AUDIT IN PRACTICE

THIS WEEK...

• In the first article Wardrope *et al* describe their experience of major trauma outcome study methodology during the first year of a prospective audit and conclude that the norms for outcome in elderly patients with single orthopaedic injuries may not be appropriate for this group but seem to work well for more seriously injured patients.

• In the second article Ellis *et al* show how five years' computerised audit data from a surgical management

system, combined with standard health service formulas, were used to create a resource planning model for testing clinical scenarios (including closing beds or earlier discharges) for their effect on workload, waiting times, and cost savings.

• Mr Gumpert and Ms Lyons describe the different levels of audit being practised in Brighton health authority and the district's organisational structure of quality assurance.

One year's experience of major trauma outcome study methodology

James Wardrope, Susan F Cross, Diana J Fothergill

Abstract

Objective—To assess the feasibility and the validity of an audit using major trauma outcome study methods in an accident and emergency department.

Design—Prospective audit of all cases of trauma in patients admitted to a hospital from an accident and emergency department.

Setting—Accident and emergency department in a teaching hospital.

Patients—1577 Patients admitted with trauma, of whom 695 met the inclusion criteria for the study—that is, were admitted for more than three days, or admitted to intensive care, or died. 17 Patients were excluded because of failure to trace their notes.

Outcome measures—Review of case notes with TRISS (trauma score, injury severity score) methodology to compare expected and observed survival.

Results—Most (421/678) admissions were due to single orthopaedic injury. Serious injury was uncommon with only 43 patients having injury severity scores >15. The calculated probability of survival matched the observed outcome for most of the seriously injured patients, with only two unexpected deaths. However, 36 of the 61 deaths in the 678 patients occurred in elderly patients with a fractured neck of the femur, and all of these patients had a high probability of survival predicted by TRISS methodology.

Conclusions—Application of TRISS methodology seems to be valid for seriously injured patients except for elderly patients with single orthopaedic injuries, in whom there were major differences between observed and expected outcomes. Using outcome norms from the United States may not be applicable for this group.

Implications—Audit of management of major injuries should be carried out by every hospital, and the methodology of the major trauma outcome study is an excellent system for carrying out such audit. The study of all patients admitted with trauma requires appreciable extra resources, but most hospitals should be able to monitor the care of seriously injured patients as their numbers are much fewer.

Introduction

The major trauma outcome study has been operating in the United States since 1982 and is a prospective

study of all trauma admissions; by 1986, 95 institutions were participating and a database of 46 000 cases had been assembled.¹ The study uses TRISS methodology, which consists of injury scoring, scoring with the revised trauma score, and age scoring to give a prediction of an individual patient's probability of survival.² The prediction is based on outcome norms for the large number of patients in the study database. Thus if a patient's observed outcome differs from that predicted their case should be the subject of rigorous peer review.

These figures may be used to compare the outcomes of trauma among institutions,² and hospitals whose results are much better than the average may require study to determine whether lessons may be learnt from their system of trauma care; hospitals whose outcomes are worse than average should review their practices.

One of the main problems with medical audit has been the definition of valid end points and measures of quality of treatment. The end points in the TRISS methodology are well defined: alive at discharge or at three months after admission or death before discharge. With this method the results of a large hospital may be compared with the outcome norms derived by analysis of survival in a large series of injured patients.

We started a prospective study in March 1988 of all patients admitted to hospital through the accident and emergency department of the Northern General Hospital. This included patients transferred to other hospitals and is therefore an audit of the system of trauma care. Since November 1988 this information has also been part of the major trauma outcome study (United Kingdom), which is a multicentre study of trauma care. We report the first year's experiences of the study.

Patients and methods

The case records of all patients admitted and transferred who were seen initially in the accident and emergency department were kept aside for consultant review. Initially, a separate trauma form was completed by the admitting doctor in the department for all patients admitted with trauma. A daily log was kept of all admissions, transfers, or deaths among patients with trauma within the department.

Patients admitted with trauma were followed up and entered into the study if they met one of the following criteria: hospital stay of more than three days, admission to the intensive care unit, and death.

Department of Accident and Emergency Medicine, Northern General Hospital, Sheffield S5 7AU
James Wardrope, FRCS, consultant
Susan F Cross, audit assistant

Jessop Hospital for Women, Sheffield S3 7RE
Diana J Fothergill, MRCCG, senior registrar

Correspondence to: Mr Wardrope.

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Follow up—For patients meeting the entry criteria the departmental record card, the trauma forms, and the inpatient notes were reviewed. Information on the patient's physiological state on admission (systolic blood pressure, Glasgow coma scale, and respiratory rate) was noted. The patient's age, cause of the trauma, and anatomical diagnoses were recorded. The notes were examined for any errors in management or for recorded complications. The outcome at discharge or at three months from the date of admission was taken as the end point of the study.

Analysis—The information was entered into a micro-computer database. The probability of survival was calculated by scoring each patient on the basis of their most severe injuries, vital signs on admission, and age (injury severity score, revised trauma score, and age code respectively).² The injuries were coded according to the abbreviated injury scale (1985 revision),³ which describes the site, type, and severity of injury. The general outline of the method of calculation may be followed in the worked example (box 1). The result indicates that statistically a patient with similar injuries would have a one in 10 chance of survival. Care should be used, however, in quoting such statistics for individual patients, and they should be used only as a general indicator of expected outcome.

Results

During the one year of the study there were 42 148 new attendances to the accident and emergency department, 74% of which were due to traumatic conditions, and 5080 admissions to hospital, most of which were to the general medical group and to medicine for the elderly.

In all, 1577 admissions of patients with trauma were recorded in the day log, 695 of which met the criteria of entry into the study. The hospital notes for 17 (2.4%) of these patients were not subsequently traced; only two of these patients seemed to have been seriously injured, one of whom was brought into the department with no signs of life after a fall and for whom the results of postmortem examination are not yet available. The data analysis therefore was based on 678 patients. The remaining 882 patients were in hospital for three days or less with mainly orthopaedic injuries or minor head injuries.

Falls at home were the commonest cause of injury (307 patients), many in elderly patients resulting in a fractured neck of the femur (154). The most serious injuries were, however, caused by road traffic accidents.

Of the 678 patients in the study 421 had single orthopaedic injuries, 355 to the lower limb. In 52 patients the major injury was to the head, in 17 to the chest, and in only nine patients was the abdomen the most seriously injured area.

There were 61 deaths in the 678 patients, only 10 of which occurred in patients aged under 65; the most common injury was a fractured neck of the femur in patients aged over 55 (36 deaths). In seven of these patients the cause of death was pre-existing terminal disease.

An injury severity score >15 is commonly accepted as indicating serious injury. Only 43 patients in the study had such a score; table I lists these scores with the cause of injury, probability of survival, and outcome. Of the 10 patients who died in this group, five had no signs of life when brought into the resuscitation room.

Two deaths were unexpected on the basis of the injury severity score and condition on arrival to hospital. One occurred in a man aged 83 (case 6) who fell at home, sustaining a severe chest injury (four fractured ribs and a pneumothorax); he also had inoperable stomach cancer and died of bronchopneu-

A man aged 65 is admitted with a systolic blood pressure of 80 mm Hg, a respiratory rate of 40 breaths/min, and a Glasgow coma scale score of 8. Eventual diagnoses are: a linear skull vault fracture with cerebral contusion, five rib fractures with pneumothorax, a contusion of the right lung, a complex ruptured spleen, a minor liver laceration, and bilateral femur fractures

Injury Severity Score (ISS)⁴

ISS area	Injury	Code
Head	Fracture skull	2
	Cerebral contusion	3
Chest	Five rib fractures and pneumothorax	4
	Right lung contusion	4
Abdomen	Rupture spleen (complex)	5
	Liver laceration (minor)	2
Extremity	Fracture femur	3
	Fracture femur	3

The highest abbreviated injury scale code from each of the three most severely injured body areas is used to calculate the injury severity score—that is, head (3), chest (4), and abdomen (5)
Injury severity score = $50 (3^2 + 4^2 + 5^2)$.

Revised trauma score (RTS)

Using the revised trauma score each of the three vital signs are assigned a score from 0-4²

	Absolute value	Code	Code × weight factor
Blood pressure	80	3	3×0.7326
Coma scale	8	2	2×0.9368
Respiratory rate	40	3	3×0.2908
Revised trauma score =			4.9438

Age code (AC)

Patient's age <55 years, age code = 0
Patient's age ≥55 years, age code = 1
Patient's age = 65, age code = 1

Probability of survival (PS)

$$P_s = 1 / (1 + e^b) \text{ where,}$$

$$b = b_0 + b_1 (\text{RTS}) + b_2 (\text{ISS}) + b_3 (\text{AC})$$

$$b = -1.6465 + (0.5175 \times 4.9438) + (-0.0739 \times 50) + (-1.9261 \times 1)$$

$$b = -4.7092$$

$$P_s = 0.09331$$

Constants b_0, b_1 and weighting factors applied to these variables are derived from analysis of large numbers of patients in the major trauma outcome study.

monia. The other occurred in a man aged 62 (case 11) who fell at home, sustaining a major vertebral wedge fracture and a displaced radial fracture, who died from disseminated lung cancer. Only one patient with a chance of survival below 50% survived (0.44) (case 37). Review of the case notes disclosed only one highly significant error of management in the seriously injured patients, in a man aged 87 admitted after a fall at home.

He was deeply unconscious, and a stroke was diagnosed. He was admitted to the medical ward and died. A postmortem examination showed a fractured base of the skull, a fracture of the seventh cervical vertebra, and a fracture of the sacrum. Even if his injuries had been correctly diagnosed, his predicted probability of survival was less than 50% (0.49).

In 635 patients the injury severity score was < 16, 51 of whom died. All of these patients had a probability of survival of >0.96. Femoral fractures in elderly patients accounted for 38 of these deaths (36 fractures of the neck and two supracondylar fractures); table II shows the diagnosis and cause of death in the remaining 13 patients.

Review of the results of postmortem examination disclosed one other unexpected death in a patient not included in the full audit. The patient had ruptured his Achilles tendon and this had been repaired. He was discharged two days after operation, and, although his admission had been noted, he was not included in the detailed audit follow up. He was readmitted to the

medical ward six days later with a pulmonary embolus. He seemed to make a good recovery with anticoagulant treatment, but three days after admission he collapsed with a further massive pulmonary embolus.

Discussion

The major trauma outcome study is widely used in the United States to monitor trauma care. Some states demand such an audit before giving trauma centre accreditation to an institution. This methodology has been recommended in the recent report on the management of major injuries issued by the Royal College of Surgeons of England.⁵

In our study the outcome in most of the seriously injured patients was as predicted by the calculated probability of survival. The overall probability of survival figures may be used to compare statistically the results in one hospital with those in another. The numbers of seriously injured patients were, however, still too small to make this calculation meaningful.

In patients with a lesser degree of trauma 51 deaths occurred when the predicted probability of survival was >95%. For example, all of the deaths in patients with fracture of the neck of the femur occurred in patients predicted as having a 96%-97% chance of survival. This might indicate a poor level of care for this group. The more likely explanation is that the outcome norms from the United States might not be applicable to this group. It is unlikely that an elderly patient with a fractured neck of the femur would be triaged to a trauma centre. In the major trauma outcome study only 2.3% of all deaths followed falls that did not cause head injury.¹ In this study 75.4% (46 deaths) were due to falls that did not cause head injury. Furthermore, in many series from the United Kingdom the mortality from fracture of the neck of the femur in elderly patients is around 10%.⁶ When the three month mortality is considered, as in this study, the most recently published results indicate a mortality of 18.6%.⁷ TRISS methodology using the present coefficient values are not directly applicable to this group. There is a high incidence of pre-existing disease and disability, and any calculation of predicted survival should try to account for these other important variables.

A full major trauma outcome study audit would be difficult to perform in most hospitals unless more resources were made available. Although only 695 patients were entered into the study, all 1577 patients had to be followed up. The process of searching the hospital computer database, requesting notes, searching notes, and completing the data collection forms took from six to 10 hours per week of medical time. Even then there was no time to follow up the notes that were hard to trace nor to computerise and analyse the data. The completion of this series was made possible only by the appointment of a research assistant with duties specifically for audit.

Appreciable costs are associated with audit; the salary of the audit assistant, stationery, and time spent by the medical records department amounted to £3500 per annum and does not include the medical time still needed to continue to monitor the audit. This amounts to between two and four hours per week.

These are mundane difficulties, but there is great enthusiasm at present for medical audit with little heed of the resources required to implement audit systems. This hospital has been fortunate in obtaining grants toward the trauma audit.

The audit might be possible in most hospitals by excluding patients with single limb injuries, of whom 438 were entered in the study. Their care should already be systematically audited by the orthopaedic department. This would reduce the numbers of patients

TABLE I—Injury severity score, cause of injury, age, probability of survival, and outcome in patients with injury severity score >15

Injury severity score	Cause of injury and details	Age of patient (years)	Probability of survival	Outcome*
16	Assault	19	0.98	5
16	Assault	24	0.99	5
16	Assault	30	0.99	5
16	Burn (home)	5	0.99	5
16	Burn (home)	35	0.98	4
16	Fall (home)	83	0.96	1
16	Sport (football)	17	0.99	5
17	Fall (home)	82	0.95	4
17	Road traffic accident (pedestrian†)	5	0.90	4
17	Road traffic accident (pedestrian†)	36	0.95	4
18	Fall (home)	62	0.95	1
18	Road traffic accident (pedestrian‡)	77	0.95	5
19	Fall (street)	26	0.99	3
19	Road traffic accident (motorcyclist)	19	0.99	4
22	Fall (home)	87	0.49	1
24	Crush (work)	51	0.99	4
24	Road traffic accident (motorcyclist)	20	0.99	4
25	Assault	50	0.97	4
25	Fall (home)	42	0.99	5
25	Fall (street)	66	0.92	5
25	Fall (street)	56	0.24	1
25	Road traffic accident (pedestrian†)	42	0.84	3
25	Sport (football)	24	0.97	5
26	Burn (home)	25	0.66	5
27	Road traffic accident (cycle)	21	0.98	5
29	Assault	23	0.61	5
29	Fall (work)	29	0.98	4
29	Road traffic accident (driver)	18	0.92	4
29	Road traffic accident (pedestrian†)	73	0.57	4
30	Road traffic accident (motorcyclist)	35	0.78	5
34	Road traffic accident (pedestrian†)	11	0.86	5
34	Road traffic accident (driver)	35	0.88	4
34	Road traffic accident (front seat passenger)	22	0.86	4
34	Road traffic accident (pedestrian†)	6	0.86	4
34	Road traffic accident (pedestrian†)	15	0.86	4
35	Road traffic accident (front seat passenger)	20	0.02	1
38	Road traffic accident (motorcyclist)	18	0.44	4
43	Road traffic accident (rear seat passenger)	23	0.75	2
45	Road traffic accident (pedestrian‡)	50	0.01	1
50	Road traffic accident (driver)	69	0.04	1
50	Road traffic accident (pedestrian†)	32	0.01	1
75	Crush (work)	35	<0.01	1
75	Road traffic accident (driver)	64	<0.01	1

*5=good recovery, 4=disability moderate, 3=disability severe, 2=vegetative, 1=dead.

†Struck by car.

‡Struck by public service vehicle.

TABLE II—Injury and cause of death in 13 patients with high predicted probability of survival (excluding fracture of femur)

Injury severity score	Diagnosis*	Age of patient (years)	Complication	Cause of death
9	Fracture of radius	87		Lung cancer
9	Fracture of radius	62		Lung cancer
9	Fracture of ankle	56	Duodenal ulcer	Bleeding ulcer
9	Fracture of ankle	91	Cerebrovascular accident	Bronchopneumonia
4	Burn	79	Cerebrovascular accident	Bronchopneumonia
9	Fracture of radius	86	? Drug induced jaundice	Bronchopneumonia
8	Fracture of pelvis	88		Bronchopneumonia
5	Burn	77		Pulmonary embolus
10	Injury to knee ligament	70		Bronchopneumonia
4	Fracture of wrist	75	Myocardial infarct	Cardiac failure
9	Fracture of six ribs	83	Pneumonia	Bronchopneumonia
1	Laceration	90		Bronchopneumonia
1	Laceration	90		Natural causes

*Of most severe injury.

requiring detailed follow up to four patients per week, which might be a more realistic target for most hospitals. All deaths from trauma would also need to be included in the audit.

The next phase of the audit is to include all the admissions of patients with serious injuries in Sheffield and to include deaths occurring out of hospital.

As many hospitals as possible should take part in the full audit and submit their data to the major trauma outcome study (UK) as only by gathering data on large numbers of patients can the analysis be amended to provide valid outcome norms for the United Kingdom.

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Extending the use of clinical audit data: a resource planning model

Brian W Ellis, Richard C Rivett, Hugh A F Dudley

Abstract

Objective—To create a means by which we can examine and understand the interrelations among the fundamental elements of hospital inpatient care (patients, beds, theatre time, and staff).

Design—Predictive study of resource utilisation based on a computerised clinical information system of five years' audit data from a surgical management system.

Setting—One surgical firm (of one consultant, one registrar, and one preregistration houseman) in a district general hospital.

Patients—5267 Patients whose admission records were part of the five years' audit of surgical management.

Main outcome measures—Mean length of stay; number of occupied beds; turnover interval; throughput (patients/bed); percentage elective theatre occupancy; waiting time for elective admissions; and theatre, hotel, and total costs.

Results—Predicted outcome was analysed in the model, taking the actual outcomes in 1988-9 as baseline values, for four clinical scenarios: an increase in accident and emergency admissions, a reduction in beds, a reduced length of stay, and creation of a new firm. Baseline values showed a mean stay of just over five days in 15 beds and with a theatre occupancy of 94%; the total cost was £812 000 (hotel costs £597 000). Increasing the accident and emergency admissions to 460/year (19%), based on projected trends from 1984 to 1988, resulted in increased hotel costs (£55 000) and reducing bed numbers (by halving admissions) in decreased use of theatres to 71%, decreased throughput, and increased waiting time, from 20 to 92 weeks, at a saving of £99 000 (12%). Reducing stay marginally reduced bed occupancy (8%) and hotel costs (14%), and creating a new surgical team considerably reduced bed occupancy (14%) and waiting time for elective operations (by 20%). The minimum number of beds for referrals, accident and emergency admissions, and planned admissions was 9-0; that for urgent elective admissions was 3-3 and for non-urgent admissions was 2-4.

Conclusion—A well designed clinical information system with the routine collection of data can provide the necessary output data to enable resource modelling.

Implication—Use of such a model will allow

clinicians to participate in resource planning on the basis of what is actually happening within the hospital.

Introduction

Resource management, introduced by the Department of Health and Social Services during 1987-8, has as its fundamental principle the notion that better information leads to improved utilisation of available resources. The exact nature of the information needed has still to be defined by pilot studies, but it seems inevitable that clinical activity will be the main variable cost and thus attention should be directed at measuring such activity. For numerical information on clinical activity to mirror the real world, however, it must be both comprehensive and faithful to what has really happened. Much evidence suggests that the current clinical input does not fulfil these requirements.¹⁻³ Existing methods of data collection are hampered by the failure of consultants and their junior staff to make the relevant data easily available in their patients' medical records. A lack of appreciation of the importance of the exercise, coupled with the scarcity of relevant feedback of information derived from the data, is probably responsible for the minimal motivation with which many clinicians approach the task of data handling. The problem is compounded in the medical records departments of many hospitals, where record clerks, who have no medical training, display low morale because they have little incentive. They must find case notes and, having deciphered longhand or typescript, assign an International Classification of Diseases (ninth revision) diagnostic code⁴ from one set of manuals and an Office of Population Censuses and Surveys (OPCS Revision 4) procedure code⁵ from another. In some hospitals the staffing and performance of these departments are both so low that many discharges are not coded.

One alternative is for the clinical input for resource management to originate from an automated clinical management system, used to run the clinical unit for audit and other purposes. Input by the clinical team is used by them for judging the effectiveness and efficiency of clinical performance,⁶ but there is considerable overlap of the basic data required for this purpose and for the best management of resources.

We present an application of a clinical management system designed primarily for audit and the running of

Ashford Hospital,
Middlesex TW15 3AA
Brian W Ellis, FRCS,
consultant surgeon

Medical Systems Ltd,
Great Missenden,
Buckinghamshire
HP16 0AL
Richard C Rivett, managing
director

St Mary's Hospital Medical
School, London W2 1NY
Hugh A F Dudley, CBE,
emeritus professor of surgery

Correspondence to:
Mr Ellis.

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