUreg) should be standardised and improved, including the provision of a clear and unique definition for a 'major trauma', in coherence with the pre-hospital triage tool that was adopted.**
- **A unique patient identifier should enable the coupling of data from the Mobile Intensive Care Unit registry with hospital discharge data (MZG – RHM).**

To the Federal Public Service Health, food chain safety and environment and INAMI – RIZIV

- **A national policy for major trauma requires to have access to high quality data for the complete trauma care pathway:**
  - **The pre-hospital phase;**
  - **The initial treatment in the emergency department;**
  - **The complete hospitalisation phase (including the phase in the intensive care unit); and**
  - **Short- and long-term outcomes including mortality, disability and patient's quality of life.**

  This information is collected in different datasets and should be centralised and coupled with a unique identifier. This could be included as a part of the new wave of the Healthdata.be initiatives.

REFERENCES

1. WHO. Injuries and violence: the facts [Web page].2010 [cited 10/02/2015]. Available from: http://www.who.int/violence_injury_prevention/key_facts/en/
2. European Association for Injury Prevention and Safety Promotion (EuroSafe). Injuries in the European Union: Summary of injury statistics for the years 2008-2010. Amsterdam: 2011. Available from: http://www.sante.public.lu/fr/publications/i/injuries-eu-stat-2008-2010/index.html
3. European Association for Injury Prevention and Safety Promotion (EuroSafe). Injuries in the European Union: Summary of injury statistics for the years 2010-2012. Amsterdam: 2013. 5th Edition Available from: http://www.sante.public.lu/fr/publications/i/injuries-eu-stat-2010-2012/index.html
4. European Association for Injury Prevention and Safety Promotion (EuroSafe). Injuries in the European Union: Summary of injury statistics for the years 2012-2014. Amsterdam: 2016. 6th Edition Available from: http://www.eurosafe.eu.com/uploads/inline-files/EuropeSafe_Master_Web_02112016%20%282%29.pdf
5. Palmer CS, Gabbe BJ, Cameron PA. Defining major trauma using the 2008 Abbreviated Injury Scale. Injury. 2016;47(1):109-15.
6. Munzberg M, Mutschler M, Paffrath T, Trentzsch H, Wafaisade A, Walcher F, et al. Level of Evidence Analysis for the Latest German National Guideline on Treatment of Patients with Severe and Multiple Injuries and ATLS. World J Surg. 2015;39(8):2061-7.
7. Trauma Association of Canada, Association Canadienne de Traumatologie. Trauma System. Accreditation Guidelines. 2011. Fourth revision Available from: https://accreditation.ca/trauma-distinction
8. Alfred Health Caring for the severely injured in Australia. Inaugural report of the Australian Trauma Registry. Melbourne, Victoria: 2014. Available from: http://ntri.org.au/img/aust-trauma-registry-inaugural-report.pdf
9. NHS England. NHS standard contract for Major Trauma Services (all ages). London: NHS England; 2013. D15/S/a Available from: https://www.england.nhs.uk/wp-content/uploads/2014/04/d15-major-trauma-0414.pdf

10. Conférence suisse des directrices et directeurs cantonaux de la santé (CDS). Prise en charge des blessés graves. Rapport final. 2015. Available from: http://www.gdk-cds.ch/fileadmin/docs/public/gdk/themen/hsm/dokumentation/03_bt_schlussbericht_trauma_reeval_zuordn_publ_def_f.pdf
11. Nederlandse Vereniging voor Traumachirurgie. Visiedocument 2016 – 2020 2016. Available from: http://www.trauma.nl/files/Visiedocument-11%20februari%202016-_0.pdf
12. Landelijk Netwerk Acute Zorg. Landelijke Traumaregistratie 2010 - 2014. Rapportage Nederland. 2015. Available from: http://www.lnaz.nl/cms/LNAZ_LTR_rapportage_2010-2014.pdf
13. Landelijk Netwerk Acute Zorg. Landelijke Traumaregistratie 2009 - 2013. Rapportage Nederland. 2014. Available from: http://www.lnaz.nl/cms/LNAZ_LTR_landelijke_rapportage_2009-2013.pdf
14. Lansink KW, Gunning AC, Spijkers AT, Leenen LP. Evaluation of trauma care in a mature level I trauma center in the Netherlands: outcomes in a Dutch mature level I trauma center. World J Surg. 2013;37(10):2353-9.
15. German Society for Trauma Surgery, Professional Association of Orthopaedic and Trauma Specialists. Whitebook Medical Care of the Severely Injured. Berlin: Deutsche Gesellschaft für Unfallchirurgie; 2012. 2nd revised and updated edition Available from: http://www.dgu-online.de/qualitaet-sicherheit/schwerverletzte/weissbuch-schwerverletztenversorgung.html
16. TraumaRegister DGU. 20 years of trauma documentation in Germany - Actual trends and developments. Injury. 2014;45, Supplement 3:S14-S9.
17. Ruchholtz S, Mand C, Lewan U, Debus F, Dankowski C, Kühne C, et al. Regionalisation of trauma care in Germany: the “TraumaNetwork DGU®-Project”. European Journal of Trauma and Emergency Surgery. 2011;38(1):11-7.
18. Committee on trauma American College of Surgeons. Resources for optimal care of the injured patient. 2014. Available from: https://www.facs.org/~/media/files/quality%20programs/trauma/tsepc/pdfs/regionaltraumasystems.ashx
19. Innledning: nasjonal traumeplan – Traumesystem i Norge 2015 [Introduction: national trauma plan - Trauma System in Norway 2015]. 2015. Available from: http://innsyn.kvinnherad.kommune.no/eInnsyn/RegistryEntry/ShowDocument?registryEntryId=329040&documentId=409921
20. Dehli T, Gaarder T, Christensen BJ, Vinjevoll OP, Wisborg T. Implementation of a trauma system in Norway: a national survey. Acta Anaesthesiol Scand. 2015;59(3):384-91.
21. Kristiansen T, Ringdal KG, Skotheimsvik T, Salthammer HK, Gaarder C, Naess PA, et al. Implementation of recommended trauma system criteria in south-eastern Norway: a cross-sectional hospital survey. Scand J Trauma Resusc Emerg Med. 2012;20:5.
22. Kristiansen T, Soreide K, Ringdal KG, Rehn M, Kruger AJ, Reite A, et al. Trauma systems and early management of severe injuries in Scandinavia: review of the current state. Injury. 2010;41(5):444-52.
23. Jansen JO, Lendrum RA, Morrison JJ. Trauma care in Scotland: The role of major trauma centres, trauma units, and local emergency hospitals. Surgeon. 2016.
24. Jansen JO, Morrison JJ, Wang H, He S, Lawrenson R, Hutchison JD, et al. Access to specialist care: Optimizing the geographic configuration of trauma systems. J Trauma Acute Care Surg. 2015;79(5):756-65.
25. Deasy C, Cronin M, Cahill F, Geary U, Houlihan P, Woodford M, et al. Implementing Major Trauma Audit in Ireland. Injury. 2016;47(1):166-72.
26. Décision concernant la planification de la médecine hautement spécialisée (MHS) dans le domaine de la prise en charge des blessés graves. 2015. Available from: https://www.admin.ch/opc/fr/federal-gazette/2015/6701.pdf
27. NHS Clinical Advisory Groups Report. Regional Networks for Major Trauma London: NHS England; 2010. Available from: http://www.uhs.nhs.uk/Media/SUHTInternet/Services/Emergencymedicine/Regionalnetworksformajortrauma.pdf
28. Australasian Trauma Verification Program Officer. The australasian trauma verification program manual 2009. Available from: https://

www.surgeons.org/media/309244/2009-08-04_Trauma_Verification_Manual.pdf

29. Senterre C, Leveque A, Di Pierdomenico L, Dramaix-Wilmet M, Pirson M. Epidemiology of injuries in Belgium: contribution of hospital data for surveillance. Biomed Res Int. 2014;2014:237486.
30. Van de Voorde P, Sabbe M, Calle P, Lesaffre E, Rizopoulos D, Tsonaka R, et al. Paediatric trauma and trauma care in Flanders (Belgium). Methodology and first descriptive results of the PENTA registry. Eur J Pediatr. 2008;167(11):1239-49.
31. Van de Voorde P, Sabbe M, Calle P, Idrissi SH, Christiaens D, Vantomme A, et al. Closing the knowledge-performance gap: an audit of medical management for severe paediatric trauma in Flanders (Belgium). Resuscitation. 2008;79(1):67-72.
32. Mortelmans LJ, Maebe S, Dieltiens G, Anseeuw K, Sabbe MB, Van de Voorde P. Are Tertiary Care Paediatricians Prepared for Disaster Situations? Prehosp Disaster Med. 2016;31(2):126-31.
33. Mortelmans LJ, Van Boxstael S, De Cauwer HG, Sabbe MB. Preparedness of Belgian civil hospitals for chemical, biological, radiation, and nuclear incidents: are we there yet? Eur J Emerg Med. 2014;21(4):296-300.
34. Mortelmans LJ, Dieltiens G, Anseeuw K, Sabbe MB. Belgian senior medical students and disaster medicine, a real disaster? Eur J Emerg Med. 2014;21(1):77-8.
35. Rainer TH, De Villiers Smit P. Trauma systems and emergency medicine. Emerg Med (Fremantle). 2003;15(1):11-7.
36. Van den Heede K, Dubois C, Devriese S, Baier N, Camaly O, Depuijdt E, et al. Organisation and payment of emergency care services in Belgium: current situation and options for reform. Health Services Research (HSR). Brussels: Belgian Health Care Knowledge Centre (KCE); 2016 29/03/2016. KCE Reports 263 Available from: http://kce.fgov.be/sites/default/files/page_documents/KCE_263_Organisation_and_payment_of_emergency_care_services.pdf
37. Cellule stratégique de la ministre des Affaires sociales et de la Santé publique. Plan d'approche - Réforme du financement des hôpitaux. Bruxelles: 2015. Available from: http://www.inami.fgov.be/SiteCollectionDocuments/hopitaux_reforme_financement.pdf
38. Ministre des Affaires sociale et de la Santé publique. Réformes et rationalisation dans le secteur hospitalier: Principes et accords dans le cadre du conclave d'octobre 2016. Bruxelles. Available from: http://www.absym-bvas.be/images/admin_bru/Bruxelles/6._161019_Reforme_et_rationalisation_secteur_hospitalier.pdf
39. Loi du 8 Juillet 1964 relative à l'aide médicale urgente, M.B. 8 Juillet 1964.
40. Arrêté royal du 10 Août 1998 fixant les normes auxquelles doit répondre une fonction " service mobile d'urgence " (SMUR) pour être agréée., M.B. 10 Août 1998.
41. Arrêté royal du 20 Septembre 2002 précisant les règles relatives au nombre maximum et fixant les critères de programmation applicables à la fonction " service mobile d'urgence", M.B. 20 Septembre 2002.
42. Nationale raad voor ziekenhuisvoorzieningen. Advies PIT. Brussel: 2014. (NRZV/D/442-2) Available from: http://overlegorganen.gezondheid.belgie.be/sites/default/files/documents/nationale_raad_voor_ziekenhuisvoorzieningen/2014_02_13_-_nrzv_d_442-2-_advies_pit.pdf
43. Cierkens K, Cobbaert L, Vanden Eynden E, Tecchiato C. Le transport des malades. 2015. 261 Available from: https://www.mc.be/binaries/mc-informations_261_fiche_info_transport_malades_tcm377-165238.pdf
44. SPF Santé Publique Sécurité de la chaine alimentaire et environnement. PIT (paramedical intervention team) [Web page]. SPF Santé Publique Sécurité de la chaine alimentaire et environnement;2016-05-04. Available from: http://www.health.belgium.be/fr/pit-paramedical-intervention-team
45. Arrêté ministériel du 6 Juillet 1998 déterminant les caractéristiques extérieures des véhicules qui interviennent dans le cadre de l'aide médicale urgente, M.B. 6 Juillet 1998.
46. Circulaire ministérielle du 15 Octobre 2015 relative à l'arrêté royal du 21 février 2014 déterminant les activités mentionnées à l'article 21quinquies, § 1er, a), b) et c). 1. Il s'agit désormais de l'article 46, §

1er, 1°, 2° et 3° de la loi coordonnée du 10 mai 2015 relative à l'exercice des professions des soins de santé de l'arrêté royal n° 78 du 10 novembre 1967 relatif à l'exercice des professions des soins de santé que le secouriste-ambulancier peut réaliser et fixant les modalités d'exécution de ces activités afférentes à la fonction de secouriste-ambulancier, adressée aux organes de gestion des hôpitaux, des services ambulanciers, des secouristes-ambulanciers, des infirmiers et des médecinsM.B. 15 Octobre 2015.

47. Arrêté royal du 13 Février 1998 relatif aux centres de formation et de perfectionnement des secouristes-ambulanciers., M.B. 13 Février 1998.
48. Arrêté royal du 25 Avril 2002 relatif à la fixation et à la liquidation du budget des moyens financiers des hôpitaux, M.B. 25 Avril 2002.
49. Loi du 16 Février 2012 contenant le budget général des dépenses pour l'année budgétaire 2012, M.B. 16 Février 2012.
50. Arrêté royal du 17 Décembre 2012 octroyant un subside aux services d'ambulance visés à l'article 5 de la loi du 8 juillet 1964 relative à l'aide médicale urgente pour l'organisation d'une permanence et fixant les conditions d'octroi de ce subside, M.B. 17 Décembre 2012.
51. Koninklijk besluit van 27 april 1998 houdende vaststelling van de normen waaraan een functie "gespecialiseerde spoedgevallenzorg" moet voldoen om erkend te worden, B.S. 19 juni 1998.
52. Koninklijk besluit van 27 april 1998 houdende vaststelling van de normen waaraan een functie "eerste opvang van spoedgevallen" moet voldoen om te worden erkend, B.S. 19 juni 1998.
53. Van de Voorde C, Van den Heede K, Obyn C, Quentin W, Geissler A, Wittenecher F, et al. Conceptual framework for the reform of the Belgian hospital payment system. Health Services Research (HSR). Brussels: Belgian Health Care Knowledge Centre (KCE); 2014 26/09/2014. KCE Reports 229 Available from: https://kce.fgov.be/sites/default/files/page_documents/KCE_229_Hospital%20Financing_Report.pdf
54. Arrêté royal du 2 avril 1965 déterminant les modalités d'organisation de l'aide médicale urgente et portant désignation des communes comme centres du système d'appel unifié., M.B. 2 avril 1965. Available from: http://www.ejustice.just.fgov.be/loi/loi.htm
55. Arrêté royal du 10 Août 1998 instituant les Commissions d'Aide médicale urgente, M.B. 10 Août 1998.
56. Service public fédéral Santé publique SdlCaeE. Vade-mecum de l'aide médicale urgente (loi du 8 Juillet 1964). Service public fédéral Santé publique, Sécurité de la Chaîne alimentaire et Environnement.; 2007. Available from: http://www.forumag.be/pdf/6_F_SMUR.pdf
57. National Audit Office. Major trauma care in England. London: National Audit Office; 2010. Available from: https://www.nao.org.uk/report/major-trauma-care-in-england/
58. Lansink KW, Reusken A, Sturms L, Schepel C. Comments from experts. In: Proceedings of Trauma System in the Netherlands; 2016.
59. Jan ten Duis H, van der Werken C. Trauma care systems in The Netherlands. Injury. 2003;34(9):722-7.
60. Westhoff J, Hildebrand F, Grotz M, Richter M, Pape HC, Krettek C. Trauma care in Germany. Injury. 2003;34(9):674-83.
61. Nederlandse Vereniging voor Traumachirurgie. Levelcriteria NVT [Web page].2013. Available from: http://www.trauma.nl/levelcriteria-nvt
62. Ministerie van Volksgezondheid WeSV. Beleidsvisie Traumazorg 2006-2010. 2006. Available from: https://www.rijksoverheid.nl/documenten/kamerstukken/2006/04/19/beleidsvisie-traumazorg-2006-2010
63. German Trauma Society, German Society of General and Visceral Surgery, German Society of Anesthesiology and Intensive Care Medicine, German Society of Endovascular and Vascular Surgery, German Society of Hand Surgery, German Society of Oto-Rhino-Laryngology HaNS, et al. S3 - Guideline on Treatrment of Patients with Severe and Multiple Injuries. English Version of the German Guideline S3 – Leitlinie Polytrauma/Schwerverletzten-Behandlung. Berlin: 2012. 012/019 Available from: http://www.awmf.org/fileadmin/user_upload/Leitlinien/012_D_Ges_fuer_Unfallchirurgie/012-019e_S3_Severe_and_Multiple_Injuries_2015-01.pdf

64. Committee on trauma American College of Surgeons, Trauma system evaluation and planning committee. Regional Trauma Systems: Optimal Elements, Integration, and Assessment, American College of Surgeons Committee on Trauma: Systems Consultation Guide 2008. Available from: https://www.facs.org/~/media/files/quality%20programs/trauma/tsepc/pdfs/regionaltraumasystems.ashx

65. The Royal College of Surgeons of England. Provision of Trauma Care Policy Briefing. 2007. Available from: http://www.em-online.com/download/medical_article/36201_FINAL%20trauma%20statement%207%20sept%2007.pdf

66. NHS England. National Peer Review Programme: Major Trauma Measures 2015. An overview of the findings from the 2015 National

Peer Review of Trauma Networks, Centres and Units in England. 2015. Available from: http://www.tquins.nhs.uk/?menu=resources

67. Landelijk Netwerk Acute Zorg. Landelijke Traumaregistratie 2011 - 2015. Rapportage Nederland. 2016. Available from: http://www.lnaz.nl/cms/LTR_landelijk_jaarrapport_2011-2015.pdf

68. Krausen U, AUC – Akademie der Unfallchirurge GmbH. Data on accredited hospitals participating in the the TraumaNetzwerk DGU® (2015) - Personal Communication. In: Proceedings of Trauma System in Germany; 2016.

69. NHS England. NHS England Regions and Local Offices alonside NHS Clinical Commissiong Groups (CGS) [Web page].2015. Available from: https://www.england.nhs.uk/wp-content/uploads/2013/01/eprr-maps.pdf

70. Debus F, Lefering R, Frink M, Kühne CA, Mand C, Bücking B, et al. Numbers of Severely Injured Patients in Germany. Dtsch Arztebl Int. 2015;112:823-9.

71. Spijkers AT, Meylaerts SA, Leenen LP. Mortality decreases by implementing a level I trauma center in a Dutch hospital. J Trauma. 2010;69(5):1138-42.

72. Twijnstra MJ, Moons KG, Simmermacher RK, Leenen LP. Regional trauma system reduces mortality and changes admission rates: a before and after study. Ann Surg. 2010;251(2):339-43.

73. Ruchholtz S, Lefering R, Lewan U, Debus F, Mand C, Siebert H, et al. Implementation of a nationwide trauma network for the care of severely injured patients. J Trauma Acute Care Surg. 2014 ;76(6):1456-61.

74. Deutsche Gesellschaft für Unfallchirurgie (DGU). TraumaRegister DGU® - Jahresbericht 2015 [Annual Report]. 2015. Available from: http://www.traumaregister-dgu.de/fileadmin/user_upload/traumaregister-dgu.de/docs/Downloads/TR-DGU-Jahresbericht_2015.pdf

75. Hipps D, Jameson S, Murty A, Gregory R, Large D, Gregson J, et al. The effect of introducing a Trauma Network on patient flow, hospital finances and trainee operating. Injury. 2015;46(2):195-200.

76. Metcalfe D, Perry DC, Bouamra O, Salim A, Woodford M, Edwards A, et al. Regionalisation of trauma care in England. Bone Joint J. 2016;98-b(9):1253-61.

77. Lansink KW, Leenen LP. History, development and future of trauma care for multiple injured patients in the Netherlands. Eur J Trauma Emerg Surg. 2013;39(1):3-7.

78. Edwards A. TARN data on major trauma patients (2014-2016) in England - Personal communication. In: Proceedings of Trauma System in England; 2016.

79. Deutsche Gesellschaft für Unfallchirurgie (DGU). TraumaRegister DGU® - Jahresbericht 2016 [Annual Report]. 2016. Available from: http://www.dgu-online.de/fileadmin/published_content/5.Qualitaet_und_Sicherheit/PDF/2016_Annual_Report_TraumaRegister_DGU_2015.pdf

80. Moran C. Comments from experts - Personal communication. In: Proceedings of Trauma System in England; 2016.

81. Rommens PM, Kuhn S. Comments from experts - Personal Communication In: Proceedings of Trauma System in Germany; 2016.

82. Bos N, Hendriks M, de Booys M, Wets M. Spoed moet goed: indicatoren en normen voor zes spoedzorgindicaties. Zorginstituut Nederland; 2015.

83. NHS. Peer Review Visit Report - Cheshire and Merseyside Collaborative MTC. 2015. Available from: https://www.tquins.nhs.uk/reports/PR-rpt_Cheshire_a_Reception_and_Resusc__T14-2B-1_150327-172558.pdf
84. NHS. Peer Review Visit Report - Cheshire and Merseyside Collaborative MTC. 2014. Available from: http://www.tquins.nhs.uk/reports/pr-joined-rpt_Cheshire_and_Merseyside_Collaborative_MTC_140610-1455.pdf
85. Advies Expertgroep spoedzorg. Indicatoren Multitrauma - Advies Expertgroep spoedzorg. 2015. Available from: https://www.zorginstituutnederland.nl/binaries/content/documents/zinl-www/documenten/rubrieken/kwaliteit/jaar-transparantie/multitrauma---consultatie-kwaliteitsindicatoren-spoedzorg/multitrauma---consultatie-kwaliteitsindicatoren-spoedzorg/Multitrauma+-+Consultatie+kwaliteitsindicatoren+spoedzorg.pdf
86. NHS Confederation. Implementing trauma systems: key issues for the NHS. 2010. Available from: http://www.nhsconfed.org/resources/2010/08/implementing-trauma-systems-key-issues-for-the-nhs
87. Mahlke L, Lefering R, Siebert H, Windolf J, Roeder N, Franz D. [Description of the severely injured in the DRG system: is treatment of the severely injured still affordable?]. Chirurg. 2013;84(11):978-86.
88. McCullough AL, Haycock JC, Forward DP, Moran CG. II. Major trauma networks in England. British Journal of Anaesthesia. 2014;113(2):202-6.
89. Bijlmakers D, Gorzeman MP. DOT-handleiding SEH-artsen. 2015. Available from: http://www.nvsha.nl/index.php/documenten/dot/176-dot-handleiding-voor-seh-artsen-knmg/file
90. Franz D, Schemmann F, Roeder N, Siebert H, Mahlke L. [Financing of inpatient orthopaedics and trauma surgery in the 2011 G-DRG System]. Unfallchirurg. 2011;114(9):829-36.
91. Franz D, Schemmann F, Roeder N, Mahlke L. [Financing of inpatient orthopedics and trauma surgery in the G-DRG system 2010]. Unfallchirurg. 2010;113(8):682-9.
92. Gershlick B. Best Practice Tariffs. Paris: Organisation for Economic Co-operation and Development (OECD); 2016. Available from: https://www.oecd.org/els/health-systems/Better-Ways-to-Pay-for-Health-Care-Background-Note-England-Best-practice-tariffs.pdf
93. Probst C, Schaefer O, Hildebrand F, Krettek C, Mahlke L. [The economic challenges of polytrauma care]. Unfallchirurg. 2009;112(11):975-80.
94. Franz D, Windolf J, Siebert CH, Roeder N. [Orthopedic and trauma surgery in the German-DRG-System 2009]. Unfallchirurg. 2009;112(1):84-90.
95. Nederlandse Vereniging voor Traumachirurgie. Beleidsplan 2010. 2010. Available from: http://www.trauma.nl/files/Beleidsplan2010_0.pdf
96. Kehoe A, Smith JE, Edwards A, Yates D, Lecky F. The changing face of major trauma in the UK. Emerg Med J. 2015;32(12):911-5.
97. Sturms LM. The Dutch Trauma Registry facts and figures 2015. In: Proceedings of Improving Trauma Care; 2016; Utrecht. Available from: http://www.lnaz.nl/cms/files/symposium2016/6._Sturms_2_nov_2016_LNAZ_symposium.pdf
98. NHS choices. Urgent and emergency care services in England [Web page]. Available from: http://www.nhs.uk/nhsengland/aboutnhsservices/emergencyandurgentcareservices/pages/majortraumaservices.aspx
99. Ministerie van Veiligheid en Justitie. Safety Regions Act. 2013.
100. Hoffmann M, Pape HC. Trauma care systems. In: Oestern H-J, Trentz O, Uranues S, editors. General Trauma Care and Related Aspects. Trauma Surgery II. Heidelberg: Springer; 2014.
101. Roessler M, Zuzan O. EMS systems in Germany. Resuscitation. 2006;68(1):45-9.
102. Sturm JA, Pape HC, Dienstknecht T. Trauma care in Germany: an inclusive system. Clin Orthop Relat Res. 2013;471(9):2912-23.

103. NHS choices. NHS ambulance services [Web page]. Available from: http://www.nhs.uk/NHSEngland/AboutNHSservices/Emergencyandurgentcareservices/Pages/Ambulanceservices.aspx
104. Workforce and Facilities Team HSCICH. Ambulance Services, England 2014-15. 2014. Available from: http://digital.nhs.uk/catalogue/PUB17722/ambu-serv-eng-2014-2015-rep.pdf
105. Association of Air Ambulances. Framework for a High Performing Air Ambulance Service 2013. 2013. Available from: http://www.associationofairambulances.co.uk/resources/events/AOAA-Framework%202013-OCT13-%20Final%20Document.pdf
106. Ambulancezorg Nederland. Policy Document on Responsible Ambulance Care. 2013. Available from: https://www.ambulancezorg.nl/engels
107. Timm A, Maegele M, Lefering R, Wendt K, Wyen H. Pre-hospital rescue times and actions in severe trauma. A comparison between two trauma systems: Germany and the Netherlands. Injury. 2014;45, Supplement 3:S43-S52.
108. Landelijk Netwerk Acute Zorg, Nederland A. MMT Inzet- en cancelcriteria. 2013. Available from: http://www.lnaz.nl/cms/Inzet-_en_cancelcriteria_MMT_-_LNAZ-AZN.PDF
109. NICE. Major trauma: service delivery. NICE guideline [NG40] 2016. Available from: https://www.nice.org.uk/guidance/ng40
110. de Jongh MA, Meeuwis JD, van Baar ME, van Stel HF, Schrijvers AJ. Evaluation of trauma care by comparing mortality risks and admission policy in a Dutch trauma region. Injury. 2008;39(9):1007-12.
111. TraumaNetzwerk DGU®. Auditierung & Zertifizierung [Web page].2016. Available from: http://www.traumanetzwerk-dgu.de/de/auditierung_zertifizierung/zertifizierungsunternehmen.html
112. Trauma Audit & Research Network (TARN). Procedures Manual. 2016. Available from: https://www.tarn.ac.uk/content/downloads/53/Complete%20Procedures%20manual%20-%20July%2016.pdf
113. Ringdal KG, Coats TJ, Lefering R, Di Bartolomeo S, Steen PA, Roise O, et al. The Utstein template for uniform reporting of data following major trauma: a joint revision by SCANTEM, TARN, DGU-TR and RITG. Scand J Trauma Resusc Emerg Med. 2008;16:7.
114. TraumaRegister DGU. Instructions for publishing results derived from TraumaRegister DGU®. 2014.
115. NHS England. National Peer Review Programme: Trauma Handbook. London: NHS England; 2014. Available from: http://www.tquins.nhs.uk/?menu=resources
116. Lendrum RA, Lockey DJ. Trauma system development. Anaesthesia. 2013;68 Suppl 1:30-9.
117. Dinh MM, Bein KJ, Gabbe BJ, Byrne CM, Petchell J, Lo S, et al. A trauma quality improvement programme associated with improved patient outcomes: 21 years of experience at an Australian Major Trauma Centre. Injury. 2014;45(5):830-4.
118. Dinh MM, Curtis K, Mitchell RJ, Bein KJ, Balogh ZJ, Seppelt I, et al. Major trauma mortality in rural and metropolitan NSW, 2009-2014: a retrospective analysis of trauma registry data. Med J Aust. 2016;205(9):403-7.
119. Dutton RP, Stansbury LG, Leone S, Kramer E, Hess JR, Scalea TM. Trauma mortality in mature trauma systems: are we doing better? An analysis of trauma mortality patterns, 1997-2008. J Trauma. 2010;69(3):620-6.
120. Goldman S, Siman-Tov M, Bahouth H, Kessel B, Klein Y, Michaelson M, et al. The Contribution of the Israeli Trauma System to the Survival of Road Traffic Casualties. Traffic Injury Prevention. 2015;16(4):368-73.
121. Harmsen AMK, Giannakopoulos GF, Terra M, de Lange de Klerk ESM, Bloemers FW. Ten year maturation period in a level-I trauma center, a cohort comparison study. European Journal of Trauma and Emergency Surgery. 2016:1-6.
122. Moore L, Hanley JA, Turgeon AF, Lavoie A. Evaluation of the Long-term Trend in Mortality from Injury in a Mature Inclusive Trauma System. World J of Surg. 2010;34(9):2069-75.
123. Moore L, Stelfox HT, Evans D, Hameed SM, Yanchar NL, Simons R, et al. Trends in Injury Outcomes Across Canadian Trauma Systems. JAMA Surg. 2016.
124. Moore L, Turgeon AF, Lauzier F, Emond M, Berthelot S, Clement J, et al. Evolution of patient outcomes over 14 years in a mature,

inclusive Canadian trauma system. World J Surg. 2015;39(6):1397-405.

125. Sarkar B, Brunsvold ME, Cherry-Bukoweic JR, Hemmila MR, Park PK, Raghavendran K, et al. American College of Surgeons' Committee on Trauma Performance Improvement and Patient Safety program: maximal impact in a mature trauma center. J Trauma. 2011;71(5):1447-53; discussion 53-4.
126. Siman-Tov M., Radomislensky I, Peleg K. Reduction in trauma mortality in Israel during the last decade (2000-2010): the impact of changes in the trauma system. Injury. 2013;44(11):1448-52.
127. Zacher MT, Kanz KG, Hanschen M, Haberle S, van Griensven M, Lefering R, et al. Association between volume of severely injured patients and mortality in German trauma hospitals. Br J Surg. 2015;102(10):1213-9.
128. Cole E, Lecky F, West A, Smith N, Brohi K, Davenport R. The Impact of a Pan-regional Inclusive Trauma System on Quality of Care. Ann Surg. 2016;264(1):188-94.
129. Metcalfe D, Bouamra O, Parsons NR, Aletrari MO, Lecky FE, Costa ML. Effect of regional trauma centralization on volume, injury severity and outcomes of injured patients admitted to trauma centres. Br J Surg. 2014;101(8):959-64.
130. Davenport RA, Tai N, West A, Bouamra O, Aylwin C, Woodford M, et al. A major trauma centre is a specialty hospital not a hospital of specialties. Br J Surg. 2010;97(1):109-17.
131. Gunning AC, Lansink KW, van Wessem KJ, Balogh ZJ, Rivara FP, Maier RV, et al. Demographic Patterns and Outcomes of Patients in Level I Trauma Centers in Three International Trauma Systems. World J Surg. 2015;39(11):2677-84.
132. Brinck T, Raj R, Skrifvars MB, Kivisaari R, Siironen J, Lefering R, et al. Unconscious trauma patients: outcome differences between southern Finland and Germany-lesson learned from trauma-registry comparisons. Eur J Trauma Emerg Surg. 2016;42(4):445-51.
133. Brinck T, Handolin L, Paffrath T, Lefering R. Trauma registry comparison: six-year results in trauma care in Southern Finland and Germany. Eur J Trauma Emerg Surg. 2015;41(5):509-16.
134. Gunning AC, Leenen LP. Applicability of the predictors of the historical trauma score in the present Dutch trauma population: modelling the TRISS predictors. J Trauma Acute Care Surg. 2014;77(4):614-9.
135. Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. J Trauma. 1999;47(3 Suppl):S25-33.
136. Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, et al. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. J Trauma. 2006;60(2):371-8; discussion 8.
137. Biewener A, Aschenbrenner U, Sauerland S, Zwipp H, Rammelt S, Sturm J. Impact of rescue pathway and hospital volume on the mortality of polytraumatized patients. Status report. Unfallchirurg. 2005;108(5):370-7.
138. Kim YJ. Relationship of trauma centre characteristics and patient outcomes: a systematic review. J Clin Nurs. 2014;23(3-4):301-14.
139. Gomez D, Alali AS, Xiong W, Zarzaur BL, Mann NC, Nathens AB. Definitive care in level 3 trauma centres after severe injury: A comparison of clinical characteristics and outcomes. Injury. 2015;46(9):1790-5.
140. Miyata S, Haltmeier T, Inaba K, Matsushima K, Goodhue C, Bliss DW. Should All Severely Injured Pediatric Patients be Treated at Pediatric Level I Trauma Centers? A National Trauma Data Bank Study. Am Surg. 2015;81(10):927-31.
141. Bouzat P, Broux C, Ageron FX, Gros I, Levrat A, Thouret JM, et al. [Impact of a trauma network on mortality in patients with severe pelvic trauma]. Ann Fr Anesth Reanim. 2013;32(12):827-32.
142. Minei JP, Fabian TC, Guffey DM, Newgard CD, Bulger EM, Brasel KJ, et al. Increased trauma center volume is associated with improved survival after severe injury: results of a Resuscitation Outcomes Consortium study. Ann Surg. 2014;260(3):456-64; discussion 64.

143. Mills B, Rowhani-Rahbar A, Simonetti JA, Vavilala MS. Facility characteristics and inhospital pediatric mortality after severe traumatic brain injury. J Neurotrauma. 2015;32(11):841-6.
144. Afifi R. Impact of Trauma System Preparedness on the Outcomes of Severe Child and Adolescent Injuries. Indian J Surg. 2015;77(Suppl 2):293-8.
145. Deasy C, Gabbe B, Palmer C, Babl FE, Bevan C, Crameri J, et al. Paediatric and adolescent trauma care within an integrated trauma system. Injury. 2012;43(12):2006-11.
146. Kuimi BL, Moore L, Cisse B, Gagne M, Lavoie A, Bourgeois G, et al. Influence of access to an integrated trauma system on in-hospital mortality and length of stay. Injury. 2015;46(7):1257-61.
147. Morrissey BE, Delaney RA, Johnstone AJ, Petrovick L, Smith RM. Do trauma systems work? A comparison of major trauma outcomes between Aberdeen Royal Infirmary and Massachusetts General Hospital. Injury. 2015;46(1):150-5.
148. Narayan M, Tesoriero R, Bruns BR, Klyushnenkova EN, Chen H, Diaz JJ. Acute care surgery: defining mortality in emergency general surgery in the state of Maryland. J Am Coll Surg. 2015;220(4):762-70.
149. Di Bartolomeo S, Marino M, Ventura C, De Palma R. Evaluation of the survival benefit of Trauma-Centre care in the Italian setting. Injury. 2014;45(1):299-303.
150. Vickers BP, Shi J, Lu B, Wheeler KK, Peng J, Groner JI, et al. Comparative study of ED mortality risk of US trauma patients treated at level I and level II vs nontrauma centers. Am J Emerg Med. 2015;33(9):1158-65.
151. Ashley DW, Pracht EE, Medeiros RS, Atkins EV, NeSmith EG, Johns TJ, et al. An analysis of the effectiveness of a state trauma system: treatment at designated trauma centers is associated with an increased probability of survival. J Trauma Acute Care Surg. 2015;78(4):706-12; discussion 12.
152. Glance LG, Osler TM, Mukamel DB, Dick AW. Impact of trauma center designation on outcomes: is there a difference between Level I and Level II trauma centers? J Am Coll Surg. 2012;215(3):372-8.
153. Matsushima K, Schaefer EW, Won EJ, Armen SB, Indeck MC, Soybel DI. Positive and negative volume-outcome relationships in the geriatric trauma population. JAMA Surg. 2014;149(4):319-26.
154. Caputo LM, Salottolo KM, Slone DS, Mains CW, Bar-Or D. The relationship between patient volume and mortality in American trauma centres: a systematic review of the evidence. Injury. 2014;45(3):478-86.
155. Clement RC, Carr BG, Kallan MJ, Wolff C, Reilly PM, Malhotra NR. Volume-outcome relationship in neurotrauma care. Journal of Neurosurgery. 2013;118(3):687-93.
156. Choi PM, Hong C, Woods S, Warner BW, Keller MS. Early Impact of American College of Surgeons-Verification at a Level-1 Pediatric Trauma Center. J Pediatr Surg. 2016.
157. Ovalle F, Xu L, Pearson WS, Spelke B, Sugerman DE. Outcomes of pediatric severe traumatic brain injury patients treated in adult trauma centers with and without added qualifications in pediatrics — United States, 2009. Inj Epidemiol. 2014;1(1).
158. Christiaens W, Van de Walle E, Devresse S, Van Halewyck D, Dubois C, Benahmed N, et al. Organisation of aftercare for patients with severe burn injuries Health Services Research (HSR). Brussels: Belgian Health Care Knowledge Centre (KCE); 2013. KCE Reports 209 (D/2013/10.273/72) Available from: https://kce.fgov.be/sites/default/files/page_documents/KCE_209_Burn_injuries.pdf

COLOPHON

Title:	Towards an inclusive trauma system for major trauma – Short Report
Authors of the report:	Maria-Isabel Farfan-Portet (KCE), Cécile Dubois (KCE), Patriek Mistiaen (KCE), Audrey Cordon (KCE), Sabine Stordeur (KCE), Koen Van Den Heede (KCE)
Authors of the 6th chapter:	Maaike Langelaan (NIVEL), Nanne Bos (NIVEL), Julie Heeren (NIVEL), Janke de Groot (NIVEL)
Project coordinator:	Sabine Stordeur (KCE)
Senior supervisor:	Koen Van den Heede (KCE)
Reviewers:	Mélanie Lefèvre (KCE), Raf Mertens (KCE), France Vrijens (KCE)
External experts:	Howard Champion (Uniformed Services University of the Health Sciences, USA), Olivier Cornu (Cliniques universitaires Saint-Luc, Belgian Orthopaedic Trauma Association [BOTA]), Peter De Paepe (UZ Gent, Trauma Task Force [TTF]), Saïd Hachimi-Idrissi (UZ Gent, Belgian Society of Emergency and Disaster Medicine [BeSEDiM]), Stefaan Nijs (UZ Leuven, Belgian Trauma Society [BTS]), François Pitance (CHR La Citadelle, Liège, Trauma Task Force [TTF]), Frank Plasschaert (UZ Gent, Belgische Vereniging voor Orthopedie en Traumatologie [BVOT]), Bart Poffyn (UZ Gent, Belgische Vereniging voor Orthopedie en Traumatologie [BVOT]), Guy Putzeys (AZ Groeninge, Belgian Orthopedic Trauma Association [BOTA]), Pol Maria Rommens (Johannes Gutenberg-Universität, Germany)
Stakeholders:	Xavier Banse (Conférence des Hôpitaux Académiques de Belgique [CHAB]), Olivier Cornu (Belgian Orthopaedic Trauma Associaton [BOTA]), Paul De Leyn (Royal Belgian Surgical Society [RBSS]), Paule Denoel (Gezondheidsinstellingen Brussel Bruxelles Institutions de Santé [GIBBIS]), Hilde De Nutte (Zorgnet – Icuro), Peter De Paepe (Trauma Task Force [TTF]), Koen De Ridder (Vlaamse Vereniging Verpleegkundigen Spoedgevallenzorg [VVVS]), Jan De Waele (Belgian Society of Intensive Care Medicine [SIZ Medica]), Diego Gouwy (FOD Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu), Saïd Hachimi-Idrissi (Belgian Society of Emergency and Disaster Medicine [BeSEDiM]), Winne Haenen (Commissie voor Dringende Geneeskundige Hulpverlening [CoDGH] – Antwerpen), Olivier Lambiet (SPF Santé publique, Sécurité de la Chaîne alimentaire et Environnement), Koenraad Monsieurs (Raad van Universitaire Ziekenhuizen RUZB), Stefaan Nijs (Belgian Trauma Society [BTS]), Frank Plasschaert (Belgische Vereniging voor Orthopedie en Traumatologie [BVOT]), François Pitance (Trauma Task Force [TTF]), Michel Praet (SANTHEA), Guy Putzeys (Belgian Orthopaedic Trauma Association [BOTA]), Michel Van Geert (FOD Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu), Pascal Vanelderen (Belgian College Of Emergency Physicians [BeCEP]), Manfredi Ventura (Union en Soins de Santé [UNESSA]), Zeger Vermeulen (Commissie voor Dringende Geneeskundige Hulpverlening [CoDGH] - Oost- en West-Vlaanderen), David Zorman (Société Royale Belge d'Orthopédie-Traumatologie)

External validators: François-Xavier Ageron (Centre Hospitalier Annecy Genevois, France), Jean-Bernard Gillet (CHU Brugmann, Belgium), Torben Wisborg (Oslo University Hospital Trust HF, Norway)

Acknowledgements: Antoinette Edwards (Trauma Audit & Research Network [TARN]), Tom Laurence (Trauma Audit & Research Network [TARN]), Chris Moran (Nottingham University Hospital – NHS England, England), Sue Shepherd (East Midlands Major Trauma Network, England), Koen Lansink (Elisabeth Tweesteden Ziekenhuis [ETZ], The Netherlands), Arold Reusken (Landelijk Netwerk Acute Zorg [LNAZ], The Netherlands), Christine Schepel (Netwerk Acute Zorg Brabant, The Netherlands), Leontien Sturms (Landelijk Netwerk Acute Zorg [LNAZ], The Netherlands), Sebastien Kuhn (Johannes Gutenberg-Universität Mainz, Germany), Ulla Krause (Akademie der Unfallchirurge GmbH [AUC], Germany), Rolf Lefering (Institut für Forschung in der Operativen Medizin [IFOM], Germany), Pol Maria Rommens (Johannes Gutenberg-Universität Mainz, Germany), Carl Decaluwe (AZ Groeninge), Philip Struyve (AZ Groeninge), Vincent Van Belleghem (AZ Groeninge), Serge Vanderschueren (AZ Groeninge), Johan Van Bussel (WIV – ISP), Paul Deceuninck (CHM Mouscron), Christophe Delbart (CHM Mouscron), Philippe Gadisseux (CHM Mouscron), Astrid Haenecour (Cliniques universitaires Saint-Luc), Jean-Louis Mariage (CHM Mouscron), Jose Panza (CHM Mouscron), Fabienne Vandercleyen (CHM Mouscron), Etienne Danse (Cliniques universitaires Saint-Luc), Philippe Meert (Cliniques universitaires Saint-Luc), Maximilien Thoma (Cliniques universitaires Saint-Luc), Eveline Depuijdt (FOD Volksgezondheid – SPF Santé Publique)

Other reported interests: All experts and stakeholders consulted within this report were selected because of their involvement in the topic of traumatology. Therefore, by definition, each of them might have a certain degree of conflict of interest to the main topic of this report'

Payments to speak, training remuneration, subsidised travel or payment for participation at a conference: Olivier Cornu (AAOS), Koen De Ridder (VVVS, Trauma lessons and organisation of help), Guy Putzeys (Participation to AO congress, a scientific trauma organisation)

Presidency or accountable function within an institution, association, department or other entity on which the results of this report could have an impact: Xavier Banse (member of the Committee of Directors of Cliniques universitaires Saint-Luc), Olivier Cornu (member of BOTA and SORBCOT; member of the Committee of Directors of Cliniques universitaires Saint-Luc), Peter De Paepe (Head of Emergency Service UZ Gent), Jan De Waele (Belgian Society of Intensive Care Medicine), Winne Haenen (President of The Commission for urgent medical help, Antwerp), Stefaan Nijs (member of the Committee of Directors UZ Leuven), François Pitance (Coordinator trauma center CHR Citadelle, Liège), Frank Plasschaert (Secretary BVOT), Guy Putzeys (Past president BOTA), Pascal Vanelderen (Vice president of the professional association BeCEP), Manfredi Ventura (Medical director of Grand Hôpital de Charleroi), Torben Wisborg (director of the Norwegian National Advisory Unit on Trauma, a governmental knowledge centre aimed to disperse knowledge on trauma care to all Norwegian health care providers in the trauma treatment chain. The findings in the present study could be viewed as to strengthen the need for further development of the Norwegian trauma system as well, and thus indirectly to support the need for further existence of the national advisory unit), Jean-Bernard Gillet (National Emergency Medical Advisory Board, FPS Public Health)

Layout: Ine Verhulst, Joyce Grijseels

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.** • **Finally, this report has been approved by a majority of votes by the Executive Board.** • **Only the KCE is responsible for errors or omissions that could persist. The policy recommendations are also under the full responsibility of the KCE.**
Publication date:	24 March 2017
Domain:	Health Services Research (HSR)
MeSH:	Trauma Centres; Multiple Trauma; Emergency Medical Services; Emergency Medical Dispatch; Quality of Health Care; Health Care Reform
NLM Classification:	WX 215
Language:	English
Format:	Adobe® PDF™ (A4)
Legal depot:	D/2017/10.273/03
ISSN:	2466-6459
Copyright:	KCE reports are published under a 'by/nc/nd' Creative Commons Licence http://kce.fgov.be/content/about-copyrights-for-kce-publications.
How to refer to this document?	Farfan-Portet M I, Dubois C, Mistiaen P, Cordon A, Stordeur S, Van Den Heede K. Towards an inclusive trauma system for major trauma – Short Report. Health Services Research (HSR) Brussels: Belgian Health Care Knowledge Centre (KCE). 2017. KCE Reports 281Cs. D/2017/10.273/03. This document is available on the website of the Belgian Health Care Knowledge Centre.