unit due to suspected myocardial infarction with and without confirmed diagnosis. *Acta Medica Scandinavica* 1982;211:453-7.
11 Engby B, Strunge P, Olsen J. The prognosis for patients referred with suspected acute myocardial infarction. *Acta Medica Scandinavica* 1985;217: 465-71.
12 Madsen JK, Thomsen BL, Sorensen JN, Kjeldgaard KM, Kromann-Andersen B. Risk factors and prognosis after discharge for patients admitted because of suspected acute myocardial infarction with the without confirmed diagnosis. *Am J Cardiol* 1987;59:1064-70.
13 Smyllie HC. Prognosis in patients discharged from a coronary care unit. *BMJ* 1986;293:541-2.
14 Metcalfe MJ, Rawles JM, Shirreffs C, Jennings K. Six year follow-up of a consecutive series of patients presenting to the coronary care unit with acute chest pain; prognostic importance of the electrocardiogram. *Br Heart J* 1990;63:267-72.
15 Herlitz J, Hjalmarson Å, Karlson BW, Bengtson A. 5-year mortality rate in patients with suspected acute myocardial infarction in relation to early diagnosis. *Cardiology* 1988;75:250-9.
16 Launbjerg J, Fruergaard P, Madsen JK, Hansen JF, DAVIT-II study group. The 3-year mortality in patients suspected of acute myocardial infarction with and without confirmed diagnosis. *Am Heart J* 1991;122:1270-3.
17 Danish multicenter Study Group. Verapamil in acute myocardial infarction. *Eur Heart J* 1984;5:516-28.
18 Rose GA, Blackburn H, Gillum RF, Preineas AJ. *Cardiovascular survey methods*. 2nd ed. Geneva: World Health Organisation, 1982.
19 Frørup E. *Statistical yearbook*. Vol 92. *Life Tables*. Copenhagen: Danmarks Statistik, 1988:37.
20 Alban Davies H, Jones DB, Rhodes J. "Esophageal angina" as the cause of chest pain. *JAMA* 1982;248:2274-8.
21 Launbjerg J, Fruergaard P, Jørgensen FB, Madsen JK, Hesse B. Prognosis and diagnostic work-up in patients admitted for, but without myocardial infarction. *Clin Physiol* 1990;10:273-7.
22 Granborg J, Grande P, Petersen A. Diagnotic and prognostic implications of transient isolated negative T waves in suspected acute myocardial infarction. *Am J Cardiol* 1986;57:203-7.
23 Mulcahy R, Awadhi AHA, Buitleor M, Tobin G, Johnson H, Contoy R. Natural history of unstable angina. *Am J Heart J* 1985;109:753-8.
24 Parisi AF, Khuri S, Deupree RH, Sharma GVRK, Scott SM, Luchi RJ. Medical compared with surgical management of unstable angina. 5-year mortality and morbidity in the veterans administration study. *Circulation* 1989;80:1176-89.
25 Wielgosz AT, Fletcher RH, McCants CB, Mckinnis RA, Haney TL, Williams RB. Unimproved chest pain in patients with minimal or no coronary disease: a behavioral phenomenen. *Am Heart J* 1984;108:67-72.
26 Launbjerg J, Fruergaard P, Jacobsen HL, Madsen JK. The long-term predictive value of an exercise thallium-201 scintigraphy for patients with acute chest pain but without myocardial infarction. *Coronary Artery Dis* 1993;4:195-200.

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Effects of case management after severe head injury

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Abstract

***Objectives*—To examine the effects of early case management for patients with severe head injury on outcome, family function, and provision of rehabilitation services.**

***Design*—Prospective controlled unmatched non-randomised study for up to two years after injury.**

***Setting*—Four district general hospitals and two university teaching hospitals, each with neurosurgical units, in east central, north, and north east London and its environs.**

***Subjects*—126 patients aged 16-60 recruited acutely and sequentially after severe head injury. All received standard rehabilitation services in each of the six hospitals and districts: case management was also provided for the 56 patients admitted to three of the hospitals.**

***Main outcome measures*—Standard measures of patients' physical and cognitive impairment; disability and handicap; and affective, behavioural, and social functioning and of relatives' affective and social functioning. Relatives' perception of burden; changes in patients' and relatives' housing, financial, vocational, recreational, and medical needs; and ongoing requirements for care and support; and the amount and type of paramedical input provided were assessed with structured questionnaires.**

***Results*—For a given severity of injury, case management increased the chance and range of contact with inpatient and outpatient rehabilitation services. However, duration of contact was not increased by case management, and there was no demonstrable improvement in outcome in the case managed group. Any trends were in favour of the control group and could be accounted for by group differences in initial severity of injury.**

***Conclusions*—Widespread introduction of early case management of patients after severe head injury is not supported, and early case management is not a substitute for improvement in provision of skilled and specialist rehabilitation for patients.**

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Introduction

There is increasing evidence that the effect of residual problems after severe head injury can be ameliorated by rehabilitation.[1] Despite this, there is a considerable shortfall in the provision of rehabilitation for victims of head injury in the United Kingdom.[2,3] The services that do exist provide early rehabilitation in the acute sector,[4,5] when physical deficits (which usually recover rapidly and completely) are most obvious.[6] On later re-entry to the community, cognitive, behavioural, and emotional disturbances cause psychological and vocational failure, social isolation, and a burden on carers, and these often increase over time.[6] Despite this, little or no rehabilitation is provided more than six months after injury.[4,5]

Newcombe *et al* proposed that fragmentation of responsibility obstructed the successful rehabilitation of such patients.[7] We proposed that service shortfalls and a tendency for patients to fall through the net of existing services may also result from inertia in the system, patients' inertia, and carers' and professionals' confusion about the nature of the problems requiring treatment after head injury.[8] Coordination of services that are potentially available, particularly in the community, by a case manager has proved effective in other vulnerable populations such as psychiatric patients in the United States[9-12] and the frail elderly in the United Kingdom.[13] In Britain case management has also been advocated, though not evaluated, for people with mental handicap[14] and is expected to underpin the coordination of community care for several client groups in this country.[15]

In principle, therefore, there is good reason to expect that case management would provide flexible and cost effective improvement in service provision in the United Kingdom for patients after head injury. However, there is no empirical evidence to show this, and our paper describes the first prospective controlled study to evaluate the effectiveness of one model of case management in improving service input and patient outcome after severe head injury.

Patients and methods

Between March 1987 and March 1988 we established working practices to be adopted by a case manager.[8,16] Briefly, after an assessment the case manager formulated a proactive rehabilitation plan, for which detailed clinical knowledge of problem areas after severe head injury was crucial, and facilitated cooperation and involvement of patients, relatives, and professionals. Other than giving general information about head injury and acting as an informal counsellor and a

support for the patient and family, the case manager did not provide any formal treatment, retraining, or education but recruited such services from other agencies as required.

At the same time we evaluated service provision after severe head injury in 11 hospitals and districts that fed into two neurosurgical units in north London.[5] We used these results to select two groups of three hospitals with roughly similar services and populations for the present study. The hospitals and districts were matched on their type, their location, the number and severity of admissions and discharges after head injury, and the hospital and community facilities. Each group contained one teaching hospital with a neurosurgical unit and two district general hospitals, one peripheral urban and one suburban.

We allocated case management to one group of hospitals by the toss of a coin. Thus, patients in the case managed hospitals received normal services plus case management while those in control hospitals received normal services alone. Between March 1988 and August 1991 we prospectively compared the outcome of case management of severely head injured patients from the hospitals and districts that received case management with outcome in the control hospitals and districts. Ethical approval was obtained from the hospitals involved at each stage of the study.

We chose a design in which hospitals rather than patients were randomised to case management or control services because the advantages of prospectively randomising patients were confounded by two factors. Firstly, there would be talk between staff and patients in the two groups in the same hospital—possibly in the same ward and even in adjacent beds—so that any change in referral practice or facilities generated by the case manager would affect both treated and control groups. Secondly, it would be impossible to blind an assessor to an individual patient's allocation.

PATIENT RECRUITMENT

We recruited patients who had sustained a closed head injury, were aged 16-60, had been in coma for six hours or had a post-traumatic amnesia of more than 48 hours, who were or whose main carer was resident in the health district of one of the hospitals in the study, and whose family had given informed consent. We excluded patients who had received hospital treatment for drug or alcohol misuse, psychiatric disturbance, or a disorder of the central nervous system during the previous year. We also excluded patients who were of no fixed abode or if follow up was unlikely. The patients were recruited acutely—within seven days of injury—whether or not they had had neurosurgery.

DATA GATHERING

Between March 1988 and November 1990 eligible patients were admitted sequentially to the study. An assessor collected data at entry and at six, 12, and 24 months after injury to determine service provision and patient and family outcome.

On recruitment, each patient's biographical and medical details were recorded on an entry form previously developed in Glasgow. Severity of injury was rated by the duration of coma, the minimum Glasgow coma score on admission,[17] and the duration of post-traumatic amnesia with the Galveston orientation and amnesia test.[18] Physical impairment and a rating of disability and handicap were recorded with the Bond neurophysical scale[19] and the disability rating scale[20] respectively. Neurosurgical input, the days and hours of paramedical input, and the duration of stay in intensive care, neurosurgery, and other wards were recorded with forms used in previous studies in Glasgow.

At six, 12, and 24 months of follow up the assessor recorded physical impairment with the Bond scale[19] and cognitive impairment with standard tests of verbal and non-verbal intelligence and memory[21-25] and of language comprehension and fluency[26,27] compared with an estimate of premorbid verbal intelligence.[28] Changes in the patients' affective, behavioural, and social functioning; changes of the patient's personality; and changes of affective and social function and burden in relatives were assessed with standard instruments[29-32] and questionnaires developed in Glasgow.[33] The Barthel index,[34] an extended version of the Glasgow outcome scale,[35] the Glasgow assessment schedule,[36] and the disability rating scale provided global ratings of patients' impairment, disability, and handicap and of the time spent in contact with paramedics, clinical psychology, and other agencies after discharge. Changes in the patients' and relatives' housing, financial, vocational, leisure, and medical needs and ongoing requirement for hours of care, support, and supervision were recorded with questionnaires used previously in Glasgow. Consumer satisfaction with services and information given to patients and relatives and satisfaction with case management was recorded by telephone interview near the end of the study with analogue self rating scales.

HYPOTHESES TESTED

Five hypotheses were tested in our study: firstly, that control variables, including those relating to severity of injury, would not differ between the two groups of patients; secondly, that case management would decrease the duration of the initial hospital stay but increase the number of patients in contact with rehabilitation and the duration of this contact; thirdly, that the degree of cognitive impairment in the patients would not be altered by case management; fourthly, that patients' potential for employment and quality of life would be improved by case management; and fifthly, that subjective and objective burden, affective disturbance, and medical input would be reduced in relatives of case managed patients.

STATISTICAL ANALYSIS

We performed routine data description and analysis with SPSS.[37] We calculated odds ratios for differences in referral rates, with and without correction for differences at intake and possibly hospital identity, by fitting a linear logistic model[38] using the statistical program EGRET.[39] Differences in time trends for the outcome variables were analysed with variance components models with the program REML.[40] In the latter models the random effects were subject, treating hospital (when it was non-negligible), and the usual residual term. The fixed terms were time, input covariates measuring severity (log score of post-traumatic amnesia, log duration of coma, and coma score), and group (case managed *v* control). The effect of severity of injury on rate of improvement was modelled by a time by log post-traumatic amnesia interaction, and possible differences between groups in rates of recovery were tested by fitting a group by time interaction. As this was almost always non-significant and more often than not in the wrong direction (case managed patients improving more slowly than the controls), this was usually dropped for the model and treatment effects estimated by the main effect of group. In all analyses 95% confidence intervals were calculated if appropriate.

A main reason for choosing a random effects model to analyse trends in outcome measures—rather than the more familiar methods of trend analysis—was the patterns of missing values in the data files. Traditional methods such as the use of multivariate analysis of variance[38] cannot cope effectively with missing data. There were inevitably a few drop outs

and missing outcome interviews, but the main source of missing data arose from the design of the trial. Patients were recruited up until six months before the end of the study. Early recruits therefore had follow up data for six, 12, and 24 months. Many patients had data for six and 12 months but not for 24 months, and the last patients to be recruited had data for six months only. The systematic paterns of missing data thus arose from the design of the study and the random date of patients' injury. Observations can therefore be regarded as missing completely at random in the analyses. Random effects models have no difficulty in coping with data of this type and were therefore selected as appropriate means of analysis.

TABLE I—*Numbers of patients with severe head injury assessed during two year study*

	Control patients		Case managed patients	
Time of assessment	Assessed	Refused	Assessed	Refused
At entry	70	5	56	3
Follow up:				
6 months	60	3	48	2
12 months	55	3	37	4
24 months	29	2	31	3

TABLE II—*Initial characteristics of patients with severe head injury. Values are numbers (percentages) unless stated otherwise*

	Control patients	Case managed patients	Odds ratio (95% confidence interval)
Patient characteristics at entry			
Mean (SD) age (years)	30·7 (14·0)	31·6 (14·4)	
No of men:No of women	53:17	39:17	
Mean (SD) premorbid IQ	106·1 (8·6)	104·2 (10·3)	
Alcohol intake at injury	19/51 (37)	15/42 (36)	
Unemployed	2/54 (4)	0/42	
Financial problems	26/53 (49)	13/39 (33)	
Housing problems	8/51 (16)	5/39 (13)	
Injury characteristics			
Road traffic accident:assault:fall:other (%)	63:14:16:7	60:16:18:5	
Mean (SD) minimum Glasgow coma score	6·6 (3·0)	5·5 (2·6)*	
Mean (SD) days unconscious	4·6 (7·5)	11·3 (13·5)*	
Mean (SD) days of post-traumatic amnesia	40·8 (75·0)	64·9 (97·5)*	
Mean (SD) disability rating (worst=30)	16·2 (7·3)	18·3 (9·7)	
Complications and interventions			
Respiratory	14/67 (21)	26/55 (47)	4·1 (1·8 to 9·3)*
Conservative management	22/70 (31)	9/56 (16)	0·4 (0·2 to 1·0)*
Tracheostomy	11/70 (16)	18/56 (32)	2·5 (1·1 to 6·0)*

*P<0·05. After admission to hospital was allowed for as a random effect in REML the differences in Glasgow coma score and post-traumatic amnesia between groups were no longer significant.

TABLE III—*Number (percentage) of patients with severe head injury referred to rehabilitation services*

	Control patients	Case managed patients	Odds ratio (95% confidence interval)
Facility referred to			
No of patients	61	49	
Rehabilitation unit	13 (21)	21 (43)	3·2 (0·7 to 14·8)*
Outpatient services	20 (33)	27 (56)	2·3 (0·9 to 5·9)*
Day centre	3 (5)	7 (15)	3·5 (0·9 to 14·2)
Inpatients referred within facilities and by service			
Facility:			
Neurosurgical unit	27/39 (69)	33/33 (100)	
District general hospital	40/52 (77)	30/33 (91)	3·2 (0·7 to 14·8)*
Rehabilitation unit	11/12 (92)	20/21 (95)	1·8 (0·1 to 32·0)
Service:			
No of patients	58	45	
Physiotherapy	46 (79)	42 (93)	3·7 (0·1 to 13·8)*
Occupation therapy	27 (47)	23 (51)	1·9 (0·9 to 4·2)
Speech therapy	16 (28)	23 (51)	2·6 (0·4 to 15·6)*
Psychology	8 (14)	19 (42)	5·6 (1·4 to 22·3)*
Social work	13 (22)	22 (49)	5·5 (1·6 to 18·6)*
Outpatients referred by service			
No of patients	60	44	
Physiotherapy	24 (40)	23 (52)	1·6 (0·8 to 3·6)
Occupational therapy	16 (27)	14 (32)	1·3 (0·6 to 3·0)
Speech therapy	4 (7)	17 (39)	8·8 (2·7 to 28·7)*
Psychology	7 (12)	12 (27)	2·8 (1·0 to 8·0)*
Psychiatry	2 (3)	1 (2)	0·7 (0·1 to 7·7)
Social work	4 (7)	6 (14)	2·2 (0·6 to 8·4)
Day centre	3 (5)	7 (16)	3·6 (0·8 to 14·8)
Employment rehabilitation centre	2 (3)	5 (11)	3·7 (0·7 to 20·1)
District nurse or community service volunteer	4 (7)	5 (11)	1·8 (0·5 to 7·1)
Other	23 (38)	17 (39)	1·0 (0·4 to 2·3)

*P<0·05. Analysis adjusted for covariates minimum Glasgow coma score, duration of unconsciousness, and post-traumatic amnesia and for hospital as random effect (REML).

Results

PATIENTS' DETAILS

In total, 56 case managed and 70 control patients were admitted to the study. Eight case managed patients and six controls died and were excluded from the study, as were four patients who were untraceable and two who were out of the country at follow up. Thirty one case managed patients and 29 controls were followed up for two years. Table I shows the numbers of patients at each stage of assessment.

Table II shows the baseline characteristics of the patients. The two groups were similar for age, sex ratio, cause of injury, alcohol intake at injury, premorbid intelligence quotient (IQ), and number of patients unemployed or with financial or housing problems before injury. The case managed patients, however, were more severely injured on entry to the study: they were unconscious for significantly longer, had more respiratory complications and tracheostomies and less conservative management, had lower minimum Glasgow coma scores on admission to hospital, and had longer post-traumatic amnesia. Subsequent analysis of service provision or outcome was adjusted for these differences and the effect of hospital membership by stratification or matching.

SERVICE PROVISION

Table III shows the number of patients referred to rehabilitation services, and table IV shows the time spent in rehabilitation. Case management increased the number of patients in contact with inpatient rehabilitation and hospital outpatient services, but the duration of contact did not differ between groups. There was a tendency also for case management to increase numbers of patients in contact with hospital and outpatient or community services, although in the last case the numbers were small

After head injury of a given severity case management increased the chance but not the length of admission to a rehabilitation unit. Case management increased the number of referrals to physiotherapy and occupational therapy and especially to clinical psychology, social work, and speech therapy. However, when contact occurred, the hours of contact were not increased by case management. In addition, inpatients with shorter post-traumatic amnesia were more likely to be referred for rehabilitation if they were case managed (table V).

Overall, therefore, case management increased the chance of a given patient coming into contact with rehabilitation facilities as an inpatient or an outpatient. However, the duration of that contact, estimated either in days admitted or hours of treatment, was not increased except for hours of treatment in a neurosurgical unit. This was probably related to an increased length of stay in a neurosurgical unit in the case managed group rather than treatment time per day, which was slightly less in this group.

PATIENT OUTCOME

Measures of patients' residual physical and cognitive impairments, personality, and affective and social functioning at six, 12, and 24 months after injury were not significantly different in the two groups: table VI shows the results for 24 months. Table VII shows the patients' residual disability and handicap, their potential for competitive employment, and their actual employment. There was no significant difference in these measures between the two groups even when severity of injury was allowed for by examining outcome separately in patients with more than two weeks of post-traumatic amnesia.

Family and relatives

Table VIII shows the results at 24 months' follow up

for distress reported by patients' families and relatives (estimated by standard questionnaires and direct questions about medical contact by the relatives), changes in the use of their leisure time, and their perception of stress within the family. Even when allowance was made for severity of injury, signficantly more relatives in the case managed group reported that the accident had had a "major" rather than "no" or "some" effect on the family. Other measures showed no significant difference at six, 12, and 24 months except that at 12 months more relatives in the case managed group reported a change in leisure activities since the injury (P=0·01).

TABLE IV—*Time spent in rehabilitation by patients with severe head injury. Values are means (SD) unless stated otherwise*

	Control patients		Case managed patients		
	Duration of treatment	No of patients	Duration of treatment	No of patients	Odds ratio (95% confidence interval)
Median length of stay (days)†:					
Hospital	25	65	35	52	0·9 (0·6 to 1·4)‡
Rehabilitation unit	125	13	88	21	1·0 (0·4 to 2·5)‡
Outpatient services	88	20	38	26	1·2 (0·5 to 2·7)‡
Hours of treatment (conditional on its receipt)					
Facility:					
Neurosurgical unit	9·5 (11·9)	27	34·0 (40·4)	33	2·0 (1·0 to 3·7)*
District general hospital	49·8 (59·6)	41	46·6 (58·1)	30	0·8 (0·4 to 1·6)
Rehabilitation unit	224·7 (139·0)	11	208·2 (217·0)	20	0·6 (0·2 to 1·5)
Service:					
Physiotherapy	66·2 (99·3)	46	74·9 (108·5)	42	1·0 (0·5 to 2·1)
Occupational therapy	58·9 (69·3)	27	63·8 (86·7)	28	0·9 (0·4 to 2·1)
Speech therapy	33·9 (37·0)	16	24·1 (22·0)	22	0·8 (0·3 to 1·9)
Psychology	10·4 (8·9)	8	7·7 (7·1)	20	0·8 (0·3 to 1·7)
Social work	12·7 (13·7)	13	11·0 (12·2)	22	1·2 (0·5 to 3·0)
All treatment	105·5 (160·6)	44	130·0 (202·1)	41	1·0 (0·4 to 2·3)

*P<0·05. Analysis adjusted for covariates minimum Glasgow coma score, duration of unconsciousness, and post-traumatic amnesia and for hospital and year of entry as random effects (REML).
†Obtained from Kaplan-Meier survival curves.
‡Hazard ratios obtained from Cox proportional hazard models for survival or failure time.

TABLE V—*Number (percentage) of patients with severe head injury referred for rehabilitation by length of post-traumatic amnesia*

	Days of post-traumatic amnesia							
	Control patients				Case managed patients			
Treatment	2-7 (n=20)	8-19 (n=10)	20-44 (n=13)	>44 (n=11)	2-7 (n=7)	8-19 (n=7)	20-44 (n=9)	>44 (n=12)
Physiotherapy	11 (55)	8 (80)	13 (100)	11 (100)	7 (100)	5 (71)	9 (100)	12 (100)
Occupational therapy	0	3 (30)	10 (77)	11 (100)	1 (14)	3 (43)	6 (67)	12 (100)
Speech therapy	0	2 (20)	5 (38)	7 (64)	0	2 (29)	5 (56)	9 (75)
Psychology	0	0	3 (23)	4 (36)	0	1 (14)	4 (44)	11 (92)
Any treatment	11 (55)	8 (80)	13 (100)	11 (100)	7 (100)	6 (86)	9 (100)	12 (100)

TABLE VI—*Residual impairments of patients at 24 months after severe head injury. Values are means (SD) unless stated otherwise*

	Control patients		Case managed patients	
	Score	No of patients	Score	No of patients
Physical ability				
Bond neurophysical scale (at 6 months after injury)	3·5 (2·7)	54	3·8 (3·0)	44
Cognitive ability				
Verbal and non-verbal IQ:				
Mill Hill vocabulary	93·6 (7·2)	29	93·0 (8·7)	20
Standard progressive matrices	108·5 (14·7)	29	112·8 (12·4)	19
Verbal and non-verbal memory:				
Logical memory (delayed)	8·5 (4·0)	29	7·3 (4·3)	21
Rey figure (delayed)	24·9 (8·3)	29	21·8 (8·5)	19
Personality change				
No (%) with changeable mood	11/24 (46)		8/17 (47)	
No (%) with childish behaviour	19/26 (73)		10/17 (59)	
Affective and social functioning				
Leeds depression scale	14·1 (2·6)	25	12·3 (4·3)	19
General health questionnaire:				
Raw scores	2·3 (3·7)	26	6·0 (7·1)	19
No (%) of "cases" (score >4)	5/26 (19)		8/19 (42)	
No (%) with change in leisure	13/27 (48)		14/18 (78)	
No (%) in medical contact with general practitioner	7/26 (27)		11/18 (61)	

Values are raw scores uncorrected for severity of injury.

In addition, there was no significant difference between groups in digit span, subjective memory questionnaire, token test, Wisconsin card sort test, Benton's controlled oral word fluency task, neurobehavioural rating scale, and abbreviated Eysenck personality questionnaire.

Table IX shows relatives' responses to questions about the financial consequences of the injury and the effects it has had on the household, including the hours of care or supervision required by the patient, at six, 12, and 24 months' follow up. Significantly more families in the case managed group thought that their household routine had been upset at 12 months, and this was confirmed by similar though not significant results at 24 months (P=0·7). In addition, more patients in the case managed group required someone to stay in the house to look after them at 12 and 24 months (P=0·04 and P=0·01 respectively).

Summary of outcome

None of the variables measured showed even a trend in favour of benefit in the case managed group let alone significant benefit. Any trends were in favour of the control group: for example, slightly less burden and significantly less effect on the family unit (table VIII) or routine (table IX) and a tendency toward better standard scale scores of disability and handicap (table VII). However, these differences can largely be accounted for by the difference between the groups in initial severity of injury.

Discussion

Over the past 10 years the concept of case management has emerged as an important element of health care systems for elderly and especially mentally ill and mentally handicapped patients.[41] External case management is also advocated in the United States for "catastrophic" illness[42] and after severe head injury,[43-45] although it has never been subjected to proper evaluation in these patients. Our study is the first to do this after severe head injury.

All models of case management aim to link the right people with the right problems[46] by networking and responsible scheming.[47] Our case manager acted as an independent case manager without a budget[48] and adopted an enabling rather than therapeutic role,[49] not providing any formal treatment but recruiting from other agencies. The work involved outreach and home based rather than office or outpatient based contact with patients, their relatives, and the appropriate services; it was felt that only in this way could rehabilitation programmes be individualised and supervised proactively. The work was time consuming, and each of the three people who acted as case manager during the study found it difficult to manage more than about 20 patients at any one time. The model thus incorporated elements of the "assertive"[12] or "clinical"[50] case management process advocated by Holloway for the mentally ill.[51] The model appeared to be accepted by other professional groups in hospitals and the community and by the patients' families, 19 of 20 families stating at two year follow up that the case manager was "very" or "extremely" helpful.

We recruited patients acutely within seven days of injury rather than months after injury to explore whether case management influenced the provision of rehabilitation services in hospital as well as in the community and the duration of hospital stay. We also thought that early contact by the case manager with the family would provide the best opportunity to ameliorate family distress. Our results show that this model of case management for patients with severe head injury significantly increased the number of patients in contact with formal rehabilitation in hospital and in the community. This effect was greatest for clinical psychology, social work, and speech therapy—services to which referrals are usually made relatively rarely.[5]

Despite case management increasing contact with formal rehabilitation, no difference in outcome was found between the two groups of patients during two

TABLE VII—*Residual disability and handicap of patients at six, 12, and 24 months after severe head injury. Values are numbers (percentages) unless stated otherwise*

	Time after injury					
	6 months		12 months		24 months	
	Control patients	Case managed patients	Control patients	Case managed patients	Control patients	Case managed patients
	Standard scales					
Suboptimal Barthel score (<20)	12/60 (20)	15/48 (31)	7/55 (13)	7/37 (19)	1/29 (3)	4/21 (19)
Extended Glasgow outcome scale (best=8):						
Mean (SD) score	5·8 (1·5)	5·3 (1·7)	6·2 (1·4)	5·5 (1·6)	6·3 (1·2)	5·6 (1·5)
No of patients	59	48	55	37	29	21
Glasgow assessment schedule (worst=87):						
Mean (SD) score	13·0 (11·4)	13·0 (11·4)	7·9 (8·0)	11·4 (10·14)	6·7 (6·3)	11·4 (9·4)
No of patients	46	46	54	36	29	21
Disability rating scale (worst=30):						
Mean (SD) score					0·76 (1·7)	2·0 (2·4)*
No of patients					29	19
	Vocational function					
At competitive work:						
All patients	15/53 (28)	10/42 (24)	14/47 (30)	9/30 (30)	9/27 (33)	7/19 (37)
Most severely injured patients†	9/30 (30)	5/29 (17)	8/27 (30)	5/24 (21)	4/17 (24)	5/16 (31)
Employable in competitive work (disability rating scale):						
All patients	27/57 (47)	15/46 (33)	26/53 (49)	16/32 (50)	25/29 (86)	14/21 (67)
Most severely injured patients†	6/14 (43)	5/15 (33)	6/14 (43)	4/12 (33)	4/10 (40)	4/9 (44)
Occasional or frequent absences from from work	25/51 (49)	24/40 (60)	12/42 (29)	6/30 (20)	7/24 (29)	3/19 (16)
Unemployed or off work	25/53 (47)	26/42 (62)	24/47 (51)	15/30 (50)	11/27 (41)	9/19 (47)

*P<0·05, Student's *t* test. †Post-traumatic amnesia >14 days.

TABLE VIII—*Distress and changes in lifestyle reported by relatives of patients at 24 months after severe head injury. Values are means (SD) unless stated otherwise*

	Control patients		Case managed patients	
	Score	No of patients	Score	No of patients
Leeds depression scale	15·3 (2·6)	23	13·1 (3·9)	17
General health questionnaire:				
Raw score	2·6 (3·6)	22	4·4 (3·9)	17
No (%) of "cases" (score >4)	6/22 (27)		5/16 (31)	
Perceived burden scale	5·7 (5·4)	26	9·4 (7·7)	17
No (%) in medical contact with general practitioner	2/23 (9)		4/16 (25)	
No (%) prescribed drugs	0		2/16 (13)	
No (%) with change in leisure	6/22 (27)		6/15 (40)	
Effect on family (No (%)):				
Some	13/24 (54)		7/17 (41)	
Major	0		8/17 (47)*	
No (%) with worse stress than before injury	15/29 (52)		10/20 (50)	

*P<0·05, values corrected for severity of injury. All other values are raw, uncorrected scores.

years of follow up. We had expected to find no significant change in measures of physical and cognitive impairment after rehabilitation since the aim of such training is to reduce dependence despite impairment rather than necessarily reducing impairment. Unexpectedly, however, we found that increased referral to rehabilitation did not improve functional ability in or outside the home, increase return to work, reduce family distress, or reduce levels of supervision and care. Similarly, early contact with and provision of information to relatives by the case manager did not have the predicted effect of reducing reported distress despite case management being regarded as helpful.

A possible explanation for these apparent anomalies is that, while case management increased referral to rehabilitation services, it did not increase hours of treatment. The importance of the length of time spent in rehabilitation training is shown by studies of rehabilitation programmes in the United States: programmes which reported a positive effect on outcome in patients with severe head injury involved hundreds of hours of rehabilitation training.[52-54] Our model of case management provided advice, support, advocacy, goal planning, and referral but not interventional training itself. A similar model has failed to show benefit in patients with chronic mental illness.[55] We therefore suggest that the failure of our model of case management to benefit severely head injured patients is because the model is unable to modify practice sufficiently to provide patients with significantly more rehabilitation training and because of the shortfall of available skilled and specialist rehabilitation for head injured patients in the United Kingdom.[2-5]

It is unlikely that insensitive outcome measures or the small numbers of patients in each group might have obscured the benefit of case management. Although the standard outcome measures available for patients at the start of the study in 1986 were relatively insensitive, we also used the battery of scales and questionnaires that have been developed in Glasgow over the past 20 years. These allow for detailed inquiry into psychosocial functioning of patients and family members after severe head injury. They have previously been shown to be sufficiently sensitive to detect changes in burden in families and deteriorating psychosocial function in patients[6] or patients' level of return to work[56] and could reasonably be expected to reflect an effect of case management. Furthermore, any trends in favour of

TABLE IX—*Financial consequences and effects on household reported by relatives of patients at six, 12, and 24 months after severe head injury. Values are numbers (percentages)*

	Time after injury					
	6 months		12 months		24 months	
	Control patients	Case managed patients	Control patients	Case managed patients	Control patients	Case managed patients
	Financial effects					
Financial problems	26/53 (49)	13/39 (33)	18/47 (38)	13/29 (45)	11/27 (41)	8/18 (44)
Compensation	1/51 (2)	1/42 (2)	3/47 (6)	0/30	1/27 (4)	3/18 (17)
Effect on income	31/53 (58)	19/39 (49)	19/47 (40)	20/30 (67)	7/26 (27)	9/18 (50)
	Effects on household					
Alterations necessary	2/49 (4)	7/37 (19)	5/46 (11)	6/30 (20)	4/27 (15)	7/19 (37)
Residential placement	1/49 (2)	1/37 (3)	0/46	0/27	0/27	0/19
Care or supervision necessary	44/51 (86)	32/40 (80)	2/43 (5)	6/29 (21)*	0/26	4/17 (24)*
Routines upset	35/54 (65)	29/40 (73)	18/47 (38)	20/30 (67)*	7/27 (26)	11/16 (69)

*P<0·05, Pearson's χ^2 test.

Clinical implications

- Despite evidence of rehabilitation ameliorating residual problems after severe head injury there is considerable shortfall in provision of such rehabilitation
- Case management has been suggested as a way of improving delivery of services that are available
- In this study early case management was provided for up to two years after severe head injury
- Case management increased patients' contact with rehabilitation services but did not increase the duration of this contact or improve outcome for patients or relatives
- Case management is not a substitute for improved provision of rehabilitation services

better outcome were found in the control group. This is probably accounted for by the group difference in initial severity of injury, but it makes it unlikely that there was any obscured benefit in the case managed group despite the small size of the groups.

We examined only one model of case management after severe head injury, and the patients were case managed for a maximum of two years after injury (after which problems may well increase rather than decrease[6]). Thus, our results throw no light on the efficacy or otherwise of other models of case management. For example, case management may benefit patients with complex problems resulting from multiple handicap or at a long time after injury, when rehabilitation input is minimal[4,5] and potentially mutable problem areas can be more readily identified. In addition, case management might be made effective if it emphasised modification of professionals' work practices, something we clearly failed to do in this study, or if it operated in the context of an improved range and quality of rehabilitation resources for patients.

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1 McMillan T, Greenwood R. Head injury. In: Greenwood R, Barnes MP, McMillan TM, Ward CD, eds. *Neurological rehabilitation.* Edinburgh: Churchill Livingstone, 1993:437-50.
2 Royal College of Physicians. Physical disability in 1986 and beyond. A report of the Royal College of Physicians. *J R Coll Physicians Lond* 1986;20:30-7.
3 Medical Disability Society. *Report of a working party on the management of traumatic brain injury.* London: Development Trust for the Young Disabled, 1988.
4 Brooks DN, Campsie LM, Beattie A, Bryden JS. Head injury and the rehabilitation professions in the west of Scotland. *Health Bull (Edinb)* 1986;44110.
5 Murphy LD, McMillan TM, Greenwood RJ, Brooks DN, Morris JR, Dunn G. Services for severely head injured patients in north London and environs. *Brain Inj* 1990;4:95-100.
6 Brooks DN, Campsie L, Symington C, Beattie A, McKinlay W. The five year outcome of severe blunt head injury: a relative's view. *J Neurol Neurosurg Psychiatry* 1986;49:764-70.
7 Newcombe F, Brooks N, Baddeley A. Rehabilitation after brain injury: an overview. *International Rehabilitation Medicine* 1980;2:133-7.
8 McMillan TM, Greenwood RJ, Morris JR, Brooks DN, Murphy L, Dunn G. An introduction to the concept of head injury case management with respect to the need for service provision. *Clinical Rehabilitation* 1988;2:319-22.
9 Mueller J, Hopp M. A demonstration of the cost-benefits of case management service for discharged mental patients. *Psychiatr Q* 1983;55:17-24.
10 Bond GR, Miller LD, Krumwied RD, Ward RS. Assertive case management in three CHMCs. A controlled study. *Hosp Community Psychiatry* 1988;39: 411-18.
11 Goering PN, Wasylenki DA, Farkas M, Lacee WJ, Ballantyne R. What difference does case management make? *Hosp Community Psychiatry* 1988;39:272-82.
12 Bush CT, Langford MW, Rosen P, Gott W. Operation outreach: intensive case management for severely psychiatrically disabled adults. *Hosp Community Psychiatry* 1990;41:647-9.
13 Challis JD, Davis B. *Case management in community care.* Aldershot: Gower, 1986.
14 Audit Commission. *Community care: developing services for people with a mental handicap.* London: HMSO, 1987. (Occasional Paper No 4.)
15 Department of Health. *Caring for people; community care in the next decade and beyond.* London: HMSO, 1989. (Cm 849.)
16 Price J. A way through the maze. *Health Service Journal* 1991;101:23.
17 Teasdale G, Jennett B. Assessment of coma and impaired consciousness. *Lancet* 1974;ii:81-4.
18 Levin HS, O'Donnell VM, Grossman RG . The Galveston orientation and amnesia test: a practical scale to assess cognition after head injury. *Journal of Nervous and Mental Diseases* 1979;167:675-84.
19 Bond MR. Assessment of the psychosocial outcome of severe head injury. *Acta Neurochir (Wien)* 1976;34:57-70.
20 Rappaport M, Hall K, Hopkins K, Berleza T, Cope DN. Disability rating scale for severe head 'trauma' patients: coma to community. *Arch Phys Med Rehabil* 1980;63:118-23.
21 Raven J C. *Mill Hill vocabulary scale.* 2nd ed. London: H K Lewis, 1958.
22 Raven JC . *Guide to the standard progressive matrices.* London: H K Lewis, 1960.
23 Rey A. *L'examen clinique en psychologie.* Paris: Presses Universitaires de France, 1964.
24 Wechsler D. A standardised memory scale for clinical use. *J Psychol* 1945;19:87-95.
25 Buschke H, Fuld PA. Evaluating storage, retention and retrieval in disordered memory and learning. *Neurology* 1974;11:1019-25.
26 Lezak M. *Neuropsychological assessment.* Oxford: Oxford University Press, 1983.
27 Nelson HE. A modified card sorting test sensitive to frontal lobe defects. *Cortex* 1976;12:313-24.
28 Nelson HE. *The national adult reading test (NART) test manual.* Windsor: NFER-Nelson, 1982.
29 Levin HS, High WM, Goethe KE, Sisson RA, Overall JE, Rhoades HM, *et al.* The neurobehavioural rating scale: assessment of the behavioural sequelae of head injury by the clinician. *J Neurol Neurosurg Psychiatry* 1987;50: 183-93.

Appendix

Questionnaires used to assess patients

Data required	Questionnaire
Demographic data (injury characteristics, medical history, and time in treatment facilities)	Entry form*
Premorbid verbal intelligence	National adult reading test
Physical impairment	Bond neurophysical scale*
Cognitive impairment:	
Duration of post-traumatic amnesia	Galveston orientation and amnesia test*
Verbal and non-verbal intelligence	Rey figure, Mill Hill vocabulary, standard progressive matrices
Verbal and non-verbal memory	Logical memory, memory questionnaire (relatives and patients assessment), Buschke's test, digit span
Language comprehension and fluency	Token test, Wisconsin card sorting test, word fluency
Measures of affective, behavioural, and social function and of personality change in patient	Abbreviated form of Eysenck personality questionnaire, neurobehavioural rating scale, Leeds depression scale, general health questionnaire, personality before and after injury (relatives, and patients' assessment)
Standardised measures of impairment, disability, and handicap	Barthel index, extended Glasgow outcome scale, Glasgow assessment schedule, disability rating scale*
Relatives' perception of burden and change in affective an social function	Perceived burden scale, Leeds depression scale, general health questionnaire
Changes in patients' and relatives' housing, financial, vocational, recreational, and medical needs and ongoing requirements for care and support	Vocational and psychosocial disadvantage at follow up†
Satisfaction with services and information provided	Consumer satisfaction
Contact with services:	
As inpatient (neurosurgery, clinical psychology, paramedics, social work, other)	Therapeutic input questionnaires*
After discharge (psychiatry, clinical psychology, paramedics, social work, district nurse, community service volunteer, day centre, employment rehabilitation centre, other)	Therapeutic input questionnaires

*Questionnaires completed at entry and as required. Remaining questionnaires completed at 6, 12, and 24 months' follow up.
†Questionnaire completed by patient's relative unaccompanied. Remaining questionnaires completed by assessor with patient or relative as appropriate.

30 Goldberg DP. *The detection of psychiatric illness, by questionnaire. Maudsley monograph No 21.* Oxford: Oxford University Press, 1972.
31 Goldberg JD, Williams P. *A user's guide to the general health questionnaire.* Windsor: NFER-Nelson, 1988.
32 Snaith RP, Bridge GWK, Hamilton M. The Leeds scales for the self-assessment of anxiety and depression. *Br J Psychiatry* 1976;128:156-65.
33 Brooks DN. Psychological deficits after severe blunt head injury: their significance and rehabilitation. In: Osborne DJ, Gruneberg MM, Eiser JR, eds. *Research in psychology and medicine.* Vol 2. London: Academic Press, 1979:469-766.
34 Mahoney FH, Barthel DW. Function evaluation: The Barthel index. *Maryland State Medical Journal* 1965;14:61-5.
35 Jennett B, Bond MR. Assessment of outcome after severe brain damage: a practical scale. *Lancet* 1975;ii:480-4.
36 Livingstone MG, Livingston HM. The Glasgow assessment schedule: clinical and research assessment of head injury outcome. *International Rehabilitation Medicine* 1985;7:145.
37 SPSS. *Statistical package for the social sciences.* PC+version 3·1. Chicago: SPSS, 1989.
38 Everitt BS, Dunn G. *Applied multivariate data analysis.* London: Edward Arnold, 1991.
39 Statistics and Epidemiology Research Corporation. *EGRET: epidemiological graphics, estimation and testing.* Seattle, WA: Statistics and Epidemiology Research, 1990.
40 Scottish Agricultural Statistical Service. *REML user's manual.* 1987.
41 Intagliata J. Improving the quality of community care for the chronically mentally disabled: the role of case management. *Schizophr Bull* 1982;8: 655-74.
42 Henderson NG, Wallack SS. Evaluating case management for catastrophic illness. *Business in Health* 1987 Jan: 7-11.
43 Matson JD. Independent third party case management. In: Rapp D, ed. *Brain injury casebook. Methods for reintegration into home, school, and community.* Springfield, IL: Thomas, 1986.
44 Dixon TP, Goll S, Stanton KM. Case management issues and practices in head injury rehabilitation. *Rehabilitation Counselling Bulletin* 1988;31:325-43.
45 Bush GW. Catastrophic case management: thoughts from a teacher/consumer/advocate. *Brain Inj* 1989;3:91-100.
46 McKeganey N, Hunter DJ. "Only Connect. . . .": tightrope walking and joint working in care of the elderly. *Policy and Politics* 1986;14:335-60.
47 Friend JK. Planning—the act of responsible scheming. *Linkage* 1983;7:8-15.
48 Ovretveit J. Case management: notes for the perplexed. *Clinical Psychology Forum* 1991;36:3-7.
49 Bachrach LL. Case management: toward a shared definition. *Hosp Community Psychiatry* 1989;40:883-4.
50 Kanter J. Clinical case management: definition, principles, components. *Hosp Community Psychiatry* 1989;40:361-8.
51 Holloway F. Case management for the mentally ill: looking at the evidence. *Int J Soc Psychiatry* 1991;37;2-13.
52 Prigitano GP, Fordyce DJ, Zeiner H, eds. *Neuropsychological rehabilitation after brain injury.* Baltimore, MD: Johns Hopkins University Press, 1986.
53 Burke WH, Wesolowski MD, Guth MC. Comprehensive head injury rehabilitation: an outcome evaluation. *Brain Inj* 1988;2:313-22.
54 Wehman PH, Kreutzer JS, West MD, Shevron PD, Zasler ND, Groah CH, *et al.* Return to work for persons with traumatic brain injury: a supported employment approach. *Arch Phys Med Rehabil* 1990;71:1047-52.
55 Franklin JL, Solovitz B, Mason M, Clemons JR, Miller GE. An evaluation of case management. *Am J Public Health* 1987;77:674-8.
56 Brooks DN, McKinlay WW, Symington C, Beattie A, Campsie L. Return to work within the first seven years of severe head injury. *Brain Inj* 1987;1: 5-19.

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Errors in blood transfusion in Britain: survey of hospital haematology departments

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Blood transfusion laboratories aim to provide a high quality service with minimum risk to patients. British guidelines for good practice in transfusion medicine exist,[1] and most hospitals have local protocols. If these procedures fail incompatible blood may be transfused, which could lead to potentially fatal haemolytic reactions. As no system of collecting data centrally exists in Britain failures of the transfusion process are not documented. In contrast, in the United States the Food and Drug Administration requires all establishments that are registered to process blood to report all errors and deaths associated with transfusion. We aimed to investigate the incidence of recognised transfusion errors in Britain in 1990 and 1991 and the cause and clinical outcome of these errors.

Methods and results

A short questionnaire about errors in blood transfusion procedures and the outcome of these errors was sent to the 400 hospital haematology laboratories in Britain in August 1992. In all, 245 (61%) laboratories responded: these supplied 3·3 million red cell units for transfusion (about three quarters of all the red cell and whole blood units collected annually in Britain). A third of responding laboratories reported incidents in which patients received the wrong blood. The table shows the results of the survey.

Comment

The error rates that we found are similar to those reported in studies from the United States.[2,3] Our data do not allow the calculation of error rates per patient transfused, which must be substantially higher than the rates in the table since most patients receive several units of blood. Several respondents indicated that multiple errors had contributed to the wrong blood being transfused; similar findings have been reported elsewhere.[4]

Twenty respondents reported (without having been asked in the questionnaire) 100 incidents in which the wrong blood sample was submitted in the compatibility tube and the error was detected in the laboratory because of a previous blood sample on the same patient. On the basis of this information and comments volunteered by other respondents, we estimate that the incidence of wrong blood being submitted in tubes is about 1/6000 red cell units issued.

Only a third of unmatched transfusions are incompatible with ABO blood groups; of these, only about a tenth are associated with a fatal outcome.[4] We should not, however, be complacent as these figures emphasise that data on mortality and morbidity, even if complete, can give only a substantial underestimate of the incidence of important failures in the transfusion process.

The data available are inadequate to determine the true incidence of errors in transfusion. All the errors found in this survey were reported by only a third of the responding laboratories; it would be surprising if the remaining laboratories had experienced no errors over two years.

We propose several ways of improving the quality and safety of the blood transfusion process in Britain. Firstly, a national system should exist for reporting critical transfusion incidents, especially those in which the wrong blood is transfused and "near misses." Regular reports to transfusion laboratories and hospital transfusion committees could be incorporated in the national external quality assurance scheme.

Results of questionnaire about errors in blood transfusion sent to 400 hospital haematology departments, of which 245 responded

	Wrong blood was transfused
Source of information (No of laboratories):	
Memory	126
Memory and written records	87
Written records	11
Not known	21
No of incidents (incidence per units supplied for transfusion)	
Total	111* (1/29 000)
Cause or place of error:	
Wrong blood in tube	23
Laboratory	6
Ward or theatre staff checked or transfused wrong blood	82
Outcome of error:	
Death	6 (1/550 000)
Morbidity	12 (1/275 000)
No adverse effect	93 (1/36 000)

*These were reported by 79 laboratories.