



BMJ Open Incomplete recovery in patients with minor head injury directly discharged home from the emergency department: a prospective cohort follow-up study

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To cite: Coffeng SM, Jacobs B, Kim LJ, *et al*. Incomplete recovery in patients with minor head injury directly discharged home from the emergency department: a prospective cohort follow-up study. *BMJ Open* 2022;**12**:e057308. doi:10.1136/bmjopen-2021-057308

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2021-057308>).

Received 14 September 2021
Accepted 18 May 2022



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ABSTRACT

Objectives To determine the frequency of post-traumatic complaints and recovery rate of non-hospitalised patients with minor head injury (MHI) and their relationship with demographic and injury characteristics. We also evaluated the differences between patient groups in this least severe category of brain and head injury.

Design Prospective cohort follow-up study.

Setting Patients admitted to the emergency department (ED) of a tertiary hospital in the Netherlands.

Participants 242 patients with MHI (n=100 with head injury only and n=142 with mild traumatic brain injury (mTBI)) discharged home directly after evaluation at the ED.

Outcome measures The primary outcome measure was incomplete recovery at 3 months measured by the Glasgow Outcome Scale-Extended score <8. Secondary outcome measures were number of post-traumatic complaints assessed 2 weeks and 3 months postinjury by a standardised questionnaire. Also the number of patients that visited their general practitioner because of persistent complaints was determined.

Results Three months postinjury 48% of patients reported more than one post-traumatic complaint. Half (51%) of patients showed incomplete recovery. Incomplete recovery was associated with headache directly postinjury (OR 3.27, 95% CI 1.28 to 8.34), age (OR 1.02, 95% CI 1.00 to 1.05) and the number of post-traumatic complaints (OR 1.24, 95% CI 1.09 to 1.40) and depression (OR 6.31, 95% CI 1.24 to 32.00) 2 weeks postinjury. Incomplete recovery was comparable between the head injury only and mTBI group (55% vs 50%, 95% CI –12.5 to –23.0). In total 36 MHI patients (28%) visited their general practitioner because of complaints related to their head injury.

Conclusion Half of the non-hospitalised patients with MHI experienced incomplete recovery after 3 months without differences between head injury only and mTBI patients. Therefore, early identification of patients at risk for incomplete recovery must be started at the ED to provide appropriate aftercare to avoid long-term post-traumatic complaints.

INTRODUCTION

Minor head injury (MHI) is one of the most common and increasing causes of admission

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study provides valuable information about the outcome and post-traumatic complaints of patients with minor head injury not admitted to the hospital.
- ⇒ By dividing minor head injury patients into a group with and without signs of mild traumatic brain injury we were able to compare their recovery rate resulting in valuable information for clinical practice.
- ⇒ A limitation is that follow-up of the included patients was incomplete, which might carry the risk of over-estimation of incomplete recovery.
- ⇒ A second limitation is that this is an explorative single centre study which limits generalisability and needs validation in a bigger patient cohort.

to the emergency department (ED).^{1 2} MHI is the least severe category within the spectrum of traumatic head and brain injury and includes patients with and without the traditional mild traumatic brain injury (mTBI) characteristics comprising loss of consciousness (LOC), post-traumatic amnesia (PTA) and focal neurological deficit.³ The majority of patients with MHI will be discharged home after the initial neurological examination and possible additional radiological evaluation at the ED.^{4 5}

Although most patients recover within several weeks after MHI, up to 40% will have persistent post-traumatic complaints and incomplete recovery.^{6–11} Post-traumatic complaints, including headache, fatigue, irritability, concentration problems and symptoms of depression or anxiety are reported with considerable impact on resumption of work and social activities.^{12 13} As a consequence, the societal impact and costs related to delayed recovery are substantial.¹⁴ Previous research on predictors for persistent post-traumatic complaints after MHI showed a variety of risk factors including both preinjury as well as trauma-related factors.^{7 8 15} However, these studies included only patients with mTBI characteristics,^{8 15} with short follow-up⁸ or focused on a



small group with many post-traumatic complaints⁷ not representing the entire non-hospitalised MHI population often seen at the ED.

In general, outpatient follow-up is not part of standard care in non-hospitalised MHI patients contrary to the patients who are admitted to the ward.¹⁶ As a consequence, early identification of patients at risk for persistent post-traumatic complaints will be challenging, especially because patients with post-traumatic symptoms mostly seek help late after injury.⁴ This is unfortunate, since therapeutic interventions, like telephonic counselling and cognitive behavioural therapy, are especially effective to reduce the incidence of chronic complaints early after trauma.^{17 18}

As non-hospitalised patients with MHI constitute a substantial part of the patient population admitted to the ED it is important to evaluate the post-traumatic course and risk for incomplete recovery in order to determine whether these patients should receive additional follow-up and treatment. This is in particular important as most guidelines comprise patients with mTBI, but not those with head injury only. Therefore, the goal of this study was to determine the frequency of post-traumatic complaints and recovery pattern of non-hospitalised patients with MHI and to identify the characteristics of the patients at risk for incomplete recovery and whether these post-traumatic complaints caused patients to seek medical help after discharge. In addition, we investigated the differences in recovery patterns between patients with head injury only and mTBI to gain insight whether this distinction in these MHI categories at the ED is justified.

MATERIAL AND METHODS

Study setting and design

This is a prospective cohort study conducted at the University Medical Center Groningen, a tertiary level-1 trauma centre with 25.000 ED visits yearly. Patients with MHI who were discharged home from the ED (non-hospitalised), were included from 1 August 2016 until 31 December 2018. MHI was defined as: blunt head injury with a Glasgow Coma Scale (GCS) score of 13–15 at presentation at the ED. LOC and PTA were registered and when present had to be less than 30 min (LOC) or 24 hours (PTA). CT scan was performed according to the national CT guideline based on the CHIP decision rule.¹⁹ If a head CT scan was not required according to the CT guideline, we assumed that an intracranial haemorrhage was highly unlikely. Before discharge, all patients received a patient flyer as part of our standard care, providing general information about MHI and complaints after trauma and which symptoms after trauma necessitate medical assistance. Patients did not receive outpatient follow-up routinely. We obtained institutional ethics and research board approval and the need for informed consent was waived.

Study population

Patients with MHI were identified at the ED by the resident neurology or the emergency physician and included consecutively. Inclusion criteria were: blunt head injury (including significant trauma to the face), discharged home from the ED, age >15 years and comprehension of Dutch language. Exclusion criteria were: age <16 years, initial GCS at the ED <13, traumatic abnormalities at head CT scan, addiction to drugs or alcohol, severe neurological disease which interfere with study follow-up including prohibiting understanding and completion of questionnaires, psychiatric disease that required admission, time since trauma >24 hours and the inability for further follow-up (like language barrier or no permanent home address). For analysis purposes we divided the MHI patients into two subgroups: a head injury only-group (patients without PTA, LOC and GCS 15 at the ED) and the mTBI-group (patients with LOC and/or PTA and GCS 13–15 at the ED).

Methods of measurement

Demographic, patient and injury-related characteristics were derived at the ED from the digital patient files. After informed consent all patients received a questionnaire at the ED to evaluate their complaints directly after injury. Preinjury mental health problems were defined as symptoms or disease necessitating treatment by a psychiatrist, psychologist and/or using psychotropic medication. A 7-point scale was used to define Dutch education level by years of education (YoE). For analysis, we dichotomised education in a low (finished secondary school (10–11 YoE or less) and a high (finished secondary school (12–16 YoE) or university degree) educational level. Traffic accidents were defined as any accident that occurred in traffic (combined low and high velocity traumas).

Questionnaires

All patients received questionnaires (web-based or by regular mail) at 2 weeks and 3 months postinjury to evaluate post-traumatic complaints and emotional distress. Patients completed the questionnaires themselves, without additional interview by telephone or at the outpatient clinic. Final recovery was evaluated at 3 months postinjury. At this time point, additional information on the follow-up and aftercare was collected by questionnaires regarding visits to a general practitioner, medical specialist (ie, neurologist, (trauma)surgeon, rehabilitation physician) and/or physiotherapist. Only referrals initiated by the patients themselves in consultation with their general practitioner were recorded, none of these appointments were already made at the ED. In absence of initial response of the patient, reminders were sent.

The following questionnaires were used:

*Head Injury Symptom Checklist:*²⁰ This questionnaire contains 19 of the most common post-traumatic symptoms and is derived from the Rivermead Post-concussion Symptoms Questionnaire. Preinjury and current symptom levels are indicated for each symptom as a score from 0

to 2 (0=never, 1=sometimes, 2=often). Each separate post-traumatic symptom was corrected for the presence of preinjury symptoms by subtracting the preinjury score from the score postinjury. The total number (sum score 0–19) and severity (severity score 0–38) of the complaints was calculated at each evaluation moment.

*Hospital Anxiety and Depression Scale (HADS):*²¹ The HADS is a 14-item list assessing feelings of depression and anxiety with seven items each. Depression (HADS-D) and anxiety (HADS-A) items were scored separately on a 4-point Likert scale, with the cut-off score of 8 or higher indicating clinically anxiety and clinically depression.

*The Impact of Event Scale (IES):*²² The IES has 15 items with scores ranging from 0 to 5 and determined post-traumatic stress. A cut-off score of 19 differentiates patients with or without symptoms of post-traumatic stress.

Outcome measures

The primary endpoint was the frequency of incomplete recovery, defined by the *Glasgow Outcome Scale Extended (GOSE)* at 3 months postinjury.²³ This questionnaire provides eight categories of outcome ranging from complete recovery (score=8) to death (score=1). Outcome was dichotomised for statistical analysis as complete (GOSE=8) or incomplete recovery (GOSE<8). Secondary outcome measures were number of post-traumatic complaints collected 2 weeks and 3 months postinjury. Also, the number of patients who visited their general practitioner because of persistent complaints was determined.

Data analysis

SPSS Data Editor V.23.0 (IBM SPSS Statistics) was used for statistical analysis. Comparisons of differences in demographic, patient and trauma characteristics between both patient groups were performed by calculating absolute differences, along with their two-sided 95% CI. For comparing medians (non-parametric test) the 95% CI calculated with the Hodges-Lehman estimate showed no good representation of the differences. Therefore, the Mann-Whitney U test was used to compare medians with a two-tailed probability <0.05 considered to be significant. For measure of variability of the medians the 25th–75th percentile was used.

Associations between characteristics and incomplete recovery, measured by the GOSE at 3 months were analysed with binary logistic regression analysis, with GOSE dichotomised in complete (GOSE=8) or incomplete recovery (GOSE<8). Univariate and multivariable correlations were performed to assess the risk factors for incomplete recovery in MHI patients. Selection of variables for univariate and multivariable analysis was based on predictive variables from previous TBI and MHI research, namely sex, age, headache at the ED, neck pain at the ED, preinjury mental health, educational level, alcohol intoxication, GCS score, PTA and complaints 2 weeks postinjury (post-traumatic complaints, and complaints of anxiety, depression and post-traumatic stress).^{8 15 24 25}

All these variables were included in multivariable analysis to avoid excluding a variable that may not be important in a univariate association, but which is important in the full multivariable model. To perform this multivariable regression analysis, a sample size of >200 was desired, taking into account a loss of follow-up up to 40%.²⁵

Due to the low number of missing patient and trauma characteristics at the ED (<5%) no variables were imputed. Patients who were lost to follow-up were excluded for the 3 months analysis.

Patient and public involvement

No patients were involved in the development of the research question, study design or interpretation of the data.

RESULTS

Characteristics of study subjects

A total of 242 patients were included; 100 patients with head injury only and 142 patients with mTBI. After 2 weeks 37.2% and after 3 months 45.0% of the included patients was lost to follow-up (figure 1). LOC, GCS scores and complaints immediately after injury were similar between responders and non-responders. However, responders more frequently experienced PTA (43.6% vs 31.2%, difference in proportions (Δ) 12.4, 95% CI 0.3 to 24.5), were older (52.5 (95% CI 48.8 to 56.2) vs 33.9 (95% CI 30.4 to 37.5), Δ 18.6, 95% CI 13.4 to 23.7), more often female (60.2% vs 35.8%, Δ 24.4, 95% CI 12.1 to 36.7) and less frequently intoxicated with alcohol (14.3% vs 32.1%, Δ -17.8, 95% CI -28.4 to -7.2) (online supplemental table 1).

Table 1 shows the demographic, patient and trauma characteristics for both MHI groups. Alcohol intoxication was less frequently present in the head injury only-group compared with the mTBI-group (15.0% vs 27.5%, Δ -12.5, 95% CI -22.6 to -2.4) and head CT was less frequently performed in the head injury only-group (73.0% vs 93.7%, Δ -20.7, 95% CI -30.2 to -11.1), the other demographic and trauma characteristics were comparable between both MHI groups.

Main results

Two weeks postinjury 66.7% of the patients with MHI reported more than one post-traumatic complaint with a median sum score of 4 (1–8 (25–75 percentiles)) and a severity score of 5 (1–10). The number of the post-traumatic complaints did not differ between the head injury only and mTBI-group (3 (1–8) vs 5 (1–8), $p=0.74$) as well as the severity of the complaints (4 (1–10 vs 5 (0–10), $p=0.66$). After 3 months the median number of post-traumatic complaints for the total MHI group was 2 (0–6) without significant differences between both groups (2 (0–5) (head injury only) vs 2 (0–6) (mTBI), $p=0.64$). The median severity score was 2 (0–6) which was also not significant different between groups (2 (0–5) (head injury only) vs 2 (0–7) (mTBI), $p=0.55$). The

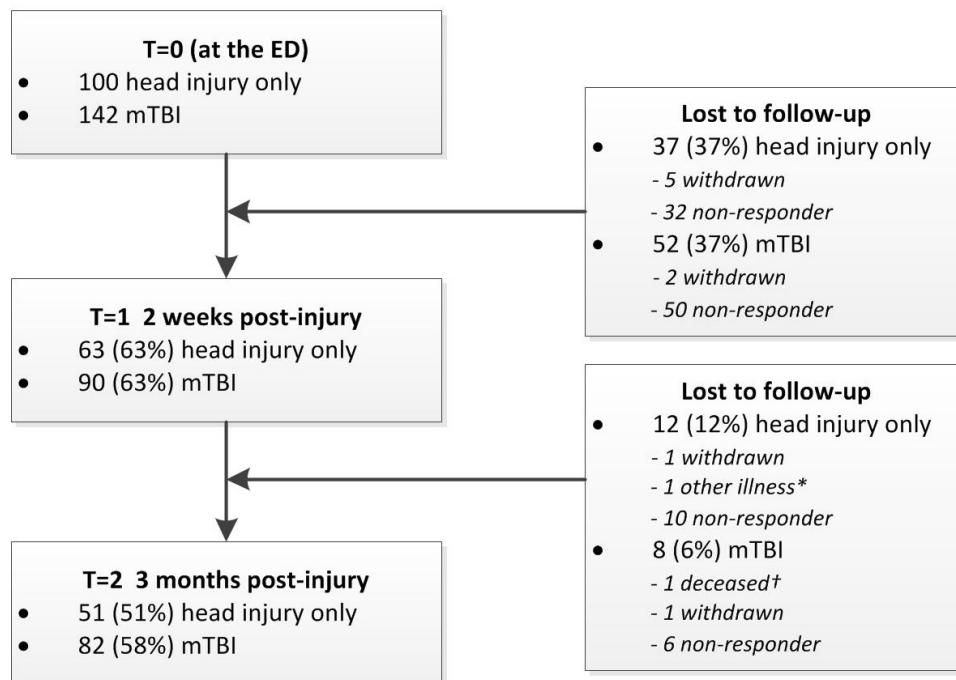


Figure 1 Flowchart. *Too ill to respond due to another illness (not trauma related); †Due to a pre-existing medical condition (not trauma related). ED, emergency department; mTBI, mild traumatic brain injury.

percentage of patients with more than one post-traumatic complaint at 3 months was 48.4% in the overall group with 38.0% versus 55.3% ($\Delta -17.3$, 95% CI -34.8 to 0.2) in the head injury only-group and mTBI-group, respectively. After 2 weeks and 3 months 22.9% and 35.4% of patients, respectively reported no post-traumatic complaints. Dizziness was the only individual post-traumatic complaint that was more frequently present 3 months postinjury in the mTBI-group compared with the head injury only-group (36.4% vs 17.6%, $\Delta 18.8$, 95% CI 3.8 to 33.8) (figures 2 and 3).

Complaints of emotional distress (anxiety, depression and post-traumatic stress) 2 weeks and 3 months postinjury for the entire group of MHI and both subgroups are shown in table 2. No significant differences in emotional distress between the head injury only and mTBI-group were present (table 2).

Of 133 MHI patients who completed 3 months follow-up, 69 patients (51.9%) showed an incomplete recovery without significant differences between the head injury only and mTBI-group (54.9% (n=28) vs 50.0% (n=41), $\Delta 4.9$, 95% CI -12.5 to 22.3). Two weeks post-injury, patients with an incomplete recovery had more post-traumatic complaints (7 (3–11) vs 1 (0–6), $p<0.01$) with a higher severity score (7 (4–14) vs 1 (0–6), $p<0.01$) compared with patients with complete recovery. They had also more frequently anxiety (27.7% (n=18) vs 8.9% (n=5) $\Delta 18.8$, 95% CI 5.6 to 32.0), depression (32.3% (n=21) vs 3.6% (n=2), $\Delta 28.7$, 95% CI 16.3 to 41.7) and post-traumatic stress (40.6% (n=26) vs 10.7% (n=6), $\Delta 29.9$, 95% CI 15.5 to 44.3) after 2 weeks. This difference was still present after 3 months, with more post-traumatic complaints (5 (2–9) vs 0 (0–2), $p<0.01$) and more severe

complaints (6 (2–10) vs 0 (0–2), $p<0.01$), more frequently anxiety (24.2% (n=16) vs 0.0% (n=0), $\Delta 24.2$, 95% CI 13.9 to 34.5) and depression (19.7% (n=13) vs 3.4% (n=2), $\Delta 16.3$, 95% CI 5.6 to 27.0). Table 3 shows results of univariate and multivariable analysis for risk factors associated with incomplete recovery 3 months postinjury.

Within 3 months postinjury 50 of 128 MHI patients (39.1%) visited their general practitioner, in 5 patients this information was lacking. In total 36 of 128 MHI patients (28.1%) visited their general practitioner because of complaints related to their MHI, which was not significant different between the head injury only-group and the mTBI-group (18.8% vs 33.8%, $\Delta -16.0\%$, 95% CI -30.1 to 0.2). Seven patients were referred to a neurologist because of complaints related to their MHI.

Regarding resumption of activities 33 patients with MHI (42.9% of the working and studying population) had called in sick from work within 3 months and 15 patients (19.5%) had not (completely) returned to work. This last group had significant more post-traumatic complaints after 2 weeks (10 (6–14) vs 4 (0–8), $p<0.01$) and 3 months (8 (3–12) vs 1 (0–5), $p<0.01$) compared with the patients who completely (return to) work. One patient deceased during follow-up, which was due to a pre-existing medical condition and was not related to the head injury.

DISCUSSION

The current study aimed to investigate the frequency of post-traumatic complaints and incomplete recovery in MHI patients discharged home directly from the ED. The main finding of our study is that half of the patients with MHI had an incomplete recovery at 3 months postinjury

Table 1 Demographic and trauma characteristics

	Total MHI group (n=242)	Head injury only (n=100)	mTBI (n=142)	Difference (95% CI)*	Missing (n)
Age	44.1 (40.4 to 49.8)	45.1 (39.9 to 46.9)	43.3 (41.3 to 46.9)	1.8 (−4.0 to 7.5)	0
Sex (female)	123 (50.8)	54 (54.0)	65 (45.8)	8.2 (−4.5 to 21.0)	0
Education level (low)	65 (26.9)	26 (26.8)	39 (28.9)	−2.1 (−13.5 to 9.3)	10
Preinjury mental health†	22 (9.1)	10 (10.0)	12 (8.5)	1.5 (−6.0 to 9.0)	0
Previous TBI	8 (3.3)	4 (4.0)	4 (2.8)	1.2 (−3.5 to 5.9)	0
Loss of consciousness	105 (43.4)	0 (0.0)	105 (73.9)	−73.9 (−81.1 to 66.7)	9
GCS score <15 at the ED	10 (4.1)	0 (0.0)	10 (7.0)	−7.0 (−11.1 to −2.8)	0
Post-traumatic amnesia	92 (38.0)	0 (0.0)	92 (64.8)	−64.8 (−72.7 to −56.9)	1
Other injuries					0
Extremities	15 (6.2)	8 (8.0)	7 (4.9)	3.1 (−3.3 to 9.5)	
Thorax	10 (4.1)	3 (3.0)	7 (4.9)	−1.9 (−6.8 to 3.0)	
Head CT performed	206 (85.1)	73 (73.0)	133 (93.7)	−20.7 (−30.2 to −11.1)	0
Cause of injury					0
Traffic accident	116 (47.9)	48 (48.0)	68 (47.9)	0.1 (−12.7 to 12.9)	
Falls	85 (35.1)	36 (36.0)	49 (34.5)	1.5 (−10.7 to 13.7)	
Violence	17 (7.0)	8 (8.0)	9 (6.3)	1.7 (−5.0 to 8.4)	
Sports	12 (5.0)	2 (2.0)	10 (7.0)	−5.0 (−10.0 to 0.0)	
Bumped head	12 (5.0)	6 (6.0)	6 (4.2)	1.8 (−3.9 to 7.5)	
Complaints at the ED					1
Headache	134 (55.4)	58 (58.0)	76 (53.5)	4.5 (−8.2 to 17.2)	
Neck pain	63 (26.0)	29 (29.0)	34 (24.1)	4.9 (−6.4 to 16.2)	
Vomiting	23 (9.5)	7 (7.0)	15 (10.6)	−3.6 (−10.7 to 3.5)	
Nausea	87 (36.0)	38 (38.0)	49 (34.8)	3.2 (−9.1 to 15.5)	
Dizziness	68 (28.1)	28 (28.0)	40 (28.4)	−0.4 (−11.9 to 11.1)	
Balance disturbance	24 (9.9)	10 (10.1)	14 (10.4)	−0.3 (−8.1 to 7.5)	
Noise intolerance	15 (6.2)	9 (9.0)	6 (4.4)	4.6 (−1.9 to 11.1)	
Profession					10
Work or student	166 (68.6)	68 (68.0)	98 (69.0)	−1.0 (−12.9 to 10.9)	
Other‡	76 (31.4)	32 (32.0)	44 (31.0)	1.0 (−10.9 to 12.9)	
Coagulation medication					0
Antiplatelet agents	21 (8.7)	12 (12.0)	9 (6.3)	5.7 (−1.8 to 13.2)	
Anticoagulant agents	2 (0.8)	0 (0.0)	2 (1.4)	−1.4 (−3.3 to 0.5)	
Alcohol intoxication	54 (22.3)	15 (15.0)	39 (27.5)	−12.5 (−22.6 to −2.4)	0

Data are n (%) or mean (95% CI).

*Difference between head injury only and mTBI group.

†Preinjury mental health problems.

‡Other=retired, voluntary work or unemployed.

CT, computed tomography; ED, emergency department; GCS, Glasgow Coma Scale; MHI, minor head injury; mTBI, mild traumatic brain injury.

and one in five MHI patients did not resume their work or study at preinjury levels. Moreover, the recovery rates were not different between patients with head injury only and mTBI patients.

In general the assumption is that non-hospitalised MHI patients will have a good recovery. It is therefore

remarkable that half of the patients in our study showed an incomplete recovery at 3 months postinjury. A recent multicentre follow-up study reported that 36% of the non-hospitalised patients with mTBI had an incomplete recovery and 14% had not resumed work at 6 months postinjury.²⁶ This underlines our findings that a significant

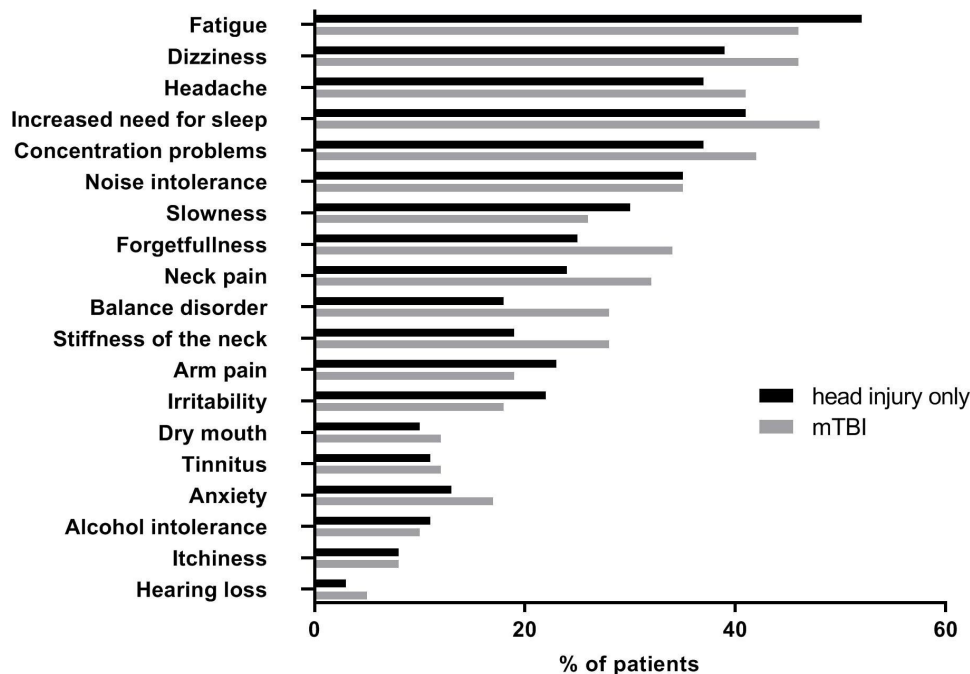


Figure 2 Post-traumatic complaints 2 weeks after MHI. MHI, minor head injury; mTBI, mild traumatic brain injury.

part of the non-hospitalised MHI patients still experiences complaints influencing their daily life even months after injury. In addition to this aforementioned study, which as opposed to our study did not include patients without mTBI characteristics, we showed that patients with only a head injury have a high rate of incomplete recovery comparable to non-hospitalised mTBI patients. Besides the finding that recovery patterns were comparable between head injury only and mTBI patients in our study, this also applies to demographic characteristics

and to complaints both at the ED and 2 weeks postinjury. Therefore, our results suggest that the severity of the traumatic impact to the head causing a temporary altered mental status (represented by LOC and/or PTA) does not influence the development of post-traumatic complaints and the recovery pattern in non-hospitalised MHI patients. Although other studies support our results, these studies comprised a limited follow-up of 15 days to 1 month postinjury, which might be too short to evaluate definitive recovery.^{6 7 27} As trauma characteristics did

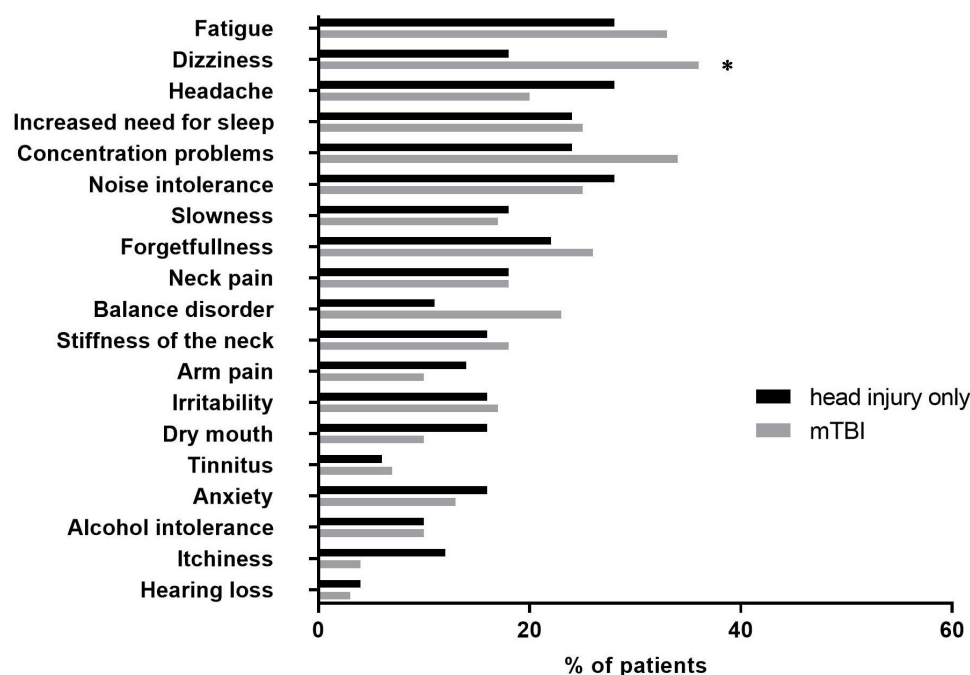


Figure 3 Post-traumatic complaints 3 months after MHI. *Significant difference $p < 0.05$. MHI, minor head injury; mTBI, mild traumatic brain injury.

Table 2 Emotional distress after MHI in head injury only versus mTBI patients

	Total group of MHI (n=153)	Head injury only (n=63)	mTBI (n=90)	Difference (95% CI)*
2 weeks postinjury				
Anxiety†	32 (20.9)	15 (23.8)	17 (18.9)	4.9 (−8.6 to 18.4)
Depression†	28 (18.3)	12 (19.0)	16 (17.8)	1.2 (−11.3 to 13.7)
Post-traumatic stress‡	40 (26.1)	14 (22.2)	26 (28.9)	−6.7 (−20.6 to 7.2)
3 months postinjury				
Anxiety†	16 (12.6)	6 (13.3)	10 (12.2)	1.1 (−11.1 to 13.3)
Depression†	15 (11.8)	3 (6.7)	12 (14.6)	−7.9 (−18.5 to 2.7)
Post-traumatic stress‡	0 (0)	0 (0)	0 (0)	NA

Data are n (%).
 *Difference between head injury and mTBI group.
 †Cut-off score of >7 for anxiety or depression on the Hospital Anxiety and Depression Scale.
 ‡Cut-off score of 19 on the Impact of Events Scale.
 MHI, minor head injury; mTBI, mild traumatic brain injury.

not explain functional outcome in our cohort of MHI patients other (personal) factors may be more important. In this current study, we found that depression was associated with incomplete recovery and previously studies underline the importance of emotional distress in the development of post-traumatic complaints and incomplete recovery.^{11 25} Besides, avoidant or passive coping strategies have influence on outcome.²⁵ Therefore, as we estimated the outcome at a later time point postinjury the influence of coping or personality characteristics

depicted by other studies might be interesting to explore in future studies.^{11 25}

In our study, one in four patients did seek medical help because of persistent complaints related to their MHI within the first 3 months postinjury. This is a considerable number of patients, especially as regular follow-up is thought to be unnecessary because of an expected favourable recovery. Nevertheless, still half of the patients with incomplete recovery and persistent post-traumatic complaints did not visit a doctor, which is in line with the

Table 3 Univariate and multivariable analysis for incomplete recovery in patients 3 months after MHI (n=133)

	Coding	Univariate		Multivariable	
		OR	95% CI	OR	95% CI
Sex	Male (0)–Female (1)	2.29	1.13 to 4.65	NS	NS
Age	(16–95)	1.02	1.00 to 1.03	1.03	1.00 to 1.05
Pre-injury mental health*	No (0)–Yes (1)	6.00	0.70 to 51.3	NS	NS
Educational level	Low (0)–High (1)	0.61	0.27 to 1.38	NS	NS
PTA	No (0)–Yes (1)	0.68	0.34 to 1.36	NS	NS
GCS<15 at the ED	No (0)–Yes (1)	4.99	0.56 to 43.3	NS	NS
Complaints at the ED					
Headache	No (0)–Yes (1)	3.57	1.74 to 7.31	3.27	1.28 to 8.34
Neck pain	No (0)–Yes (1)	2.20	0.94 to 5.17	NS	NS
Alcohol intoxication	No (0)–Yes (1)	0.49	0.18 to 1.33	NS	NS
Complaints 2 weeks postinjury					
Depression†	No (0)–Yes (1)	12.89	2.86 to 57.99	6.31	1.24 to 32.00
Anxiety†	No (0)–Yes (1)	3.91	1.34 to 11.36	NS	NS
Post-traumatic stress‡	No (0)–Yes (1)	5.70	2.13 to 15.24	NS	NS
Post-traumatic complaints	(0–15)	1.29	1.16 to 1.44	1.24	1.09 to 1.40

*Preinjury mental health problems.
 †Cut-off score of >7 for anxiety or depression on the Hospital Anxiety and Depression Scale.
 ‡Cut-off score of 19 on the Impact of Events Scale.
 ED, emergency department; GCS, Glasgow Coma Scale; MHI, minor head injury; NS, not significant in multivariable analysis; PTA, post-traumatic amnesia.



observation that patients with post-traumatic symptoms after mTBI also seek help late after injury.⁴ This is noteworthy, because treatment of post-traumatic complaints is particularly effective when started early postinjury.^{18 28} To prevent chronic post-traumatic complaints and incomplete recovery, we therefore postulate that it is important to find risk factors at an early stage to identify those patients at risk for incomplete recovery. Our study discerned four factors that were associated with incomplete recovery: headache directly postinjury, increasing age together with an increasing number of post-traumatic complaints and depression 2 weeks postinjury. Other patient and trauma characteristics did not seem to play a role in incomplete recovery in our study population. Consequently, these findings suggest a role for the physician at the ED to identify patients at risk for incomplete recovery. Besides, it is also important to identify patients with depression and several post-traumatic complaints 2 weeks after injury. These factors 2 weeks after injury are known predictors of incomplete recovery in mTBI patients, but were not previously described in non-hospitalised patients with MHI.^{25 29} The few studies that included non-hospitalised MHI patients have only evaluated factors which can be identified at the ED.^{7 8 15}

Without regular follow-up after MHI, early identification of patients with persistent post-traumatic complaints will be challenging, especially as two of the main factors associated with incomplete recovery cannot be evaluated directly at the ED. It is therefore important to provide patients or their next-of-kin information (orally and written) directly at the ED to search for medical help if they still experience post-traumatic complaints at 2 weeks postinjury. However, almost 50% of the patients could not reproduce oral or written information that was given at the ED and even adding video information to standard care at the ED did not improve the severity of post-traumatic symptoms.^{30 31} Another option to consider is to provide all non-hospitalised MHI patients with telephonic aftercare 2 weeks postinjury to assess feelings of post-traumatic complaints and depression since these factors were found to be predictors of incomplete recovery.^{17 32} Although there is a risk of unnecessary care consumption with this telephonic aftercare, it may eventually prevent long-term post-traumatic complaints and thereby for instance less absenteeism from work and better quality of life at the long term. Irrespective of the method of patient information or follow-up, it is important that physicians at the ED are more aware of post-traumatic complaints and incomplete recovery after MHI, especially in those patients who are discharged home directly from the ED. It is challenging to consider the role of the physician at the ED to inform these patients about potential complaints and evaluate the recovery course by an appointment for (telephonic) aftercare.

Some limitations of our study should be mentioned. First, follow-up of the included patients was incomplete, with a loss to follow-up rate of 45% even though reminders were sent to these patients. Non-responders were younger,

more frequently male and intoxicated at the day of injury. This might have resulted in a bias towards worse outcome, as women and non-intoxicated patients are known to have more post-traumatic complaints after mTBI.^{24 25} On the other hand, our dropout rate was comparable to other longitudinal mTBI follow-up studies.^{15 25 33} Second, inclusion bias was not completely preventable because the attending physicians were responsible for the inclusion of patients. In case of overcrowding at the ED, potential participants therefore might have been missed. Third, not all included patients after MHI were scanned, because they did not meet the criteria for CT scanning according to the CT decision rule used at the ED. Therefore, patients with intracranial lesions might have been missed. However, it is unlikely that an important CT abnormality was missed as the CT decision rule has high sensitivity for traumatic intracranial lesions.¹⁹ Finally, this is a single centre study and thereby the external validity of this study is limited. We also did not include a control group in our study. However, a previous study from our group already has shown that non-head trauma controls have significantly less post-traumatic complaints and a different subset compared with mTBI patients.²⁰ As this study was also conducted in our hospital, including patients reasonably similar to our population using the same questionnaires, we therefore decided not to include an extra control group in this study. For future research, the confirmation of our results in a prospective multi-centre study will be necessary. This eventually will provide the opportunity to define appropriate aftercare which can be incorporated in guidelines or decision rules.

In conclusion, although non-hospitalised patients after MHI are the least severe category within the head and brain injury spectrum, our study showed that half of these patients still experienced incomplete recovery at 3 months postinjury. Risk factors for incomplete recovery were increasing age, headache at the ED and the presence of post-traumatic complaints or depression 2 weeks postinjury. It is important to identify these patients at risk at an early stage in order to provide appropriate follow-up and aftercare to avoid long-term post-traumatic complaints and incomplete recovery.

Contributors SMC, JvdN and BJ conceived the study and designed the trial. JvdN, BJ and JcTM supervised the conduct of the trial and data collection. SMC and LJK undertook recruitment of patients and managed the data, including quality control. SMC analysed the data. SMC drafted the manuscript, and all authors contributed substantially to its revision. JvdN is the guarantor and accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The Medical Ethical Committee of the University Medical Center Groningen reviewed the study protocol prior to the start of the study (reference number METc 2016/179) and decided that, in accordance with Dutch law, the study

met criteria for exempt research. Informed consent was obtained from all patients before participation in the study.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Anonymised patient level data are available on reasonable request from the corresponding author at j.van.der.naalt@umcg.nl.

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