ABSTRACT

The paper outlines the nature and severity of the injuries suffered by pedestrians in motor vehicle accidents in England. Pedestrian admissions to hospitals in England as recorded in the Hospital Episode Statistics (HES) over a nine year period were compared with accidents recorded in Great Britain’s national road casualties database (STATS19). Alongside this, the most frequently injured regions and individual injuries of the pedestrians were investigated. The relationship between individual injuries and the length of time spent at hospital was investigated. The changes in frequency of individual injuries were investigated to see whether recent changes in vehicle design could have altered the types of injuries received by pedestrian casualties.

The HES data from April 1998 to March 2007 in England contained details of 82,811 pedestrian admissions following accidents involving motor vehicles. In the same time period there were 65,526 killed or seriously injured pedestrians recorded in the STATS19 database. It was found that over the nine year period, the number of pedestrian casualties in HES remained relatively constant, while the number in STATS19 has reduced. In this period, HES data shows that tibia and femur fractures have reduced slightly. This could be due to a number of factors including improved vehicle design.

The nature of the HES data means that very little information is included about the characteristics of the accident, which prevents possible causes of pedestrian injuries to be studied using the HES dataset by itself. However, this paper shows the potential of hospital data as an important tool in accident research, as the injury information can give evidence of the effects of the changing vehicle fleet, along with other road safety interventions. Further, through an in-depth understanding of the frequency and consequences of different injuries, future injury prevention strategies can be prioritised.

INTRODUCTION

Every year in the UK thousands of people are killed and tens of thousands are seriously injured in traffic accidents. As well as the personal tragedy of these events, road traffic accidents have economic implications. An understanding of how injuries occur in accidents is sought in order to implement ideas to try and mitigate them, and a major part of gaining this understanding is looking at national level statistics. The importance of these statistics is such that they can affect Government and local authority initiatives, policy, spending and legislation, and even vehicle manufacturing decisions. Hence the need for them to be accurate and reliable is prevalent.

This project presents an opportunity to investigate two such sources of national statistics: the data recorded by the Police (STATS19) and the data recorded by the hospitals (Hospital Episode Statistics). While the purpose of STATS19 is to record traffic accidents, recording details of traffic casualties is only a small part of the Hospital Episode Statistics (HES). As such, only limited accident analysis has been performed using HES in the past. This paper provides the opportunity to investigate how HES can be used in accident investigation, and how it relates to STATS19.

Hospital Episode Statistics (HES)

Hospital Episode Statistics are compiled by the Department of Health and record details of all hospital admissions, finished consultant episodes and hospital discharges for England. Data of this type has been collected since 1989, with its main purpose being to ensure correct funding of hospitals from their Primary Care Trust (PCT) [1]. HES contain data such as age, sex, dates of admission and discharge, diagnoses, operations and procedures, place of residence and ethnicity, with approximately 12 million new records being added each year. Information regarding the diagnosis of injury and its causation is coded using the ‘International Classification of Diseases’ (ICD), of which the latest version ICD-10 has been used since 1995. Injuries
sustained in road traffic accidents can easily be identified when coded in this way. It should be noted that HES do not include details of any casualties treated in Accident and Emergency (A&E) that are not admitted to hospital [2].

Great Britain’s National Road Casualties Database (STATS19)

STATS19 data is comprised of the details of road traffic accidents attended by the police in Great Britain. The Police are required to attend every road traffic accident that involves an injury and whilst on scene, officers fill out a series of standard forms. Officers make a judgement, often without further information from hospitals, and record the severity of the injured casualties and the overall accident as ‘slight’, ‘serious’ or ‘killed’. This data is then collected, collated and analysed by the UK’s Department for Transport (DfT).

STATS19 is, in principle, the national database in which all traffic accidents that result in injury to at least one person are recorded, although it is acknowledged that some injury accidents are missing from the database and a few non-injury accidents are included [3]. The database primarily records information on where the accident took place, when the accident occurred, the conditions at the time and location of the accident, details of the vehicles involved and information about the casualties. Approximately 50 pieces of information are collected for each accident [4].

The accidents that are recorded in STATS19 are summarised annually in the DfT “Road Casualties Great Britain” (RCGB) series.

Overview Of Accidents In Great Britain

The number of killed and seriously injured road casualties per year has been decreasing for pedestrians from 1996 to 2006 (see Figure 1); however the decrease has been less from 2004 to 2006. This trend is the same for pedal cyclist and car user casualties. Motorcyclist casualties increased between 1996 and 2003, decreasing back to the 1994-98 average by 2006.

Figure 1. Trend of road casualties in Great Britain by road user type [5].

In 2006, 1.2% of all road user casualties suffered fatal injuries. Both pedestrians and motorcyclists had above average rates of fatalities with 2.2% and 2.6% of those injured being killed respectively [4]. In total, of all the fatally injured casualties on Britain’s roads in 2006, 675 (21%) were pedestrians. Of all the killed or seriously injured casualties, 7,051 (22%) were pedestrians.

Apart from being a large group of the road casualties in Great Britain, there are a number of reasons for investigating pedestrians in HES and STATS19. Arguably, compared to car occupants, the injury epidemiology and characteristics of pedestrians are less well understood, because of the lack of large pedestrian-focused accident studies.

Supported by the European Commission (EC), the European Enhanced Vehicle-safety Committee Working Group 10 (EEVC WG10) and 11 developed testing methods and standards for pedestrian protection in frontal impacts with cars. These new standards have been introduced in a 2-stage approach, the first of which was the EC Directive 2003/102/EC. This directive introduced a number of tests, including limits on the results of impacts between a lower leg form and the bumper, and a head form to the bonnet top. This new pedestrian legislation has meant that the design of cars has and will continue to change, so it is important to find any corresponding change in pedestrian injury epidemiology.

In addition to the pedestrian regulation, Euro NCAP undertakes pedestrian sub-system impactor tests. Leg forms impact with the bumper and the bonnet leading edge and the head forms (child and adult) strike the bonnet at a variety of locations. As of 2009, the pedestrian tests have become an integral part of the new overall score given by Euro NCAP for any new car [5].

Pedestrian casualties are amongst the most vulnerable road users. Children have a large exposure to traffic as pedestrians, especially on their journey to and
from school. Elderly people, who may not have another form of transport available to them, are also exposed and at greatest risk of serious injuries if they are involved in an accident. These are also the two groups of pedestrians who are proportionally less well equipped for the road-crossing task.

Previous studies [3] have found that the difference in the number of casualties recorded in HES and STATS19 is greatest for vulnerable road users. Vulnerable road users include pedal cyclists and pedestrians; the relationship between HES and STATS19 for pedal cyclists has already been explored [4].

METHODOLOGY

This section explains some of the systems that were used to analyse the databases which are referred to later in the paper.

**International Statistical Classification of Diseases (ICD)** - In HES, injuries are recorded in 14 fields (7 before April 2002), which contain information about a patient’s illness or condition [6]. The first of these fields contains the primary diagnosis and the other fields contain secondary/subsidiary diagnoses. The codes are defined in the International Statistical Classification of Diseases, Injuries and Causes of Death [7]. HES records currently use the tenth revision (ICD-10). Diagnosis codes start with a letter and are followed by two or three digits.

The ICD-10 codes are recorded in HES in both their 3-character and 4-character formats. The first 3 characters of the ICD-10 code provide the core classification of the injury, whereas the first 4 characters of the code provide a more specific injury description. An example of this would be a 3-character code of “S01 – an open wound of the head” [7]. When split into its 4-character codes it could be any of the following:

- S01.1 – Open wound of eyelid and periocular area
- S01.2 – Open wound of nose
- S01.3 – Open wound of ear
- S01.4 – Open wound of cheek and temporomandibular
- S01.5 – Open wound of lip and oral cavity
- S01.7 – Multiple open wounds of head
- S01.8 – Open wound of parts of head
- S01.9 – Open wound of head, part unspecified

**Operation Codes** - There are twelve fields in HES (four prior to April 2002), which contain information about a patient’s surgical operations. The first code contains the main (i.e. most resource intensive) procedure. The other fields contain secondary procedures. The codes are defined in the Tabular List of the Classification of Surgical Operations and Procedures. The current version is OPCS4 [8]. Procedure codes start with a letter and are followed by two or three digits. The third digit identifies variations on a main procedure code containing two digits. A single operation may contain more than one procedure.

RESULTS

This section of the paper presents an overview of the two datasets, and compares the datasets where possible. Comparisons include the number of pedestrian casualties in both databases, the vehicles involved in the accidents, and the age and gender of the pedestrian casualties. The data analysed for this report included all pedestrian casualties contained in HES from April 1998 to March 2007 in England, and all the killed or seriously injured pedestrian casualties in STATS19 from April 1998 to March 2007 in England. The period of April to March is referred to as a ‘financial year’.

It is expected that the majority of pedestrian casualties recorded in HES should be present in STATS19. This is because of the definition of a “serious” casualty in STATS19, which includes “detention in hospital as an in-patient, either immediately or later” [9]. Most of these should be in HES, which contains all patients “admitted” to hospital. The reverse is not true: there are likely to be many pedestrians in STATS19 who would not appear in HES. This could be because they had an injury which did not require admission to hospital, or because they died at the scene so were not admitted to hospital.

**Summary of Casualties**

**Hospital Episode Statistics** - In HES there were 82,908 admissions and 80,116 patients in the original dataset, which shows that some of the patients were admitted more than once. However, some of these admissions were duplicated in the dataset due to coding errors, once these were removed, there were 82,811 unique admissions for the 80,116 patients. This is summarised in Table 1.
Table 1. Number of admissions and patients in HES

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of admissions in original dataset</td>
<td>82,908</td>
</tr>
<tr>
<td>Number of patients in original dataset</td>
<td>80,116</td>
</tr>
<tr>
<td>Number of unique admissions, after duplicate records removed</td>
<td>82,811</td>
</tr>
<tr>
<td>Number of patients, after duplicate records removed</td>
<td>80,116</td>
</tr>
</tbody>
</table>

These admissions were then broken down by their accident type classification, using their 4 digit causation code. From these codes the admissions which were described as non-traffic or unspecified non-traffic were eliminated for comparison with STATS19. This resulted in 72,878 admissions for analysis.

**Police Statistics (STATS19)** - The pedestrian casualties used for analysis in STATS19 were selected to be only those who were killed or seriously injured as only these pedestrians could have been admitted to hospital and therefore be in the HES dataset. In the same 1998 to 2007 time period there were 64,233 pedestrian accidents in England recorded in STATS19. This consisted of 64,253 vehicles and 65,526 pedestrian KSI casualties. The casualties in this dataset were only those of fatal or serious severity, the 65,526 casualties consisting of 6,000 fatalities and 59,526 seriously injured pedestrians.

**Accident Characteristics**

**Admission Date** - The year in which the patient was admitted is recorded in HES and is compared, in this section, to the year of accident in STATS19. Figure 2 shows the number of HES admissions per year split by the type of accident as recorded by 4 digit causation code. As described earlier, from these codes the admissions which were described as non-traffic or unspecified non-traffic were eliminated for comparison with STATS19. From this figure it can be seen that the number of pedestrians admitted in HES who were selected for analysis decreased from 8,907 admissions in 1998 to 7,726 in 2003, but has been at a fairly constant level of around 7,800 admissions from 2003 to 2007. STATS19 data shows pedestrian accidents to have been on a steady decrease throughout the financial year groups decreasing from 8,888 in 1998/99 to 6,132 in 2006/07.

**Figure 2. Number of pedestrian casualties from 1998 to 2007 in HES and STATS19**

This shows that at the beginning of the years analysed, the numbers of pedestrian accidents recorded were very similar in both datasets, however, in recent years the numbers have become less similar. These fluctuations could be due to a number of reasons. It should be noted that a warning is given on the HES website about the admission date data stating:

"Fluctuations in the data can occur for a number of reasons, e.g. organisational changes, reviews of best practice within the medical community, the adoption of new coding schemes and data quality problems that are often year specific. These variations can lead to false assumptions about trends." [6].

**Vehicle Type** - The accidents recorded in both STATS19 and HES were broken down by the vehicle type that struck the pedestrian. The vehicle type categories were selected based on the codes used in HES.

From analysis of the HES data, it was found that the majority, 84%, of the pedestrians admitted were struck by vehicles in the “Car/pickup/van” category compared to 86% of those in STATS19. The percentage of pedestrians struck by a pedal cycle in HES was 3% which is higher than the 1% of those in STATS19, in contrast, the number of pedestrians struck by “Heavy transport vehicles” in STATS19 was 8%, which was higher than the 6% of pedestrians in HES. Overall the distributions of the vehicle types that struck pedestrians look very similar.
Casualty Characteristics

**Gender** - The difference between the gender percentages in STATS19 and HES were minimal. Males were the most frequent in both datasets with 61% of STATS19 pedestrians and 63% of HES pedestrians being male.

**Age** - The age of pedestrian casualties peaked for 5-20 year olds in both datasets, with around 19% of casualties aged 10-15 in both datasets. For the younger age groups (particularly the 0-9 year olds), the percentage of casualties in STATS19 was lower than the percentage in HES. Overall the distribution of age in the datasets looks similar.

![Figure 3. Age of pedestrian casualties in HES and STATS19.](image)

When split by gender, a second peak was seen for females of 70 to 89 years of age (Figure 5), whereas males aged over 20 years peaked in pedestrian casualties at the age of 40-49 (Figure 4). These peaks occurred at the same ages for both HES and STATS19 datasets.

![Figure 4. Age of male pedestrians by gender in HES and STATS19.](image)

![Figure 5. Age of female pedestrians by gender in HES and STATS19.](image)

Injury Characteristics

Analysis in this section used the ICD-10 diagnosis codes to analyse the most frequent injuries, injury regions and numbers of injuries received by pedestrians in HES. Also investigated in this section, is the number and type of operations received by pedestrians as classified in OPCS4. ICD-10 and OPCS4 are described in the methodology section of this paper.

**Overall Severity** - STATS19 records the overall severity of the injuries received by the pedestrian which has been analysed in this section.

Overall, 91% of KSI pedestrian casualties in STATS19 were recorded to be serious and 9% fatal. From Figure 6 it can be seen that males proportionally suffered more fatal injuries when involved in pedestrian accidents than females.

![Figure 6. KSI pedestrians’ severity split by gender in STATS19.](image)

Figure 7 shows that younger pedestrians received a higher proportion of serious injuries, with older pedestrians being those that were killed more frequently in pedestrian accidents.
Cookson 6

**ICD Analysis** - The most frequently injured regions coded as primary injuries in HES using 3-character ICD10 codes are shown in Figure 8. The most frequent injury, received by 12,442 of the pedestrians in HES was a fracture to the lower leg including ankle, followed by 9,345 with unspecified injuries of the head. Of these most frequent injuries, a large proportion were other injuries to the head and legs.

The injuries coded using the 4-character codes were then analysed and are shown in Figure 9. The most frequent primary injury in this field was an unspecified injury to the head, which 9,051 pedestrians had. Fractures to the shaft of the tibia were present in 6,987 of the pedestrians. The next two top injury categories were also fractures to the tibia, with 3,526 pedestrians receiving fractures to the lower end of the tibia and 3,054 with fractures to the upper end of the tibia.

When grouped into body regions it was found that 38% of pedestrians had head injuries as their primary diagnosis and 29% had knee and lower leg injuries.

When all the injuries for each pedestrian were combined (i.e. the primary injury and all secondary/subsidiary injuries recorded) and the region of these injuries defined, the head and neck was the most frequently injured region still with 38% of the injuries being to this region. The next most frequently injured region was the lower limb region (does not include pelvis) with 32% of the injuries occurring here.

**Operations** - From analysis of the number of operations each pedestrian underwent, it was found that 52% of the 72,878 pedestrians had no operations after their accidents. Of those that had operations, the most common number of operations to have was three; 16% of pedestrians had three operations and 38% had three or more operations.

The areas of the primary operations recorded in HES for pedestrians were also analysed. After the “no operation” category, the most frequent operation area was “other bones and joints” with 21,066 pedestrians having an operation in this area. “Other bones and joints” includes any bones and joints other than those in the neck and spine.

Assuming that the majority of primary operations were carried out on the primary injury regions, most (75%) of the other bones and joints operations were performed on those with leg injuries. Arm injuries were the next highest injury category with 18% of other bones and joints operations correlated with this region.

**Injury Numbers** - The number of injuries recorded in HES for each pedestrian was calculated and is presented in Figure 10. It should be noted that the increase in the number of injuries which could be recorded in the HES dataset increased from 7 in 2002

---

**Figure 7.** Severity split by age group for KSI pedestrians in STATS19.

**Figure 8.** Most frequent primary injuries (using 3-character code) in HES.

**Figure 9.** Most frequent primary injuries (using 4-character code) in HES.

When grouped into body regions it was found that 38% of pedestrians had head injuries as their primary diagnosis and 29% had knee and lower leg injuries.

When all the injuries for each pedestrian were combined (i.e. the primary injury and all secondary/subsidiary injuries recorded) and the region of these injuries defined, the head and neck was the most frequently injured region still with 38% of the injuries being to this region. The next most frequently injured region was the lower limb region (does not include pelvis) with 32% of the injuries occurring here.

**Operations** - From analysis of the number of operations each pedestrian underwent, it was found that 52% of the 72,878 pedestrians had no operations after their accidents. Of those that had operations, the most common number of operations to have was three; 16% of pedestrians had three operations and 38% had three or more operations.

The areas of the primary operations recorded in HES for pedestrians were also analysed. After the “no operation” category, the most frequent operation area was “other bones and joints” with 21,066 pedestrians having an operation in this area. “Other bones and joints” includes any bones and joints other than those in the neck and spine.

Assuming that the majority of primary operations were carried out on the primary injury regions, most (75%) of the other bones and joints operations were performed on those with leg injuries. Arm injuries were the next highest injury category with 18% of other bones and joints operations correlated with this region.

**Injury Numbers** - The number of injuries recorded in HES for each pedestrian was calculated and is presented in Figure 10. It should be noted that the increase in the number of injuries which could be recorded in the HES dataset increased from 7 in 2002
and therefore only 3% had 7 or more injuries. Pedestrians with only one injury made up 33% of the sample, the percentage of pedestrians then decreased with the increasing number of injuries.

Figure 10. Number of recorded injuries for pedestrian casualties in HES.

**Injuries with respect to age** - The percentage of pedestrians with head injuries decreased with increasing age, as can be seen in Figure 11. Hip and thigh injuries were fairly constant for all ages until 59 years of age, after which the percentage of the age group with injuries in that region increased from 5% for 50-59 to 16% for those over 90. Knee and lower leg injuries had the opposite trend, decreasing from 30% for 60-69 year olds to 23% of over 90 year olds. Injuries in the shoulder and arm region were particularly low for those aged up to 9 years, but were then fairly constant for all other age groups.

Figure 11. Relationship between the most frequent injuries and age of pedestrians, as a percentage of pedestrians in each age range in HES.

**Injuries related to striking vehicle** - Knee and lower leg injuries were the most common injury regions for pedestrians struck by all vehicle types apart from 2/3 wheel motor vehicles for which wrist and hand injuries were slightly more frequent. Pedestrians hit by heavy transport vehicles received the highest rate of injuries to multiple body regions, the abdominal region and the shoulder. Pedestrians struck by pedal cycles received the highest rate of ankle and foot, and thorax injuries.

Figure 12. Pedestrian injuries caused by different vehicle types in HES.

**Injuries related to time in hospital** - It can be seen in Figure 13 that the number of pedestrians who stay in hospital for 0 days increased from 745 in 1998/99 to 1,345 in 2006/07. This may be due to the improvement in treatment over this time period or could be due to changes in admission procedures. It could also potentially be due to an increase in traffic congestion and therefore lower impact speeds so lower severity injuries or the better and/or different vehicle designs. The number of pedestrians in hospital for 2 or more days has decreased from 5,093 to 3,494, but the stays of 1 day (and unknown stays) remained fairly constant at about 2,000 pedestrians per year.

Figure 13. Number of pedestrian admissions from 1998-2007, and duration of stay in HES.

The duration of stay for pedestrians peaked with 25% of pedestrians staying for 1 day. The next two most frequent lengths of stay were 0 or 2 days both accounting for 11% of pedestrians.
When comparing primary injury regions with duration of stay, it can be seen that the length of stay for those with head injuries peaked at 1 day, whereas those with knee and lower leg injuries peaked at 2 days. Patients who were admitted for 2 days or more, most commonly had leg injuries compared to head injuries.

Figure 16 is a box plot which shows how primary injuries in different regions related to the length of time spent in hospital. The central horizontal line within the bars gives the median duration of stay, and the bars themselves give the upper and lower quartiles. The lines extending from the bars contain approximately 99% of the pedestrians. The circles and stars outside these lines are outliers. The body regions themselves are sorted by the mean duration of stay, descending from the left. The mean duration of stay for the different injury regions is shown in Table 2.

Primary injuries to the hip and thigh were associated with the longest mean and median duration of stay in hospital. There were a lot of outlying points for injuries to all body regions, where the pedestrian had been in hospital for a relatively long time. This was especially true for injuries to the head, where the quartiles of the duration of stay were close together, but there were a lot of outliers who were in hospital for much longer. This seems to be because a large number of pedestrians had relatively minor head injuries, and were only in hospital for one day, compared to a relatively small sub-set who spent over 5 days in hospital with serious or life threatening head injury.

Table 2.
Mean duration of stay by primary injury region in HES

<table>
<thead>
<tr>
<th>Primary injury region</th>
<th>No. of pedestrians</th>
<th>Mean duration of stay (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip and thigh</td>
<td>4714</td>
<td>16.7</td>
</tr>
<tr>
<td>Neck</td>
<td>695</td>
<td>15.1</td>
</tr>
<tr>
<td>Injuries involving multiple body regions</td>
<td>732</td>
<td>10.4</td>
</tr>
<tr>
<td>Abdomen, lower back, lumbar spine and pelvis</td>
<td>4085</td>
<td>10.2</td>
</tr>
<tr>
<td>Knee and lower leg</td>
<td>20342</td>
<td>8.9</td>
</tr>
<tr>
<td>Thorax</td>
<td>1670</td>
<td>8.1</td>
</tr>
<tr>
<td>Certain early complications of trauma</td>
<td>100</td>
<td>6.7</td>
</tr>
<tr>
<td>Not S or T group</td>
<td>2183</td>
<td>6.4</td>
</tr>
<tr>
<td>Burns and Corrosions</td>
<td>122</td>
<td>6.3</td>
</tr>
<tr>
<td>Shoulder and upper arm</td>
<td>4340</td>
<td>6.1</td>
</tr>
<tr>
<td>Ankle and foot</td>
<td>2355</td>
<td>5.9</td>
</tr>
<tr>
<td>Elbow and forearm</td>
<td>2964</td>
<td>4.7</td>
</tr>
<tr>
<td>Head</td>
<td>26841</td>
<td>3.7</td>
</tr>
<tr>
<td>Unspecified parts of trunk, limb or body region</td>
<td>481</td>
<td>3.4</td>
</tr>
<tr>
<td>Wrist and hand</td>
<td>1212</td>
<td>2.6</td>
</tr>
</tbody>
</table>
These injuries were then broken down into the more specific injuries as shown in Figure 17, which gives the 10 injuries with the highest mean duration of stay, received by at least 100 pedestrians. The injuries are coded using the 4 character ICD code, the descriptions of which are given in Table 3. The longest mean duration of stay was 68 days for those pedestrians with fractured cervical vertebra. This large mean duration was due to two pedestrians who received this injury and were in hospital for 1,082 and 2,878 days.

The majority of other injuries which led to long durations of stay were fractures of the legs. As with the other body region injuries, there was a large spread in the duration of stay of the pedestrians suffering lower limb injuries.

Table 3.

<table>
<thead>
<tr>
<th>4 char code</th>
<th>Injury description</th>
<th>No. of pedestrians</th>
<th>Mean stay duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S122</td>
<td>Fracture of other specified cervical vertebra</td>
<td>101</td>
<td>67.5</td>
</tr>
<tr>
<td>T025</td>
<td>Fractures to multiple regions of both legs</td>
<td>100</td>
<td>33.9</td>
</tr>
<tr>
<td>S327</td>
<td>Multiple fractures of lumbar spine and pelvis</td>
<td>150</td>
<td>25.3</td>
</tr>
<tr>
<td>S324</td>
<td>Fracture of acetabulum</td>
<td>308</td>
<td>24.4</td>
</tr>
<tr>
<td>S723</td>
<td>Fracture of shaft of femur</td>
<td>1335</td>
<td>21.9</td>
</tr>
<tr>
<td>S722</td>
<td>Subtrochanteric fracture of femur</td>
<td>154</td>
<td>20.9</td>
</tr>
<tr>
<td>S729</td>
<td>Fracture of femur, part unspecified</td>
<td>336</td>
<td>20.3</td>
</tr>
<tr>
<td>S062</td>
<td>Diffuse brain injury</td>
<td>924</td>
<td>19.1</td>
</tr>
<tr>
<td>S721</td>
<td>Pertrochanteric fracture of femur</td>
<td>379</td>
<td>18.6</td>
</tr>
<tr>
<td>S720</td>
<td>Fracture of neck of femur</td>
<td>1067</td>
<td>17.5</td>
</tr>
</tbody>
</table>

Changes Over Time

The large amount of data present in the HES dataset from 1998-2007 enabled some variations in pedestrian injuries over time to be investigated.

Table 4 compares the ten most frequent injuries recorded in 2006/2007, using the 3-character ICD codes.

Table 5 compares the most frequent 4-character ICD codes recorded in 2006/2007. In these tables, the percentage point difference to the 1998/1999 figures for that injury are presented in brackets.

Although the most frequent injuries have changed very little, the changes in the proportion of pedestrians receiving these injuries paint an interesting picture. With the exception of “fractures of other part of lower leg”, all of the injuries which have increased in proportion are relatively minor, while those that have decreased are fractures and other serious injuries. This suggests that pedestrians received less severe injuries in 2006/2007 compared to those in 1998/1999.
Table 4. Most frequent 3-character ICD codes, 2006/2007 in HES

<table>
<thead>
<tr>
<th>Injury description</th>
<th>No. of pedestrians</th>
<th>% of pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture of lower leg, including ankle</td>
<td>1867</td>
<td>23.7 (-1.6)</td>
</tr>
<tr>
<td>Other and unspecified injuries of head</td>
<td>816</td>
<td>10.3 (-4.1)</td>
</tr>
<tr>
<td>Open wound of head</td>
<td>616</td>
<td>7.8 (+1.9)</td>
</tr>
<tr>
<td>Intracranial injury</td>
<td>524</td>
<td>6.6 (-1.4)</td>
</tr>
<tr>
<td>Superficial injury of head</td>
<td>519</td>
<td>6.6 (+2.7)</td>
</tr>
<tr>
<td>Fracture of shoulder and upper arm</td>
<td>400</td>
<td>5.1 (-0.5)</td>
</tr>
<tr>
<td>Fracture of femur</td>
<td>383</td>
<td>4.9 (-1.3)</td>
</tr>
<tr>
<td>Fracture of skull and facial bones</td>
<td>382</td>
<td>4.8 (-0.6)</td>
</tr>
<tr>
<td>Fracture of lumbar spine and pelvis</td>
<td>268</td>
<td>3.4 (-0.2)</td>
</tr>
<tr>
<td>Fracture of forearm</td>
<td>266</td>
<td>3.4 (-)</td>
</tr>
</tbody>
</table>

Table 5. Most frequent 4-character ICD codes, 2006/2007 in HES

<table>
<thead>
<tr>
<th>Injury description</th>
<th>No. of pedestrians</th>
<th>% of pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unspecified injury of head</td>
<td>791</td>
<td>10.0 (-3.8)</td>
</tr>
<tr>
<td>Fracture of shaft of tibia</td>
<td>646</td>
<td>8.2 (-2.4)</td>
</tr>
<tr>
<td>Fracture of lower end of tibia</td>
<td>367</td>
<td>4.7 (-)</td>
</tr>
<tr>
<td>Fracture of upper end of tibia</td>
<td>298</td>
<td>3.8 (-0.4)</td>
</tr>
<tr>
<td>Open wound of other parts of head</td>
<td>233</td>
<td>3.0 (+0.7)</td>
</tr>
<tr>
<td>Fractures of other parts of lower leg</td>
<td>215</td>
<td>2.7 (+0.2)</td>
</tr>
<tr>
<td>Superficial injury of other parts of head</td>
<td>198</td>
<td>2.5 (+0.9)</td>
</tr>
<tr>
<td>Open wound of scalp</td>
<td>179</td>
<td>2.3 (+0.8)</td>
</tr>
<tr>
<td>Fracture of upper end of humerus</td>
<td>157</td>
<td>2.0 (-0.5)</td>
</tr>
<tr>
<td>Superficial injury of head, part unspecified</td>
<td>150</td>
<td>1.9 (+0.9)</td>
</tr>
<tr>
<td>Fracture of pubis</td>
<td>140</td>
<td>1.8 (-0.3)</td>
</tr>
<tr>
<td>Fracture of shaft of femur</td>
<td>100</td>
<td>1.3 (-1.2)</td>
</tr>
<tr>
<td>Intracranial injury, unspecified</td>
<td>40</td>
<td>0.5 (-1.5)</td>
</tr>
</tbody>
</table>

Figure 18 shows the change with respect to time of two of the injuries which were shown to have reduced in frequency between 1998/1999 and 2006/2007. These were the fractures to the shaft of the tibia and femur. This graph shows that there has been a steady decline in these injuries over the last few years.

Figure 19 compares the distribution of the primary injuries for the pedestrians admitted in 1998/1999 and 2006/2007. There was a small decrease in the proportion of head and/or neck and lower limb injuries, and a slight increase in the proportion of upper limb and thorax injuries.

Figure 20 compares the age distribution in 1998/1999 and 2006/2007 of the pedestrians in the HES dataset. This shows that the largest difference was a reduction in the number of 5-9 year old pedestrian casualties. The most significant proportional increase was for pedestrians aged 40-49 years.
This showed that there was very little change in the proportion of pedestrians who were male or female from 1998/1999 to 2006/2007.

The change in the distribution of the vehicles involved in the pedestrian accidents in 1998/1999 and 2006/2007 was also analysed in STATS19 and HES. There was a slight increase in the proportion of pedestrians impacted by heavy transport vehicles, and a slight decrease in the proportion of pedestrians struck by cars/pickups/vans.

Figure 23 shows how the proportion of pedestrians struck by heavy vehicles and cars varied in the HES dataset from 1998/1999 to 2006/2007. The proportions of the two vehicles are shown on different scales because of the large difference between them. This figure shows that the proportion of pedestrian accidents involving heavy vehicles has been steadily increasing. The proportion due to impacts with cars/pickups/vans decreased from 1998/1999 to 2003/2004, but since then remained relatively constant.

**DISCUSSION**

Comparing the number of pedestrians recorded in HES and STATS19 from 1998 to 2007 showed that while the number of pedestrian admissions in HES has remained relatively constant, the number of killed and seriously injured pedestrians recorded in STATS19 has reduced considerably from 1998 to 2007. This may be due to a number of reasons. Possibly the most important is the warning that HES gives on its data stating that fluctuations can occur due to such factors as organisational changes, reviews of best practice within the medical community, the adoption of new coding schemes and data quality...
problems that are often year specific. STATS19 may also be subject to variations in the number of pedestrian accidents recorded per year due to factors such as the number of pedestrian accidents that are actually reported to the police. Reasons for these differences have been discussed previously by other authors [10, 11, 12, 13].

Comparisons of age and gender showed that in general the two datasets are very similar with respect to these casualty characteristics. The largest difference is an increase in the proportion of pedestrians in HES aged 0-9 years old. At the time of writing the reason for this difference is not clear, but potentially could be associated with under-reporting by the police of these collisions, due to their characteristics.

STATS19 can also be used to distinguish between killed and seriously injured pedestrians, information which was not contained in the HES data. This shows that males were slightly more likely to be involved in fatal accidents, and that children were more likely to survive the impact than older pedestrians. This is believed to be because of their greater tolerance to injury and their different sizes and potentially crash types.

Injuries

The most valuable part of the HES dataset is the injuries it records for pedestrians, data which is not available in any other database on such a large scale.

The most frequent injuries recorded for the pedestrians in HES are head and lower leg injuries. This is true whether the 3-character or the more detailed 4-character ICD codes are used.

Using the 4-character ICD codes, the most frequent injury is “unspecified injury of head”, however, we do not know the severity of this injury due to the ICD coding system not including a measure of injury severity. This also means that different injuries can not be compared with respect to their severity.

The next four most frequent injuries are all fractures of the lower leg, and the majority of the top ten most frequent injuries are head and leg injuries. This agrees with previous studies on smaller samples of pedestrians [14].

The relationship between the age of the pedestrian and the proportion of injury in the four most frequently injured regions was investigated. This showed that the rate of head injuries decreases with age, and the rate of hip and thigh injuries increases with age. The rate of hip and thigh injuries increases most above the age of 60, which would coincide with the decreasing bone density and strength of older people, especially women. This would help to explain why the number of female pedestrian casualties increases above the age of 70.

The incidence of head injuries was greatest for young children (0-9), which is likely to be because they will receive a more direct contact to the head from the front of the vehicle, because of their height. From the age of 16 and older, the proportion of pedestrian casualties with a head injury remains relatively constant. It might be expected that elderly pedestrians would also see an increase in head injuries because they are generally less tolerant to injury. However, it may be that these pedestrians are being seriously injured at lower impact speeds (receiving leg fractures), which may counterbalance their reduced tolerance to head injuries. Some knowledge of impact type and speeds involved would be required to determine whether or not this was true.

Duration of Stay

The duration of the stay in hospital is one way in which the HES data can be used to estimate the cost to the hospital of different injuries and the severity with respect to the affects on the casualties’ life. Overall the duration of stay in hospital of the pedestrian casualties in HES is a very skewed distribution, with a large number of pedestrians staying for only one day, and a very small number of pedestrians remaining in hospital for very long periods of time. This distribution is a similar shape when individual injuries are investigated. For this reason, the relationship between individual injuries and the duration of stay in hospital has been investigated using the mean stay in hospital, and box-plots showing the distribution of the length of stay for different injuries.

Measuring the mean duration of stay shows that injuries to the hip and thigh and neck result in the longest average stay in hospital. Injuries to the hip and thigh are also some of the most frequent so, combined with the long duration of stay in hospital, injuries to this region will be some of the most costly. This could, however, also be due to the hip and thigh injuries frequently being associated with older women who generally stay in hospital longer for all injuries.

Looking at individual injuries shows that a fracture of the cervical spine leads to the longest mean duration in hospital, but this is mainly due to one pedestrian who received this injury and remained in hospital for almost eight years. Apart from this spinal injury, multiple fractures of the lower legs led to the longest
mean stay in hospital. The remainder of the ten longest mean durations of stay in hospital are mostly made up of fractures to the femur.

There are a number of limitations to using this method of determining which injuries are most costly to the hospitals. The first is that it only takes into account the primary injury, and not any other injuries sustained. Secondly, it does not take into account other costs, such as operations and procedures in the hospital, post-hospital care, and the effect on quality of life. These are things which could be investigated, but would need information other than that in the HES data.

The HES data provided to TRL covers a period of nine years, and the large number of pedestrians recorded in each year has enabled some of the changes over time to be investigated. Some injuries, such as fractures to the shaft of the tibia and fibula, show a small but steady decline over the ten year period. This could be evidence that improved car design in recent years has reduced the rate of these injuries. However, further evidence would be required relating to the characteristics of the crashes and injury mechanisms before this could be known.

The most startling change over the 9 years of HES data is the way that the distribution of the age of the pedestrian casualties has altered. Specifically, the proportion of pedestrians aged 5-9 years has dropped from 15% to 10%, and the proportion of pedestrians aged 40-49 years has increased from 6% to 9%. It is not clear why these changes have occurred. Previously it was shown that the proportion of 5-9 year olds was different in STATS19 and HES, which could have meant that the reduction in 5-9 year olds is caused by something which affects the HES data only. However, a drop in the proportion of 5-9 year old pedestrian casualties is also seen in STATS19. This is evidence that it is a real effect, which could perhaps be related to a reduction in the exposure of children to traffic, for example if fewer children walk to school. Or it could be related to road safety schemes aimed at this age group, such as the UK’s THINK! campaign [15] proving effective.

Other changes over the nine years were a reduction in the proportion of casualties who were in impacts with cars, and a reduction in the proportion of casualties who lived in the 10% most socially and economically deprived areas of England.

CONCLUSIONS

TRL successfully collaborated with the South East Health Observatory (SEPHO) who provided Hospital Episode Statistics (HES) data for pedestrian casualties admitted to hospitals in England from April 1998 to March 2007. This data was analysed, along with STATS19, to explore what the dataset contained, how it could be used in the field of accident research, and how it compared to STATS19. A multi-disciplinary team of researchers designed the research study and undertook the work programme.

While the number of pedestrian casualties in HES remains relatively constant, the number of killed and seriously injured casualties in STATS19 has reduced over the last nine years. This difference matched the observations in previous research which looked at all road users.

In general, the distribution of age, gender, and striking vehicle were similar in STATS19 and HES. Apart from date, these were the only variables which could be directly compared.

The most frequent injuries recorded for pedestrians in the HES datasets were head and lower leg injuries. The most frequent individual recorded injury was “unspecified injury of head”, followed by four different types of lower leg fractures.

The proportion of head injuries decreased with age, while hip and thigh injuries increased with age.

The duration of stay in hospital was used as a measure to determine which injuries resulted in the highest cost to the hospital. With the exception of the relatively infrequent cervical spine fractures, the injuries which resulted in the longest stay in hospital were leg injuries, especially fractures of the femur.

Leg injuries seem to be the area with the greatest potential for injury prevention. Tibia fractures were among the most frequent injuries, and femur fractures led to some of the longest mean durations of stay in hospital, so preventing these injuries may have the largest benefit in terms of cost to the hospitals.

There has been a large decrease in the proportion of 5-9 year olds in the HES and STATS19 datasets over the last nine years.
ACKNOWLEDGEMENTS

The work described in this report was carried out in the Accident Research Group of the Transport Research Laboratory.

TRL would also like to acknowledge the contributions of Harry Rutter, Steve Morgan, Jo Watson and Bryony Tatem of the South East Public Health Observatory who supplied the data and information required for the analysis of the HES data, and provided help and advice throughout.

REFERENCES


