into an integrated team. The functioning of trauma teams and the need for clear and effective of clinical leadership is discussed by Tiel Groenestege-Kreb and colleagues.9

Our understanding of the pathophysiology of resuscitation and trauma is evolving and changing. The haemodynamic response to haemorrhage may be changed by the type of injury. For example, blast injury to the chest may exacerbate the hypotension seen in seriously injured patients. Drugs such as morphine may modify the haemodynamic response to trauma resuscitation, but the response varies between species and research is currently being undertaken to characterize the impact of opiates on the haemodynamic response to injury in man. Our evolving understanding in this arena is reviewed by Kirkman and Watts.10 The implications of management of penetrating injuries are reviewed by Sheffy and colleagues.11 Bullets can take an unpredictable course through the body and seemingly innocuous gunshot injuries can cause extensive damage. Gunshot wounds to the thorax, abdomen, and pelvis can be associated with injuries that precipitate sudden haemodynamic deterioration.

Lecky and colleagues12 describe the different scoring systems and tools that are available for triage and identify the tension between over-triage whereby too many patients are referred for major trauma care and under-triage which may lead to seriously injured patients not receiving trauma centre care from the outset. An effective trauma system requires a degree of over-triage to avoid the latter hazard. They go on to examine the central role of large databases such as the Trauma and Audit Research Network (TARN) in audit, governance, and quality improvement in trauma services.

Taken together, the narrative is an inspiring story of advances in medical care improving outcomes for individual patients. Much has been done to advance trauma care in the UK and around the world and both organizations and individuals are working to build on this with further improvements.

**Declaration of interest**

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3. Lockey DJ, Crewdon K, Lossius HM. Pre-hospital anaesthesia; the same but different. Br J Anaesth 2014; 113: 211–19
patients who have a relatively low probability of death but a high probability of permanent disability. The latter group have a high personal and socio-economic cost and so the new trauma system in England has included both groups of patients.1

The most common cause of major trauma in England is road traffic accidents. The National Audit Office estimate 20 000 cases of major trauma occur in England each year resulting in 5400 deaths.2 Patients presenting with severe injury benefit from management in units with specifically trained multidisciplinary teams, providing rapid and organized care. Evidence from the USA, Australia, and Germany demonstrates significantly improved care and outcomes with rationalized trauma services3–5 and the Trauma Audit and Research Network (TARN) has demonstrated significant variability in mortality between hospitals in England.

In England, trauma victims were previously taken to the nearest hospital, irrespective of the severity and type of injuries sustained, and also irrespective of the capability of the hospital to provide resuscitation or definitive care.6 Numerous reports7–12 over the past 60 yr have identified problems inherent to the system of trauma care that evolved within the National Health Service (NHS). These reports included recommendations to establish regional major trauma centres, enhance training for ambulance staff, and improve communication and prehospital transport. Some individual units, such as the Birmingham Accident Hospital and the Royal London Hospital, became centres of excellence for trauma care, providing for their local populations. However, despite these reports, and increasing evidence from TARN that trauma care in the NHS did not reach international standards, there was little change in the system of major trauma care.

The NCEPOD 2007 report ‘Trauma – Who Cares?’ raised political awareness and the first National Clinical Director for Trauma (Prof. Keith Willett) was appointed in December 2008.13 Further major impetus to improve care came with the publication of the National Audit Office Report ‘Major Trauma Care in England’ in 2010.1 This clearly identified deficiencies in trauma care within the NHS and a failure to reorganize care, despite repeated reports and evidence of poor outcomes. This report recommended the establishment of regional Major Trauma Network.

London led the way in improving the delivery of major trauma care by establishing three Major Trauma Centres within the capital city. Service specifications were developed and independent experts appointed to review facilities and designate centres. These went live in April 2010 and a fourth commenced in April 2011.

The trauma system in Greater London is exclusive. This means that all patients identified pre-hospital with major trauma are transported directly to one of the four Major Trauma Centres and all other hospitals are bypassed. This system is effective within London because of the small geographical area and short transport times: the average is 17 min and virtually all patients reach a Major Trauma Centre within 45 min. The London system is supported by a Helicopter Emergency Medical Service (HEMS) that allows the rapid delivery of prehospital medical care. The system has been carefully audited by the London Trauma Office and has demonstrated an improved care process and better outcomes with a significant increase in the number of patients surviving major trauma in London.14

For the regional trauma networks, a national clinical advisory group, including medical experts from multiple specialities, patients and carers, and other key experts from nursing, allied health professionals, and management, was formed. This group developed service specifications for a patient-focused approach to major trauma. Recommendations for service delivery included the whole patient pathway with four key stages: pre-hospital care, reception and resuscitation, definitive care, and rehabilitation. Each region then took these recommendations and adapted them for differing facilities, geography, and populations served. These bespoke networks were designed to deliver good care, irrespective of where the injury occurred, getting the patient to the ‘right place at the right time for the right care’.15

Transfer times from accident to hospital are much longer outside urban conurbations and so the exclusive trauma system developed in London was not suitable in other areas. Each region has developed a network of hospitals based upon available facilities and transfer times and this has led to the designation of three tiers of hospital providing trauma care: Major Trauma Centres, Trauma Units, and Local Emergency Hospitals. Pre-hospital teams now use major trauma triage tools to identify patients who may have suffered severe injuries. These tools are based upon physiological criteria, injuries identified at scene, and mechanism of injury. Triage-positive patients who are within 45 min transfer time of a Major Trauma Centre are taken directly there, bypassing all hospitals on route unless there is an immediate life-threatening condition such as unrelieved airway obstruction. Major Trauma Centres have all the facilities to provide resuscitation, emergency surgery, and interventional radiology with consultant-led trauma teams 24/7, massive transfusion protocols, and immediate access to operating theatres. Immediate access to computed tomography (CT) and magnetic resonance imaging is also required, along with dedicated major trauma beds, intensive care, and facilities to provide comprehensive and definitive care and rehabilitation of all injury patterns.

<table>
<thead>
<tr>
<th>Body regions</th>
<th>Injury severity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head or neck</td>
<td>Minor</td>
<td>1</td>
</tr>
<tr>
<td>Face</td>
<td>Moderate</td>
<td>2</td>
</tr>
<tr>
<td>Chest</td>
<td>Serious</td>
<td>3</td>
</tr>
<tr>
<td>Abdomen or pelvic contents</td>
<td>Severe</td>
<td>4</td>
</tr>
<tr>
<td>Pelvic skeleton</td>
<td>Critical</td>
<td>5</td>
</tr>
<tr>
<td>External</td>
<td>Maximal (currently untreatable)</td>
<td>6</td>
</tr>
</tbody>
</table>
Fig 1 Major Trauma Centres (MTCs) in England. Copyright NHS Choices 2012.
Patients with longer transfer times are taken to the nearest Trauma Unit. These units have the facilities to provide resuscitation and manage immediately life-threatening conditions, including severe abdominal haemorrhage requiring laparotomy. However, they lack specialist services such as neurosurgery or cardiothoracic surgery and cannot provide comprehensive definitive care for all injury patterns. Within the networks, the function of the Trauma Unit is to resuscitate the patient and provide expert triage so that patients are then transferred safely and rapidly to the Major Trauma Centre for definitive care. Local Emergency Hospitals lack the facilities for receiving patients with major trauma and are always bypassed for triage-positive patients. They continue to provide general Accident and Emergency services for their local population.

There are currently 26 Major Trauma Networks in England (Fig. 1), each with a Major Trauma Centre. Twelve provide care for adults and children (this includes the four in London), eight provide care for adults only, and four provide care for children only (this will increase to five when the new Children’s Hospital in Bristol opens later in 2014). The final two are based in Manchester and Liverpool. These two cities lack any single hospital that can provide comprehensive trauma care because key specialities are located in different hospitals within the cities. A collaborative system has been developed, with the various hospitals working together to provide major trauma care. Most regional Major Trauma Networks went live in April 2011 and the 58.5 million population of England is now covered by the networks. In a time of severe economic depression, funding has been an issue, but this was addressed by a modification of the payment structure (Payment by Results) for major trauma, so that funding reflected both severity of diagnosis and complexity of procedures. Additional funding of £37 million was secured as a best practice tariff (Table 2).

The initial results of the networks have been very encouraging. In the first year (April 2011–2), 16 000 patients were treated in the major trauma centres. All of these centres have large populations within a 45 min transfer time and so 12 000 patients were taken directly to the centres while 4000 had initial treatment at a Trauma Unit and secondary transfer to the Major Trauma Centre. Network performance has been monitored using TARN data and all metrics have shown significant improvement. Key indicators include an increase in the number of patients with severe injury (ISS >15) being received by a consultant-led trauma team from 50% in 2011 to 75% in 2013 \( (P=0.001) \). The increase in senior leadership is reflected in the number of patients in coma (GCS of 8 or less) who receive a definitive airway within 30 min of arrival. This has increased from 50% to 75% in a year \( (P=0.002) \). Trauma CT, with rapid scan from the head to pelvis, has become a key part of trauma management allowing early identification of life-threatening injuries. Within the first 30 min of arrival, 45% of CT scans are now performed. Safe and rapid transfer to CT can only be achieved if a Trauma Team is functioning well and this is probably a good process measure for the system. Within 60 min, 90% of patients with head injury who fit NICE guidelines for early CT now receive a scan.\(^{16}\) The end result has been a significant 19% improvement in the probability of survival after trauma \( (ISS>8) \) for the population of England. Variation between centres remains and indeed should be considered normal, but the gap between centres has narrowed with an 85% reduction in the variance as the process of care has become more standardized.

A somewhat unexpected finding since the advent of the new trauma system has been the number of patients over the age of 60 yr that suffer severe injuries. Some of these are due to high energy trauma, such as road traffic accidents, but a large proportion are due to low energy trauma from simple falls or a fall down stairs. Many of these patients have significant chest injuries with multiple rib fractures and were previously managed within multiple pathways within hospitals. The new system has brought these patients into a single pathway and many of the Major Trauma Centres have established pain management guidelines for this patient group that include early epidural anaesthesia with rapid mobilization and physiotherapy. Many of these older patients have multiple co-morbidities along with social and care issues that are similar to patients with hip fracture. It is likely that healthcare of the elderly physicians, such as orthogeriatricians, will become integral to major trauma management in the future.

Good rehabilitation is key to making optimal recovery after trauma and improving rehabilitation services remains one of the biggest challenges facing the new trauma system in England. From the outset, the Regional Trauma Networks

### Table 2 The major trauma best practice tariff uses the ISS to assign one of the two levels of tariff based on ISS > 8 or > 15

<table>
<thead>
<tr>
<th>Level 1 (ISS &gt; 8)</th>
<th>£1515</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient treated in a Major Trauma Centre</td>
<td>TARN data completed and submitted within 60 days of discharge</td>
</tr>
<tr>
<td>Patient transferred as a non-emergency must be admitted to the MTC within 2 calendar days of referral</td>
<td></td>
</tr>
<tr>
<td>Level 2 (ISS &gt; 15)</td>
<td>£2913</td>
</tr>
<tr>
<td>Level 1 criteria met</td>
<td>Patient received by a trauma team led by a consultant (who must be present within 5 min for those with full MTC implementation)</td>
</tr>
<tr>
<td>or</td>
<td>Patient transferred as a non-emergency must be admitted to the MTC within 2 calendar days of referral</td>
</tr>
</tbody>
</table>
tried to focus on rehabilitation, but lack of facilities and manpower has been a significant issue. All Major Trauma Centres now have rehabilitation coordinators and all patients are assigned a key worker. Rather than being an afterthought, rehabilitation medicine is now involved in patient management within 72 h of injury. The best practice tariff requires that patients are assessed and have a written rehabilitation prescription within this time frame. Most Major Trauma Centres have been able to increase the number of therapists involved in trauma care and have also improved access to other key rehabilitation specialists, such as neuropsychiatrists. Indeed, the more holistic approach required within the trauma networks has resulted in much greater recognition of the major psychosocial impact of trauma on patients, family, and carers and the need for far more psychological and social support. Despite these improvements, future improvements in trauma care in England will require a reorganization of the delivery of rehabilitation and may require an increase in facilities and manpower.

International experience suggests that it takes up to 5 yr for trauma networks to mature and, as clinical teams gain experience, outcomes after trauma in England are expected to improve still further. Major Trauma Networks are now part of the national peer-review system and undergo annual peer-review coupled with a self-assessment exercise. This review looks at facilities, organization, clinical governance, and outcomes. Outcome measures will expand from mortality alone to include patient-reported outcome measures. These will include general health measures, such as the EDQ5 (a five-item self-report health state questionnaire measuring subjective health belief), and injury-specific outcome measures such as the Glasgow Outcome Scale for head injuries. In addition, an analysis of the socio-economic impact of the new trauma system is essential.

In summary, 16,000 major trauma victims were treated within the Major Trauma Networks in England in the first year and this has resulted in a significant improvement in the probability of surviving major trauma; further improvement is expected.

Authors’ contributions

All authors contributed to the writing up and editing of this paper.

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Declaration of interest

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