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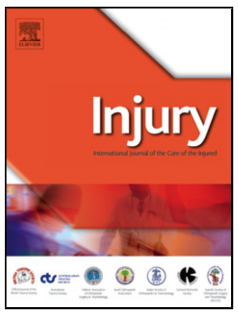

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The use of secure anonymised data linkage to determine changes in healthcare utilisation following severe open tibial fractures

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Contributorship

PP and RT drafted and revised the paper and contributed to analysis of the results.

AW, LP, CB and SR planned the methodology. HH performed the statistical analysis.

IP oversaw study design, drafting and revision of the paper. PP is guarantor.

The use of secure anonymised data linkage to determine changes in healthcare utilisation following severe open tibial fractures

Abstract

Severe open fractures of the lower limbs are complex injuries requiring expert multidisciplinary management in appropriate orthoplastic centres. This study aimed to assess the impact of open fractures on healthcare utilisation and test the null hypotheses that there is no difference in healthcare utilisation between the year before and year after injury, and that there is no difference in healthcare utilisation in the year post-injury between patients admitted directly to an orthoplastic centre in keeping with the joint BOA / BAPRAS standards and those having initial surgery elsewhere.

This retrospective cohort study utilising secure anonymised information linkage (SAIL), a novel databank of anonymised nationally pooled health records, recruited patients over 18 years of age sustaining severe open lower limb fractures managed primarily or secondarily at our centre and who had data available in the SAIL databank. 101 patients met inclusion criteria and 90 of these had records in the SAIL databank. The number of days in hospital, number of primary care attendances, number of outpatient attendances and number of emergency department attendances in the years prior and subsequent to injury were recorded.

Patients sustaining open fractures had significantly different healthcare utilisation in the year after injury when compared with the year before, in terms of days spent in hospital (23.42 vs. 1.70, p=0.000), outpatient attendances (11.98 vs. 1.05, p=0.000), primary care attendances (29.48 vs. 11.99, p=0.000) and emergency department presentations (0.2 vs. 0.01, p=0.025). Patients admitted directly to orthoplastic centres had significantly fewer operations (1.78 vs. 3.31) and GP attendances (23.6 vs. 33.52) than those transferred in subsequent to initial management in other units.

There is a significant increase in healthcare utilisation after open tibial fracture. Adherence to national standards minimises the impact of this on both patients and health services.

Keywords

open fracture

orthoplastic

limb reconstruction

trauma network

Background

The complexity of the surgical care of major injuries tends to naturally focus interest upon the service demands and procedural intricacy, at the expense of understanding the impact on healthcare utilisation as a whole. While a number of registries exist, they tend to record either one type of healthcare or multiple types but within one institution. Data linkage offers the opportunity to explore the impact of illness or injury upon groups of individuals across time by connecting different databases and registries and providing a comprehensive dataset for an individual patient. This may be particularly illuminating for conditions which require multidisciplinary care or transfer between hospital services.

Open fractures of the lower limbs are severe injuries, often requiring complex multidisciplinary management. Their treatment in the United Kingdom has evolved over many years to a common set of standards (1) defined jointly by the British Orthopaedic Association (BOA) and the British Association for Plastic, Reconstructive and Aesthetic Surgery (BAPRAS). These standards focus on meticulous debridement and technically sound fracture stabilisation, performed in a manner which preserves future options for soft tissue cover. One of the core principles of these standards is "right surgeon, right place, right time", shifting the emphasis in management from emergency exploration and debridement at the admitting hospital towards expedited transfer for primary surgical management at specialist orthoplastic centres, typically regional centres where orthopaedic and plastic surgical teams can operate together regularly and provide conjoint outpatient follow-up. This represents a conceptual shift, recognizing the importance of radical and effective debridement, rather than its timing. Despite this change in emphasis, there are numerous reasons, clinical or logistical, why immediate transfer may prove unfeasible. In such circumstances, the patient may still require and receive initial surgical treatment in the hospital local to their place of injury, mirroring the management recommended in previous guidelines (2).

There has been significant investigation of the injury profile and clinical outcomes of open lower limb fractures (3). From the perspective of the patient, an open tibial fracture represents a significant and often permanent change in health status. Discharge from in-patient and subsequently out-patient care are only transient waypoints along the patient's route to recovery (4). It has been demonstrated repeatedly that both reconstruction and amputation have substantial impact on both functional outcome and quality of life (4,5) and the longer term occupational outlook for these patients can be poor, with only half of patients in similar employment at 2 years post-injury regardless of their surgical management (6). The impact of the injury and the experience of subsequent recovery has been described from a qualitative perspective (7). It is also evident that there is a need to better understand how completely and quickly patients recover following these injuries, before determining the most successful surgical strategies. In particular, a method of accurately measuring patient important outcomes beyond health related quality of life is essential (7).

Whilst a number of papers give an appreciation of acute demands of these injuries in terms of days in hospital and number of operative interventions (4) these measures cannot, given the high burden of rehabilitation, pain management and secondary infection give an accurate reflection of the full impact of open fractures. Data also exist to show the short-term effect of open fractures of the lower limb on healthcare systems (8). These generally pertain to their index admission and episode of care. This is exemplified by the finding that almost half of those patients who have undergone debridement and fracture stabilisation in a non-specialist setting may require revision of the fracture fixation, while also being at higher risk of infective complications (9).

In this study, we set out to describe a broader picture of the effects on both patients and healthcare systems in the medium term. We undertook a service evaluation in the form of a retrospective cohort study of healthcare utilisation in the year prior to and year after sustaining an open lower limb fracture, using the novel Secure Anonymised Information Linkage (SAIL) databank to capture healthcare utilisation across multiple providers (primary care and hospital services).

The aims of the study were to test the following null hypotheses:

1. There is no difference between the healthcare utilisation in the year prior to open tibial fracture and the year after.

2. There is no difference in the healthcare utilisation following open tibial fracture between those patients admitted directly to a specialist orthoplastic unit and those treated elsewhere.

Methods

Study design

This was a retrospective service evaluation based on a cohort of patients managed in a regional tertiary orthoplastic centre.

Ethics

The data held by the Health Information Research Unit (HIRU) in the SAIL System are anonymised and have been obtained with the permission of the relevant Caldicott Guardian/Data Protection Officer. Therefore the National Research Ethics Service (NRES) has stated that no ethical review is required for studies using this dataset. Approval was obtained from the HIRU Information Governance Review Panel (IGRP) to use the SAIL system for this research question.

Setting

This study was based in a UK tertiary centre for the management of complex trauma serving a population of just under 2 million patients (10).

Study Population

The sample population was from the era immediately prior to the publication current standards (1), in which initial emergency surgery was usually performed in local hospitals prior to transfer for definitive care. Thus the sample population comprised those who were admitted directly from the scene of wounding to the orthoplastic centre (as their local emergency unit), and those who were transferred after surgery from neighbouring hospitals, in keeping with the guidelines of the time. Selecting this sample population afforded the best opportunity to examine both hypotheses.

Patients with open tibial fracture were identified from 2 sources: the Open Lower Extremity Fracture (OLEF) database and the Patient Electronic Database for Wales (PEDW). The OLEF database is a prospectively maintained database detailing all patients admitted through the orthopaedic and plastic surgical departments at our unit with a diagnosis of an open lower extremity fracture (including injuries to the pelvis, femur, tibia, ankle and foot. These records were then checked against those retrieved from PEDW which were coded for an open tibial fracture (ICD-10 code S8211, S8221, S8231 open). PEDW is a national database detailing all in-patient episodes of treatment occurring in any hospital in Wales. The clinical records of patients appearing in either database were retrieved and their injuries confirmed. Inclusion criteria for further analysis were all adult patients (aged 16 or more), of either gender with a diagnosis of a Gustilo-Anderson Classification Grade II or III open tibial fracture (fractures of the shaft, and/or fractures of the proximal or distal tibial articular surfaces AO41, 42, 43 classifications). Patients admitted directly to the orthoplastic service (Directly Admitted Patients – DAP) were differentiated from those who were transferred after initial management at another facility (Transferred Patients – TP). Patients referred for limb salvage after failed definitive treatment at another facility were also included in the preliminary analysis, but excluded from subsequent sub-group analysis to avoid skewing data concerning the transferred patients. All patients meeting these criteria presenting between April 2006 and December 2009 were included. A 1 year period pre- and post-injury was examined in all patients.

Data Sources

The Secure Anonymised Information Linkage Databank (SAIL) is an anonymous data linkage system that holds a wide array of routinely-collected data for research, evaluation and development purposes whilst complying with confidentiality guidelines and data protection legislation (saildatabank.com). The datasets of the study population were provided to SAIL using the split file process. Demographic details including name, address, post code, date of birth and gender are separated from the clinical data relating to the injury. The demographic details (file 1) were sent to NHS Wales Informatics Service (NWIS) who act as a Trusted Third Party; the clinical data (file 2) was sent to SAIL. The matching and anonymization process is carried out by NWIS. A third file is created which replaces the identifiable variables in file 1 with an Anonymous Linking Field (ALF). This third file is sent to SAIL where it is relinked with the clinical data in file 2. The ALF field is further encrypted at SAIL to create an ALF_E (Anonymous Linking Field – Encrypted) (11). The ALF_E field allows linkage to other datasets held within the SAIL databank. In this study, the cohort was linked to the National secondary care datasets including the Patient Episode Database for Wales (PEDW) in-patient and out-patient data sets, the Emergency Department dataset and the primary care GP dataset.

Variables

For each patient, the SAIL database was queried to ascertain the health care utilisation in the year prior to and post injury. The PEDW in-patients dataset was used to find the length of stay and the number of operations carried out. The out-patients data was used to find the number of appointments and the number of attendances. The Emergency Department dataset was used to find the number of attendances to the Emergency Department. The GP dataset was used to find the number of events, which may be a doctor or practice nurse appointment, or may be telephone consultation or repeat prescription re-issue.

Statistical Analysis

Data were analysed using SPSS v20 (IBM Corporation). Data were analysed using parametric statistical tests throughout (Chi-square or independent samples t test). Data are presented as mean (+/- SD) and counts. Mean changes in the outcome variable between the TP and DAP patients from baseline to 1 year post injury were compared using independent samples t tests, and are presented as mean difference with 95% confidence intervals.

Results

Baseline Characteristics

A total of 101 patients were identified who met the inclusion criteria. Of these, 100 patients had data retrievable at local level and could subsequently be linked through SAIL to their PEDW and GP data. There were 10 limb salvage patients, 58 DAP and 32 TP patients (Table 1) with no significant differences between the groups in sex or age. The limb salvage patients are included in the overall group analysis (Table 2) but excluded from subgroup analysis.

Data from the overall cohort was compared before and after injury. There were significant differences in each of the variables assessed (Table 2). The GP events field was poorly populated within the SAIL database. Consequently, analysis excluded all patients where the GP event field was missing. This analysis also demonstrated a statistically significant difference in events before and after injury.

Following exclusion of the limb salvage patients, further analysis was performed to assess the differences between those patients transferred for surgery following initial treatment at another centre (TP) and those patients admitted directly to the orthoplastic unit (DAP). The within group differences between pre and post-injury remained apparent throughout. In addition, there was a statistically significant difference observed in the number of GP events and total number of operations between the DAP and TP groups (Table 3), with the DAP group having a reduced impact on both variables.

Discussion

This study has demonstrated that patients with open tibial fractures have significantly increased healthcare service needs (both in primary care and hospital services) in the year following their injury. They require lengthy inpatient stays and have a greater number of outpatient appointments than during the year prior to their injury. The significant increases in attendances to the Emergency Department and GP events in the year following injury were arguably to be expected; effects of major injury such as depression or secondary injury such as falls due to poor lower limb function may manifest in these data. Without further coding, however, it is not possible to ascertain what, if any, element of the original injury underpins these consultations.

Those patients who are directly admitted to a specialist orthoplastic centre require significantly fewer operations and GP events compared to those patients who are transferred after initial surgery elsewhere. On average, directly admitted patients had shorter lengths of stay and also attend fewer outpatient appointments, although this was not statistically significant.

The SAIL technology has given a unique picture of the wider health effects and service utilisation of these severe injuries. It allows analysis of data across different types of healthcare encounter, providing a novel insight into the true impact of open lower limb fracture upon healthcare utilisation. The robust nature of the SAIL dataset, utilising multiple data sources provides a greater confidence that the majority of healthcare encounters have been captured. The inherent benefit of the methodology is that continuous longitudinal follow-up of this patient cohort is possible and does not rely upon the patient attending a specific follow-up appointment or clinic.

The novel approach to this overview of healthcare has some inherent limitations. The SAIL methodology captures data from a number of health services. Utilisation outside areas which feed into the SAIL databank cannot be captured and analysed. Thus patients being treated in by units that are not included by the SAIL databank will not be captured and included in analysis. The GP event data represents any event in the GP setting that is recorded for a particular patient. Thus a consultation, a GP reading a letter from the hospital, checking a blood result or receiving a telephone call all represent GP events. While these are all markers of care activity, it cannot be unequivocally asserted that these are patient attendances.

In addition, the GP event data was incomplete within the primary care GP dataset as there were a proportion of primary care providers whose activity was not accessible to the SAIL method at the time when these patients were being treated. It was subsequently confirmed that their practices did not submit data to the SAIL databank. We have treated this as missing data and excluded it from analysis using pairwise deletion. We felt it extremely unlikely that patients undergoing reconstructive surgery for an open tibial fracture will not have required at least one GP event, particularly considering that the coding of events means that they include scanning and acknowledging communication from secondary care. A further concern about data completeness is that some numbers are low but not zero – they have not, therefore, been excluded as incomplete data but have contributed to the analysis even if they risk skew of the findings.

While the number of ED attendances is low in the post-operative year, it nonetheless represents a twenty-fold increase in utilization in the subsequent year. One would hope that a patient receiving high-quality follow-up ought to be able to access nearly all the required healthcare via their multidisciplinary team and so the absolutely small but relatively very large increase in utilization may reflect that fact that not many of these patients attended the ED prior to injury, and not many but slightly more did in the year after.

The other databases used are also subject to the same limitations; PEDW is reliant on specific centres populating timely and accurate data, while OLEF as a local database has been a successful endeavour but is heavily reliant on staff populating it as an extra duty.

The inherent strength of the SAIL methodology is also a principal weakness. Follow-up episodes are not linked to a specific event. There is no guarantee that further healthcare episodes relate to the index injury or an independent health problem. Whilst this may influence the differences observed between the pre- and post-injury observations for the whole cohort, there are no obvious confounding variables to suggest that the DAP and TP would be affected in different ways.

The use of the SAIL methodology has allowed the impact of open fractures across both primary and secondary healthcare to be described. The increase in Emergency Department attendances and GP events following open tibial fracture highlights the importance of examining the impact of these severe injuries on the entire healthcare system, rather than simply focusing upon the well-described surgical aspects of their management.

The difference in number of operations required between the DAP and TP groups is a key finding; peripheral centres are simply not equipped to fully manage such complex patients and, when it has been demonstrated that debridement is less time-critical than previously thought, subjecting a patient to two operations where one would suffice cannot be justified. This message chimes with the current British Orthopaedic Association campaign of “Getting it right first time” (12). There is inherent risk to the patient in having multiple general anaesthetics and a wealth of evidence linking operative time to surgical site infection rates (13). From a health economics perspective, the finite resource of operating list time must be carefully managed and any approach which may unburden a hospital must be given consideration.

Similar follow-up requirements between the DAP and TP groups are seen in terms of outpatient appointments and attendances. However, the transferred patients on average, attended the Emergency Department, more frequently than the DAP group in the year following injury. This was paralleled by a significant increase in GP events for these patients. These findings may have multiple explanations. It has previously been identified that psychological support following complex lower limb injury is often sub-optimal and one may speculate that the physical distance between the transferred patients' home location and the specialist centre may lead them to seek advice and reassurance more frequently from their local, more accessible services (14).

It is also possible that unplanned re-presentations may relate to complications arising from the injury. Hence, in this study unplanned treatment may be represented by the surrogate marker of Emergency Department attendance and perhaps also primary care encounters. Wound problems and difficulties with pain control are common in complex trauma patients (15) and, while most services aim to provide a specialist point of contact in office hours, patients can find that out of hours an Emergency Department is the only source of support which can offer imaging and point of care investigations (16). It is clear that this is burdensome and distressing for patients, and represents a further stress on services often already stretched to capacity. It is perhaps unfair to blame the system exclusively, though, as work from the US demonstrated persistently high ED usage from some patient groups regardless of planned secondary care contacts made available to them (17). This has not been demonstrated previously in the literature.

The significant increase in primary care events in the TP group may also represent an alternative means of seeking analgesia or unplanned wound review. In addition, social factors such as fitness for work certification, employment support allowance and social services support are likely to represent the reasons behind some of these events. Although the reform of the UK benefits system potentially reduces the involvement of healthcare practitioners in assessing entitlement to benefits (18), in this context fully informing patients who may need to navigate a complex claims system becomes even more important.

Although this is a relatively large cohort study, it may be underpowered to demonstrate all of the differences between the DAP and TP groups. In a system evolving rapidly to deal with major trauma, secondary transfer for specialist care is often a delaying factor due to logistical limitations. It may be that until patient transfers become more rapid, the benefit of transferring care to expert centres will be confounded to some extent by the delays they introduce. An approach to circumvent this, however, may be to ring-fence major trauma beds so that patients waiting for transfer do not join a long list of patients awaiting transfer for less urgent reasons.

Service planning is a vital part of delivering effective healthcare for these complex injuries; the focus of the Standards in Open Fracture Care is on planned and appropriately resourced intervention and support. Thus identifying the burden placed on units regularly treating these injuries is important. This has been encapsulated in American work seeking to differentiate acute care from unplanned care, finding that targeted strategies to avoid readmission by providing more acute care for defined problems could reduce emergency presentations (19). Other studies have attempted to quantify the resource requirements of musculoskeletal trauma more generally; Kilgore et al (8), for example, described the costs associated with different fractures within the Medicare system over 6 years. Whilst undoubtedly useful in North American healthcare economics terms, these data are limited by its age, lack of discrimination between open and closed fractures and the lack of generalizability to the healthcare model in the UK. A more wide-ranging model was outlined by Willenberg et al. in a systematic review of the cost of trauma (20). This drew data from a number of high-income countries, finding that although much more research is needed, there is a trend towards polytrauma being the most expensive form of trauma care provided. This study clearly demonstrates that by adherence to advocated best practice, the episode costs associated with open lower limb trauma can be better controlled. In our model, the tariff for open fracture care includes £2060 per theatre session, £110 per bed-night and £128 per outpatient attendance. ED attendances add a further £200 each. Surgery or ED encounters avoidable by adherence to the open fracture standards carry, therefore, a high financial cost.

There will always be a group of patients for whom direct admission is not possible; it is made clear in the Standards that patients too unstable to transfer should have their initial surgery performed at the hospital to which they have presented. However, the suggestion from this dataset that it is advantageous for open tibial fracture patients to undergo all their surgery within specialist centre, which should confer the benefits of fewer operations, a shorter length of hospital stay and a lower requirement for Emergency Department attendances and GP events in the following year.

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Tables

Table 1: Demographic details of the baseline DAP and TP populations

Group	Variable	p-value
 DAP (N=58) TP (N=32)	Sex 14 F: 44M 7F: 25M	 0.81 #
 DAP (N=58) TP (N=32)	Age at injury 42.64 (+/-24.46) 40.09 (+/-24.02)	 0.633 ##

Chi- square test

Independent samples t-test

Table 2: Comparison of the observed variables before and after injury (paired samples t-test)

Outcome Variable	N	Mean pre-injury	Mean post-injury	Mean Diff (post-pre)	P value
Length of stay	100	1.70	23.42	21.71	0.000
GP events	67 (missing values excluded)	11.99	29.48	17.49	0.000
Outpatient attendances	99	1.05	11.98	10.93	0.000
Emergency Department attendances	100	0.01	0.20	0.19	0.025

Table 3: Comparison between the DAP and TP groups before and after injury

Outcome Variable	Patient type	N	Mean pre-injury (SD)	Mean post injury (SD)	Mean Diff (post-pre) (SD)	Mean Diff (95% CI) DAP vs TP
Inpatient Length of Stay	DAP	58	1.48 (6.18)	18.86 (43.35)	17.38 (44.39)	-7.50 (-23.92 to 8.93)
	TP	32	2.47 (11.53)	27.34 (22.35)	24.88 (19.39)	
GP Events **	DAP	40	14.13 (16.66)	23.60 (17.61)	10.51 (15.71)	-14.24 (-24.84 to -3.64)* p=0.009
	TP	20	10.40 (9.39)	33.52 (24.30)	24.75 (28.84)	
Outpatient Appointments	DAP	58	1.14 (2.05)	12.28 (10.13)	11.14 (10.40)	-3.36 (-7.69 to 0.97)
	TP	32	1.50 (3.06)	16 (9.02)	14.50 (8.89)	
Outpatients Attendances	DAP	58	0.86 (1.73)	10.43 (9.44)	9.57 (9.61)	-2.12 (-6.02 to 1.79)
	TP	32	1.34 (2.81)	13.03 (7.29)	11.69 (7.51)	

Number of Operations	DAP	58	0.14 (0.58)	1.78 (1.31)	1.64 (1.35)	-1.55 (-2.24 to - 0.86)* p=0.000
	TP	32	0.13 (0.34)	3.31 (1.89)	3.19 (1.93)	
Number of Emergency Department attendances	DAP	58	0.02 (0.13)	0.10 (0.41)	0.09 (0.43)	-0.13 (-0.35 to 0.09)
	TP	32	0.00 (0.00)	0.22 (0.61)	0.22 (0.61)	

*Significant

** GP visit data was populated less completely than the remaining fields within the SAIL dataset. This accounts for the reduced numbers of patients within each group.

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