Chapter 2
Epidemiology of Polytrauma

Fiona E. Lecky, Omar Bouamra, Maralyn Woodford, Roxana Alexandrescu, and Sarah Jane O’Brien

Epidemiology is the study of health and disease in populations, the scientific approach typifying public health medicine. The paradigms are somewhat different from the reductionist approach of much clinical science, which seeks to understand disease processes at an “omic” level. The rationale that underpins epidemiology suggests that effective disease control must begin and end by understanding the impact of a disease (and its prevention/management strategies) at a population level – globally, nationally, and locally – including the identification of vulnerable groups, etiological factors, and societal costs.

An epidemiological perspective on polytrauma – significant injuries affecting more than one body region – and its management must draw from the significant “injury control” literature. The latter often does not distinguish between polytrauma and major injury to a single body system. However, it sets an important context for more detailed descriptions of polytrauma found in trauma registries. This chapter will therefore first describe the global injury burden prior to a polytrauma focus.

2.1 Global Burden of Injury

Trauma fulfills the disease classification criteria for a global pandemic, this being a recurrent and significant cause of morbidity and mortality over time and across continents despite efforts to control its impact. Worldwide, about 16,000 people die every day as a result of an injury (5.8 million deaths per year), and the projections for 2020 show that 8.4 million deaths per year are expected [1, 2]. Consequently, injury will be the second most common cause of disability adjusted years of life lost

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within the next 13 years (second only to HIV/AIDS). Undoubtedly, the major burden of injury is increasingly occurring in the developing world as it industrializes, adopts motorized transportation, and remains the major center for armed conflict [2]. Despite a lower population incidence, injury remains the most common cause of death and disability in children and young adults in the developed world [2].

Incidence and trends vary across the developed world. National statistics are quoted as showing crude annual rates of approximately 1,095/100,000 injury deaths and hospitalizations in England and Wales [3, 4]. These data are obtained from national statistics that use International Classification of Disease codes, a taxonomy with limited descriptions of injury severity. The abbreviated injury scale (AIS) dictionary has a greater level of detail (over 2,000 injury codes) and allocates to every injury a severity score between 1 (mild) and 6 (maximal) [5]. These can be summed into the injury severity score (ISS) [6] as a global reflection of the anatomical severity of injury suffered by each individual patient. Severe injury is defined as ISS >15. Within Europe, most hospital admissions with injury have much lower ISS values (range 4–9), due to single isolated limb fractures in children or the elderly (falls), and isolated mild head injury (blunt assault) in young adults.

This latter AIS/ISS taxonomy has been utilized to describe injury incidence in continental Europe and the US; consequently, rates appear considerably lower than in England and Wales. Across continental Europe, the annual rates of death and severe injury (ISS >15) varies from 25 per 100,000 in Germany to 52.2 [7] in one region of Italy [8]. In Canada, the annual rate of death and severe injury (with ISS >12) is estimated at 71.5 per 100,000 [9]; a lower ISS is utilized here, but, in fact, the occurrence of ISS scores 13–15 is low, so this probably reflects a truly higher incidence of injury morbidity in Canada compared to continental Western Europe.

The incidence in most of continental Europe has declined in recent years (Figs. 2.1 and 2.2). There is limited literature available on the economics of injury, but they are an important source of direct medical costs as well as indirect costs resulting from economic production losses; in the Netherlands, for example, the direct costs of injury represents 5% of the health care budget, whereas in Spain, the total costs associated with traffic injuries alone account for 1.35% of the gross national product [10, 11]. In both countries, injury has been shown to be a more expensive disease than cancer or cardiovascular disease once societal costs are accounted for.

2.2 Etiology and Vulnerable Groups

Etiology and vulnerable groups are inextricably linked and reflect the nature of the disease. Injury results from a transfer of energy – most commonly kinetic, but, within armed conflict, thermal, chemical, blast, and radiation become important – to the patient. The nature/severity of the injuries sustained depends on the type and magnitude of impacting energy and vulnerability of the host.

Clearly, risk-taking behavior involving transportation ± alcohol, more prevalent in younger males, conveys a higher likelihood of injury. Indeed, statistics
Fig. 2.1 SDR (standardized death rates), external cause injury and poison, all ages per 100,000 male. (Reprinted with permission by WHO from Appendix V. Health of All Database, June 2006, WHO. http://www.euro.who.int/eprise/main/WHO/InformationSources/Data/20051173;http://www.euro.who.int/eprise/main/WHO/InformationSources/Data/2005117%203.)

Fig. 2.2 SDR (standardized death rates), external cause injury and poison, all ages per 100,000 female. (Reprinted with permission by WHO from Appendix V. Health of All Database, June 2006, WHO. http://www.euro.who.int/eprise/main/WHO/InformationSources/Data/20051173;http://www.euro.who.int/eprise/main/WHO/InformationSources/Data/2005117%203.)
show that males predominate in injury hospitalizations up until the age of 65 [3, 4]. Among senior citizens, this type of risk-taking behavior is less common but falls secondary to medical diseases, sensory impairment, and musculoskeletal conditions, which occur increasingly with age. Osteoporosis in older women makes them more vulnerable to injury from falls at home – usually hip and upper limb fractures – but true polytrauma is relatively rare amongst this group.

As polytrauma usually results from high energy impact to more than one body system, it is not surprising that Road Traffic Crashes predominate as the causal mechanism for deaths and severe injuries in Europe [8]. In areas where interpersonal violence/firearms are more commonly used, intentional injury is sometimes the primary etiological factor in death and hospitalization for severe injury [12]. However, the latter may not truly reflect polytrauma, as single high velocity gunshot wounds (GSW) to vital organs carry a high morbidity. There is a well-described social class gradient, particularly among younger patients who are more vulnerable to intentional and non-intentional injury [13].

2.3 Data Sources for the Study of Polytrauma

A large European trauma registry has been employed to enable description of demography, mechanism/patterns of injury, and mortality from polytrauma. The advantage of using hospital-based trauma registries is that accurate injury descriptions are made using AIS codes, making it possible to identify true polytrauma – significant injury to more than one body region. AIS grades the severity of each single injury from 1 (mild) to 6 (maximal) on an ordinal scale: A serious injury to any body region is usually regarded as an AIS >2 [5, 6]. Therefore, polytrauma can be regarded as an AIS >2 in more than one of the following six body regions (ISS >17). It is often impossible to identify patients in this way from the ICD-based injury description in routine statistics.

Polytrauma can be defined as significant injury in at least two out of the following six body regions:

- Head, neck, and cervical spine
- Face
- Chest and thoracic spine
- Abdomen and lumbar spine
- Limbs and bony pelvis
- External (skin)

It is important to note that the limbs and bony pelvis constitute one body region; therefore multiple limb fractures, or a limb and pelvic fracture, will not constitute polytrauma without injuries to either head/abdomen/thorax.

The disadvantage of utilizing hospital trauma registries for descriptive epidemiology is that they are not easily linked to defined populations and often do not include
pre-hospital deaths. Not an insignificant consideration, in urban environments more than 50% of deaths from injury occur in the pre-hospital environment [14]; in rural areas, this figure may be as high as 75% [15].

This potentially limits the epidemiological usefulness of trauma registries for primary and secondary prevention initiatives; however, many effective programs are already well proven:

primary = reducing the likelihood of an injury event occurrence: speed restrictions, gun control, drink driving legislation,

secondary = reducing the likelihood of injury in the event of an occurrence: helmets for motorcyclists, seatbelts for car occupants)

However, due to the interplay of human behavior and powerful vectors, injury remains a major health problem even where prevention programs have had an impact. It probably is reasonable to assume that a significant proportion of polytrauma victims (reaching hospital alive) in a region covered by a trauma registry will be detailed therein in terms of injuries and clinical care. Therefore, for the purposes of injury control, large and well-established trauma registries can inform post-event injury care or tertiary prevention that reduces the effects of injury in patients who reach hospital alive.

Data on victims of polytrauma has been taken from the Trauma Audit and Research Network (TARN [16]). TARN records data from patients of all ages who sustain injury resulting in immediate admission to hospital for 3 days or longer and/or subsequent death/critical care or inter-hospital transfer. This is in line with the original “Major Trauma Outcome Study (MTOS)” trauma registry criteria [17]. Approximately 50% of the trauma-receiving hospitals in England and Wales and some European hospitals submit data to TARN. Glasgow Coma Scale, blood pressure, and respiratory rate are recorded when the patient enters the Emergency Department. Every injury is recorded and defined according to the AIS [5]. This is used by trained coders to enable calculation of the ISS [6]. Each hospital transfers leads to the generation of a separate record that is attached to the records from the initial presentation. The patient’s age (but no patient identifier) is also recorded, and outcome in terms of survival or death is based on assessment at discharge or 30 days, whichever is first. Patients over 65 years with isolated fracture of the femoral neck or pubic ramus and those with single uncomplicated or single closed limb injuries (excepting femoral fractures) are prospectively excluded.

Table 2.1 describes all cases in the TARN database by age group from 1989 to 2007. It can be seen that, for all age groups, most cases are not polytrauma as for there to be significant trauma to more than one body region the ISS should be >17; the median ISS for all age groups is 9 or 10 in the trauma registry sample. The mortality rates increase significantly after age 65 when RTC causes a much lower proportion of injuries. Within this age group, there is also a reversal of male preponderance and an association of higher mortality with male gender, which is probably due to comorbidity and has been described elsewhere [18].
2.4 Polytrauma Demography and Causes, Incidence within Trauma Registry, and Outcome

It can be seen from Table 2.2 that approximately 16% of trauma registry cases have polytrauma, that is, significant injuries in more than one body region (given that the limbs and pelvis constitute one body region). The proportion is lowest in the elderly. The median ages for polytrauma do not differ significantly from that from other trauma registry cases: children with polytrauma tending to be slightly older, 11 vs. 8.4 years, whereas the proportion of cases caused by road traffic collisions almost doubles across all age groups to 65–82%. Penetrating trauma is responsible for 2.4% (629) of all polytrauma cases over this timeframe. The degree of male preponderance does not change among the younger age groups. Among the elderly, there is almost a 50:50 gender split in terms of polytrauma cases, which differs from the female preponderance in all elderly trauma registry cases. ISS scores

Table 2.1 Trauma audit and research network (TARN) data: all injured patients submitted from 1989 to 2007, by age group

<table>
<thead>
<tr>
<th>Age groups</th>
<th>0–15 (N=22,281)</th>
<th>16–65 (N=108,881)</th>
<th>&gt;65 (N=31,203)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Male 8.70</td>
<td>34.30</td>
<td>75.80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Median Female 8.00</td>
<td>43.40</td>
<td>80.00</td>
<td></td>
</tr>
<tr>
<td>ISS (median)</td>
<td>Male 9</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female 9</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>% male</td>
<td>67.4</td>
<td>74.3</td>
<td>36.4</td>
<td></td>
</tr>
<tr>
<td>% injured by RTC</td>
<td>45.7</td>
<td>45.1</td>
<td>23.7</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>Male 4.2</td>
<td>6.5</td>
<td>20.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female 4.9</td>
<td>5.5</td>
<td>12.6</td>
<td></td>
</tr>
</tbody>
</table>

Data from Appendix V. Health of All Database, June 2006, WHO

Table 2.2 Trauma audit and research network (TARN): polytrauma cases by age group, 1989–2007

<table>
<thead>
<tr>
<th>Overall total</th>
<th>0–15</th>
<th>16–65</th>
<th>&gt;65</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age</td>
<td>Male 11.0</td>
<td>32.5</td>
<td>76.0</td>
<td>33.3</td>
</tr>
<tr>
<td>ISS median ISS</td>
<td>Male 26</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Cause of injuries</td>
<td>Male RTC 2305</td>
<td>14507</td>
<td>2359</td>
<td>19171</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>82.0</td>
<td>72.1</td>
<td>65.9</td>
</tr>
<tr>
<td>Gender</td>
<td>Male 1820</td>
<td>15807</td>
<td>1771</td>
<td>19398</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>64.7</td>
<td>78.6</td>
<td>49.4</td>
</tr>
<tr>
<td>Mortality at 30 days</td>
<td>Male 18.1</td>
<td>17.1</td>
<td>42.7</td>
<td>19.5</td>
</tr>
<tr>
<td></td>
<td>Female 19.0</td>
<td>17.9</td>
<td>35.6</td>
<td>22.6</td>
</tr>
</tbody>
</table>

Data from Appendix V. Health of All Database, June 2006, WHO
increase by a factor of 2.5, and mortality increases three- to fourfold in the younger age groups to approximately 20% in the young, and doubles to 39% in the over 65 years age group. However, 75% of deaths occur in children and adults of working age.

### 2.4.1 Patterns of Injury as Markers for Polytrauma

Of the 26,541 polytrauma cases detailed here, 71.3% (18,904/26,514) have at least one limb± or pelvic fracture that is open, displaced, or comminuted. However, most limb/pelvic fractures on the registry have ((49,200/68,014) = 72.3%) occurred in isolation. Half of all polytrauma cases have either a head and/or a thoracic injury, but, in contrast to thoracic injury, significant head injury occurs in isolation in two-thirds of head injury patients. Significant thoracic trauma is more likely to occur in the context of polytrauma (13,625/25,355 = 53.7% of patients with any thoracic injury) as is significant abdominal trauma (4,249/6,874 = 61.8% of patients with any abdominal injury). Significant abdominal trauma, however, is present in only 16.0% of polytrauma cases (4,249/26,514). Injuries to the face and external (skin) body regions are rare in the context of polytrauma.

### 2.4.2 Polytrauma Mortality: Impact of Age and Body Area

In terms of mortality, polytrauma with abdominal injury has the highest rate across all age groups (36.9%, 33.3%, 64.1%). In children, polytrauma with thoracic trauma confers the next highest risk of mortality (30.3%), whereas, in adults, it is polytrauma with head injury (29.3%, 56.2%). For isolated injuries and polytrauma, mortality does not appear significantly different between children and adults of working age, but there is a sharp rise in mortality for all patterns of injury after 65 years; interestingly, the relative increase in mortality with age is greater for cases of isolated injury where rates always more than double the mortality in younger age groups, perhaps suggesting that it is the younger, fitter elderly patients who fall victim to polytrauma. The relative impact of age in terms of mortality is greatest for limb/pelvic trauma, indicating the vulnerability of older patients to the complications of immobility.

In terms of overall mortality, it is first interesting to note that the impact of polytrauma is greater than the sum of its parts for children and young adults. For example, if the rates of mortality for isolated injuries of limb/pelvis, head, thorax, and abdomen are summated for children from Table 2.3, this comes to 14.3%, which is less than the polytrauma mortality rates for children with head/chest or abdominal injuries. Finally, although polytrauma accounted for only 16% of cases in this trauma registry sample, it accounted for almost half the deaths (5,393/12,611 = 43%), the remainder occurring mainly in the context of isolated significant head injury and
limb fractures in the elderly. This analysis has not dealt in detail with the disability consequences of polytrauma; inevitably, they are considerable, but large studies are rare due to the challenges of follow-up [19].

### 2.5 Summary and Conclusion

Injury is a global pandemic, and the second most costly disease worldwide, with the burden set to increase. Within civilian European MTOS-type trauma registries, true polytrauma using AIS criteria occurs in only 10% of cases, but causes up to half of all deaths in patients reaching hospital alive, mainly in male children and adults <65 years. Road traffic collisions are the predominant cause. The extremities and the pelvis are the most frequently injured body areas; however, thoracic trauma and abdominal trauma are specific markers for polytrauma and carry the greatest mortality risk in the young. Overall, most polytrauma deaths occur in the context of head and thoracic trauma. Polytrauma is rare in those over 65 years, and has double the mortality of younger adults. Within the younger age groups, the mortality associated with polytrauma is greater than the sum of its parts, suggesting a role for targeted improvements in care.

**Acknowledgment** The following hospitals have contributed data and funding to TARN allowing this work to take place: Addenbrooke’s Hospital, Cambridge; Heatherwood & Wexham Park.

### Table 2.3 Patterns of injury and mortality in polytrauma and isolated injury, by age group, 1989–2007

<table>
<thead>
<tr>
<th></th>
<th>0–15 years mortality %, No. of deaths</th>
<th>16–65 years mortality %, No. of deaths</th>
<th>&gt;65 years mortality %, No. of deaths</th>
<th>Overall mortality %, No. of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Limb/pelvis (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated</td>
<td>49,200</td>
<td>0.1%10</td>
<td>0.9%263</td>
<td>6.8%750</td>
</tr>
<tr>
<td>With polytrauma</td>
<td>18,904</td>
<td>12.2%236</td>
<td>13.1%187</td>
<td>33.2%885</td>
</tr>
<tr>
<td><strong>Head (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated</td>
<td>25,776</td>
<td>6.9%371</td>
<td>12.9%2099</td>
<td>35.4%1477</td>
</tr>
<tr>
<td>With polytrauma</td>
<td>12,340</td>
<td>25.5%477</td>
<td>29.3%2579</td>
<td>56.2%941</td>
</tr>
<tr>
<td><strong>Thorax (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated</td>
<td>11,730</td>
<td>5.2%24</td>
<td>4.9%442</td>
<td>16%356</td>
</tr>
<tr>
<td>With polytrauma</td>
<td>13,625</td>
<td>30.3%358</td>
<td>25.3%2704</td>
<td>54.9%973</td>
</tr>
<tr>
<td><strong>Abdomen (n)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated</td>
<td>2,625</td>
<td>2.1%10</td>
<td>5.1%104</td>
<td>22%24</td>
</tr>
<tr>
<td>With polytrauma</td>
<td>4,249</td>
<td>36.9%152</td>
<td>33.3%1152</td>
<td>64.1%239</td>
</tr>
</tbody>
</table>

*Not mutually exclusive

Data from Appendix V. Health of All Database, June 2006, WHO
Epidemiology of Polytrauma

Hospital, Slough; Rotherham District General Hospital, Rotherham; The Princess Royal Hospital, Shropshire; Airedale General Hospital, Yorkshire; Hillingdon Hospital, Middlesex; Royal Albert Edward Infirmary, Wigan; Torbay Hospital, Devon; Arrowe Park Hospital, Merseyside; Hinchingbrooke Hospital, Cambridgeshire; Royal Berkshire Hospital, Reading; Trafford General Hospital, Manchester; Ashford General Hospital, London; Homerton Hospital, London; Royal Bolton Hospital, Farnworth; University Hospital Lewisham, London; Atkinson Morley’s Hospital, London; Hope Hospital, Salford; Royal Cornwall Hospital, Truro; University Hospital of Hartlepool, Hartlepool; Barnsley District General Hospital, Yorkshire; Huddersfield Royal Infirmary; Royal Devon & Exeter Hospital; University Hospital of North Staffordshire; Basildon Hospital, Essex; Hull Royal Infirmary, North Humberside; Royal Gwent Hospital, Newport; University Hospital of North Tees; Cleveland Bassettlaw Hospital, Nottinghamshire; Ipswich Hospital, Suffolk; Royal Hallamshire Hospital, Sheffield; University Hospital of Wales; Cardiff Bedford Hospital; James Cook University Hospital, Cleveland; Royal Hampshire County Hospital, Winchester; University Hospital, Aintree Liverpool; Birmingham Heartlands Hospital; James Paget Hospital, Norfolk; Royal Lancaster Infirmary; Walton Centre for Neurology, Liverpool; Blackburn Royal Infirmary, Lancashire; Jersey General Hospital; Royal Liverpool Children's Hospital, Alder Hey; Wansbeck General Hospital, Northumberland; Blackpool Victoria Hospital; John Coupland Hospital; Royal Liverpool University Hospital; Warrington Hospital Cheshire; Booth Hall Children’s Hospital, Manchester; John Radcliffe Hospital, Oxon; Royal London Hospital; Warwick Hospital, Warwick; Bradford Royal Infirmary, Yorkshire; Kent & Canterbury Hospital; Royal Manchester Children's Hospital, Pendlebury; Waterford Regional Hospital, Ireland; Bristol Royal Infirmary; Kent & Sussex Hospital; Royal Oldham Hospital; Watford General Hospital, Herts; Bromley Hospital, Kent; Kettering General Hospital, Northamptonshire; Royal Preston Hospital; West Cumberland Hospital, Cumbria; Broomfield Hospital, Essex; Kings College Hospital; London Royal Shrewsbury Hospital, Shropshire; West Middlesex University Hospital; Burnley General Hospital; Kings Mill Hospital, Nottinghamshire; Royal Surrey County Hospital; West Wales General Hospital, Dyfed; Calderdale Royal Hospital, Halifax; Leeds General Infirmary; Royal Sussex County Hospital, Brighton; Weston General Hospital, Avon; Cheltenham General Hospital; Leicester Royal Infirmary; Royal United Hospital Bath Weymouth & District Hospital Dorset; Chesterfield & Nth Derbyshire Royal Hospital; Leigh Infirmary; Royal Victoria Hospital, Belfast N Ireland; Whips Cross Hospital, London; Chorley District General Hospital; Leighont Hospital, Cheshire; Royal Victoria Infirmary, Newcastle Upon Tyne; Whiston Hospital, Liverpool; City Hospital, Birmingham; Lincoln County Hospital; Sandwell District General Hospital, West Midlands; William Harvey Hospital, Kent; Colchester General Hospital, Essex; Maidstone General Hospital, Kent; Scarborough Hospital North, Yorkshire; Withington Hospital, Manchester; Conquest Hospital East, Sussex; Manchester Royal Infirmary; Scunthorpe General Hospital, South Humberside; Withybush General Hospital, Dyfed; Countess of Chester Hospital; Medway Hospital, Kent; Selby Oak Hospital, Birmingham; Worcester Royal Infirmary; County Hospital, Hereford; Milton Keynes Hospital Sheffield Children's Hospital; Worthing Hospital, West Sussex; Coventry & Warwickshire Hospital; Morriston Hospital, Swansea; Skegness & District Hospital, Lincolnshire; Wrexham Maelor Hospital, Clwyd; Craigavon Area Hospital Co. Armagh; Nevill Hall Hospital, Wales; South Tyneside District Hospital Tyne & Wear Wycombe Hospital, High Bucks; Crawley Hospital, West Sussex; Newcastle General Hospital; Southampton General Hospital; Wythenshawe Hospital Manchester; Cumberland Infirmary, Cumbria; Norfolk & Norwich General Hospital; Southend Hospital, Essex; York District Hospital; Daisy Hill Hospital, County Down, Northern Ireland; North Manchester General Hospital; Southmead Hospital Bristol Ysbyty Gwynedd District General; Darrent Valley Hospital, Kent; North Tyneside General Hospital Tyne & Wear Southport & Fornby District General Hospital; Derbyshire Royal Infirmary; Northampton General Hospital; St Bartholomews Hospital, London; Derriford Hospital, Plymouth; Northern General Hospital, Sheffield; St George’s Hospital, London; Dewsbury District Hospital, Yorkshire; Northwick Park Hospital, Middlesex; St Helier Hospital, Surrey; Diana, Princess of Wales Children's Hospital, Birmingham; Nottingham University Hospital St James’ University Hospital, Leeds; Diana, Princess of Wales Hospital, South Humberside; Ormskirk & District Hospital St Mary’s Hospital,
London; Doncaster Royal Infirmary; Peterborough District Hospital; St Peters Hospital, Surrey; Ealing Hospital, Middlesex; Pilgrim Hospital, Lincs; St Thomas’ Hospital, London; East Surrey Hospital, Redhill; Surrey Pinderfields General Hospital, Wakefield; Stepping Hill Hospital, Stockport; Eastbourne District General Hospital, East Sussex; Pontefract General Infirmary; Stoke Mandeville Hospital, Buckinghamshire; Epsom Hospital, Surrey; Queen Elizabeth Hospital; Kings Lynn; Sunderland Royal Hospital, Fairfield; General Hospital, Bury; Queen Elizabeth, Queen Mother Hospital, Kent; Tameside General Hospital Ashton Under Lyne Hammersmith Hospital, London; Regional Spinal Injuries Unit, Southport Merseyside; Taunton & Somerset Hospital; Harrogate District Hospital, Yorkshire; Rochdale Infirmary, Lancashire; The Horton Hospital, Oxfordshire.

References

16. www.tarn.ac.uk
