Neurobehavioural symptoms one year after a head injury

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Background Neurobehavioural symptoms are common immediately after a minor head injury but have not been studied one year after the injury.

Aims To estimate the rate and pattern of neurobehavioural symptoms one year after a head injury of varying severity.

Method Adults who had been hospitalised after a head injury (n=196, 164 of whom had a face-to-face interview) and showed indirect evidence of brain assault were assessed for the presence of neurobehavioural symptoms with the help of a behaviour rating scale.

Results About 40% had three or more symptoms. Individual symptoms varied among 3% (social disinhibition), 15% (lack of initiative) and 35% (irritability) of the cohort. Premorbid factors such as lower social class and lower educational achievement, head-injury-related factors such a low Glasgow coma score, and outcome-related factors such as the presence of a disability according to the Edinburgh Rehabilitation Status Scale and psychiatric caseness according to the Clinical Interview Schedule – Revised, significantly influenced the rate and the pattern of behavioural symptoms. The pattern of symptoms varied between age groups and according to the severity of the head injury.

Conclusions A significant proportion of patients with varying degrees of severity of head injury showed behavioural symptoms after one-year of head injury.

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Despite the emphasis placed on physical disability following a head injury, it is cognitive and neurobehavioural problems which give rise to major morbidity that impairs the capacity to return to work and maintain social activities (Medical Disability Society, 1988). Neurobehavioural symptoms such as poor concentration and memory, lack of initiative, difficulty in planning, fatigue, irritability, mood swings, headaches and dizziness are commonly observed in patients after a head injury and may persist in a proportion of cases long after the initial injury. This cluster of symptoms has collectively been labelled 'post-concussional syndrome', particularly in the context of a minor head injury. However, both the diagnosis and the aetiology of post-concussional syndrome have remained controversial. These symptoms have been shown to be most prevalent in the early weeks following a minor head injury and, subsequently, tend to subside – although in a proportion of cases these symptoms can be detected 6–12 months after the head injury (Rutherford *et al*, 1978; Levin *et al*, 1987; Lishman, 1988; Fenton *et al*, 1993).

Lishman (1988) formulated that the initial risk factors precipitating neurobehavioural symptoms associated with post-concussional syndrome are mainly organic, whereas the risk factors associated with persistent symptoms are more psychosocial in nature. However, the occurrence of behavioural symptoms is likely to depend on a complex interaction of many factors. These factors may include: (a) sociodemographic variables such as patients' age, gender and social class; (b) premorbid factors such as premorbid personality, previous history of head injury, history of a psychiatric illness, premorbid alcohol intake, premorbid occupation, premorbid IQ and level of educational achievement; (c) factors related to the head injury such as initial severity of head injury and its subsequent complications, type of head injury, type of accident and type and severity of brain damage; (d) post-injury factors such as level of alcohol intake after the head injury, level and type of treatment and support available after the head injury; and (e) outcome factors such as the global outcome, associated cognitive deficits and presence of psychiatric illness. In the past, most studies included patients from specialist centres and assessed them within the first few weeks to months of the injury. Most assessed specific areas of deficits. We have, therefore, decided to study the rate of behavioural symptoms one year after a head injury in a group of hospitalised patients with varying degrees of severity of head injury who came from a known geographical area. We carried out a comprehensive assessment of outcome with standardised assessment methods and evaluated the relative impact of various risk factors on the rate and pattern of behavioural symptoms.

METHOD

Subjects

Over a one-year period 3667 adults over the age of 17 years with a diagnosis of head injury (trauma to the head) had attended the Accident and Emergency Department of the Cardiff Royal Infirmary in Wales. Of these, 14% (n=515) were admitted to a hospital (data from Cardiff Royal Infirmary Accident and Emergency Department). This excluded patients who only had injury to facial, nasal and orbital bones. Of those who were admitted to hospital, 86% (n=442) had a known address within the South Glamorgan Health District in Wales (general adult population around 300 000). By using ICD–9 (World Health Organization, 1978) codes, the names of all those patients who were admitted to a hospital between 1 July 1994 and 30 June 1995 with a diagnosis of a head injury (n=346) were ascertained from the Health Authority's central database. According to the case notes, 196 patients met at least one of the following inclusion criteria: (a) a period of unconsciousness; (b) evidence of fracture on skull X-rays; (c) contusion or haemorrhage in computerised tomography/magnetic resonance imaging scans; (d) focal neurological signs; (e) a Glasgow Coma Scale (GCS; Jennett & Bond, 1975) score of less than 15. These 196 patients formed the cohort of the study. The above inclusion criteria were used to emphasise

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the brain injury associated with the head trauma.

Patients were invited, by post, to take part in the study. Those who did not respond received a reminder letter after six weeks and again 12 weeks after receiving the initial letter. In some cases patients were contacted by telephone or through their general practitioners. Consultants under whose care the patients were admitted gave consent for the research staff to examine the patients' medical case notes. The study was approved by the local ethics committee. After a complete description of the study to the subjects, written, informed consent was obtained, a copy of which was sent to the patients' general practitioners.

Instruments used

A purpose-designed questionnaire was devised based on the head injury evaluation chart (first and second part) produced by the European Brain Injury Society (Truell *et al*, 1994) for the purpose of collecting data from patients and their relatives. The data for the questionnaire were collected from patients' case notes and from a face-to-face interview with the patients and their relatives, primarily in their home settings. Two research staff (I.L. and C.K.) interviewed these patients and their relatives approximately one year after the head injury. Data were collected on the following: patients' age, gender, date of head injury, severity of head injury according to initial GCS scores (mild=15–13, moderate=12–9, severe <9), history of alcohol consumption prior to head injury, previous history of head injury, past history of psychiatric illness, patients' and paternal social class according to their occupation, and number of years in formal education. Although two research staff (I.L. and C.K.) collected information regarding the length of post-traumatic amnesia (PTA), they were not confident that these data were reliable. Therefore, in this study we have primarily used the GCS score to define the severity of head injury.

Assessment of outcome

During the interview the research staff assessed patients' overall disability using the Glasgow Outcome Scale (GOS; Jennett *et al*, 1981; 1=dead, 2=persistent vegetative stage, 3=severe disability, 4=moderate disability, 5=no disability). The GOS was supplemented by the Edinburgh Rehabilitation Status Scale (ERSS; Affleck *et al*, 1988) for the assessment of global outcome because it places more emphasis on psychosocial outcome. A score of more than two was accepted as evidence of presence of disability according to the ERSS (this arbitrary cut-off score was used by McClelland *et al*, 1994 and is cited in Deb *et al*, 1998). Patients' overall cognitive state was assessed by using the score according to the Mini-Mental State Examination (MMSE; Folstein *et al*, 1975). A score of less than 24 was taken as evidence of the presence of a cognitive deficit.

Patients' premorbid IQ was assessed using the National Adult Reading Test (NART; Nelson, 1982). The Clinical Interview Schedule–Revised (CIS–R; Lewis *et al*, 1992) along with the Psychosis Screening Questionnaire (PSQ; Bebbington & Nayani, 1995) were administered to assess psychiatric caseness (defined as a score of 12 or more on the CIS–R scale or a positive score on one of the eight psychotic symptoms of the PSQ). Both the CIS–R and the PSQ were shown to be reliable instruments for the detection of psychiatric caseness among the general population (Meltzer *et al*, 1995).

Assessment of neurobehavioural symptoms

With the help of a purpose-designed behaviour checklist the following 16 neurobehavioural symptoms were recorded on a 1–6 ranking scale: impatience, irritability, mood swings, slowness in thinking, sleep problems, fatigue, safety hazard, poor memory, difficulty in planning, lack of initiative, lack of social or sexual inhibitions, depressed mood, dependence on others, problems with socialisation, eating problems and verbal outbursts. The research staff asked patients about the above behaviours and sought corroboration of their answers from a relative or a carer where possible. Patients and relatives were interviewed at the same time, approximately within one year after the head injury. For the purpose of data analysis the behaviours were recoded under three headings: (a) behaviour absent; (b) behaviour present but causing mild to moderate problems; and (c) behaviour present and causing moderate to severe problems.

Statistical analysis

The data were analysed using SPSS for Windows (Norušis, 1993) on a personal computer equipped with a 75 Pentium processor. The analysis involved an estimation of percentages and 95% confidence intervals (CIs) of the rate of neurobehavioural symptoms. Chi-squared analysis was used to compare the rate of neurobehavioural symptoms in different subgroups of the cohort. A logistic regression analysis of the factors which might affect the rate and pattern of neurobehavioural symptoms was also carried out.

In a brief paper (Deb *et al*, 1998) we have reported data on global outcome according to GOS, ERSS, Barthel index, MMSE score, CIS–R and common behavioural problems in patients with mild head injuries (GCS score of 15–13; *n*=148) from the current cohort. In another paper (Deb *et al*, 1999) we have reported the details of psychiatric illnesses diagnosed according to the Schedules for Clinical Assessment in Neuropsychiatry (SCAN; Wing *et al*, 1990) interview on the whole cohort (*n*=196) and compared our data with that of a household survey of the general population. In the current paper we shall describe in detail the rate and pattern of neurobehavioural symptoms in the whole cohort (*n*=196) and in the subgroups.

RESULTS

Background data

The age range of the cohort was between 18 and 94 years (median=43.5, quartile=28). One hundred and twenty-seven (65%) were male and 69 (35%) were female. Seventy-eight per cent sustained a minor head injury and 22% a moderate to severe degree of head injury according to the GCS score. Thirty-two of these patients were either deceased or were not available for an interview. According to the GOS, one patient was in a persistent vegetative state, 12 (7.3%) developed a severe disability, 46 (28%) a moderate disability and 105 (64%) had no disability at one-year follow-up. Those patients who had a severe or a moderate degree of disability were deemed to have an 'unfavourable' outcome and those who had no disability were deemed to have a 'favourable' outcome according to the GOS. According to the ERSS rating, 36.6% (*n*=60) of the whole cohort showed a significant disability. Twenty-eight patients (17%) were diagnosed as psychiatric cases according to CIS–R and PSQ. Forty-two patients (26%) scored less than 24 on the MMSE. Cognitive impairment was more

Table 1 Rate and severity of different neurobehavioural symptoms among 164 patients with head injuries

Symptom	Absent n (%)	Severe/moderate problem n (%)	Moderate/mild problem n (%)
Impatience	114 (69.5)	24 (14.6)	26 (15.9)
Irritability	106 (64.7)	23 (14)	35 (21.3)
Mood swings	118 (72)	23 (14)	23 (14)
Slowness in thinking	134 (82)	15 (9)	15 (9)
Sleep problems	112 (68.4)	28 (17)	24 (14.6)
Socialisation problems	120 (73.2)	22 (13.4)	22 (13.4)
Fatigue	125 (76.2)	21 (12.8)	18 (11)
Lack of initiative	139 (85)	13 (8)	12 (7)
Poor memory	112 (68.3)	22 (13.4)	30 (18.3)
Difficulty in planning	144 (88)	10 (6)	10 (6)
Socially disinhibited behaviour	159 (97)	1 (0.6)	4 (2.4)
Depressed mood	132 (80.6)	15 (9)	17 (10.4)
Verbal outbursts	139 (85)	10 (6)	15 (9)

common in the elderly ($Z=6.643$, $P<0.005$) and in the severely head injured group ($Z=-1.120$, $P<0.05$).

Rate and severity of neurobehavioural symptoms

The rate and severity of different neurobehavioural symptoms among the whole cohort of 164 patients with head injuries who were interviewed and various subgroups, are shown in Tables 1 and 2. Overall, 101 patients (61.6%; 95% CI 53.6–68.9%) had one or more behavioural symptoms. Sixty-five patients (39.6%; 95% CI 32.2–47.6%) had three or more of these symptoms.

Thirty-six patients (22%; 95% CI 16–29.2%) had one or two symptoms, whereas 34 patients (20.7%; 95% CI 15–28%) had 3–6 symptoms and 31 patients (18.9%; 95% CI 13.4–26%) had more than six neurobehavioural symptoms.

Risk factors related to neurobehavioural symptoms

To assess the relative influence of various risk factors on the rate of behavioural symptoms, a logistic regression analysis was carried out by using the presence of one or more neurobehavioural symptoms as a dependent variable and the following factors as covariates: (a) socio-demographic factors such as age and gender; (b) premorbid factors such as the number of years in formal education, patients' and paternal social class, history of pre-injury alcohol intake, history of previous head injury, history of psychiatric illness, and premorbid IQ according to the NART; (c) head injury-related factors such as the severity according to the GCS score; and (d) outcome-related factors such as the ERSS score, MMSE score and CIS–R score. Statistically significant associations were found with premorbid factors such as a lower number of years in formal education ($P<0.05$), lower paternal social class ($P<0.005$), head injury-related factors such as a lower GCS score ($P<0.05$; but not with the length of PTA), and outcome-related factors such as a higher ERSS ($P<0.02$) and CIS–R score ($P<0.01$). Thirty-four (21%) patients were involved in compensation claims at the time of the study. No statistically significant difference emerged in the rate of neurobehavioural symptoms between those who were and were not involved in compensation claims (60% power at 5% significance level).

It is possible that risk factors are more influential in causing behavioural symptoms in patients with minor head injuries than in those with severe to moderate head injuries. To assess this hypothesis, the whole cohort was divided into two groups, namely patients with minor head injuries and patients with moderate to severe head injuries. A logistic regression analysis was then carried out using the same covariates as before in each group. No significant association was detected between any of the

Table 2 Number (percentage) of patients with multiple neurobehavioural symptoms in different subgroups

Number of neurobehavioural symptoms	Gender		Age group, years			MMSE score		CIS–R score		GOS outcome		GCS score	
	Male (n=110)	Female (n=54)	18–40 (n=83)	41–64 (n=37)	Over 64 (n=44)	<24 (n=42)	≥24 (n=121)	<12 (n=135)	≥12 (n=28)	Unfavourable (n=59)	Favourable (n=105)	13–15 (n=134)	<13 (n=30)
None	41 (37.3)	22 (40.7)	36 (43.4)	13 (35)	14 (31.8)	12 (28.6)	51 (42)	59 (43.7)	4 (14.3)	8 (13.6)	55 (52.4)	57 (42.5)	6 (20)
1–2	24 (21.8)	12 (22.2)	16 (19.3)	7 (18.9)	13 (29.5)	9 (21.4)	27 (22.3)	35 (25.9)	1 (3.6)	7 (11.9)	29 (27.6)	30 (22.4)	6 (20)
3–6	24 (21.8)	10 (18.5)	14 (16.9)	10 (27)	10 (22.7)	10 (23.8)	24 (19.8)	26 (19.3)	8 (28.6)	20 (33.8)	14 (13.3)	23 (17.2)	11 (36.7)
More than 6	21 (19)	10 (18.5)	17 (20.5)	7 (18.9)	7 (15.9)	11 (26.2)	19 (15.7)	15 (11)	15[1] (53.5)	24 (40.7)	7[2] (6.7)	24 (17.9)	7[3] (23.3)

MMSE, Mini Mental State Examination; CIS–R, Clinical Interview Schedule–Revised; GOS, Glasgow Outcome Scale; GCS, Glasgow Coma Scale.

1. $\chi^2=8.18$, d.f.=3, $P<0.05$.
2. $\chi^2=36.37$, d.f.=3, $P<0.0005$.
3. $\chi^2=63.32$, d.f.=3, $P<0.0005$.

risk factors and the rate of behavioural symptoms among those with severe to moderate head injuries. In the mild head injury group, significant associations were detected with a fewer number of years in formal education ($P<0.02$), a higher ERSS score ($P<0.02$) and a higher CIS–R score ($P<0.005$). There was also a trend of association between patients' lower social class and the presence of neurobehavioural symptoms ($P=0.05$), which did not reach a level of statistical significance.

Pattern of neurobehavioural symptoms

Although in the present study age did not affect the rate of behavioural symptoms, the possibility remained that the pattern of spread of individual neurobehavioural symptoms might vary according to age or according to the severity of the head injury. To assess this hypothesis, the rates of individual symptoms were compared in the subgroups of the cohort according to the age of the patients and the severity of the head injury. Symptoms with inter-group differences shown in the rates of behavioural symptoms are reported in Tables 3 and 4.

Clustering of neurobehavioural symptoms

A factor analysis was carried out to establish whether the behavioural symptoms tend to cluster or not (see Table 5). An analysis of variance between these three factors and different subgroups showed a positive correlation between Factor 1 and age (i.e. the higher the age, the more common the factor), a negative correlation between Factor 3 and age (i.e. the lower the age, the more common the factor) but no correlation between Factor 2 and age. No statistically significant correlation was found between any of the factors and either gender group or severity of the head injury groups. Twenty-one patients (12.8%, 95% CI 8.28–19.13%) had a diagnosis of depressive illness (Deb *et al*, 1999). Twenty-four patients (14.6%) had a diagnosis of psychiatric caseness and also showed behavioural symptoms. Similarly, in 27 (16.5%) cases both cognitive deficit (MMSE score <24) and behavioural symptoms were present.

Eighty-five per cent of those who had a psychiatric illness showed behavioural symptoms, whereas 18% of those who showed behavioural symptoms had a psychiatric illness. This difference was statistically significant ($\chi^2=6.47$, d.f.=1, $P=0.01$). However, 67% of those whose MMSE score was below 24 showed behavioural symptoms, and 28% of those who showed behavioural symptoms, had an MMSE score of less than 24. This difference was not statistically significant. Whereas the overlap between psychiatric caseness and behavioural symptoms was observed consistently across the subgroups of the cohort, the overlap between cognitive deficit and behavioural symptoms was observed primarily in elderly patients and in patients with a moderate to severe degree of head injury.

DISCUSSION

Methodological difficulties

Despite our attempt to collect a population-based cohort it is likely that by using ICD–9 codes to access the health authority's database, an incomplete list of hospitalised patients with head injuries was collected (Deb, 1999). Also, because of the selection criteria used in the present study, the data presented in this paper are more relevant to those at the severe end of the minor head injury group, rather than the whole spectrum of patients with minor head injuries. Some retrospective data collection, such as GCS score which was gathered from medical case notes, remains a likely source of unreliability. In a number of case notes no documentation was found regarding the length of the coma or the GCS score, and case notes were not available for some patients. The neurobehavioural check-list used in this study has not been tested for inter-rater reliability. However, given the simple nature of the check-list and the standard method of scoring, these data are likely to be reliable.

Table 3 Number (percentage) of patients with different neurobehavioural symptoms in three age groups

Age group	Dependence	Disinhibition	Difficulty in planning	Poor memory	Safety hazard	Fatigue	Sleep problems	Slowness in thinking
18–40 years (n=83)	4 (4.8)	2 (2.4)	8 (9.6)	19 (22.9)	6 (7.2)	23 (27.7)	29 (34.9)	11 (13.3)
41–64 years (n=37)	4 (10.8)	1 (2.7)	4 (10.8)	15 (40.5)	1 (2.7)	10 (27)	15 (40.5)	4 (10.3)
Over 64 years (n=44)	17 (37.8)[1]	2 (4.4)	8 (17.8)	18 (40)	8 (17.8)[2]	6 (13.3)	8 (17.8)	15 (33.3)[3]

1. $\chi^2=25.35$, d.f.=2, $P<0.0001$.
2. $\chi^2=6.2$, d.f.=2, $P<0.05$.
3. $\chi^2=9.65$, d.f.=2, $P<0.01$.

Table 4 Number (percentage) of patients with different neurobehavioural symptoms in groups according to Glasgow Coma Scale (GCS) scores (only the symptoms which have shown statistically significant inter-group differences are shown here)

GCS score	Dependence	Depressed mood	Difficulty in planning	Poor memory	Mood swings	Irritability
13–15 (minor head injury) (n=134)	16 (11.9)	22 (16.3)	13 (9.6)	37 (27.4)	33 (24.4)	41 (30.4)
3–12 (moderate/severe head injury) (n=30)	9 (30)[1]	10 (33.3)[2]	7 (23.3)[3]	15 (50)[4]	13 (43.3)[5]	17 (56.7)[6]

1. $\chi^2=6.28$, d.f.=1, $P<0.02$.
2. $\chi^2=4.55$, d.f.=1, $P<0.05$.
3. $\chi^2=4.32$, d.f.=1, $P<0.05$.
4. $\chi^2=5.80$, d.f.=1, $P<0.02$.
5. $\chi^2=4.35$, d.f.=1, $P<0.05$.
6. $\chi^2=7.44$, d.f.=1, $P<0.01$.

Table 5 Results of factor analysis of neurobehavioural symptoms

Neurobehavioural symptom	Factor 1	Factor 2	Factor 3
Difficulty in planning	0.808		
Slowness in thinking	0.797		
Dependence on others	0.749		
Lack of initiative	0.734		
Social disinhibiiton	0.551		
Safety hazard	0.507		
Fatigue		0.780	
Depressed mood		0.770	
Sleep problems		0.749	
Eating problems		0.585	
Irritability			0.838
Impatience			0.820
Mood swings			0.604
Verbal outbursts	0.506		0.573

Rate of neurobehavioural symptoms

It is difficult, in the absence of population-based prevalence figures and in the absence of a control group, to assess whether behavioural symptoms shown by the patients in the present study were in anyway related to their head injury. However, the difficulty of finding a properly matched control group for patients with head injuries is well known because these patients often possess certain premorbid characteristics which are not representative of the general population. One previous study (Gouvier *et al*, 1988), however, showed a high rate of neurobehavioural symptoms such as irritability (30.6–42.9%), tiredness (27.6–34.7%) and impatience (42.3–49%) among young adult students. In the present study, although a substantial proportion of the study cohort showed at least one of the neurobehavioural symptoms, the rate of individual symptoms varied between 15% (lack of initiative) and 35% (irritability) of the cohort. Meltzer *et al* (1995) found fatigue in 30%, sleep problems in 26%, irritability in 22% and depressed mood in 12% of the adult Welsh general population (aged 16–64 years).

Risk factors affecting neurobehavioural symptoms

Lishman (1988) hypothesised originally that symptoms of post-concussional syndrome in patients with head injuries are often precipitated by organic factors in the beginning, but are perpetuated by psychosocial factors. The controversy regarding the organic *v.* environmental aetiology has lasted ever since. Whereas in the past, the effect of individual risk factors on behavioural symptoms was studied, in the present study the relative influence of an array of risk factors on the same cohort was assessed.

Behavioural symptoms were found to be more common among the severe to moderate head injury group compared with the minor head injury group. It is, however, important to emphasise here the difficulty of defining the initial severity of the head injury. Retrospective collection of GCS scores is open to criticism, and, in the present study, the data collected on the length of PTA were deemed unreliable. It is also important to note that the difference in the rate of behavioural symptoms according to the severity of head injury only reached a marginal level of significance according to the GCS score, and was not found to be statistically significant according to PTA duration. Similarly, the rate of symptoms was not affected by compensation claims. These findings may point more towards an organic aetiology for the symptoms. The association found in this study between a poor global outcome and the rate of behavioural symptoms may reflect a confounding effect between the two conditions rather than a causal link. Similarly, the association found between psychiatric caseness and behavioural symptoms may merely reflect an overlap between the two diagnoses.

Pattern of neurobehavioural symptoms

Although no association was detected between the rate of behavioural symptoms and age, there were significant differences between age groups in terms of individual symptoms. Most of the differences were predicted; however, there were some exceptions. For example, both sleep problems and fatigue were more common among younger patients than the elderly, and lack of inhibition was more common among elderly compared with younger patients. Similarly, the pattern of symptoms in patients with different degrees of severity of head injury was largely predictable, with some exceptions. Depressed mood, mood swings and irritability were all more common in the moderate to severe head injury group compared with the minor head injury group.

Clustering of neurobehavioural symptoms

The clustering of symptoms found according to the factor analysis is, to some extent, clinically expected. However, this remains a statistical exercise in the absence of any physiological basis or prognostic value for each of these clusters. Similar clustering of behavioural symptoms following head injury has been reported before (Levin *et al*, 1987; Bohnen *et al*, 1992; Cicerone & Kalmar, 1995).

Although there was some association between these factors and age groups, the lack of association with these factors and gender groups as well as the severity of head injury group was not totally expected. It is possible that a proportion of elderly patients who suffered from a mild head injury had pre-existing brain damage (possibly due to a dementing illness) as is evident from their low MMSE score. This pre-existing brain damage may have given rise to a cluster of symptoms predisposed by organic factors, thus blurring the correlation between symptom clusters and the severity of head injury. Whether there is an association between these factors and the areas of the brain damaged during the head injury remains to be discovered in future research.

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CLINICAL IMPLICATIONS

- Approximately 40% of patients with head injuries had three or more neurobehavioural symptoms one year after head injury.
- Individual symptoms varied among 3% (social disinhibition), 15% (lack of initiative) and 35% (irritability) of the cohort.
- Certain premorbid and post-injury factors influenced the rate of behavioural symptoms, but compensation claims did not affect the rate of symptoms.

LIMITATIONS

- It is likely that an incomplete list of hospitalised patients with head injuries was obtained using ICD–9 codes to access the health authority's central database.
- The behaviour rating scale used for the detection of neurobehavioural symptoms was not tested for interrater reliability.
- No control group was available for comparison.

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