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EUROPEAN SOCIETY FOR TRAUMA AND EMERGENCY SURGERY

WHITEBOOK

Polytrauma and Management of Severely Injured Patients

Recommendations on structure, organisation, installations and equipment to promote quality, safety and reliability in the medical care of the severely injured in Europe

Editors:
Roman Pfeifer, Frank Hildebrand, Tina Gaarder, Ingo Marzi

Publisher:

The European Journal of Trauma and Emergency Surgery

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European Journal of Trauma and Emergency Surgery (2025) 51:156
https://doi.org/10.1007/s00068-025-02833-7

LETTER TO THE EDITOR

Letter to the European Society for Trauma and Emergency Surgery (ESTES): the European white book on polytrauma management

Hayato Kurihara[2] · **Hans-Christoph Pape**[1]

Received: 6 March 2025 / Accepted: 13 March 2025

The European Society of Trauma and Emergency Surgery (ESTES) is proud to present this White Book, a comprehensive guide addressing trauma care and its myriad of challenges. Compiled by an esteemed group of authors, this publication explores key aspects of trauma management, encompassing emergency and orthopaedic surgery to address acute injuries and their consequences. On behalf of the Board, it is an honour to introduce this pivotal work, which aims to set the standard for managing acute injuries and musculoskeletal conditions across Europe and beyond.

ESTES fosters a unique sense of community—a family of surgeons and other physicians, nurses, and other healthcare professionals from diverse backgrounds, united by their commitment to caring for injured patients. The editors and contributors to this White Book bring not only vast clinical experience but also decades of dedication to education and advancing one of the most demanding surgical disciplines: trauma management in both skeletal and visceral domains—in other words, polytrauma.

Editors Roman Pfeifer, Frank Hildebrand, Christine Gaarder, and Ingo Marzi have worked tirelessly to outline the fundamental requirements and actions necessary to optimise trauma care in European countries. The contributors were carefully selected from all ESTES sections, representing Emergency Surgery, Polytrauma, Visceral (General) Trauma, Skeletal Trauma and Sports Medicine, as well as Disaster and Military Surgery.

As noted by editor Christine Gaarder, "This generation of surgeons will probably be the last to take concrete actions to limit the loss of thousands of patients." The field of surgery overall is increasingly shaped by hyper-specialisation, with many European countries lacking subspecialties in acute care and trauma surgery. This has stymied the development of clinical standards and professional accreditation guidelines, highlighting the urgent need for progress.

Our discipline faces additional challenges, including a declining interest among younger surgeons, attributed to reduced exposure to trauma cases. Advances in conservative treatments, resuscitation techniques, and interventional radiology have markedly reduced the number of severe visceral injuries, while traffic-related fatalities have significantly declined thanks to initiatives like the Decade of Action for Road Safety (2011–2020), spearheaded by the World Health Organization and the United Nations.

Looking ahead, the UN's Decade of Action for Road Safety 2021–2030 aims to halve road traffic deaths and injuries by 2030. While this ambitious target promises to save countless lives, it also underscores the need for surgeons to preserve and enhance trauma management skills.

This White Book, "*Polytrauma and Management of Severely Injured Patients*", provides a comprehensive overview of trauma care requirements, spanning prevention programmes, trauma system development, pre-hospital and in-hospital management, inter-hospital communication and networking, and rehabilitation. It also addresses education, quality improvement, and research needs, offering a roadmap for optimizing care for the critically injured.

The European Society for Trauma and Emergency Surgery is proud to support this vital project, dedicated to healthcare professionals, stakeholders, and above all, the patients whose lives depend on these efforts. We hope this publication inspires readers and drives the implementation of its recommendations, ultimately saving lives and improving outcomes.

Author contributions All authors have wrote the main manuscript.

Data availability No datasets were generated or analysed during the current study.

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Published online: 28 March 2025

Declarations

Competing interests The authors declare no competing interests.

European Journal of Trauma and Emergency Surgery (2025) 51:170
https://doi.org/10.1007/s00068-025-02834-6

EDITORIAL

European white book on polytrauma management – setting standards for trauma care across Europe

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Received: 6 March 2025 / Accepted: 13 March 2025

Trauma remains a leading cause of death and disability in Europe, particularly affecting young individuals in their most productive years. Every year, about 5.3 million people experience injuries severe enough to need hospitalization; in the EU, trauma accounts for 8% of all deaths. The socioeconomic impact is substantial, with direct medical costs estimated at €80 billion annually and indirect costs, including lost productivity and long-term disability, approaching €180 billion.

Recognising this significant public health challenge, the European Society for Trauma and Emergency Surgery (ESTES) identified the urgent need for a comprehensive framework to standardise and optimise trauma care across Europe. This White Book represents a landmark effort to address the complexities of managing severely injured patients within diverse healthcare systems.

Within Europe, significant differences persist between countries in terms of structure, quality, and capacity. Historical, geographical, and socioeconomic factors have shaped the development of trauma care systems within individual member states. These variations extend to the organisation of pre-hospital services, the structure of hospital networks, the training of healthcare professionals, and the implementation of quality assurance measures. Some regions boast sophisticated trauma networks with designated centres of excellence, while others are still in the process of building the necessary infrastructure. The medical professionals involved in trauma care also vary: some countries rely on emergency physicians or anaesthetists, others on general surgeons or orthopaedic trauma surgeons.

Despite these disparities, one principle is universal: every trauma patient deserves access to optimal care, regardless of location or circumstances. This White Book seeks to bridge the gap between current practices and best standards by providing evidence-based recommendations for the organisation, structure, and delivery of trauma care. It outlines essential requirements for personnel, equipment, and infrastructure while allowing flexibility for adaptation to local contexts.

The recommendations presented here result from extensive collaboration among leading trauma experts from across Europe, covering the entire continuum of trauma care—from pre-hospital management and acute hospital care to rehabilitation and follow-up. Key focus areas include:

- Organising trauma networks and centres.
- Defining personnel qualifications and staffing requirements.
- Establishing minimum equipment and infrastructure standards.
- Implementing quality assurance measures and outcome assessment.
- Identifying research priorities and data collection requirements.
- Setting training and education standards for healthcare professionals.

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Published online: 09 April 2025

Recognising the diversity of healthcare systems across Europe, this White Book offers a flexible framework adaptable to individual countries. Some nations may prioritise developing basic infrastructure, while others focus on optimising existing systems. The White Book is adaptable, providing a framework that can be tailored to local conditions while maintaining high standards of care.

This document serves multiple stakeholders within the European healthcare landscape:

- For healthcare professionals, it provides clear guidelines for delivering optimal trauma care.
- For hospital administrators, it outlines the resources and organisational structures required.
- For policymakers, it offers evidence-based standards to inform healthcare planning.
- For educational institutions, it defines core competencies for trauma care training.
- For researchers, it identifies priority areas for further investigation.
- For European institutions, it lays a foundation for harmonising trauma care standards.

As European healthcare systems face challenges, including aging populations, rising costs, and workforce shortages, the need for efficient, standardised approaches to trauma care is ever more pressing. In addition, recent global emergencies have underscored the importance of robust, resilient healthcare systems capable of managing mass casualties and complex crises.

Looking to the future, this White Book aspires to catalyse positive change in European trauma care. Its recommendations aim to inspire national and regional initiatives to enhance trauma systems, foster cross-border collaboration, and drive continuous quality improvement. The document also includes relevant literature and guidelines for optimising trauma care.

ESTES extends its deepest gratitude to all contributors who made this White Book possible. Their expertise and dedication have resulted in a document poised to shape the future of trauma care across Europe. Special thanks are due to the chapter authors, who distilled current best practices into practical, actionable recommendations.

We also acknowledge the invaluable support of national societies, healthcare organisations, and individual professionals, whose diverse perspectives have enriched this publication and ensured its applicability across varied healthcare settings.

This White Book is more than a collection of recommendations—it is a shared vision for the future of trauma care in Europe. It reflects our collective commitment to reducing mortality and morbidity, improving outcomes for trauma patients, and advancing the science and practice of trauma care. We urge all stakeholders to adopt its recommendations and work together toward their implementation, with the ultimate goal of providing the best possible care for every trauma patient in Europe.

The task ahead is challenging, but with collaboration and dedication, we can establish effective trauma care systems that deliver consistent, high-quality outcomes for all European citizens, regardless of differing medical and structural backgrounds.

Author contributions All authors wrote the text of the main manuscript.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

European Journal of Trauma and Emergency Surgery (2025) 51:155
https://doi.org/10.1007/s00068-025-02824-8

ORIGINAL ARTICLE

Impact of trauma on society

Sascha Halvachizadeh[1] · Diego Mariani[2] · Roman Pfeifer[1]

Received: 11 February 2025 / Accepted: 6 March 2025

Abstract
Trauma is the leading cause of death in the working population. The World Health Organisation (WHO) reports 4.4 million deaths annually due to unintentional or violence-related injuries; one in three of these deaths results from road traffic injuries (RTIs). For individuals aged 5–29 years, three of the top five causes of death are injury-related. Major trauma is the eighth leading cause of death across all age groups and the leading cause of death among children and young adults. The highest rates of trauma-related deaths are observed in low-income countries. Globally, men face twice the risk of dying from injuries as women, with approximately 75% of injury-related deaths resulting from trauma and RTIs.

Keywords Polytrauma · Whitebook · ESTES

Current situation in Europe

In 2020, 153,500 people in the European Union died from accidents, accounting for approximately 3.0% of all deaths (Fig. 1).

Trauma is the leading cause of mortality and disability-adjusted life-years (DALYs), particularly in Europeans aged 40 years and below. Following deaths due to malignant neoplasms of the trachea, bronchus, and lung (20.6% of all causes), injuries account for 20.2% of deaths in the European working population. Between 2011 and 2020, the overall mortality rate from RTIs declined from 7% to 4.9%. More than one-third of all deaths among individuals aged 15–19 years in Europe were trauma-related (Fig. 1).

Depending on the country, 2.3% to 13.7% of European residents aged 15 years and older reported experiencing injuries at home or during leisure activities within a one-year period (Fig. 2).

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In 2021, the number of country-specific hospital discharges for inpatients with injuries ranged from 614 to 2389 per 100,000 inhabitants (Figs. 3, 4).

On average, the length of stay following injuries in Europe was 7.2 days (±2.0) in 2016 and 7.0 days (±1.7) in 2021. Patients with major fractures (e.g., femur fractures) experienced a decrease in length of stay by an average of 1.3 days (±0.9) (see Fig. 5).

Road traffic injuries (RTIs)

Frequency: RTIs are a leading cause of trauma in Europe, contributing to a substantial number of injuries and deaths. Factors including increased motorisation and road infrastructure play a role in their frequency.

Consequences: These incidents have profound consequences for individuals and public health systems. Years of life lost (YLL) and years lived with disability (YLD) are metrics used to quantify the burden of disease. RTIs result in significant burdens of YLL and YLD, reflecting the impact of both fatalities and long-term disabilities. Fatalities and severe injuries often cause extensive YLL, while survivors may experience long-term disabilities, contributing to YLD (see Fig. 6).

Published online: 26 March 2025

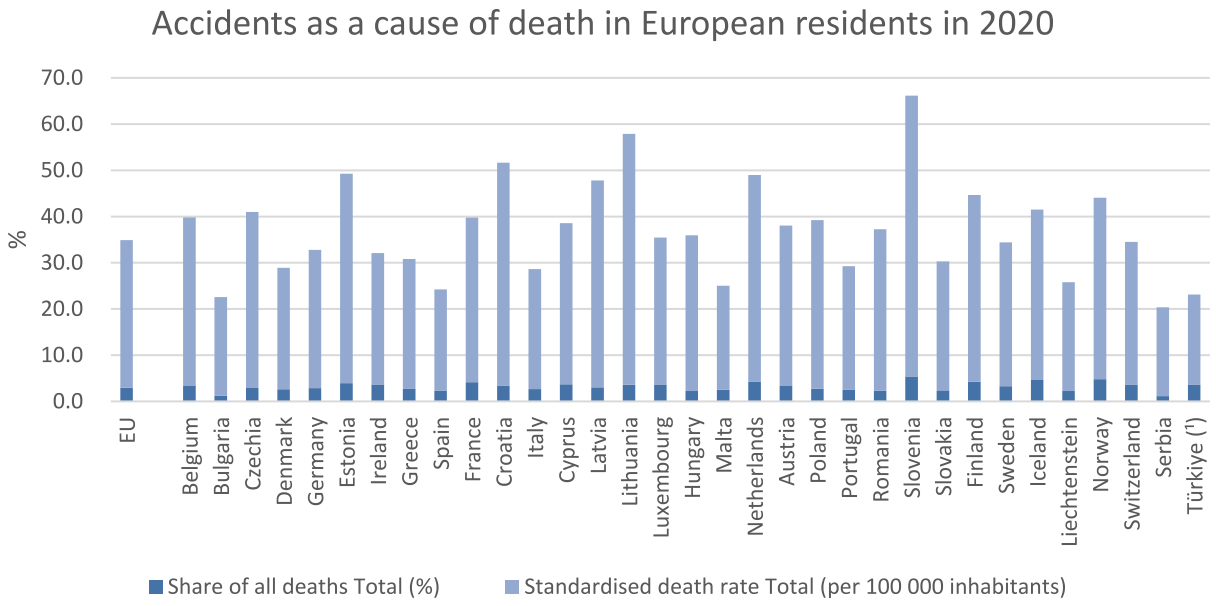

Fig. 1 Accidents as a cause of death among European residents in 2020. (Publicly available data from Eurostat)

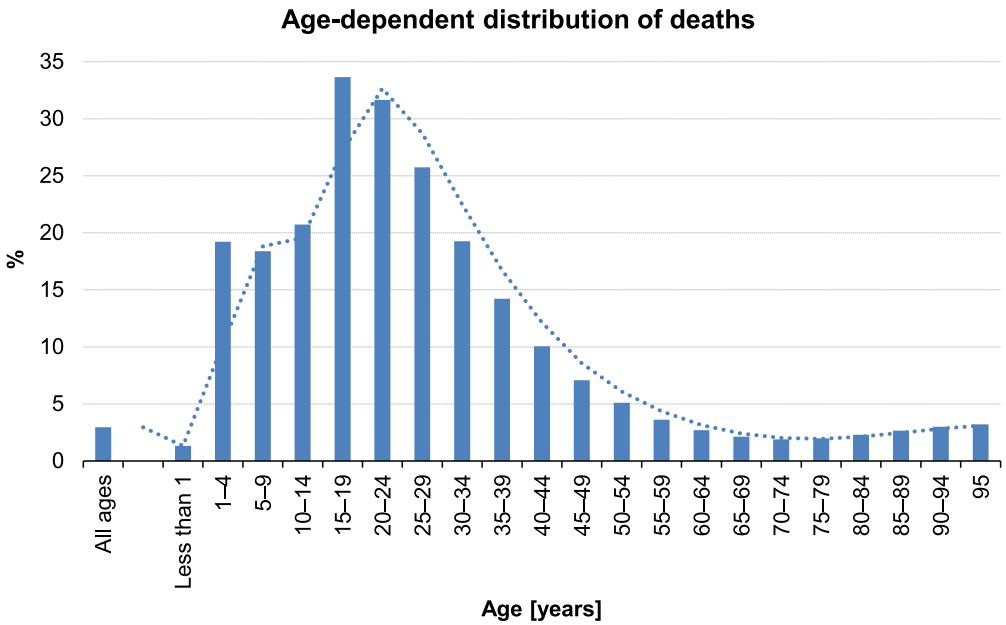

Fig. 2 Trauma-related share of all deaths in the European population stratified by age, adopted from publicly available data from Eurostat

Self-harm and violence

Frequency: Interpersonal violence and self-inflicted injuries are major mechanisms of trauma. The average rate is 0.4 per 100,000 people (updated 2020 source, Small Arms Survey). These incidents vary across European countries, influenced by socio-economic factors, mental health issues, and societal circumstances.

Consequences: Interpersonal violence and self-inflicted injuries contribute significantly to both premature death and long-term disability, adding to YLL and YLD. The psychological impact on survivors is often profound.

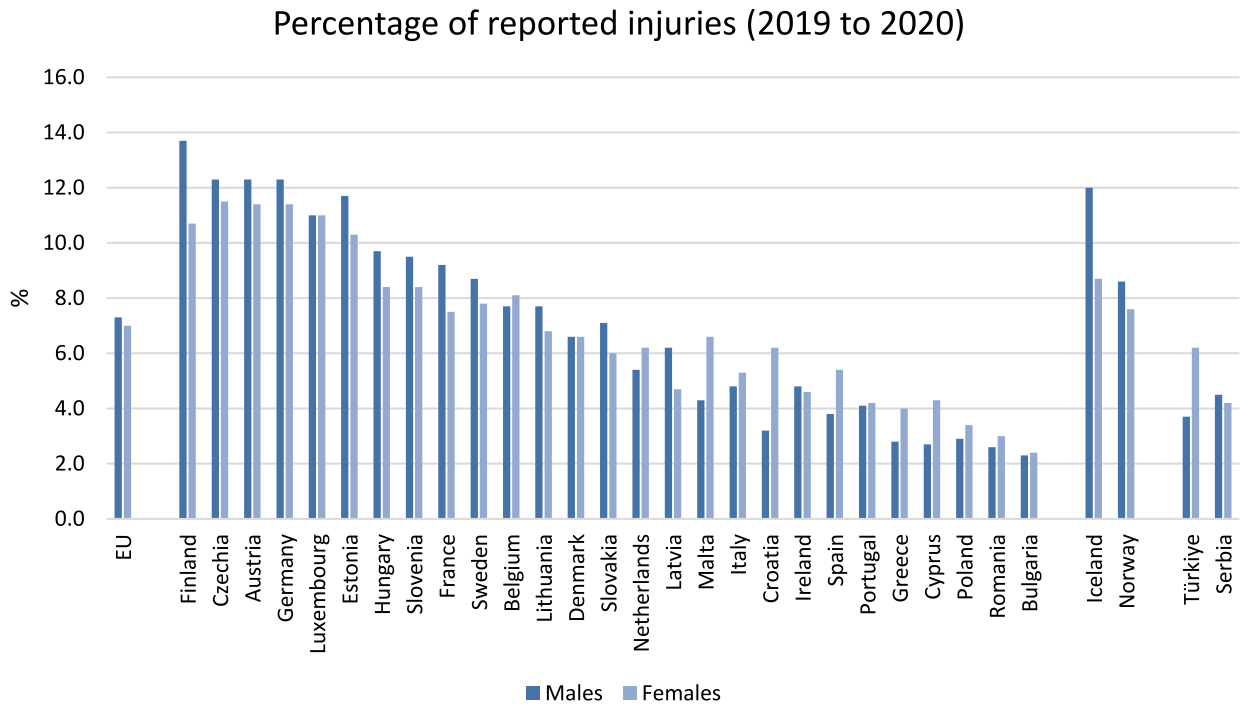

Fig. 3 Male and Female Europeans aged 15 years and older reporting injuries within one year (publicly available data from Eurostat)

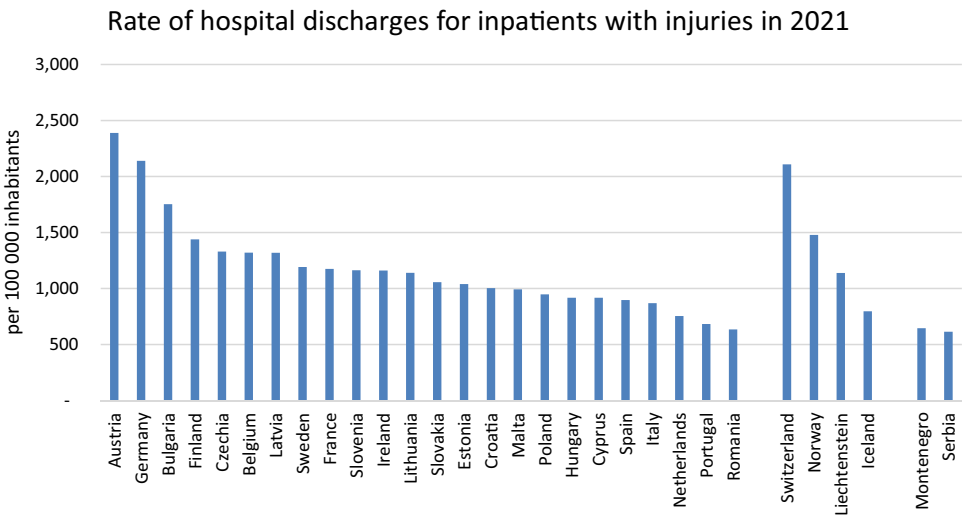

Fig. 4 The rate of hospital discharges for inpatients with injuries in European countries in 2021 (publicly available data from Eurostat)

Unintentional injuries

Frequency: Unintentional injuries, including falls, burns, and other mechanisms, are common. Their frequency is influenced by environmental hazards and individual behaviours.

Consequences: The outcomes of unintentional injuries vary but often lead to YLD due to disabilities caused by injuries. Severe cases can also result in YLL.

Reported global data

Studies have shown that trauma patients die at an early stage—either on site due to severe head injuries or within 48 h due to severe haemorrhage.

Improvement in trauma care is evident in the steady decline of mortality rates. Mortality rates dropped from 37 to 22% between the 1970s and 1990s. By the late 1990s,

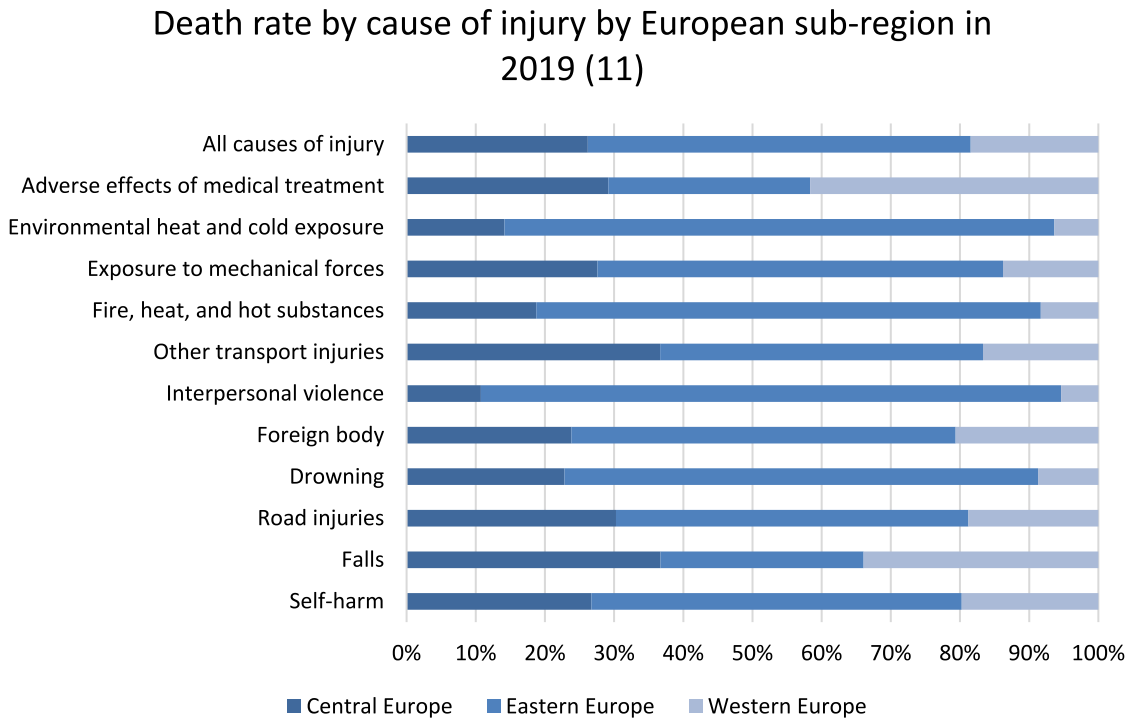

Fig. 5 Death rate by cause of injury stratified by European sub-region in 2019

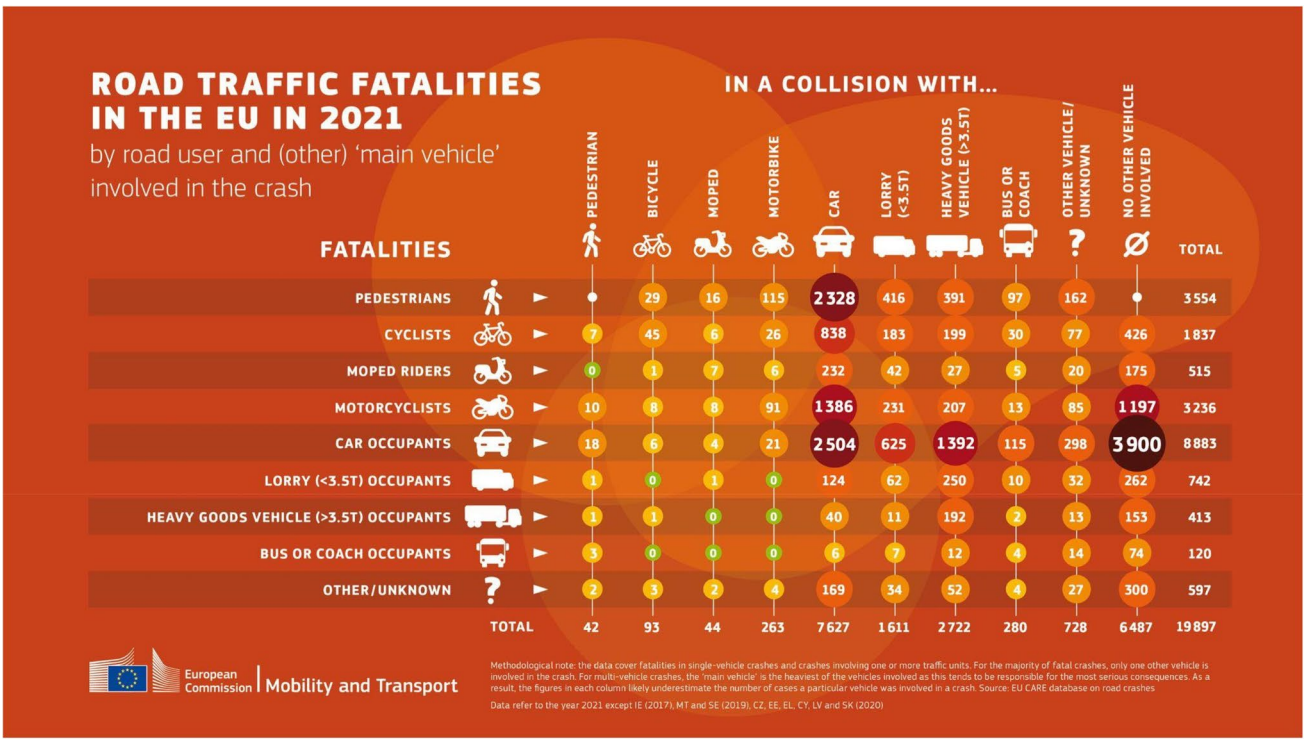

Fig. 6 Road traffic Injuries in the EU

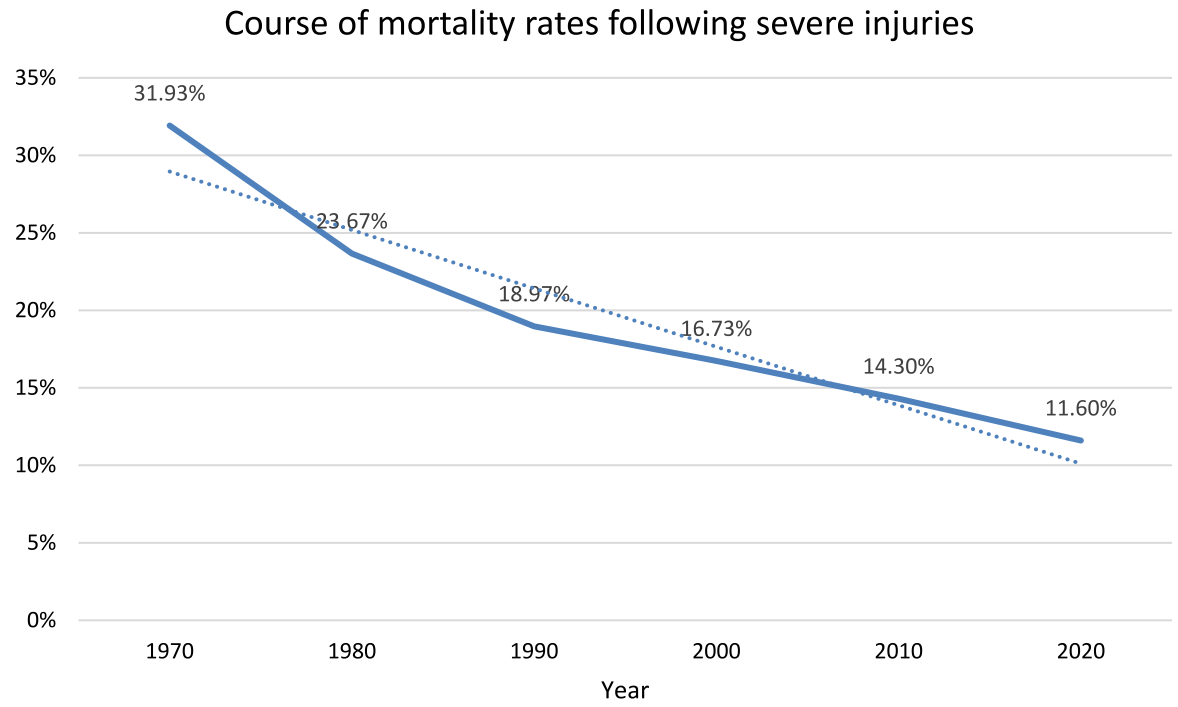

Fig. 7 The global course of mean mortality rates following severe injuries over the past 5 decades

a mortality rate of 13.9% following severe injuries was reported (see fig. 7).

A summary of data regarding trauma related deaths published between 1980 and 2008 showed a decrease of haemorrhage-induced deaths from 25 to 18%. Traumatic brain injuries, however, are associated with an annual 2.5% increase in mortality rate (95% CI 1.9–3.0%).

The burden of injury in Europe

In 2019, the disability-adjusted life years (DALYs) resulting from trauma ranged between 1781 and 5129 per 100 000 people in Europe (13). The highest DALYs were observed following RTIs, ranging from 1061.3 (95% CI 928.4–1,226.4) in Eastern Europe, to 648.2 (95% CI 551.5–754.0) in Central Europe, and the lowest, 314.6 (95% CI 291.2–341.2) in Western Europe. Trauma mortality rates followed the same patterns. Over the past decade, an increase of 0.5% in DALYs has been reported following falls in Western Europe, reaching 580.5 (95% CI 440.4–768.2) DALYs. Falls represent the leading cause of trauma-related DALYs in Europe, ranging from 580.5 (95% CI 440.4–768.2) in Western Europe to 712.9 (95% CI 566.8–924.1) in Eastern Europe. This gradient in DALYs across Europe may be attributed to a lack of unified trauma management structures and the absence of coordinated trauma systems (see fig. 8).

In Europe, the most significant injuries contributing to the highest YLD (Years Lived with Disability) are traumatic brain injuries, followed by spinal cord injuries and upper extremity amputations (Table 1).

Conclusion and needs for the future

Trauma remains the leading cause of mortality and DALYs, particularly among the European population aged 40 years and below. The improvement of trauma care in European countries often follows national initiatives; however, this leads to an unequal evolution of trauma care across Europe. Since advanced trauma systems improve survival rates and enhance quality of life, their implementation and maturation in each European country is of critical importance.

The trauma surgeon plays a vital role in this process, extending their involvement beyond surgical intervention to include the pre-hospital, hospital, and rehabilitation phases of trauma patient care. A Europe-wide consensus on trauma care could facilitate international communication and promote proportional improvements in national trauma systems.

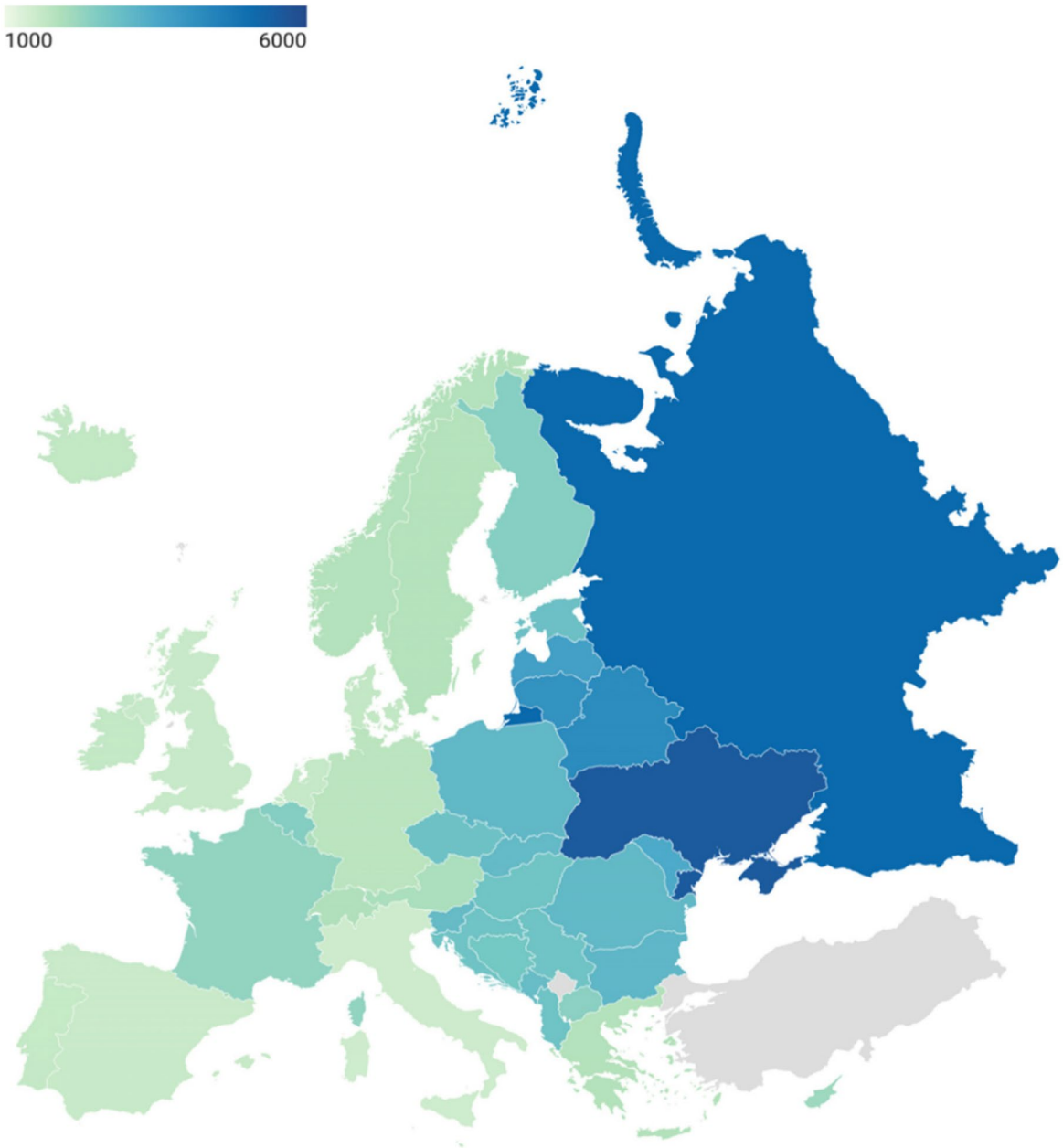

Fig. 8 Age-standardised DALY rate of injury per 100,000 people per country, 2019. *Countries in grey indicate that they are not part of the GBD European sub-regions

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Table 1 Ranking of injuries with the highest impact on YLD in Europe (14)

Injury	Years lived with disability (YLD)
Traumatic brain injury	86.8
Spinal cord injury	82.6
Amputation (upper extremity)	33.5
Hip fracture	30.4
Nerve injury	24.6
Amputation (lower extremity)	22.0
Femur shaft fracture	8.2
Lower leg fracture	1.0
Spine fracture	0.7
Elbow and forearm fracture	0.7

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Author contributions All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript.

Funding Open access funding provided by University of Zurich.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

European Journal of Trauma and Emergency Surgery (2025) 51:152
https://doi.org/10.1007/s00068-025-02832-8

REVIEW ARTICLE

Prevention programs

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Received: 11 February 2025 / Accepted: 6 March 2025

Abstract
With a rise in traumatic incidents across Europe, there is an escalating need for a proactive and coordinated approach to trauma prevention. This chapter outlines evidence-informed strategies and collaborative efforts aimed at reducing the incidence and impact of trauma in Europe.

Keywords Whitebook · Polytrauma · ESTES

Introduction

Effective trauma prevention begins with a thorough understanding of its causes and consequences. Trauma results from a variety of mechanisms, including road traffic injuries (RTIs), falls, violence, and natural disasters. A robust public health approach must identify and address risk factors, promote safer environments, and advocate for policies that prioritise injury prevention.

The role of healthcare professionals

Healthcare professionals play a central role in trauma prevention. Beyond emergency response and rehabilitation, they encourage preventive measures such as promoting healthier lifestyles, regular check-ups, and safety awareness. Improving the quality and accessibility of trauma care, particularly in underserved areas, can significantly reduce the impact of traumatic events.

Integrating **Traumatic Injury Prevention Programs (TIPP)** into healthcare systems reduces injuries and deaths across all populations. Fostering trauma-informed care within the healthcare sector also addresses the long-term consequences of trauma, including psychological repercussions.

The role of lead agencies

Lead agencies coordinate prevention strategies at regional, state, and local levels. By collaborating with public health authorities, community organisations, scientific societies, and the private sector, they can develop, implement, and evaluate injury prevention programs. Evidence-informed strategies based on systematic epidemiologic data ensure targeted and effective interventions.

Collaborative partnerships across sectors enhance efficiency and impact. Establishing an **injury control network**—a broad alliance involving healthcare, professional, and community organisations—facilitates coordinated efforts. Specific attention must be given to vulnerable populations, including children, older adults, and others at heightened risk.

Levels of prevention

Trauma prevention efforts operate at three distinct levels:

- **Primary prevention**: Aimed at the entire population to decrease the overall risk of injury (e.g., civil engineering guidelines, window guards, smoke detectors).

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Published online: 26 March 2025

- **Secondary prevention**: Targeted at high-risk populations to mitigate the effects of traumatic events (e.g., car seats, seat belts, helmets).
- **Tertiary prevention**: Focused on reducing the long-term impact of trauma on individuals and communities (e.g., EMS and trauma systems support, rehabilitation, access to care).

Prevention strategies must be tailored to the needs of local communities, with adequate funding, staffing, and partnerships to ensure successful implementation.

Conclusion and needs for the future

Preventing trauma in Europe requires a proactive, evidence-based approach integrating public health initiatives, education, and healthcare services. Key priorities include:

- Embedding prevention strategies into public policies.
- Focusing on education, training, and safety promotion.
- Enhancing healthcare services, particularly in underserved areas.
- Addressing root causes of trauma through collaboration across sectors.

By fostering a comprehensive and coordinated strategy, Europe can achieve a significant reduction in trauma incidence, safeguarding public health and improving the quality of life for individuals across all communities.

Author contributions All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. Both authors wrote the main manuscript text.

Funding Open access funding provided by University of Zurich

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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European Journal of Trauma and Emergency Surgery (2025) 51:143
https://doi.org/10.1007/s00068-025-02828-4

REVIEW ARTICLE

Trauma systems in Europe / hospital categories

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Received: 11 February 2025 / Accepted: 6 March 2025

Abstract

Trauma systems are vital components of healthcare infrastructure, addressing the significant burden of severe injuries across Europe. Effective trauma systems improve patient outcomes and reduce mortality by providing timely, specialised care. However, significant disparities remain between countries, with only a few well-structured and maintained systems currently operating in Europe.

Developing trauma systems requires collaboration among healthcare providers, emergency services, and government agencies. Standardised protocols for triage, transport, and treatment are essential, supported by robust infrastructure, public education, and injury prevention initiatives.

Trauma systems comprise four core components:

- Injury Prevention.
- Pre-Hospital Care.
- Facility Care.
- Post-Hospital Care/Rehabilitation.

These components rely on key elements such as leadership, professional resources, education, quality improvement, and funding. Political commitment, geographical considerations, and the efforts of dedicated clinicians are crucial for ensuring system success.

Trauma systems across Europe are evolving under diverse healthcare structures. Over recent decades, dedicated clinicians, often with support from national medical societies, have initiated and sustained these systems. Typically, trauma hospitals, or trauma centres (TCs), are categorised into two or three levels, with the highest being 'Level I TC' or 'Major TC,' capable of managing the most complex cases. This chapter outlines general requirements for these categories, leaving individual nations to tailor standards to their healthcare systems.

Keywords Polytrauma · Whitebook · ESTES

Introduction

The need for trauma systems in Europe has grown steadily with the rising incidence of traumatic injuries. This has coincided with increasing sub-specialisation of healthcare personnel and reductions in working hours. Traffic accidents, occupational incidents, and incidents related to violence contribute significantly to the burden of trauma cases across the region. Studies have shown that the timely and appropriate delivery of trauma care can significantly impact patient survival rates and long-term functional outcomes.

Following the implementation of an inclusive trauma system in the United States, Europe has been slower to adopt similar measures. In many European countries, trauma systems have not been designed and developed

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Published online: 19 March 2025

based on international standards and quality guidelines, but instead reflect historical, geographical, and demographic circumstances. Although there is no universal gold standard for trauma systems, generic elements remain consistent, and guidelines have been developed that apply across all countries.

Essential components and infrastructure of trauma systems

The organisation of trauma systems is a critical aspect of providing effective and comprehensive care to individuals with traumatic injuries. The American College of Surgeons (ACS) and the American Association for the Surgery of Trauma (AAST) have outlined a framework for trauma systems with the four fundamental components mentioned above.

Within these four fundamental components, the following elements should be considered: Leadership, Professional Resources, Infrastructure, Education and Advocacy, Information, Finances, Quality Improvement, Research, Technology, and Disaster Preparedness and Response. Each of these elements has specific requirements that must be fulfilled and maintained.

Injury prevention

Injury prevention aims to reduce the occurrence of traumatic injuries through educational initiatives, safety campaigns, and policy development. This component focuses on minimising the risk of injuries in the first place. The infrastructure elements within this component may include:

- **Leadership**: Appoint leaders or committees for injury prevention.
- **Professional Resources**: Engage experts in injury prevention strategies.
- **Education and Advocacy**: Promote public education and safety policies.
- **Information**: Use injury data to guide prevention efforts.
- **Finances**: Secure funding for prevention programmes.

Pre-hospital care

This component involves providing rapid and appropriate care at the scene of the injury and during transportation to a pre-defined healthcare facility. Infrastructure elements within pre-hospital care may include:

- **Leadership**: Establish roles to coordinate pre-hospital care services.
- **Professional Resources**: Ensure trained first responders (e.g., paramedics, EMTs).
- **Education and Advocacy**: Train responders in triage and transport protocols.
- **Technology and Infrastructure**: Equip responders with assessment and communication tools.
- **Information**: Establish communication systems for patient handover.

Facility-based care

Facility-based care involves the treatment and management of traumatic injuries in healthcare facilities, ranging from dedicated TCs (trauma center) to general hospitals with trauma care capabilities and rehabilitation centres. Hospitals should be categorised to clearly define their roles and responsibilities. Determining how many major TCs are needed for a specific population and how the network around the TCs should be organised remains a task that has not been undertaken in many European countries.

- **Leadership**: Designating leadership roles to oversee trauma care delivery at all hospital levels, including the Emergency Department (ED) trauma team and inpatient services.
- **Professional Resources**: Assembling skilled trauma teams and specialists including trauma surgeons, nurses, anaesthesiologists, and other specialists. Dedicated TCs must provide acute and critical care, surgical interventions, definitive management and multidisciplinary rehabilitation services. They need a dedicated trauma service coordinating multidisciplinary care throughout the hospital stay.
- **Education and Advocacy**: Providing ongoing training based on predefined competency goals for all personnel involved, focusing on the latest trauma care techniques.
- **Technology and Infrastructure**: Ensuring minimum equipment requirements for hospitals certified to treat trauma patients.
- **Information**: Establishing systems to share patient information and treatment protocols among different healthcare facilities.
- **Quality Improvement**: Implementing systems that use data and self-evaluations for continuous care assessment and quality assurance.
- **Finances**: Allocating resources to maintain well-equipped major TCs and support specialised staff, with clearly defined requirements for hospitals treating trauma patients.

Post hospital Care / Rehabilitation

This component focuses on the long-term recovery and rehabilitation of trauma survivors after discharge from the healthcare facilities. Infrastructure elements within post-hospital care include:

- **Leadership**: Identifying or establishing roles to coordinate post-hospital care services.
- **Professional Resources**: Connecting patients with appropriate rehabilitation specialists, counsellors, and support groups.
- **Education and Advocacy**: Raising awareness of post-hospital care and resources.
- **Information**: Sharing patient progress and treatment plans among healthcare providers.
- **Quality Improvement**: Collecting data and self-evaluations for internal quality assurance.
- **Finances**: Securing funding for rehabilitation services and ongoing support.

Overall, the organisation of trauma systems based on these four fundamental components and their corresponding infrastructure elements helps ensure a coordinated and comprehensive approach to trauma care. To effectively manage trauma cases, trauma systems in Europe should work collaboratively to implement them.

Generic needs for an inclusive trauma system

- **Communication Systems**: Effective communication networks between EMS providers, trauma centres, and other healthcare facilities are needed to transmit vital information about the patient's condition. These networks facilitate timely decision-making and coordinate resources for optimal patient care.
- **Trauma Registries**: Trauma registries are databases that collect and store detailed information on trauma cases, treatment outcomes, and long-term follow-up data. These registries are used to assess the effectiveness of trauma systems, identify areas for improvement, and conduct research to enhance trauma care practices.
- **Continuous Quality Improvement**: Regular evaluation and improvement of trauma care processes through quality improvement initiatives enhance the overall trauma system performance. This involves analysing outcomes (e.g., data audits and mortality/morbidity meetings), identifying trends, and implementing evidence-based best practices to optimise patient care.

The influence of politics and geography

The establishment and functioning of trauma systems in Europe are significantly influenced by political factors operating at national, regional, and local levels. Political commitment and support, in addition to dedicated medical professionals, are needed to develop and sustain trauma systems. Adequate funding ensures the availability of resources, staffing, and infrastructure required to deliver high-quality trauma care. Moreover, legislation and policies related to trauma care, such as seatbelt laws, traffic regulations, and workplace safety standards, can significantly impact the incidence and severity of traumatic injuries.

Geographical factors also play a significant role in shaping European trauma systems. Diverse topography, population distribution, and transportation networks affect the accessibility and availability of trauma care in different regions. Rural and remote areas may face challenges in ensuring timely access to trauma hospitals, necessitating strategies for efficient pre-hospital care and inter-facility transfers. Regions with high traffic density or those prone to specific types of injuries may require tailored approaches to trauma system organisation and resource allocation.

Conclusion and needs for the future

Trauma systems in Europe are essential for addressing the growing burden of severe injuries and providing timely and specialised care to trauma victims. The coordination of designated trauma centres, efficient triage and transport protocols, robust communication systems, trauma registries, and continuous quality improvement initiatives form the foundation of these systems. Effective organisation, political commitment, and geographical considerations are crucial for the successful implementation and sustainability of trauma systems across the diverse European landscape. Given the heterogeneity of European healthcare systems, specific adaptations must be made for each country (Fig 1).

Hospital categories and their roles in the trauma system

Introduction

Trauma hospital classification ensures optimal resource allocation and patient care. The benefits include:

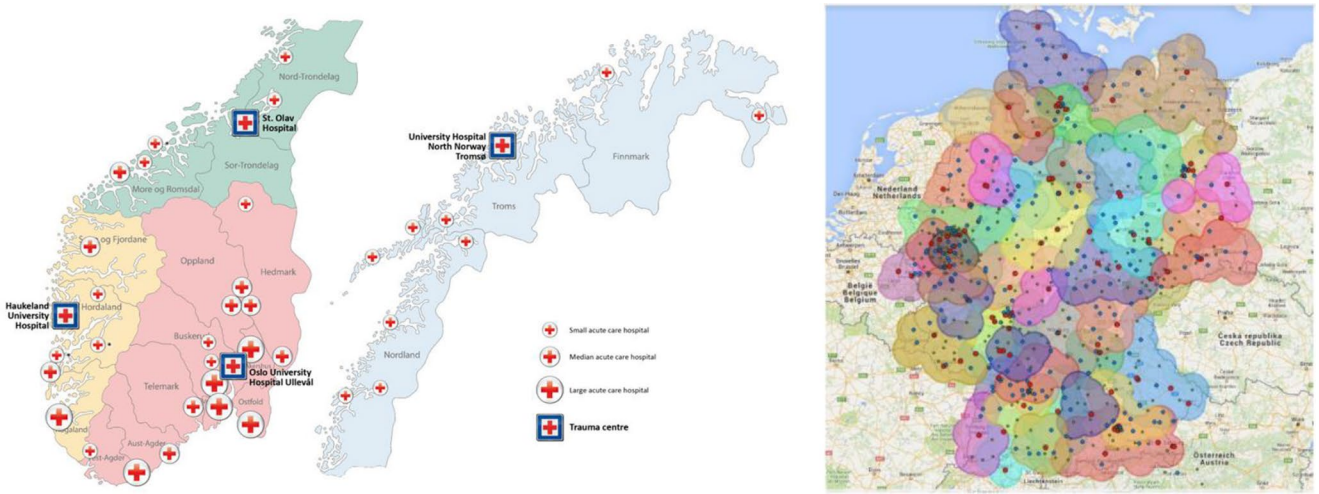

Fig. 1 Trauma Networks (**a**) Norway and (**b**) Germany. Note: Naming conventions for trauma hospitals vary across countries. In this document, 'Level I TC,' 'Level II TC,' and 'Level III TC' are used generically to describe maximum, intermediate, and basic levels of trauma care. Equivalent terms, such as "major trauma centres" or "trauma units," may apply depending on the national healthcare system

- **Severity-Based Categorisation**: Patients are referred to facilities best equipped for their injuries.
- **Efficient Resource Allocation**: Aligns hospital resources with patient needs.
- **Improved Field Triage**: Guides EMS to transport patients to the nearest appropriate facility.
- **Multidisciplinary Care**: Higher-level centres offer specialised expertise for complex injuries.
- **Continuous Improvement**: Training and research at TCs advance trauma care standards.
- **Guideline Compliance**: Hospitals meet care standards, including transfer protocols.
- **Mass Casualty Management**: Higher-level centres are better equipped for large-scale emergencies.

General descriptions of hospital levels

The descriptions below provide a generic overview of trauma-receiving facilities, as each country must adjust requirements to its specific healthcare system. For detailed descriptions, refer to examples from the German Trauma Society, the updated UK NICE guidelines, the American College of Surgeons (ACS) guidelines, and national system descriptions developed by some European countries.

In general, hospitals lacking essential 24/7 infrastructure should not be designated for trauma patient care.

Maximum level of care (Major TC or level I TC)

Major TCs (often university hospitals) are responsible for the comprehensive care of multiple and severe injuries. In addition, these centres treat patients with exceptionally complex or rare injury patterns. A dedicated trauma service is mandatory, with all specialties available. These TCs must have intensive care and surgical capacity for immediate admission at all times. Clear criteria should be established for transferring patients from lower-level trauma hospitals to the highest level of care within the network.

Medium level of care (Level II TC)

Medium-level trauma hospitals provide comprehensive emergency and definitive care for severely injured patients. Key elements include the permanent presence of specialists trained in trauma care and access to consultants from other disciplines (e.g., neurosurgery). These hospitals must also have adequate diagnostic, therapeutic, and surgical equipment. Medium-level trauma hospitals should be capable of managing the majority of injuries and their sequelae with definitive care.

Minimum level of care (Level III TC, trauma units, or emergency Hospitals)

The primary role of these hospitals is to provide care for common isolated injuries. In addition, these centres serve as the first point of contact, especially in rural areas, providing appropriate emergency care, including Damage Control Surgery (DCS), resuscitation, and referral of severely injured patients to higher levels of care. Treating life-threatening conditions and ensuring transport to the nearest appropriate trauma centre are the primary responsibilities of these facilities.

Levels of care (summary)

In short, the levels of care are defined as follows:

- **Level I (Maximum Care)**: Comprehensive care for multiple, severe, and complex injuries with 24/7 dedicated trauma service and specialty coverage from all involved specialities.
- **Level II (Intermediate Care)**: Full emergency and definitive care capabilities, including consultant access and multidisciplinary expertise.
- **Level III (Basic Care)**: First-line care for isolated or life-threatening injuries, focusing on stabilization and referral.

Conclusion and needs for the future

The diversity in European healthcare systems necessitates tailored approaches to trauma care. Future efforts should prioritize integrating trauma networks, fostering collaboration among all levels of care, and developing active systems where none exist. Such initiatives will ensure equitable, high-quality trauma care across regions.

Author contributions All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. All authors wrote the main manuscript text.

Funding Open access funding provided by University of Zurich

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests

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European Journal of Trauma and Emergency Surgery (2025) 51:198
https://doi.org/10.1007/s00068-025-02825-7

REVIEW ARTICLE

5. Prehospital management

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Received: 11 February 2025 / Accepted: 6 March 2025

Abstract
This chapter outlines the essential requirements for emergency responses to severe injuries. It emphasises the critical steps healthcare professionals must take in urgent situations, including: Rapid assessment and triage to prioritise treatment; Techniques for controlling massive external haemorrhages to prevent life-threatening blood loss; Maintaining a clear airway, ventilation, and neck stabilisation to support breathing and minimise spinal injury risks; Intravenous fluid replacement and medication administration to stabilise patients' conditions; Proper immobilisation of injuries to prevent further harm during transportation; Facilitating rapid and effective transfers to specialised medical centres, with clear communication ensuring seamless continuity of care. By adhering to these protocols, healthcare providers can efficiently navigate emergency situations, saving lives and minimising the long-term impact of critical injuries and illnesses.

Keywords ESTES · Polytrauma · WhiteBook

Organisation

The management of severely injured patients has evolved significantly over recent decades due to improvements in pre-hospital organisation, on-site assessment, initial care, and transportation protocols. The process begins at the trauma site and requires an interdisciplinary approach.

The initial "Chain of Rescue" consists of:

- Pre-hospital care
- Accident and Emergency Unit
- Damage control (emergency) interventions

Beside the type of injury (e.g., head injuries and severe bleeding), pre-hospital time is the most critical independent factor predicting mortality. The treatment approach also depends on transportation time. In urban settings (short transportation time), a "scoop and run" or "load and go" concept is preferred. In rural settings (long transportation time), a "stay and play" concept may be necessary.

Note

The balance between "load and go" and "stay and play" approaches must prioritise the urgency of life-saving interventions. While critical interventions such as airway management or haemorrhage control may require immediate action at the scene and should not be deferred to reduce pre-hospital time, certain measures like surgical haemostasis of internal bleeding are best performed in hospital settings.

Transfer of information and triage

Alarming and notification

- 112 is the universally accepted emergency number within the EU (European Union) (calls to 911 should be automatically redirected to 112).
- Communication systems must include a phone line (cable/optical fibre), wireless (GSM), and radio line, with at least one alternative system available.
- The dispatch centre (local or regional) is the primary point of coordination for alarming and resource management.

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Published online: 06 May 2025

Arrival and scene information

- Effective organisation and command must be established (e.g., a team commander, clearly marked, with mandatory radio communication).
- Scene security and safe access must be coordinated with relevant authorities:
    - Fire services for traffic accidents, building collapses, poisoning, and entrapped patients.
    - Police for demonstrations, dangerous situations, tear gas, or smoke.
    - Special Forces: For armed conflicts (e.g., AMOK incidents) or terrorist attacks.
- Access to victims is permitted only after a "safe approach" has been declared.
- The triage system should be adapted to the number of victims, available rescue teams, and situational protocols (e.g., major incidents, hazardous material (HAZMAT) events).

Actors at the scene

- First responders: Act based on instructions from the dispatch centre or the scene commander after notification.
- Rescue teams: May include paramedics, emergency medics, and other pre-hospital personnel.
    - Teams without a physician can provide Basic Life Support (BLS) or partial Advanced Life Support (ALS).
    - Teams with an emergency physician can apply principles of Pre-hospital Trauma Life Support (PHTLS) or Advanced Trauma Life Support (ATLS).
- Command Coordination: When multiple teams are onsite, the most experienced person or physician should oversee coordination and command.

Triage in mass casualty events

- When sufficient rescue resources are available, treatment should follow the principle "treat first what kills first" using PHTLS/ATLS (ABCDE) protocols?
- In mass casualty scenarios, TRIAGE systems and zones must be established for patients based on severity:
    - Green: Minor injuries.
    - Yellow: Moderate but non-life-threatening injuries.
    - Red: Life-threatening injuries requiring immediate intervention.
    - Black: Deceased or non-survivable injuries.
- Triage should incorporate primary (SIEVE ((Secondary Triage)) triage and secondary (SORT ((Secondary Organ Rescue Triage)) triage, based on physiological parameters (e.g., respiratory rate, systolic blood pressure, Glasgow Coma Scale) and anatomical considerations.

Initial assessment and management requirements

A time-critical approach saves lives. The goals are hospital admission within 60 min and definitive clinical treatment within 90 min. Achieving these goals may be challenged by issues such as entrapped patients, prolonged rescue or transportation times, and other complicating factors.

Life saving measures must always take ultimate priority. If impaired vital functions are present in polytrauma patients, interventions should be performed as soon as possible, following PHTLS/ATLS principles—either at the scene after rescue or during transport:

Additional measures include:

- Positioning and immobilisation of patients (e.g., using spinal blocks, spine boards, stretchers, or splints).
- Early initiation of care for thermal injuries and burns.
- Identification and management of concomitant injuries (e.g., deafness as a potential symptom of a blast syndrome).
- Collecting information on pre-medications (e.g., anticoagulants) whenever possible.

The ultimate goal to reduce mortality is timely transport to an appropriate trauma hospital. Criteria for transportation to different categories of hospitals (as detailed in Chapter 4) should align with internationally accepted standards.

Transportation modalities

- Ground-based transport: Severely injured patients can be transported by regular ambulances staffed with medically trained personal (paramedics) or physician-equipped ambulances.
- Air transport: Helicopters are effective for primary transport, particularly in rural areas with long transportation times, and for secondary interhospital transfers. However, their use may be limited by darkness and adverse weather conditions.

- Central Coordination of Transport: Transportation should be centrally directed (e.g., via dispatch with active communication). This is especially critical during major or mass casualty incidents to prevent overloading certain hospitals or inappropriate transfers to facilities lacking the necessary diagnostic and therapeutic capabilities (e.g., neurosurgery, cardiovascular or thoracic surgery).

When there is sufficient capacity, transport should be prioritised as follows:

- Red → Yellow → Green patients.
- In officially declared "decompensated" situations", priority should be given to patients with the greatest chance of survival.

A unified telematics system for data exchange and cross-border assistance could help avoid transport inefficiencies and ensure equitable access to care.

Conclusion and needs for the future

To ensure optimal outcomes for severely injured patients, more uniform organisation and appropriately equipped and trained rescue teams are needed in the pre-hospital setting, which serves as the first link of the rescue chain. Continuous implementation and evolution of PHTLS and ATLS principles are essential. Further development and modernisation of equipment for pre-hospital care is required. A unified telematics system for data exchange and medical coordination within and across EU countries should be established to improve outcomes and ensure seamless cooperation.

Author contribution All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. Both authors wrote the main manuscript text.

Funding Open access funding provided by University of Zurich.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no conflict of interests.

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European Journal of Trauma and Emergency Surgery (2025) 51:151
https://doi.org/10.1007/s00068-025-02827-5

REVIEW ARTICLE

Networking between hospitals

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Received: 11 February 2025 / Accepted: 6 March 2025

Abstract
Not all hospitals have the resources to manage trauma patients, which is why many countries have introduced trauma systems to connect hospitals within specific regions. When definitive care cannot be provided at a hospital, the patient should be transferred to the closest appropriate facility with the necessary resources and capabilities. Telecommunication is a critical tool for data exchange (e.g., imaging) and multidisciplinary consultations. Ideally, a unified telecommunication system should be implemented across all hospitals in a network, with the long-term goal of nationwide or even European-level standardisation. While criteria for onward transfer vary slightly between trauma systems across countries, they can be adapted to meet the needs of any healthcare system. Decisions regarding patient transfer should be based on objective, prospectively agreed criteria. In addition, a common European trauma registry is essential to evaluate quality of care.

Keywords ESTES · Polytrauma · Whitebook

Inter-hospital communication

Because some hospitals lack the capacity to manage severely injured patients, trauma systems linking hospitals have been developed in certain regions. Within these networks, each hospital's facilities and capabilities are well-defined. Each trauma region should include at least one maximum-level trauma hospital equipped with the necessary resources to treat severely injured patients. If a hospital cannot provide definitive care, the patient should be transferred to the closest appropriate facility with the required capabilities. Such facilities also have an obligation to accept these patients.

Every inter-hospital transfer carries risks. Current documentation practices for inter-hospital transfers of trauma patients often lack critical physiological and ATLS variables, increasing the potential for adverse events. This underscores the need for education, training and the implementation of standardised trauma transfer protocols to improve system-wide information sharing. Robust inter-hospital communication is vital to mitigate risks and enhance outcomes.

Before a transfer, direct communication must occur between the referring and receiving surgeons. This should be conducted via phone or other communication technologies. Referring professionals should use a standardised template to provide receiving trauma surgeons with all necessary information for the patient's further care.

Example checklist:

- WHO Acute Transfer Checklist.

In addition, referring professionals must send all available documentation (e.g., lab results, consultations) to the receiving surgeon, preferably electronically and in compliance with national data protection regulations. Diagnostic imaging already performed should accompany the patient, either via physical media (e.g., CD, DVD) or, ideally, through telecommunication. Regular training on these protocols is essential.

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Published online: 26 March 2025

Inter-hospital telecommunication (Tele-Cooperation)

Telecommunication or telemedicine supports healthcare delivery over long distances and is increasingly critical for data exchange within trauma networks. Its applications include:

- Supporting on-site treatment of severely injured patients in hospitals with limited resources.
- Facilitating the exchange of radiological data (e.g., CT scans, MRI) and enabling multidisciplinary consultations before patient transport.

In most countries, maximum-level trauma hospitals are in urban areas; thus, patients in rural regions may face longer transport times and lower chances of survival. Telecommunication bridges this gap by providing remote support and enabling hospitals with limited trauma-care capacities to offer improved initial care. This is especially vital in rural settings, where timely and accurate guidance can enhance outcomes for patient awaiting transfer to major trauma centres.

Cross-Border Cooperation

While many countries have established national trauma networks with corresponding decreases in mortality, these networks rarely extend beyond national borders. This presents a significant challenge in Europe, where numerous borders separate neighbouring countries. Cross-border initiatives, such as the EGALURG Project (France and Spain) and Boundless Trauma Care Central Europe (Germany, Netherlands, Belgium, Luxembourg, France, and Switzerland), provide valuable insights for addressing these issues.

Key challenges include:

- Establishing cross-border trauma regions.
- Facilitating cross-border cooperation between hospitals.
- Creating a European trauma network.
- Addressing differences in laws, regulations, and financial compensation for medical care.
- Standardising quality criteria for trauma care.
- Developing a unified European trauma registry.

Collaboration between the European Union and organisations such as the European Society of Trauma and Emergency Surgery (ESTES) is critical to overcoming these challenges. Existing cross-border initiatives can serve as models for expanding European trauma networks.

Criteria for onward transfer

Decisions to transfer patients for specialised care depend on several factors, including the nature and severity of injuries, the expected progression of these injuries, and the capabilities of the receiving facility.

Primary triage The goal is to transport patients directly from the field to facilities capable of providing definitive care. However, factors including airway management, rural settings, or inclement weather may necessitate primary stabilisation at a closer facility before secondary transfer.

Secondary triage Conducted at the initial receiving facility, secondary triage offers several advantages.

- It prioritises transferring the most severely injured patients to higher-level facilities, preserving resources for those in greatest need.
- It allows patients with less severe injuries to receive care closer to their own community (8).

While criteria for onward transfer differ between trauma networks, these decisions should always be based on objective, prospectively agreed criteria. Regular evaluation and training for stakeholders (prehospital care providers, hospitals) are essential to ensure consistent application of these criteria.

Trauma registries

Comprehensive epidemiological data, treatment methods, and outcomes are essential for improving trauma care. This underscores the importance of trauma registries, which have been established in several European countries, including:

- British Trauma Audit and Research Network (TARN).
- Trauma Registry of the German Society of Trauma Surgery (DGU-TR).
- Dutch Trauma Registry (DTR).
- Norwegian Trauma Registry (NTR).

Despite progress, variations in inclusion criteria, datasets, and outcome prediction methods remain. The Utstein template for uniform reporting of major trauma data (developed in 2007) serves as a foundation, but must be built upon, to create a unified European trauma registry. Standardisation is critical for facilitating cross-border trauma care and network integration.

Conclusion and needs for the future

Trauma systems in Europe must establish comprehensive networks where polytrauma patients are transferred to the closest appropriate hospital with the resources to provide definitive care. These networks should incorporate robust telecommunication systems to facilitate data exchange (e.g., CT scans, MRI) and multidisciplinary consultations.

Key priorities include:

- Establishing a unified telecommunication system on a national and European scale.
- Defining nationally standardised criteria for onward transfer.
- Developing a unified European trauma registry to enhance data-driven improvements in trauma care and ensure equitable outcomes across Europe.

Collaboration among European stakeholders is essential to meet these goals and address current gaps in trauma care delivery.

Author contributions All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. Both authors wrote the main manuscript text.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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European Journal of Trauma and Emergency Surgery (2025) 51:139
https://doi.org/10.1007/s00068-025-02820-y

REVIEW ARTICLE

Trauma room requirements

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Received: 24 February 2025 / Accepted: 3 March 2025

Abstract
Effective shock (or trauma) room management requires thorough preparation, staff competence, dedicated infrastructure and organised protocols. Shock rooms must be sufficiently equipped according to the hospital's designated level of care. This chapter outlines essential aspects, including equipment and facilities, staff qualifications and composition, and communication practices. Key areas including initial assessment, diagnostic procedures, emergency interventions, and future aspects in the care of severely injured patients are addressed, along with emerging innovations in trauma care.

Keywords Whitebook · Polytrauma · ESTE

Organisation

Preparation

Preparation in trauma care begins with structured protocols, adequate communication with pre-hospital personnel (see Chap. 5), crew resource management, teamwork, and utilisation of facilities and resources. These elements should be established as the standard of care and practised regularly. Team members must be called immediately, preferably via an automated system, and must know their assigned roles and tasks.

Team members

The resuscitation team may vary according to the country or level of care, but must include a sufficient number of trained specialists, including:

- Trauma team leader: The most experienced physician, preferably with surgical expertise, to oversee trauma management.
- Surgeons, anaesthesiologists, and specified nurses trained in trauma care.
- Radiology Personnel: To perform immediate diagnostic imaging.
- Specialists: Neurosurgeons or other experts are recommended to be present during resuscitation for severe trauma or available for consultation, depending on injury severity.

Communication

Closed-loop communication, where input from team members is actively incorporated while the leader maintains an overview, is critical for coordinated care. Trauma team leaders must ensure constant information flow, and regular team training is mandatory to optimise communication and treatment skills.

Facilities and resources

Shock rooms must provide:

- Diagnostic tools including X-ray equipment and ultrasound for eFAST.
- Resources for emergency procedures, including chest tubes, pelvic binders, C-clamp fixation, heaters, and rapid infusers.

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Published online: 18 March 2025

- Supplies for massive transfusion protocols, including blood products. Familiarity with available blood products' possibilities and limitations is essential for all team members.
- ABCDE-charts, handover checklists, and a visible clock for time tracking.

Next steps

The chain of care must ensure:

- Intensive care unit (ICU) and operating room (OR) readiness.
- Early transport to facilities with adequate resources if required.
- Consultation with external specialists when necessary.

Initial assessment and management requirements

Training and workflow

All team members must be trained in the ABCDE approach, using recognised courses such as ATLS, ETC, or similar programmes, to ensure a common routine and language for processes, essential steps, and workflows. Throughput times should be as limited as possible to prioritise timely intervention. Regular trauma resuscitation practice is recommended to improve collaboration and reinforce the required team mindset.

Operating room team members must also undergo advanced trauma care training (e.g., ASSET ((Advanced Surgical Skills for Exposure in Trauma)), ATOM ((Advanced Trauma Operations Management)), DSTC ((Definitive Surgical Trauma Care)) (DATC ((Definitive Acute Trauma Care)) or DPNTC (Definitive Pre-Hospital and Trauma Care)), focusing on surgical procedures including clamshell thoracotomy, laparotomy, control of junctional bleeding, pelvic stabilisation and packing. These programmes develop critical skills in a team environment, emphasising communication and coordination for managing the most severely injured patients.

Diagnostics

Timely diagnosis is critical for trauma patients. Shock rooms must be equipped with the necessary tools to detect life-threatening injuries, which must always be available. These include:

- Ultrasound and X-ray capabilities for the entire thorax and pelvis.
- Computed tomography (CT), which should ideally be located within the shock room to avoid risky handovers but must, at minimum, be nearby.
- Laboratory tests for instant data on basic vital parameters, such as blood gas analysis, with 24/7 accessibility.
- Visco-elastic point-of-care devices for coagulative status analysis, if available.
- Routine blood tests, which must be immediately transported to the laboratory.
- Interventional angiography to control bleeding of vessels near the trunk.
- Access to MRI, infrequently requested but available on a 24/7 basis when needed.

Blood products

Trauma patients frequently require blood transfusions. Hospitals must provide immediate access to donor blood and its components. For those without in-house blood banks, reliable supply chains must be established. Pre-testing protocols should be in place to ensure timely availability, and facilities must have the capacity to conduct compatibility tests and antibody screening.

Protocols for massive transfusions must be readily available, regularly practised, and include appropriate checklists to streamline the process.

Conclusion and needs for the future

Effective trauma room management relies on thorough preparation, skilled teams, and well-equipped facilities to provide optimal care for severely injured patients. Innovations such as hybrid operating rooms (ORs), which combine open surgery and endovascular procedures in a single setting, are transforming trauma care by streamlining logistics and reducing intervention times. To fully realise their potential, hybrid ORs must be integrated into daily practice and resuscitative algorithms, ensuring they become a standard component of trauma management.

Where hybrid ORs are not feasible, maintaining well-practiced routines in standard ORs remains essential to ensuring patient safety and minimising adverse events. Emerging technologies like 3D imaging further enhance trauma care by supporting navigated procedures and minimally invasive techniques, but these tools must complement—not replace—comprehensive trauma care strategies.

Looking ahead, standardisation of protocols, continued team training, and integration of advanced technologies will drive improvements in trauma room efficiency and

outcomes. By combining preparation, expertise, and innovation, trauma systems can continue to save lives and reduce complications in the most critical moments of patient care.

Author contributions All authors wrote the main manuscript text.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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European Journal of Trauma and Emergency Surgery (2025) 51:135
https://doi.org/10.1007/s00068-025-02823-9

REVIEW ARTICLE

Operating room (OR) requirements

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Received: 11 February 2025 / Accepted: 6 March 2025

Abstract
The *International Health Facility Guidelines 2023* provide critical recommendations for operating room (OR) design and management, addressing layout, equipment specifications, and safety protocols. By adhering to these guidelines, healthcare facilities can ensure optimal conditions for surgical procedures, minimise risks to patients and staff, and enhance overall efficiency. These recommendations serve as a vital resource for healthcare administrators, architects, and medical personnel, facilitating high-quality surgical care and improved outcomes for trauma patients.

Keywords Polytrauma · White Book · ESTES

Introduction

This chapter is based on the *International Health Facility Guidelines 2023*. These guidelines establish minimum acceptable standards for health facilities, bridging the gap between national regulations and international best practices.

Several key factors must be considered when assessing OR requirements for treating trauma patients:

Institutional and administrative provisions

- Facility briefing and accessibility.
- Mobility and engineering services.
- Environmental design.
- Feasibility planning and cost guidelines.

Medical provisions

- Infection control measures.
- Equipment planning.
- Staffing qualified healthcare professionals.

Operating units provide a safe, controlled environment for diagnostic and/or surgical procedures under anaesthesia and peri-operative care, including post-procedure recovery. These units, often large theatres, accommodate multidisciplinary teams and vary depending on hospital infrastructure.

Key considerations for OR design and functionality

Location and access

- Operating units must be located near the emergency unit, trauma bay, and intensive care unit (ICU) to enable rapid, direct, and discreet transfer of patients. Transport through public corridors should be avoided where possible.
- Corridors must be wide enough to accommodate patient beds, trolleys, or stretchers, along with accompanying personnel and equipment such as respirators, infusion stands, and monitors. Special attention must be paid to door widths for easy passage between units.

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Published online: 18 March 2025

Functional and safety standards

- ORs must accommodate multiple medical specialties simultaneously while maintaining uninterrupted functionality (including electricity).
- Infection control requires:
  - Adherence to hand hygiene, aseptic techniques, and 'standard precautions'.
  - Positive pressure air-conditioning and HEPA filtration to meet international standards.
  - Antiseptic cleaning protocols facilitated by OR design.
  - Local temperature control for the OR environment.
- Radiation Protection measures must comply with national and international guidelines for radiation shielding, with plans and specifications reviewed by certified physicists or qualified experts.

Staff safety and protection equipment

Measures to ensure staff safety include:

- Sterile surgical gowns, gloves, and caps.
- Eye and face protection.
- X-ray aprons for radiation safety.
- Guidelines for the disposal of sharps and contaminated waste.
- Restricted access to the OR for unauthorised personnel.

Minimum equipment for trauma ORs

Trauma patients should be treated in dedicated trauma ORs equipped to address a wide range of potential injuries. Essential equipment is listed below. If a dedicated trauma OR is unavailable, pre-prepared trolleys with essential equipment should be mobilised to the OR in use.

Diagnostic and surgical equipment

- Essential Tools:
  - Modern X-ray fluoroscopic equipment with dedicated OR radiology technician(s).
  - Interventional hybrid operation capabilities.
  - Radiolucent operating table(s) suitable for trauma management.
  - Fracture table applicable for trauma management.
- Emergency Surgery Equipment:
  - Laparotomy and thoracotomy systems.
  - Chest tubes and surgical airway systems.
  - Neurosurgical intervention tools (e.g., craniotomy, burr holes).
  - External fracture fixation and pelvic reduction systems.
- Definitive Surgery Equipment:
  - Intramedullary nailing systems for long bones.
  - Plating systems (mini, small, large, locked, and standard).
  - Hip fracture fixation plates and nails.
  - (Hemi-) Arthroplasty systems for the hip, knee, and shoulder.
  - Pelvic and acetabular plate systems.
  - Cannulated screw sets (large and small).
  - Power drills, saws, burrs, and reamers.
  - Bone reduction clamp system.
  - Screw removal sets.
  - Arthroscopy systems.

Conclusion and needs for the future

The future of trauma operating rooms lies in addressing challenges through innovative and collaborative solutions. Advanced technology integration, such as hybrid ORs and evolving surgical tools, holds the potential to enhance both efficiency and outcomes. However, ensuring compatibility and usability requires careful planning and robust training programmes for healthcare professionals.

Emergency preparedness remains critical, necessitating fully equipped ORs and comprehensive protocols for triage, resource allocation, and communication. Staffing skilled surgical teams and providing continuous professional development are equally essential to maintaining high standards of trauma care.

By prioritising these areas and fostering collaboration among healthcare administrators, policymakers, and clinicians, Europe can advance trauma care and ensure operating rooms are equipped to meet the demands of the future while delivering optimal outcomes for patients.

Author contributions All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. All authors wrote the main manuscript text.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

Ethical approval No ethical approval is required.

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European Journal of Trauma and Emergency Surgery (2025) 51:134
https://doi.org/10.1007/s00068-025-02821-x

REVIEW ARTICLE

ICU requirements

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Received: 24 February 2025 / Accepted: 3 March 2025

Abstract
This section outlines the essential requirements for managing trauma patients in ICUs across Europe. It emphasizes the need for ICU accreditation at the highest national level and highlights criteria, including staffing, equipment, training programmes, protocols, and documentation for quality control. Key requirements encompass 24/7 admission capability, trained staff, multidisciplinary rounds, specialised observation beds, organ donation programmes, and participation in trauma resuscitations and hospital disaster planning. Desirable criteria, such as education, research activities, trauma protocol development, cross-rotation training, outreach services, and combined team training are also discussed, focused on fostering collaboration between trauma and intensive care services to ensure comprehensive trauma management.

Keywords ESTES · Polytrauma · Whitebook

Introduction

The management of trauma patients in ICUs should adhere to the highest ICU designation category within each country, as regulated and standardised by the relevant professional bodies governing intensive or critical care. Although practices and regulation vary across Europe, the shared goal is to deliver the highest quality of care for trauma patients.

Essential criteria

To ensure optimal care for trauma patients in the ICU, the following essential criteria must be met:

- **ICU accreditation**: Adherence to the highest national standards for ICU accreditation.
- **Staffing**: Adequate medical, nursing, and allied health personnel.
- **Essential equipment**: Availability of critical care tools and technologies.
- **Training Programmes**: Comprehensive ICU medical training for all staff.
- **Protocols and procedures**: Implementation of general ICU guidelines and policies.
- **Documentation**: Systems for quality control, such as trauma registries and audits.

Additional trauma-specific criteria include:

- **24/7 capability**: Continuous admission capability with a no-refusal policy for trauma cases.
- **Training**: All ICU staff must be ABCDE-trained to manage trauma patients effectively.
- **Multidisciplinary rounds**: Regular collaboration between ICU and trauma service staff (especially the trauma surgeons).
- **High-dependency observation beds**: Dedicated beds for high-risk, non-ventilated trauma patients, including those with solid organ injuries, spinal cord injuries, traumatic brain injuries, severe chest injuries, free flaps, and major postoperative cases.
- **Organ donation programmes**: Active participation in organ procurement, with established links to transplantation units.
- **Trauma resuscitations**: ICU doctors must participate in trauma resuscitations to provide timely interventions.
- **Trauma committee representation**: An ICU representative should liaise with the hospital trauma committee.
- **Isolation rooms**: Available for infectious diseases to prevent cross-contamination.

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Published online: 16 March 2025

- **Advanced interventions**: Protocols and equipment for life-support interventions (e.g., extracorporeal membrane oxygenation (ECMO), renal replacement therapy).
- **Non-invasive ventilation**: Availability of equipment and protocols to support respiratory function.
- **Procedure protocols**: Standardised guidelines for common ICU procedures, such as tracheostomy, vascular line placement, chest tube insertion, and open abdomen management.
- **Nutrition protocols**: Implementation of enteral and parenteral nutrition.
- **Nosocomial infection control**: Prevention and surveillance protocols, along with antibiotic stewardship programmes, to minimise healthcare-associated infections.
- **Delirium management**: Screening protocols and prevention strategies to manage ICU delirium.
- **Point-of-care testing**: Real-time blood gas and coagulation monitoring capabilities.
- **Disaster planning**: Active involvement in hospital-wide disaster preparedness exercises and cross-hospital mass casualty responses.
- **Transport protocols**: Clear guidelines for intra- and inter-hospital trauma patient transfers.
- **Venous thrombosis prophylaxis**: Protocols to prevent thromboembolic complications.
- **Rapid-response system**: ICU participation in the hospital-wide rapid emergency care efforts, including the management of deteriorating non-ICU patients.

Desirable criteria

While essential criteria ensure baseline care, the following desirable criteria can enhance ICU services:

- **Education activities**: ICU participation in trauma service training sessions to foster ongoing professional development.
- **Identifiable trauma lead**: A designated trauma lead from the ICU to streamline communication and coordination with trauma services.
- **Research**: Involvement in trauma service research activities to advance care practices and improve outcomes.
- **Protocol development**: Contributions to developing trauma-specific guidelines (e.g., massive transfusion and spinal clearance protocols).
- **Cross-rotation**: Training rotations between the ICU and trauma services to enhance interdisciplinary collaboration and balanced skills.
- **Outreach services**: Support for trauma wards managing high-risk discharged patients, helping to prevent complications and readmissions.
- **Team training**: Regular combined team training sessions for patient transport, trauma resuscitation, and management of deteriorating patients.
- **Faculty participation**: ICU staff serving as faculty in trauma training courses for broader healthcare education.

Conclusion and needs for the future

The delivery of high-quality ICU care for trauma patients must balance international standards with local adaptations across Europe. Essential criteria, including staffing, equipment, and protocols, form the foundation for patient safety and optimal outcomes. Desirable criteria, such as research initiatives, cross-disciplinary collaboration, and advanced training programmes, further elevate the quality of care and foster innovation.

Geographical and systemic variations across European ICUs necessitate flexibility in implementation. For instance, anaesthesiologists may support trauma resuscitation teams in place of ICU physicians, or dual-role physicians may provide both anaesthesia and critical care. Such adaptations should be assessed individually to ensure they uphold patient safety and enhance trauma care delivery.

Looking ahead, collaboration among healthcare professionals, administrators, and policymakers is essential to harmonise practices and bridge disparities in trauma care. By building on shared knowledge and prioritising both foundational and aspirational standards, European ICUs can continue advancing the care of trauma patients, ensuring consistency and excellence across diverse healthcare systems.

Author contributions All authors wrote the main manuscript text.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

European Journal of Trauma and Emergency Surgery (2025) 51:149
https://doi.org/10.1007/s00068-025-02830-w

REVIEW ARTICLE

Rehabilitation of severely injured patients

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Received: 11 February 2025 / Accepted: 6 March 2025

Abstract
Rehabilitation is a vital component of the holistic care of severely injured patients, addressing physical limitations, preventing complications, and promoting social and professional reintegration. Tailored measures are required across all phases of care, depending on individual injury patterns. Adequate early rehabilitation within inpatient settings necessitates appropriate personnel and infrastructure. Rehabilitation teams must include specialists from diverse therapeutic disciplines. Although financial frameworks vary by country, comprehensive funding for high-quality therapy programmes is essential for effective treatment.

keywords Trauma · Rehabilitation · Outcome · Trauma care

Introduction

Rehabilitation plays an integral role in the care of severely injured patients, bridging the gap between acute medical treatment and professional or social reintegration. This encompasses measures to eliminate, reduce, or compensate for physical limitations caused by trauma, mitigate complications, and address any resulting care needs. Rehabilitation efforts should commence during acute inpatient treatment and continue throughout all phases of polytrauma care, as they significantly influence the extent of a patient's recovery and long-term outcomes.

The type and scope of rehabilitative measures depend on the injury pattern and severity. Broadly, therapeutic strategies can be broadly categorised into three primary domains:

1. Injuries to the head and brain.
2. Injuries to the trunk including thoracic, abdominal and intrapelvic organ systems.
3. Injuries to the extremities.

Here, the rehabilitation goals focus in varying degrees on cognitive, motor and sensory deficits along with general thromboembolism prophylaxis in the context of limited mobility due to injuries (Figs. 1, 2 and 3).

Inpatient rehabilitation/physiotherapy

Personnel requirements

Medical management

Rehabilitation of severely injured patients requires medical oversight by specialists in orthopaedics and trauma surgery or general surgery with trauma subspecialisation. Alternatively, specialists in physical and rehabilitative medicine can fulfil this role. These professionals should also have sociomedical competence through additional training in rehabilitation or social medicine. Accreditation for further training in these qualifications is recommended.

The multidisciplinary rehabilitation team should include the following disciplines:

- Healthcare and nursing

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Published online: 25 March 2025

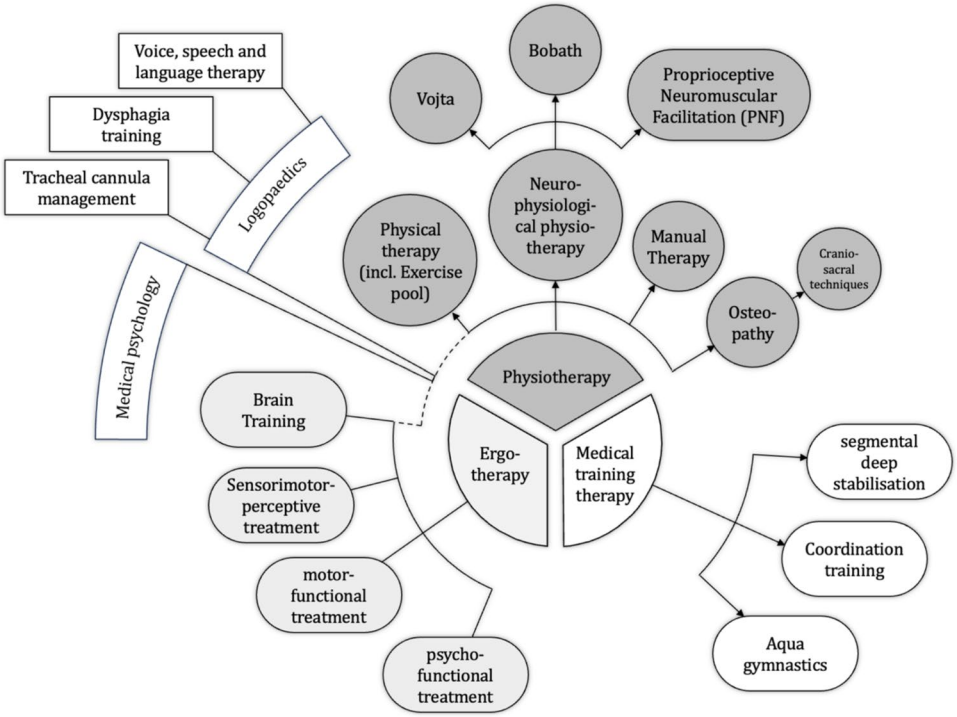

Fig. 1 Treatment approach to severely injured patients with traumatic brain injury and/or spinal trauma

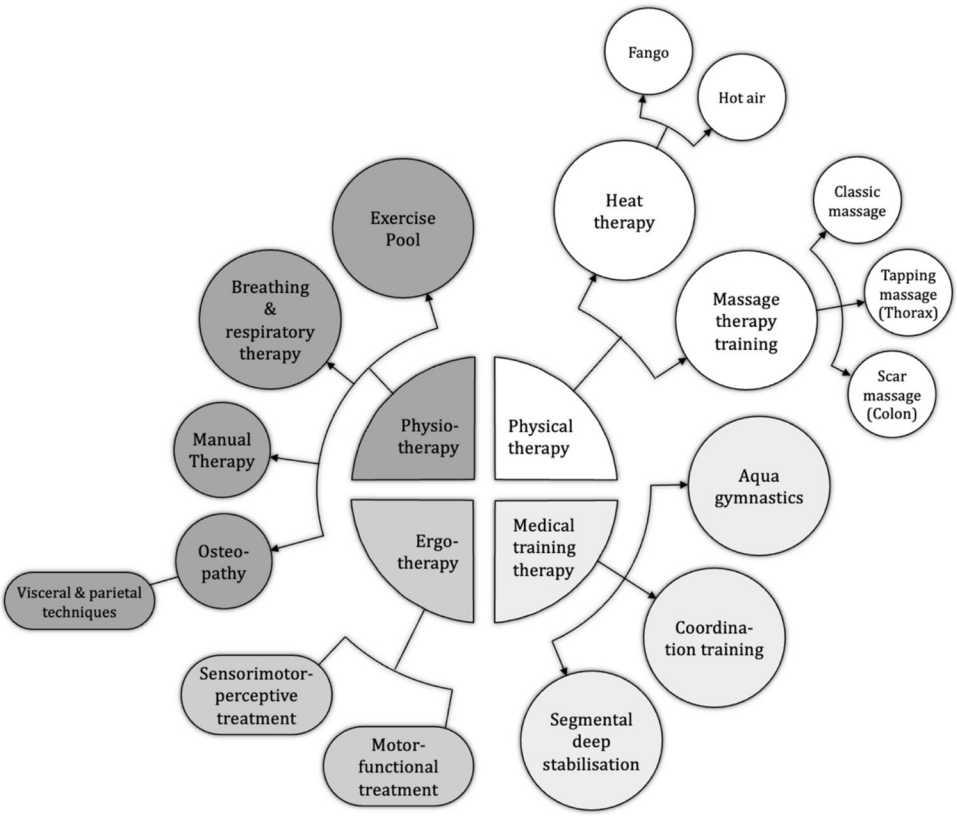

Fig. 2 Treatment approach to severely injured persons with body trunk injuries

- Physiotherapy
- Massage therapy
- Ergotherapy
- Sports therapy

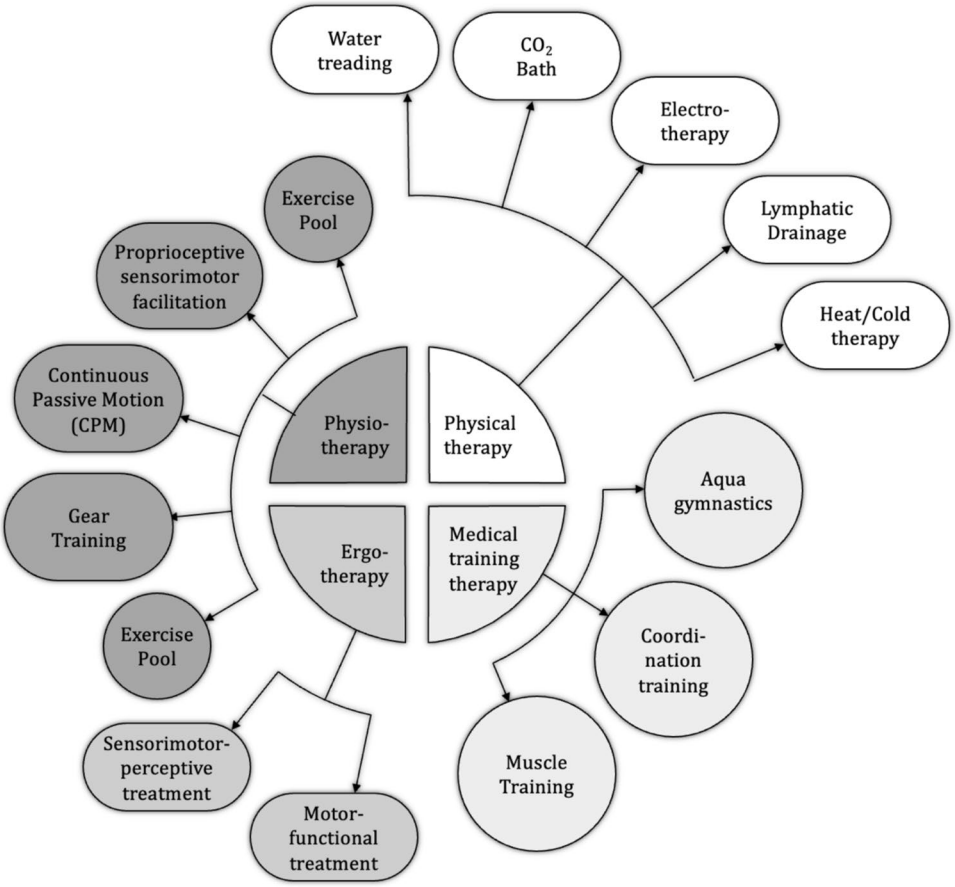

Fig. 3 Treatment approach to severely injured patients with extremity injuries

- Clinical psychology and neuropsychology
- Psychotherapy
- Speech and swallowing therapy
- Dietary assistance

Early psychological support should be provided for both the patient and their family. Additionally, social services must be available to facilitate social and professional reintegration.

Quality assurance

Standardised early rehabilitation assessments or disease-specific scoring systems should be used to evaluate functional deficits. These tools help document treatment outcomes and inform subsequent therapy goals.

Diagnostic equipment

Rehabilitation facilities must have the necessary equipment for specialised diagnostic procedures, including:

- Ultrasound
- Electrocardiography (ECG)
- Spirometry

Therapeutic equipment

To support multimodal rehabilitation effectively, facilities must provide equipment that addresses the specific physical limitations of patients.

Financial considerations

The reimbursement of rehabilitation services varies across European healthcare systems. In most countries, costs are partially covered by basic state funding, with patients often relying on private supplementary insurance for comprehensive coverage. Gaps in state funding can significantly hinder access to high-quality rehabilitative care, particularly for severely injured individuals.

Conclusion and needs for the future

Rehabilitation must be a cornerstone of holistic trauma care across Europe, ensuring severely injured patients receive tailored, high-quality therapy that addresses both physical

and psychological needs. Comprehensive funding frameworks are essential to bridge disparities in access and ensure equitable care. Future efforts should focus on standardizing guidelines, fostering collaboration between rehabilitation facilities, and addressing financial inequalities across European healthcare systems. By integrating these priorities, rehabilitation can significantly enhance the recovery and reintegration of polytrauma patients.

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Author contribution All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. All authors wrote the main manuscript text.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of Interest The authors declare no competing interests.

European Journal of Trauma and Emergency Surgery (2025) 51:166
https://doi.org/10.1007/s00068-025-02831-9

REVIEW ARTICLE

Education and continued professional development

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Received: 11 February 2025 / Accepted: 6 March 2025

Abstract
Trauma care requires a multidisciplinary approach, with surgeons ensuring timely and effective treatment for severely injured patients while collaborating closely with intensivists, emergency physicians, and rehabilitation teams. In addition to advanced surgical skills, trauma surgeons develop non-technical competencies such as leadership, communication, and decision-making to coordinate care effectively. This chapter addresses the challenges of maintaining trauma surgical competence in Europe, focusing on essential training programmes, quality improvement initiatives, and interdisciplinary collaboration. It also examines the impact of an ageing population, the integration of new technologies, and the vital role of surgical involvement in intensive care units (ICUs). Structured education and continuous professional development are critical to improving outcomes for trauma patients. ESTES, Polytrauma, Whitebook.

Introduction

Trauma care is a complex field requiring surgeons to apply advanced skills, critical decision-making, and effective teamwork to manage severely injured patients. Surgeons guide care from initial stabilisation to rehabilitation, making their expertise essential for achieving positive outcomes. Across Europe, maintaining trauma surgical competence poses challenges due to varying healthcare systems and training frameworks.

This chapter, based on *What Trauma Patients Need: The European Dilemma*, outlines the core educational and professional requirements for trauma surgeons. It details the technical and non-technical skills necessary for managing trauma patients, emphasises the importance of multidisciplinary collaboration, and highlights the role of quality improvement processes. Additionally, the chapter explores challenges such as an ageing population and the adoption of new technologies, underscoring the need for adaptable and comprehensive training to meet the evolving demands of trauma care.

Surgical knowledge and skills

The complex and acute nature of trauma care demands a broad understanding of physiology, anatomy, and surgical techniques, combined with non-technical skills such as communication, leadership, and organisational expertise. Multidisciplinary and interdisciplinary collaboration is essential for improving outcomes across the trauma care continuum.

Non-technical skills: leadership and teamwork

Leadership, communication, and logistical management are fundamental for trauma surgeons. Trauma care inherently requires a team-based, multidisciplinary approach. In high-pressure situations, pre-established routines and a standardised mindset for surgical decision-making are essential.

Regular simulated team practice should be a cornerstone of training to reinforce these routines. As Archilochus aptly stated, 'We don't rise to the level of our expectations; we fall to the level of our training.' Training and standardisation

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Published online: 07 April 2025

must extend beyond the emergency department, encompassing all phases of care, from admission to rehabilitation.

Trauma surgeons guide the patient through the entire care pathway, ensuring coordination among various teams. Leadership is particularly vital during transitions of care and in the emergency department, where early decisions have long-lasting consequences.

Timing and decision-making

Trauma care requires precise, timely decisions tailored to the patient's physiology and injury profile. Key considerations include:

1. Assessment of Interventions:

- Determine whether surgical or non-surgical management is appropriate based on the patient's condition and injury severity.

2. Prioritisation and Timing:

- Balance the urgency of interventions with the patient's physiological tolerance to ensure optimal outcomes.
- Consider a stepwise approach to procedures when necessary.

3. Extent of Surgical Procedures:

- Tailor the scope of surgery to minimise the physiological burden on the patient.
- Recognise when damage control surgery is required as an initial stabilisation measure before definitive management.

4. Decision Not to Operate:

- Understand that the decision to delay or omit surgery can be equally critical and should be based on the patient's overall condition, including immunological and physiological factors.

5. Surgeon's Expertise:

- Develop proficiency in understanding and managing the physiological impacts of interventions.
- Apply specialised knowledge of resuscitation, critical care support, and trauma-specific surgical techniques.

Effective trauma care requires surgeons to balance urgency with precision, tailoring interventions to the patient's unique physiology and injury profile. Mastery of timing, decision-making, and damage control surgery, along with understanding the physiological impact of procedures, begins in residency and is refined through fellowships and ongoing professional development. The goal remains achieving confidence to make lifesaving decisions in the moment.

Training programmes

Core competencies for trauma surgeons can be developed through internationally recognised courses, including:

- **ATLS/ETC**: Foundational skills for managing severely injured patients.
- **DSTC/DSATC**: Advanced trauma surgery techniques, focusing on critical decision-making and technical expertise.
- **ATOM and ASSET**: Essential surgical skills for complex injuries.

These courses establish a minimum skill set for trauma care. Additional training tailored to regional needs, such as lifesaving neurosurgical procedures or vascular shunting, may be necessary. Trauma surgeons should also be proficient in stabilising extremity injuries and managing vascular trauma during resuscitation.

Quality improvement programmes

Continuous quality improvement is essential for optimising trauma care. Regular analysis of patient pathways and feedback on team performance ensure effective learning and adaptation. Key practices include:

- Mortality and morbidity meetings.
- Trauma-specific debriefings involving all team members.
- Identification of improvement areas, such as communication, updated protocols, and technical skills training.
- Regular trauma team simulations to reinforce crew resource management (CRM).

A structured approach can be summarized with the following formula:

$$\begin{aligned}\text{Competence} = &\text{Modular training and}\\ &\text{basic skill maintenance}\\ &\times \text{Patient journey analysis}\\ &\times \text{Ongoing knowledge updates}\end{aligned}$$

This formula underscores the interconnected elements required for trauma surgeons to develop and maintain expertise. For instance, modular training in decision-making can

be reinforced through regular pathway reviews, ensuring surgeons are equipped to address both common and emerging challenges.

These processes ensure all stakeholders focus on the injured patient as a unique entity while enabling discussions and implementation of new strategies. Quality improvement is an ongoing process, integrating feedback to refine protocols and improve outcomes.

Challenges of an ageing population

The ageing population across Europe introduces new challenges for trauma care, including:

- Fragile bones and comorbidities.
- Increased use of anticoagulants and associated risks.
- Atherosclerotic vascular disease complicating recovery.

Simultaneously, the rapid introduction of new techniques and devices necessitates careful evaluation. Trauma surgeons must critically assess the risks, indications, and timing of these innovations, balancing patient safety with cost-effectiveness. Continuing education ensures surgeons remain equipped to address these challenges.

Trauma patients in the ICU

ICUs in Europe are predominantly staffed by intensivists with backgrounds in anaesthesiology, internal medicine, neurology, or cardiology. Surgeons offer complementary expertise in surgical decision-making and trauma-specific physiology.

Effective surgical contributions to trauma care in the ICU require combined generalist medical knowledge and specific expertise in trauma care. Unfortunately, training in intensive care medicine within surgical residency programmes across Europe is often limited, and insufficient for mastering the complexities of managing critically ill trauma patients.

Addressing gaps in surgical ICU training

To improve surgical contributions in the ICU:

- Residency programmes should integrate intensive care training, emphasising the physiological principles underlying trauma management.
- Fellowships or scholarships should provide advanced critical care training for trauma surgeons.
- Flexible pathways are needed to address time and workload constraints imposed by operative practice and European working time regulations.

ICU formats and collaboration

Closed-format ICUs, led by intensivists, have demonstrated reduced morbidity and mortality. This approach benefits from integrated care, avoiding segmentation by organ systems, and is applicable to trauma patients, who require coordinated, multidisciplinary care throughout their recovery.

Regardless of the ICU format—closed, open, or mixed—surgical involvement remains critical. Collaboration between surgeons and intensivists ensures trauma patients receive coordinated, multidisciplinary care tailored to their needs.

Conclusion and needs for the future

While trauma systems and training structures differ across Europe, the need for consistent, high-quality care for severely injured patients remains universal. Effective trauma management relies on multidisciplinary teams, with surgeons central to leadership, decision-making, and patient care.

To address evolving challenges such as an ageing population and advancing technology, surgical education must integrate technical skills, physiology, communication, and teamwork. Comprehensive training programmes and fellowships should be paired with ongoing quality improvement initiatives and interdisciplinary collaboration, particularly in intensive care settings.

As trauma care evolves, surgical expertise in both operative and non-operative management must be ensured. Trauma surgeons must be recognised as specialists in critical care decision-making and strengthen partnerships with intensivists to deliver integrated, patient-centred care. Future efforts should prioritise training, collaboration, and quality improvement to meet the demands of modern trauma care across Europe.

Author contributions All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. All authors wrote the main manuscript text.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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European Journal of Trauma and Emergency Surgery (2025) 51:186
https://doi.org/10.1007/s00068-025-02826-6

REVIEW ARTICLE

Quality improvement program for the severely injured

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Received: 11 February 2025 / Accepted: 6 March 2025

Abstract
Over recent decades, advancements in trauma care have significantly reduced mortality rates among severely injured patients. These improvements are largely attributable to the establishment of trauma care systems, including prehospital management protocols and the creation of trauma centres with immediate surgical team availability. However, patient outcomes continue to vary, reflecting differences in the quality of trauma care influenced by organisational models and local practices. To address this, governments and scientific organisations have underscored the importance of evaluating care quality at local, national, and international levels. This chapter explores strategies for assessing quality of trauma care, establishing reliable quality indicators (QIs), and standardising auditing processes to guide improvements in patient outcomes and system performance.

Keywords Whitebook · ESTES · Polytruama

Introduction

The World Health Organization (WHO) defines quality of care as "the degree to which healthcare services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge." This definition underscores two critical concepts: first, that quality of care can and should be measured; and second, that quality is goal-oriented, reliant on clearly defined objectives.

(WHO document) *Guidelines for trauma quality improvement programmes (who.int)*.

Valid and reliable measures of trauma system performance are essential for guiding quality improvement initiatives, benchmarking outcomes, public reporting, investment decisions, and research. Constructing quality indicators (QIs) is a complex process requiring several components, including clear definitions, justification, formulas, data sources, and target populations. Effective QIs should meet four key criteria: importance, usefulness, scientific robustness, and feasibility.

Since the 1970s, when high mortality rates linked to suboptimal trauma care spurred the development of trauma systems and major trauma centres in the United States, preventable deaths and risk-adjusted mortality have become standard metrics for evaluating trauma system and centre performance. However, as preventable mortality rates have declined, these metrics have become less effective as sole indicators of quality. Traditional in-hospital mortality measures also fail to account for the broader continuum of trauma care, including prehospital and post-hospital management, long-term recovery, and the societal and economic impacts of trauma-related disability.

The Donabedian framework offers a conceptual model for evaluating healthcare quality, consisting of three interrelated components:

- Structure: The environment in which care is delivered, including facilities, resources, and organisational characteristics (e.g., trauma centre designations, trauma centre volume, trauma registry availability). While

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Published online: 29 April 2025

structural indicators are straightforward and objective, their presence does not guarantee quality.
- Process: The methods and activities involved in delivering care (e.g., prehospital times, trauma team activation, adherence to massive transfusion protocols). Process indicators are widely used but require more complex data collection.
- Outcome: The results of care, encompassing metrics such as mortality (e.g., pre-hospital deaths, mortality < 48 h), ICU length of stay, and even patient satisfaction. Outcome indicators are the most challenging to measure but are critical for conditions like trauma, which are characterised by high incidence and severity.

In the 1980s, the American College of Surgeons (ACS) proposed trauma quality indicators for severely injured patients. Subsequent reviews, such as one by Stelfox et al., identified over 1,500 QIs spanning categories including ACS status, patient safety, care outcomes, expert reviews, general auditing, and adherence to guidelines. However, these indicators lack international standardisation and robust evidence supporting their validity and reliability. The development of universally accepted, evidence-based QIs for trauma care remains an urgent priority.

Moreover, trauma care extends beyond the hospital stay, encompassing prevention, post-traumatic management, and societal reintegration. Quality assessment should reflect these broader phases, addressing both direct and indirect costs at national and international levels. Examples include:

- Prevention QIs: Measuring injury risk perception, the impact of public awareness programmes, or psychological consequences in witnesses.
- Post-traumatic Management QIs: Assessing long-term physical and psychological disability support or the tangible costs of care.
- Societal Reintegration QIs: Evaluating career outcomes, psychological outcomes, or outcomes related to support dependency for trauma survivors or witnesses.

A recent international expert panel conducted a web-based consensus survey involving 200 specialists from all WHO regions to evaluate 82 trauma QIs selected from an initial list of 1288. The findings revealed that a globally accepted, evidence-based set of trauma QIs has yet to be established. Current indicators are heterogeneous and inconsistently applied; international collaboration is called for to standardise quality assessment in trauma care.

Strategies to promote quality and reliability auditing

Severe trauma presents a significant challenge to healthcare systems due to its diversity of presentation, variability in care delivery, frequent deficiencies or errors in care, and the reality that part of the associated mortality remains avoidable. Addressing these challenges requires ongoing quality assessment to identify gaps, implement improvements, reduce morbidity and mortality rates, and enhance survivors' functional outcomes and quality of life.

Quality improvement relies on continuous education, learning processes, and systematic evaluation of care delivery. Two primary methods for assessing care processes include:

- Medical **Auditing**: A retrospective, systematic analysis conducted by the professionals responsible for providing care.
- **Monitoring**: A continuous and structured quality measurement system that uses predefined quality indicators (QIs) with established optimal benchmarks.

However, a 2009 Cochrane review found no study of sufficient scientific quality to determine whether auditing in trauma care effectively improves outcomes or reduces mortality. While the evidence remains inconclusive, feedback has emerged as a promising tool to improve performance and ensure ongoing quality monitoring.

The role of feedback in trauma care

Feedback—helpful information or constructive criticism aimed at improving performance—has been shown to enhance surgical and clinical outcomes. Effective feedback mechanisms are integral to continuous monitoring and learning, as demonstrated by several notable examples.

Case example 1: Ramban model (Haifa, Israel)

A two-part feedback system was implemented to evaluate and improve trauma care:

1. Prehospital Care: Focused on key aspects including airway management, cervical collar application, spinal fixation using backboards, pain assessment and management, and the completeness of prehospital documentation.
2. Hospital Care: Assessed primary hospital-level management including imaging, laboratory investigations, emergency department documentation,

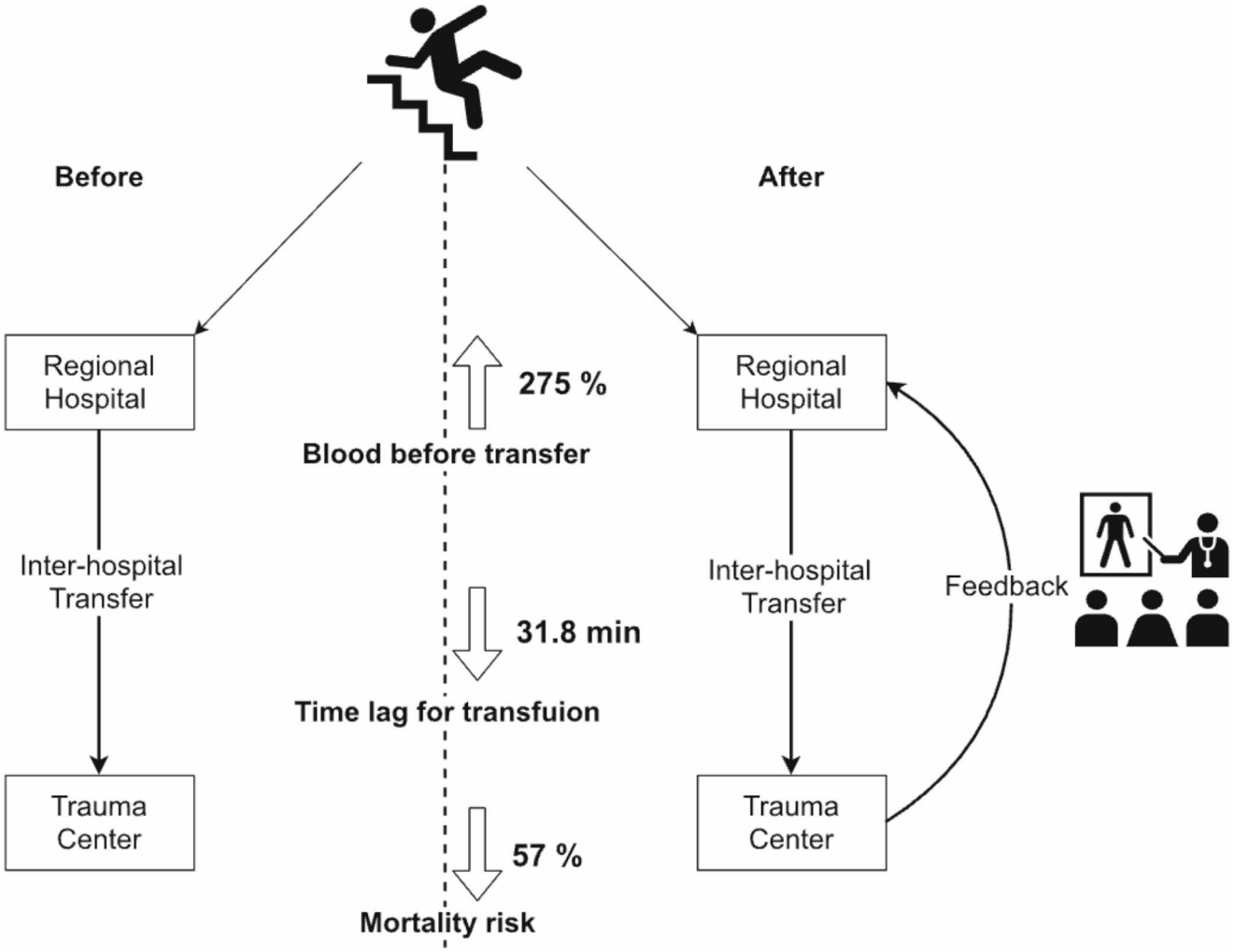

Fig. 1 Effect of interhospital feedback on blood transfusion quality in Taiwan. (From Wang CJ et al.)

electrocardiograms (ECGs), mechanism-of-injury analysis, treatment timelines, and Glasgow Coma Scale (GCS) scoring.

The feedback system, studied over two time periods, demonstrated measurable improvements in trauma patient management. Importantly, feedback was coupled with corrective actions to address cases of mismanagement, ensuring actionable solutions rather than simply identifying issues.

Case example 2: interhospital feedback in Taiwan

A study by Wang et al. retrospectively analysed data on trauma patients transferred between hospitals across two periods—before and after the introduction of feedback. The feedback approach included:

- Outcome Lectures: Focused on the results of transferred patient care.
- Collaborative Review: Trauma surgeons and emergency department physicians worked together to discuss transfer details, fostering a problem-solving approach rather than assigning blame.

Breaking the transfer process into smaller steps allowed for targeted problem identification and encouraged cooperation. After adjusting for confounding factors, the feedback-driven period was associated with:

- Higher rates of blood transfusion prior to transfer,
- Shorter time intervals before the first transfusion,
- A marginal reduction in mortality risk (Fig. 1).

The perfect checklist

The Performance Assessment of Emergency Teams and Communication in Trauma Care (PERFECT) checklist is another notable tool designed to evaluate prehospital trauma

training. Developed through qualitative and quantitative analyses and input from experienced academics, clinicians, and emergency medicine trainers, the PERFECT checklist objectively assesses trauma scenarios or real patient care.

The checklist evaluates seven key performance domains essential for clinical competence in trauma care:

1. Primary assessment.
2. Procedures.
3. Technical skills.
4. Trauma communication.
5. Non-technical skills.
6. Global performance.
7. Overall scenario evaluation.

The PERFECT checklist provides a validated and standardised method for assessing prehospital trauma training, ensuring comparability across different scenarios or care settings. In principle, this validated checklist could be used for any prehospital training.

Trauma registries

Trauma registries (TR) are structured databases containing uniform, consensus-based information collected by experts in trauma care. The primary aim is to provide information that improves the efficiency and quality of trauma care, facilitates epidemiological and clinical research, and supports outcome evaluations. To remain relevant, trauma registries must be adaptable to different healthcare settings and capable of evolving based on findings.

Data collection challenges

Despite their utility, trauma registries often fail to capture a comprehensive, population-based trauma sample. Many are hospital-based and therefore exclude less severely injured patients or critical cases where death occurs at the scene of the incident. Furthermore, voluntary participation by trauma centres can lead to issues with sample representativeness unless the registry is managed within a single centre framework or a highly organised trauma system.

Accurate quality evaluation hinges on high-quality data, which requires case ascertainment—ensuring all relevant cases are included in the registry. A recent Japanese study comparing the Japan Trauma Data Bank with government evaluation data revealed significant discrepancies, highlighting issues with case ascertainment, coding variability, and data completeness. These inconsistencies undermine the validity of administrative and registry data, which are critical for risk adjustment and outcome evaluation.

In contrast to hospital administrative databases, trauma registries provide more detailed and relevant data for research purposes. However, they often suffer from data quality challenges such as incomplete records, coding inaccuracies, and variability across hospitals.

Trauma registries in Europe

Europe has developed several trauma registries, ranging from single-centre initiatives to large multicentre networks. Notable examples include:

- *The German National Trauma Registry.*
- *The British Trauma Audit and Research Network (TARN).*
- *The Italian National Registry for Major Injuries.*
- *The Scandinavian Networking Group for Trauma and Emergency Management.*
- The Norwegian National Trauma Registry (NTR).

Efforts to standardise European trauma registries have led to the development of the **Utstein Template for Uniform Reporting of Data Following Major Trauma**. This 35-variable template defines core data required for inclusion and divides variables into three key categories:

- **Predictive Model Variables**: Patient and injury data relevant for outcome prediction.
- **System Characteristic Descriptors**: Data describing system-level differences to enable comparisons.
- **Process Mapping Variables**: Information capturing trauma care processes at individual trauma centres.

While the feasibility of a unified European trauma registry has been demonstrated—particularly through web-based systems requiring minimal additional infrastructure—progress remains limited. Since 2008, collaborative efforts across European trauma professionals have aimed to create a single **European Trauma Registry Network** capable of enabling large-scale, standardised data collection and comparison.

Ensuring data quality

Validation is critical to ensuring the reliability and utility of trauma registries. Validation can take two forms:

- Internal Validation: Comparison with original data sources to ensure accuracy and consistency.
- External Validation: Ensuring registries capture all relevant cases within the intended population.

Key characteristics for an evaluation of data quality include:

- Accuracy: Exact agreement between datasets.
- Correlation: The association of variables and changes with respect to one another.
- Correctness: Ensuring data falls within acceptable ranges.
- Precision: Specificity of data.
- Consistency: Logical alignment across related data points.
- Completeness: Capturing all required data points and cases.
- Comparability: Standardisation across systems for meaningful comparisons.
- Timeliness: Ensuring data is available when needed.

Few studies have formally evaluated trauma registry quality, and there is currently no universally standardised method for auditing or validating these registries. Establishing clear indicators and reproducible methods for data quality evaluation is therefore essential for improving trauma care.

Future directions

To enhance the quality of trauma care, international collaboration is essential for developing consensus-based trauma registries and associated quality indicators. These indicators must measure relevant processes, structures, and outcomes, enabling meaningful comparisons and driving improvements in patient care.

As trauma surgeon and author Karim Brohi aptly stated:

> Important for this will be legislative policy at national and European levels to support the development of an informatics infrastructure for trauma and the collection of such data on a population-wide basis. However, we must rapidly move towards a whole system approach to data collection, for it is only in the complexity of our trauma patients, and the multitude of interventions they are exposed to, that the true future of trauma care resides.

Conclusion and needs for the future

The pursuit of high-quality trauma care is a multifaceted endeavour requiring systematic evaluation, continuous feedback, and standardised data collection. Quality indicators play a pivotal role in assessing care processes, benchmarking outcomes, and identifying areas for improvement.

While medical auditing, monitoring, and feedback mechanisms have demonstrated their value, significant challenges remain. The lack of internationally agreed-upon quality indicators and risk adjustment methodologies highlights the need for urgent collaboration among trauma care professionals, policymakers, and researchers.

Trauma registries provide a critical foundation for evaluating care quality and outcomes. However, their effectiveness depends on validation, standardisation, and ongoing refinement to ensure data accuracy and reliability. Moving forward, a unified, consensus-driven approach to trauma data collection at local, national, and international levels must be adopted. This will enable healthcare systems to deliver consistent, evidence-based trauma care and ultimately improve patient outcomes worldwide.

Author contributions All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. All authors wrote the main manuscript text.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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European Journal of Trauma and Emergency Surgery (2025) 51:195
https://doi.org/10.1007/s00068-025-02859-x

REVIEW ARTICLE

Clinical and healthcare research

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Received: 11 February 2025 / Accepted: 3 April 2025

Abstract
Research in trauma care is indispensable for advancing the field of trauma surgery and healthcare delivery. The outcomes of such research have the potential to save lives, reduce disability, and optimise healthcare resource allocation. This chapters summarises key types of research in trauma care, highlights funding opportunities, and outlines future research priorities in Europe.

Keywords WhiteBook · Polytrauma · ESTES

Introduction

Clinical research plays a pivotal role in advancing trauma surgery and improving healthcare outcomes. Trauma surgery involves managing critically injured patients, often in life-threatening scenarios requiring rapid, evidence-based interventions. Clinical research serves as the foundation for improving patient outcomes, refining treatment strategies, and optimising the delivery of trauma care.

Translational research bridges the gap between experimental studies and clinical practice, enabling the implementation of innovative procedures, agents, or medications that have demonstrated promise in preclinical settings. However, introducing new concepts into patient care involves significant administrative and regulatory challenges.

Healthcare research in trauma surgery is inherently multidisciplinary, addressing a wide range of complex issues, including optimal resuscitation protocols, surgical techniques, postoperative care, and long-term rehabilitation. Through systematic investigations, researchers evaluate the safety, efficacy, and applicability of new interventions, while identifying areas for improvement in existing practices.

Clinical research underpins evidence-based decision-making, ensuring that trauma care aligns with the latest knowledge and best practices. This encompasses health services research, which analyses large-scale patient databases, such as insurance data and quality registries, to assess healthcare delivery and outcomes. By fostering rigorous scientific inquiry, this research drives advancements that save lives, reduce disability, and enhance healthcare resource efficiency, ultimately improving patient well-being and recovery.

Basic research

Basic research in trauma surgery forms the cornerstone of the trauma research continuum, providing critical insights into the cellular, molecular, and physiological processes underlying traumatic injuries. These findings serve as the foundation for translational and clinical innovations aimed at improving trauma care.

Key areas of basic research in trauma surgery:

- Injury mechanisms:

Basic research focuses on elucidating the complex mechanisms by which traumatic injuries occur, including tissue damage, inflammation, coagulation cascades, and cellular responses. Understanding these processes is essential for guiding clinical decision-making and developing effective interventions.

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Published online: 06 May 2025

- Wound and bone healing and regeneration

Investigating the biology of wound healing, bone repair, and tissue regeneration is crucial for trauma surgery. Research explores factors influencing tissue repair, scar formation, and regenerative potential, informing the development of interventions to optimise healing and recovery.

- Biomarker discovery

Biomarkers are critical for assessing injury severity, predicting prognosis, and monitoring treatment response. Basic research aims to identify and validate biomarkers that enable clinicians to make timely, evidence-based decisions. The future focus will be on understanding the source, function, and clinical significance of these biomarkers to enhance patient care.

- Drug development

Basic research provides the foundation for developing pharmacological agents that address key challenges in trauma care, such as inflammation, coagulation, pain management, and infection control. A future goal is personalised pharmacotherapy, tailored to the individual patient's pathophysiological profile for optimal outcomes.

- Biomechanics

Biomechanical research investigates the forces and stresses that lead to different types of injuries, providing valuable insights for designing protective equipment and safety measures to prevent trauma. Additionally, biomechanical considerations are critical for developing effective implants, prosthetics, and biological scaffolds.

The role of basic research

Basic research is defined by its commitment to uncovering fundamental principles and expanding our understanding of traumatic injuries. While the immediate clinical applications may not always be apparent, the knowledge gained from basic research is indispensable for driving advancements in trauma care.

By providing essential insights into injury mechanisms, healing processes, and therapeutic targets, basic research fuels translational and clinical studies that lead to tangible improvements in patient outcomes. This relentless pursuit of knowledge ultimately enhances trauma care, reduces morbidity, and contributes to better long-term recovery for trauma patients.

Translational research

Translational research in trauma surgery serves as a vital bridge between laboratory discoveries and clinical practice, aiming to improve patient outcomes and advance the field of trauma care. This multidisciplinary approach transforms insights from basic science into practical applications that address real-world challenges in trauma management. It is a dynamic process that continuously refines scientific knowledge to deliver tangible benefits to patients.

Key objectives of translational research in trauma surgery:

- Bridging bench to bedside

Translational research begins with understanding injury mechanisms, wound healing, and tissue regeneration through laboratory studies. Researchers identify novel therapeutic targets, biomarkers, and innovative strategies, which are then rigorously evaluated and integrated into clinical practice.

- Improving diagnostics

Enhancing the speed and accuracy of trauma diagnosis is a central goal. Translational research drives the development of advanced imaging techniques, biomarker-based diagnostics, and point-of-care tools, enabling clinicians to assess injury severity and initiate timely interventions.

- Innovating surgical techniques

Translational efforts fuel the creation of advanced surgical approaches, including minimally invasive techniques and robotic-assisted surgeries. These innovations aim to optimise patient outcomes while minimising surgical trauma and recovery times.

- Personalised medicine

Tailoring treatment to individual patients based on genetic profiles, injury-specific characteristics, and anatomical variations is a cornerstone of translational research. By integrating patient-specific data, clinicians can make more precise therapeutic decisions, improving recovery rates and outcomes.

- Rehabilitation, long-term care, and quality of life

Translational research extends beyond immediate surgical care, focusing on innovative rehabilitation strategies

and long-term patient management to enhance functional recovery. Measuring quality of life outcomes is crucial for evaluating the effectiveness of therapeutic and surgical interventions.

Translational research operates as a continuum, where findings are validated through clinical trials, refined based on patient outcomes, and iteratively improved. This dynamic process allows trauma surgeons to integrate the latest advancements into clinical practice, enhancing survival rates, reducing disability, and improving patients'overall quality of life. The collaborative efforts of researchers, clinicians, and healthcare providers underpin the evolution of trauma surgery, ensuring that innovations translate into meaningful benefits for trauma patients.

Clinical research

Clinical research in trauma surgery is essential for advancing treatment protocols, improving patient outcomes, and refining surgical techniques. Unlike isolated case reports or single-centre studies, valid clinical research requires well-designed, prospective trials with predefined hypotheses and sufficient statistical power. If patient recruitment is limited, multicentre studies should be prioritised to ensure robust and generalisable findings.

Compared to registry studies, clinical trials allow researchers to investigate causal relationships, answering targeted research questions with greater precision. Establishing multicentre and multinational trials is critical for achieving the highest-quality results and advancing evidence-based practices in trauma surgery.

Key contributions of clinical research in trauma surgery

- Optimising treatment strategies

Clinical research identifies the most effective practices for managing trauma cases, considering factors such as injury severity, patient demographics, and recovery trajectories. Through rigorous trials and longitudinal studies, researchers evaluate the optimal timing, techniques, and adjunct therapies to maximise recovery and minimise long-term complications.

- Adopting innovative technologies

Clinical research facilitates the safe evaluation and adoption of emerging technologies, tools, and surgical techniques. By assessing the efficacy, safety, and benefits of innovations such as advanced implants, robotic-assisted surgery, and novel devices, researchers ensure that trauma surgeons have access to cutting-edge tools for improved precision, reduced operative times, and fewer postoperative complications.

- Promoting collaboration

Clinical research fosters the exchange of knowledge and expertise among healthcare professionals, driving interdisciplinary collaboration. This shared understanding accelerates the dissemination of best practices and enhances the collective ability to address the complexities of trauma care.

- Public funding and research prioritisation

To advance trauma care, robust public funding support is essential for well-defined clinical studies. By prioritising and funding high-quality research initiatives, public agencies can drive transformative breakthroughs that optimise treatment strategies, improve patient outcomes, and enhance long-term quality of life for trauma survivors.

Through meticulously designed trials, clinical research serves as a catalyst for continuous improvement in trauma care. It ensures that treatment strategies are evidence-based, innovations are rigorously evaluated, and patients receive the best possible care. By fostering collaboration and securing adequate funding, clinical research will continue to shape the future of trauma surgery and deliver meaningful advancements for patients and healthcare systems alike.

Registry research

Trauma registries are well established in many European countries, including the Trauma Register of the German Society for Trauma Surgery, the Trauma Audit and Research Network (TARN) of the British NHS, and registries in Scandinavia, the Netherlands, and other regions. These registries typically follow defined datasets, enabling system comparisons using frameworks such as the Utstein template.

The primary strength of registry research is its ability to reflect the realities of clinical care through broad datasets and large patient numbers, which often provide results with high external validity. Such data are frequently used for quality assurance, allowing evaluation of care structures, procedural processes, and the effects of new measures or changing conditions on patient outcomes (Q: Weißbuch 3.0).

To ensure meaningful and clinically relevant conclusions, registry data must meet several criteria:

- Data quality

High-quality, complete datasets are essential. Centralised monitoring systems, including plausibility filters, can

significantly improve data accuracy and reliability. (Q: Bouillon et al., Unfallchirurg 2016 119:469–474).

- Clear definitions

Precise definitions of individual data points are needed to ensure accuracy and clinical relevance.

- Statistical relevance

Larger registries increase the risk of detecting statistically significant but clinically irrelevant results. Therefore, research questions must be clearly defined a priori to maintain focus and validity

- Correlations vs. causality

It is critical to recognise that registries identify correlations, not causality, when interpreting results.

Sustainable funding and active participation by healthcare providers are key to maintaining robust trauma registries. Motivating centres to consistently enter data ensures completeness and reliability, allowing registries to drive meaningful advancements in trauma care.

Health services research

Health services research examines the organisation, management, and financing of trauma care. Closely linked to registry-based research, it provides insights into the practical implementation of new clinical measures.

This research often utilises large datasets from hospitals, insurance providers, and national healthcare systems to assess established and newly introduced treatment protocols over extended follow-up periods. By identifying trends and early indicators, health services research highlights areas for improvement and supports further clinical investigations.

The findings of health services research directly influence healthcare policy and funding decisions, guiding resource allocation, care structures, and the overall financing of trauma care systems. These results are particularly valuable to governments and policymakers striving to optimise cost-efficiency and improve patient outcomes.

Prevention of trauma

Trauma prevention is of paramount importance to communities, insurers, and policymakers. Research in this area demonstrates how technical advances, public policies, and awareness campaigns can significantly reduce the incidence of severe trauma and its associated long-term costs.

A notable example is the improvement in car safety over recent decades, which has effectively prevented severe injuries and reduced follow-up care costs for individuals and insurers alike. Similarly, workplace safety initiatives, led by worker compensation organisations and government bodies, have successfully limited occupational injuries, benefiting both individuals and insurers.

However, evolving societal trends introduce new challenges. For instance, the growing popularity of cycling and e-scooter use has led to a surge in related injuries, undermining existing prevention strategies. Trauma prevention research must adapt to changing patterns, offering innovative solutions to mitigate risks and protect public health.

Public interest and funding

Severe trauma has profound consequences for patients, their families, and society. Traumatised individuals often face sudden disruptions to their personal and professional lives, including loss of income, career opportunities, and social stability. These challenges are further exacerbated by financial strain, particularly for patients without robust insurance or social support systems.

Compared to patients with cardiovascular diseases or cancers, trauma patients are often younger and of working age. The societal impact of trauma is therefore disproportionately high, as it results in lost productivity and increased reliance on insurance and pension systems. Given these far-reaching implications, trauma prevention and research warrant significant public and private interest.

Funding opportunities

Trauma research is supported through diverse funding channels, including national, European, and transnational grants. Examples include:

Name	Country/region	Funding options	Internet
European Research Council (ERC)	Europe	Any research; EU membership required	https://erc.europa.eu/
European Society of Trauma and Emergency Surgery (ESTES)	Europe	Scholarships and small grants	https://www.estesonline.org

Name	Country/region	Funding options	Internet
German Scientific Society (DFG)	Germany	Basic and clinical research	https://www.dfg.de/ https://anr.fr/en/
French National Research Agency (ANR)	France	General research initiatives	
Osteosynthesis & Trauma Care Foundation (OTC)	Europe	Research grants up to $50,000 for members	https://otcfoundation.org/research/
AO Trauma Foundation	Europe	Mini and large project grants for members	https://www.aofoundation.org/
Horizon Europe	Europe	EU research and innovation funding	https://research-and-innovation.ec.europa.eu/

These opportunities highlight the breadth of support available for trauma research, encouraging researchers to pursue innovative projects that address key challenges in trauma care.

Conclusion and needs for the future

The future of trauma research—encompassing translational, clinical, and health services research—relies on addressing complex healthcare challenges, integrating advanced technologies, and fostering interdisciplinary collaboration. Key priorities include:

- *Defining optimal trauma care in Europe*: Establishing benchmarks for high-quality trauma care that accommodate the diversity of European healthcare systems.
- *Data integration and standardisation:* Developing a unified European trauma registry, funded by the EU, to enable seamless data collection, integration, and analysis across systems.
- *Facilitating clinical trials:* Streamlining regulatory processes to facilitate large-scale, multicentre clinical studies that introduce safer, more effective treatment procedures. Cross-border collaboration and investment in research infrastructure are critical to achieving this goal.
- *Prioritising prevention research:* Supporting studies that focus on injury prevention, workplace safety, and early intervention strategies to mitigate long-term trauma impacts.
- *Advancing translational research:* Allocating resources to innovative translational research that bridges scientific discovery and clinical practice. Prioritising personalised medicine, novel diagnostics, and rehabilitation strategies will enhance patient-centred care.

By addressing these priorities, trauma research can deliver transformative advancements, improving survival rates, reducing disability, and enhancing the quality of life for trauma patients. Sustained public and private funding, along with cross-disciplinary collaboration, will be essential for driving progress and meeting the evolving challenges of trauma care.

Author contributions All authors contributed to the writing and editing of the manuscript. All authors agreed the submission of the manuscript. All authors wrote the main manuscript text.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

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Trauma remains a leading cause of death and disability in Europe, with severe injuries hospitalizing 5.3 million people annually and costing over €80 billion. The European Society for Trauma and Emergency Surgery (ESTES) has developed this White Book to standardize and optimize trauma care across diverse healthcare systems. Significant variations exist in trauma care structures, personnel, and resources across European countries.

This document provides recommendations for organizing trauma networks, defining personnel qualifications, setting equipment standards, and ensuring quality assurance. It serves multiple stakeholders, including healthcare professionals, policymakers, and researchers, offering a flexible framework adaptable to different national contexts. As healthcare systems face increasing challenges, implementing these standards will enhance trauma care, improve patient outcomes, and strengthen resilience.

Publisher
European Society for Trauma and Emergency Surgery (ESTES)
www.estesonline.org

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