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Brief Communication

Subjective cognitive functioning in adults hospitalized after traumatic brain injury: A four-year follow-up

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Abstract

Objective: To document the evolution of subjective cognitive functioning over four years in adults hospitalized after traumatic brain injury (TBI), comparing mild and moderate-severe TBI, and accounting for sociodemographic and clinical factors. **Method:** This secondary analysis of a longitudinal observational cohort study includes 222 adult participants hospitalized following a TBI (mean age = 41 ± 15 years; 29% women; 65% mild, 35% moderate-severe TBI). Data were collected via in-person/telephone interview and self-report questionnaires administered 4, 8, 12, 24, 36, and 48 months post-TBI. The primary outcome measure for subjective cognitive functioning was the Medical Outcomes Study Cognitive Functioning Scale (MOS-COG). **Results:** Mixed model analyses revealed a significant Time effect, with post hoc tests showing a better perceived cognitive functioning on the MOS-COG at 4 months than at 24 and 36 months after TBI. The TBI severity effect and TBI severity*Time interaction were not significant. Secondary effects revealed that poorer subjective cognitive functioning was associated with higher levels of symptoms of depression, anxiety, insomnia, and fatigue, and lower quality of life. Overall, the MOS-Cog score was about one standard deviation below the normative mean, suggesting greater cognitive complaints than in the general population, regardless of injury severity. **Conclusions:** The results suggest that subjective cognitive functioning is poorer than normative values and fairly stable over four years after TBI, with a slight decrease between 4 and 24–36 months, and is similar between mild and moderate-severe TBI.

Keywords: Head injuries; cognition; rehabilitation; longitudinal study; cohort study; adult

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Statement of research significance

Research Topic: This study examined the four-year evolution of subjective cognitive functioning in a longitudinal cohort of 222 adults hospitalized after traumatic brain injury (TBI). **Main Findings:** Subjective cognitive functioning was consistently lower than normative values, with similar levels observed across mild and moderate-severe TBI. Subjective cognition remained relatively stable over the four-year post-TBI period, and it was associated with depression, anxiety, insomnia, fatigue, and lower quality of life. **Study Contributions:** This study strengthens existing evidence regarding the persistence of cognitive complaints in individuals who were hospitalized after TBI, and the interplay of subjective cognition with other symptoms, across all injury severity levels.

Introduction

Traumatic brain injury (TBI) is among the most common neurological disorders affecting the Canadian population, and its prevalence is projected to increase in the years to come (Public Health Agency of Canada, 2014). TBI can lead to numerous physical, cognitive, and emotional repercussions that can have a significant impact on daily life (Levy et al., 2023). Subjective cognitive difficulties, or cognitive complaints, correspond to perceived difficulties in one or more cognitive abilities in everyday life. Several studies have shown that cognitive complaints in individuals with TBI are common but not consistently related to objective performance on cognitive testing (Anderson, 2021; Jamora et al., 2012; Stenberg et al., 2020). A recent systematic review found that the frequency of self-reported cognitive symptoms after TBI varied from 9 to 30% for memory, from 6 to 60% for concentration, and from 15 to 25% for processing speed (Levy et al., 2023). However, all but one of the included studies were limited to the first-year post-injury. Thus, despite being one of the most frequently reported symptoms, cognitive complaints have rarely been studied over a period of several years. Although they are not associated with objective cognitive functioning, their impact on everyday functioning is no less significant. Cognitive complaints are associated with the presence of symptoms of depression, anxiety, and somatization (Stenberg et al., 2020). This highlights the importance of taking a more specific interest in cognitive complaints and their evolution in the

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years following TBI, independently of objective cognitive functioning. The objective of this study was to document the evolution of subjective cognitive functioning in adults who were hospitalized after TBI over a period of four years, comparing mild and moderate-severe injuries, and accounting for socio-demographic (age, sex, education) and clinical (psychological functioning, fatigue, insomnia, pain, quality of life, participation) factors.

Methods

This article reports secondary analyses of a longitudinal study on mental health after TBI approved by the ethical review boards of the *CHU de Québec-Université Laval* (CHU; #2014-1229), the *CIUSSS de la Capitale-Nationale* (# 2014-679), and the *McGill University Health Centre* (MUHC; #13-472), in accordance with Helsinki declaration.

Participants

The sample included 222 individuals aged 18–65 years who were admitted to a Level I trauma center in Québec (CHU) or Montréal (MUHC), QC, Canada after a mild to severe TBI between December 2013 and October 2016. TBI diagnosis and severity (dichotomized into mild, moderate-severe) were determined by physicians at the trauma centers according to provincial guidelines (Ministère de la santé et des services sociaux & Société de l'assurance automobile du Québec, 2005) (see Supplemental Material for detailed criteria). Exclusion criteria were a history of neurological condition, a spinal cord injury concomitant to the TBI, and an inability to provide informed consent.

Procedure

A liaison nurse (CHU) or research assistant (MUHC) approached hospitalized individuals who met criteria to obtain their verbal consent to be contacted. Three months after TBI, the research coordinator contacted potential participants to provide detailed information about the study. For those agreeing to participate, the consent form was mailed and sociodemographic data were collected. The study included six assessments, carried out 4, 8, 12, 24, 36 and 48 months post-TBI, each including a face-to-face or telephone interview and self-report questionnaires sent out by mail with a prepaid return envelope.

Measures

Subjective cognitive functioning

The *Medical Outcomes Study Cognitive Functioning Scale* (MOS-COG) (Stewart et al., 1992) is a self-report questionnaire including six items on the frequency of cognitive difficulties, answered on a five-point scale (reasoning, concentration, confusion, forgetfulness, sustained attention, reacting slowly). The total score is transformed into a 0–100 scale, higher scores suggesting better cognitive functioning. Scores obtained in this study were compared to the original normative sample comprised of 3053 adults aged 18–98 years (M = 82.40; SD = 16.50) (Stewart et al., 1992). Internal consistency was very high in this sample (Cronbach's alpha ranging from .92 to .93 across the six assessments), and comparable to the original validation study (.87) (Stewart et al., 1992). Item-total correlations were very high in the current study, ranging between .73 and .87 across the six assessments. The validation study suggests good convergent and discriminant validity.

Sociodemographic and clinical factors

Age at injury, sex, and years of education were collected at the initial contact. The presence of any anxiety, depression, or substance use disorders was evaluated (dichotomic variable, yes/no; lifetime pre-TBI, evaluated retrospectively once; and prospectively at each assessment) using the French version of the *Structured Clinical Interview for DSM-IV* (First et al., 1997), a semi-structured diagnostic interview based on DSM-IV criteria. The other factors were assessed by validated French versions of self-report questionnaires. The *Insomnia Severity Index* (ISI) (Morin et al., 2011) is a 7-item self-report questionnaire that assesses sleep difficulties (total score: 0–28). The *Fatigue Severity Scale* (FSS) (Krupp et al., 1989) is a 9-item questionnaire used to evaluate the severity and impact of fatigue (total score: 0–63). Anxiety and depression symptoms were documented with the *Hospital Anxiety and Depression Scale* (HADS) (Zigmond & Snatih, 1983), each subscale (HADS-A, HADS-D) including 7 items (total score: 0–21 for each subscale). The *Quality of Life after Brain Injury* (QOLIBRI) (von Steinbüchel et al., 2010) is a 36-item questionnaire covering six dimensions of health-related quality of life after TBI (total score: 0–100). Social participation was documented with the 17-item version of the *Participation Assessment with Recombined Tools-Objective* (PART-O) (Whiteneck et al., 2011), assessing productivity, social relations, and being out and about in the community (balanced total score: less than 0–5). The *Bodily Pain* subscale of the *SF-36 Health Survey* (SF-Pain) (Ware et al., 2000) was used to evaluate pain severity and impact (total score: 0–100). For the ISI, FSS, HADS-A, and HADS-D, higher scores suggest greater symptoms or poorer functioning, whereas for the QOLIBRI, PART-O, and SF-Pain, higher scores reflect better functioning.

Statistical analyses

Analyses were performed with IBM SPSS Statistics (version 28). Linear repeated measures mixed models analyses of variance were used. The dependent variable was the MOS-COG total score. As it was not normally distributed, raw data were transformed into rank-ordered data to compute mixed models. The final model was rerun with raw data to obtain estimated marginal means for Table 1 and Figure 1. The main fixed effects were TBI severity (mild, moderate-severe) and Time (4, 8, 12, 24, 36, 48 months post-TBI), and the TBI severity*Time interaction. Two random effects were included: participant nested in TBI severity and recruitment site (Québec, Montréal). For the other secondary fixed effects, the following variables were initially considered: four variables assessed once and remaining constant: age at injury, sex, education, and pre-TBI psychological diagnosis; and eight variables assessed at each assessment: ISI, FSS, HADS-D, HADS-A, QOLIBRI, PART-O, SF-Pain, and post-TBI psychological diagnosis. Education and pre-TBI psychological diagnosis were excluded from further analyses due to high rate of missing data (19 and 23%, respectively). Bivariate correlations were computed between each secondary effect and the dependent variable. Two variables were excluded from further analyses because they did not correlate with the MOS-COG: age ($r = .059$; $p = .068$) and sex ($r = .036$; $p = .265$). Then, a linear mixed model analysis was performed with the final list of secondary fixed effects. Backward variable selection was used to select the secondary fixed effects to be included in the final model. At each step, 17 covariance matrix structures were tested and the first-order autoregressive structure with heterogeneous

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Table 1. Tests of fixed effects from the backward variable selection of linear mixed models with subjective cognitive functioning (MOS-COG) as the dependent variable

Effect	Model 1	Model 2	Model 3	Model 4 (final)
Severity	F (1, 210.27) = 3.06; p = .082	F (1, 211.52) = 3.16; p = .077	F (1, 204.60) = 2.95; p = .087	F (1, 208.17) = 3.53; p = .062
Time	F (5, 198.98) = 2.15; p = .061	F (5, 202.65) = 2.19; p = .057	F (5, 202.18) = 2.29; p = .047	F (5, 219.84) = 2.79; p = .018
Severity X Time	F (5, 195.87) = 1.03; p = .403	F (5, 199.50) = 1.09; p = .367	F (5, 199.72) = 1.07; p = .378	F (5, 218.13) = 1.54; p = .180
Anxiety (HADS-A)	F (1, 842.32) = 16.05; p < .001	F (1, 845.46) = 16.79; p < .001	F (1, 846.50) = 16.56; p < .001	F (1, 886.83) = 20.04; p < .001
Depression (HADS-D)	F (1; 812.99) = 2.90; p = .089	F (1, 814.74) = 3.17; p = .075	F (1, 816.41) = 3.14; p = .077	F (1, 858.49) = 4.45; p = .035
Fatigue (FSS)	F (1, 815.55) = 11.42; p < .001	F (1, 821.96) = 10.89; p = .001	F (1, 823.37) = 10.58; p = .001	F (1, 863.37) = 12.37; p < .001
Insomnia (ISI)	F (1, 823.84) = 22.07; p < .001	F (1, 837.77) = 20.46; p < .001	F (1, 840.79) = 20.07; p < .001	F (1, 875.84) = 18.55; p < .001
Quality of life (QOLIBRI)	F (1, 846.25) = 94.73; p < .001	F (1, 849.57) = 100.02; p < .001	F (1, 849.55) = 101.45; p < .001	F (1, 886.22) = 101.85; p < .001
Psychological diagnosis	F (1, 799.78) = .82; p = .366	F (1, 803.27) = .65; p = .420	F (1, 807.28) = .70; p = .405	
Pain (SF-36 Pain)	F (1, 830.02) = .40; p = .527	F (1, 836.53) = .28; p = .595		
Participation (PART-O)	F (1, 775.05) = .13; p = .724			

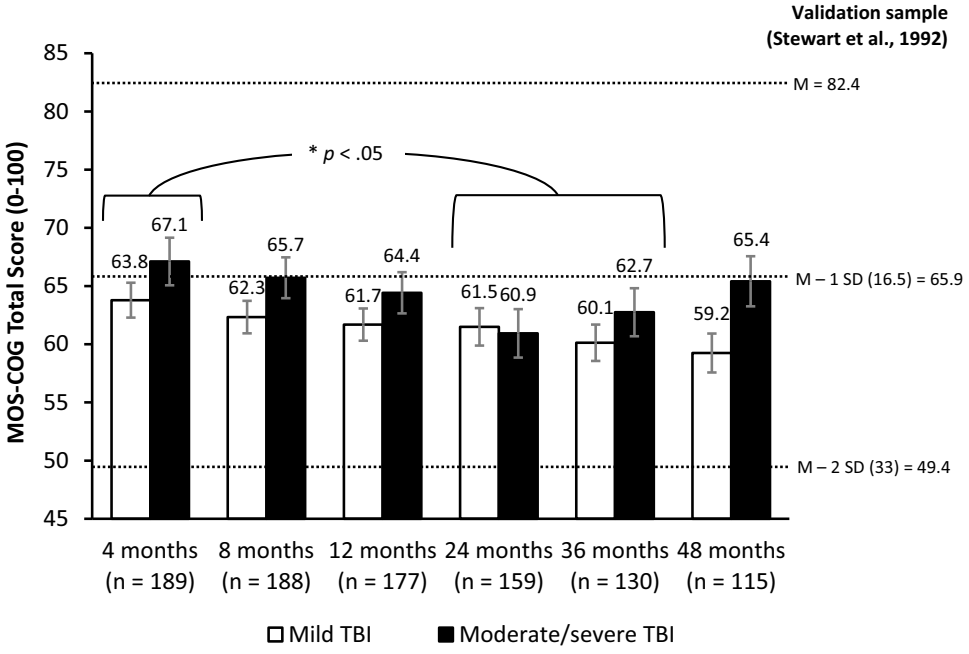

Figure 1. Subjective cognitive functioning assessed by the MOS-COG, over time and according to TBI severity. Cognitive functioning at 4 months post-TBI was better than at 24 and 36 months post-TBI (p < .05).

variances (ARH1) was chosen based on lowest corrected Akaike information criterion and/or Bayesian information criterion.

Results

The final sample includes 222 adults (mean age = 41.36 ± 15.17 years; 28% women) who completed the main outcome measure, the MOS-COG, at least once across the six assessment points. Of this number, 196 completed at least two assessments, including 82 who completed all six assessments. See Supplemental Material at [update to provide the DOI here] for sample characteristics. TBI severity was mild for 65%, moderate for 21%, and severe for 13%. The mechanism of injury was motor vehicle/traffic accident for 57%, fall for 27%, and other for 15%. Concomitant neck, upper-limb, lower-limb, or trunk injuries were reported by 75% of participants. Of the 222 participants, 189 completed the assessment at 4 months post-TBI (69% mild TBI), 188 at 8 months (64% mild TBI), 177 at 12 months (65% mild TBI), 159 at 24 months (65% mild TBI), 130 at 36 months (66% mild TBI), and 115 at 48 months (64% mild TBI) (see Supplemental Materials at [update to provide the DOI here] for a complete flow chart and information on missing data and loss to follow-up). Table 1 presents the results of the mixed models' analyses. Mean MOS-COG total scores ranged from 59.2 to 67.1, depending on the assessment time and TBI severity subgroup, which is around one standard deviation below the mean of the validation sample (82.4–16.5 = 65.9; see Figure 1). In the first three iterations of the backward variable selection, social participation (PART-O; p = .724), pain (SF-Pain; p = .595), and psychological diagnosis (p = .405) were successively removed. The fourth iteration (final model) revealed that all remaining secondary fixed effects were statistically significant. The main effect of TBI severity and the TBI severity*Time interaction were not statistically significant, but the Time effect was significant (see Figure 1). Post-hoc comparisons were computed between the 15 assessment time pairs with a Holm-Bonferroni correction (alpha for each contrast ranked in ascending order of p-value: .05 ¸ [16 – contrast's rank]). Two contrasts were statistically significant, with the MOS-COG being significantly higher, suggesting better subjective cognitive functioning, at 4 months compared to 24 months (p = .001) and 36 months (p = .003). Finally, results of the secondary fixed effects suggest that better subjective cognitive functioning (MOS-COG) is associated with lower levels of depression (HADS-D; Parameter estimate ± standard error = −4.88 ± 2.32), anxiety (HADS-A; −8.72 ± 1.95), fatigue

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(FSS; −1.74 ± 0.50), and insomnia (ISI; −5.14 ± 1.19), and better quality of life (QOLIBRI, 5.93 ± 0.59).

Discussion

The aim of this study was to document the evolution of subjective cognitive functioning over four years after TBI, comparing mild and moderate-severe injuries, and accounting for sociodemographic and clinical factors. The results indicated that, overall, subjective cognitive functioning was generally stable in the first four years after TBI, except for a slightly better perceived functioning at the initial assessment (4 months post-TBI) compared to two of the later ones (24 and 36 months post-TBI). Notably, subjective cognitive functioning did not differ between mild and moderate-severe TBI, and the interaction between severity and time was not significant either. Worse subjective cognition was significantly associated with symptoms of anxiety, depression, fatigue, and insomnia, and with poorer quality of life, but not with age, sex, social participation, pain, or the presence of a psychological diagnosis.

More severe injuries are known to be associated with greater and more persistent cognitive impairments (Rassovsky et al., 2015). However, our results showed that subjective cognitive functioning did not differ between mild and moderate-severe TBI from 4 months to 4 years post-injury. In addition, it has been suggested that persons with mild TBI may overestimate their cognitive symptoms (Miller & Donders, 2001), whereas those with moderate to severe TBI may underestimate their symptoms due to impaired self-awareness (Dirette & Plaisier, 2007), leading to similar levels of cognitive complaints. Nevertheless, compared to the original normative sample of the MOS-COG, results from our sample are about one standard deviation below the mean, suggesting greater cognitive complaints than in the general population, regardless of injury severity, and even four years post-injury. Consistent with our findings, other studies have found that cognitive complaints were not significantly correlated with any injury severity measure (Vallat-Azouvi et al., 2018). The absence of differences between mild and moderate-severe TBI subgroups on subjective cognitive functioning could also be partially related to the fact that our sample consisted of individuals who had been hospitalized, suggesting more severe mild TBIs or concomitant injuries.

The length of the follow-up period was a notable feature of the study. Results showed that subjective cognitive functioning was slightly higher at 4 months than at 24 and 36 months post-TBI. Particularly for moderate and severe injuries, the first few months after the accident are generally devoted to rehabilitation and recovery, and it is possible that when resuming daily activities several months later, people with TBI are more confronted with their cognitive problems. This may also be the case for individuals with mild TBI who are hospitalized, as they may have concomitant injuries affecting their daily functioning for a longer time than expected. In their study, Machamer et al. (2022) examined the prevalence and persistence of symptom endorsement during the first year after TBI. In agreement with the results of our study, they observed a later predominance of cognitive symptoms, with a more marked decrease in symptoms within the first three months after TBI. In our study, perceived cognitive functioning was relatively stable over time. It could be hypothesized that the inclusion of an earlier assessment, such as 1–2 months post-injury, would have better captured changes over time. Factors that could be linked to this stability include self-awareness, sensitivity, and vigilance regarding cognitive (and other) symptoms, for which there may be TBI severity and individual differences. Nonetheless, the fact that cognitive complaints are still present four years after TBI of any severity highlights the need for interventions and management interventions, such as metacognitive strategies (e.g., planning and breaking tasks into smaller steps) and cognitive-behavioral techniques (e.g., cognitive restructuring).

Our results indicate an association between subjective cognitive functioning and anxiety, depression, fatigue, insomnia symptoms and lower quality of life. This finding aligns with existing literature demonstrating that individuals with cognitive complaints often experience elevated somatic and psychological symptoms, fatigue, and reduced quality of life (Stenberg et al., 2020; Stulemeijer et al., 2007; Vallat-Azouvi et al., 2018). While the precise direction of these associations remains unclear and requires further investigation further, they are likely complex and bidirectional. These associations may be influenced by factors such as the severity of TBI and the individual's level of self-awareness, as previously noted regarding subjective cognitive functioning. For example, in mild TBI, subjective cognitive complaints may be more strongly associated with better self-awareness, psychological distress and insomnia, whereas in moderate-severe TBI, objective cognitive impairments and fatigue may be more prominent. This cluster of commonly co-occurring symptoms underscores the need for holistic therapeutic approaches, such as cognitive-behavioral therapy or physical exercise, which may be more effective in addressing these interconnected challenges and improving health-related quality than treatments targeting individual symptoms in isolation.

This study has several methodological limitations that warrant consideration. First, the sample is limited to hospitalized patients, who are likely to have sustained more severe injuries, particularly in the mild TBI subgroup, and may also have concomitant injuries to other body parts. This limits the generalizability of the results to the broader TBI population. Second, the study lacked both objective cognitive measures and proxy-reported subjective cognitive measures. This could have helped to contrast cognitive performance and perceived cognition, and estimate self-awareness in the sample. Third, the main outcome measure comprised only six items. Additionally, freely available normative data lack stratification by age or other sociodemographic characteristics. Furthermore, these data originate from a different country (United States *vs.* Canada) and a different language (English *vs.* French) than those used in the study. Fourth, due to missing data, it was not possible to include education and pre-TBI psychological diagnoses as factors potentially associated with subjective cognition. However, this investigation has several strengths, including a systematic longitudinal follow-up with six assessment times up to four years post-TBI and relatively low attrition, the use of validated instruments, and a large sample size allowing the use of a multivariate statistical model accounting for several factors. In conclusion, this study sheds new light on the evolution of subjective cognitive functioning over the first four years following mild, moderate, or severe TBI. Future studies should investigate when and how to intervene on cognitive complaints and concomitant symptoms.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355617725000207.

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