ORIGINAL ARTICLE

Is Age Associated With the Severity of Post–Mild Traumatic Brain Injury Symptoms?

Tina Hu, Cindy Hunt, Donna Ouchterlony

ABSTRACT: ***Background:*** Mild traumatic brain injury (mTBI) is a significant public health concern. Research has shown that mTBI is associated with persistent physical, cognitive, and behavioural symptoms, leading to significant direct and indirect medical costs. Our objective was to determine if age impacts the type and severity of post-mTBI symptoms experienced. ***Methods:*** Retrospective analysis of prospectively collected data at a level 1 tertiary care outpatient head injury clinic. Participants (N = 167) were patients seen at the clinic following an mTBI. The Rivermead Post-Concussion Symptoms Questionnaire was used to assess symptom severity. ***Results:*** In our sample, the mean age was 44 ± 16 years with 51% males. Compared with other age groups, patients >66 years of age were significantly more likely to report an mTBI between 6 AM to 12 PM (69%). Middle-aged patients (36-55 years) were more likely to report higher severity of certain post-mTBI symptoms (headache, nausea and vomiting, irritability, poor concentration, sleep disturbance, blurry vision, light sensitivity, and taking longer to think) compared with patients >66 years of age. ***Conclusions:*** In general, middle-aged patients reported higher severity of post-mTBI symptoms compared with the oldest patients. Thus, there was a significant association between age and the severity of specific mTBI symptoms, which highlights the need for targeted management. Additional research is needed to understand the mechanisms that could be contributing to the higher symptom severity experienced by the middle-aged group.

RÉSUMÉ: L'âge est-il associé à la sévérité des symptômes suite à un traumatisme crânien léger? ***Contexte:*** Le traumatisme crânien léger (TCL) constitue une préoccupation importante en santé publique. La recherche a montré que le TCL entraîne des symptômes physiques, cognitifs et comportementaux persistants, générant des coûts médicaux directs et indirects importants. Notre objectif était de déterminer si l'âge a un impact sur le type et la sévérité des symptômes post TCL chez un patient. ***Méthodologie:*** Nous avons effectué une analyse rétrospective de données recueillies prospectivement à une clinique externe de traumatisme crânien dans un centre de soins tertiaires de niveau 1. Les participants (N = 167) étaient des patients référés à la clinique après un TCL. Nous avons utilisé le *Rivermead Post-Concussion Symptoms Questionnaire* pour évaluer la sévérité des symptômes ***Résultats:*** L'âge moyen des patients de notre échantillon était de 44 ± 16 ans, dont 51% étaient des hommes. Les patients de plus de 66 ans étaient significativement plus susceptibles de rapporter un TCL entre 6 AM et 12 PM (69%) par rapport aux patients des autres groupes d'âge. Les patients d'âge moyen (36 à 55 ans) était plus susceptibles de rapporter que certains symptômes post TCL étaient plus sévères (céphalée, nausées et vomissements, irritabilité, difficulté à se concentrer, troubles du sommeil, vision embrouillée, sensibilité à la lumière et idéation lente) que les patients de plus de 66 ans. ***Conclusions:*** En général, les patients d'âge moyen ont rapporté que la sévérité de leurs symptômes post-TCL était plus importante que celle rapportée par les patients plus âgés. Il y avait donc une association significative entre l'âge et la sévérité des symptômes spécifiques du TCL, ce qui souligne l'importance d'une gestion ciblée de ces symptômes. D'autres études devront être réalisées pour comprendre les mécanismes qui pourraient contribuer à la plus grande sévérité des symptômes éprouvés par le groupe de patients d'âge moyen.

Keywords: Head Trauma, Brain Injury-Traumatic

doi:10.1017/cjn.2016.441 Can J Neurol Sci. 2017; 44: 384-390

Traumatic brain injury (TBI) is the leading cause of mortality and morbidity in the world for individuals younger than age 45.[1] Mild TBI (mTBI) accounts for approximately 70% to 90% of all TBIs and is a major source of morbidity in up to 15% of patients experiencing long-term symptoms.[2-5] Data have shown that age plays a significant role in mTBI incidence, with a bimodal distribution with peaks occurring in young adulthood (15-19 years) and those >65.[6,7] Different age groups experience different injury mechanisms: falls are responsible for more than 50% of TBI among individuals older than age 65, whereas motor vehicle accidents are the leading cause of TBI-related mortality in young adults.[6,8]

It is generally believed that increased age leads to worse health outcomes following TBI. This may be due to several reasons: older adults may have less complete recovery compared with younger individuals with comparable injuries because of less capacity for compensation, older patients may be at higher risk for progressive cognitive decline after TBI because of age-related reductions in cerebral reserve, and older patients may be at higher risk for complications because of preexisting comorbidities.[9-11] However, the

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Received July 13, 2016. Final Revisions Submitted October 6, 2016. Date of Acceptance November 7, 2016.

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literature is unclear on whether age affects mTBI outcomes: some studies have suggested that increased age leads to worse outcomes, but other studies have shown that older adults actually do better than younger individuals on global outcome measures.[7,12-16] Thus, the discriminating effects of age on mTBI outcomes is uncertain.

mTBI symptoms are broadly categorized into three domains: physical (headache, nausea, vomiting), behavioural/emotional (fatigue, depression), and cognitive (memory changes). mTBI can often cause persistent symptoms and long-term disability, which can have detrimental effects on the patient's life, occupation, and psychosocial functioning.[17] Several studies have examined the impact of age on post-mTBI symptoms, but results are inconclusive: some studies indicated that older age is associated with greater severity of cognitive symptoms, whereas other studies have suggested that there are no differences in type or severity of post-mTBI symptoms between young and older age groups.[7,13,15,17-20] This study aims to primarily examine age and its association with mTBI symptomatology and severity using a validated mTBI symptom questionnaire, with the goal of guiding clinical practice with respect to assessments and interventions.

Methods

Participants

This study was approved by the Research Ethics Board of St. Michael's Hospital (Toronto, Ontario, Canada). The population in this study was 167 patients seen at the Head Injury Clinic (HIC), a level 1 tertiary outpatient clinic at St. Michael's Hospital from June 2013 to January 2015, who met the criteria for mTBI and were >16 years of age. For this study, we used the definition of mTBI created by the American Congress of Rehabilitation Medicine. mTBI was defined as a "traumatically induced physiologic disruption of brain function including at least 1 of the following: any period of loss of consciousness, any loss of memory for events immediately before or after the accident (post-traumatic amnesia), any alteration in mental state at the time of accident (feeling disoriented, dazed, or confused), or focal neurological deficits, but where the severity of the injury did not exceed the following: loss of consciousness of 30 minutes or less, an initial Glasgow Coma Scale of 13-15 after 30 minutes, and post-traumatic amnesia not greater than 24 hours." [21]

Study Instruments

Upon their first visit to the HIC, patients were required to complete the HIC Screening Tool, which collected information on demographics, place of injury, injury mechanism, mTBI characteristics, and comorbidities. The HIC Screening Tool was designed using common data elements for TBI from several internationally recognized sources such as the National Institute of Neurological Disorders and Stroke and the Ontario Neurotrauma Foundation Clinical Guidelines, with the goal of ensuring standardization in data collection for a better understanding of mTBI diagnosis and prognosis.[22] All patients completed the Rivermead Post-Concussion Symptoms Questionnaire (RPQ), which was intended to give insight into the severity of 16 postconcussion symptoms that patients may be experiencing. In the RPQ, there were five response alternatives on an ordinal level that patients used to indicate the degree to which symptoms are more of a problem compared to preinjury levels. The RPQ has been shown to measure severity of postconcussion symptoms reliably with good test-retest and inter-rater reliability for individual symptom scores.[23] Current research has suggested splitting the RPQ into two subscale scores: RPQ-3 uses the sum of scores from three items (headaches, dizziness, and nausea) and RPQ-13 uses the sum of scores of the other 13 items.[24,25] Higher scores especially for the RPQ-13 subscale are associated with greater impact on lifestyle.[25]

Table 1: Characteristics of participants by age group

	16-25 years (n = 27)	26-35 years (n = 31)	36-45 years (n = 29)	46-55 years (n = 42)	56-65 years (n = 24)	66 + years (n = 14)	p value
Gender (% female)	56	39	48	48	50	57	0.82
Highest education (%)							0.35
Less than high school	24	15	7.4	12	4.8	29	
High school	28	19	11	18	19	21	
Postsecondary studies	48	67	82	70	76	50	
Country of birth (% Canada)	85	74	81	73	38	42*	0.002*
Language at home (% English)	85	96	92%	100	90	75	0.08
Living alone (%)	3.8	15	16	27	43	54*	0.002*
Living with children <21 years of age (%)	3.8	11	46†	33	9.5	0	<0.001†
Employed preinjury (%)	64	89	92	94%	85%	50*	0.001*
Current employment status							<0.001†
% working	25	38	44	39	30	23	
% sick leave/laid off	8.3	17	11.1%	6.1	10	0	
% unemployed	4.2	4.2	11.1	6.1	5.0	0	
% disabled	29	33	33	46	40	0	
% retired	0	0	0	0	15	70†	

$p < 0.01$; †$p < 0.001$. Data were analyzed using chi-square analyses with Bonferroni post-hoc testing.

https://doi.org/10.1017/cjn.2016.441 Published online by Cambridge University Press

Statistical Analysis

All data were analyzed using SPSS. For these analyses, patients were separated into age groups (16-25, 26-35, 36-45, 46-55, 56-65, >66 years). Descriptive analyses using chi-square analyses with Bonferroni corrections were used to examine characteristics of each age group in terms of determinants of health preinjury as well as characteristics of the mTBI event. Ordinal logistic regressions were used to determine the odd ratios of severe post-mTBI symptoms in each age group while controlling for days since injury, gender, and injury mechanism. Forward stepwise linear regressions were used to determine the odds ratio of higher RPQ subscale scores in relation to increasing age. Significance was assigned at $p < 0.05$.

Results

Characteristics of Participants

A total of 167 patients seen at the HIC met the American Congress of Rehabilitation Medicine criteria for mTBI and were included in the study. Descriptive statistics for patient characteristics by age group are shown in Table 1. The mean age in the overall sample was 44 ± 16 years (51% males). Approximately 50% of the oldest age group was employed preinjury, which was significantly lower compared with other age groups ($p = 0.001$). A total of 46% of the 36- to 45-year-old age group reported living with children younger than 21 years old, which was higher compared with other age groups ($p < 0.001$). There were no significant differences in comorbidities across age groups ($p > 0.05$ for all).

mTBI Characteristics

Descriptive statistics for mTBI time and mechanisms are shown in Table 2. Sixty-nine percent of mTBI in the oldest age group occurred during the morning (6 AM-12 PM), which was a significantly higher proportion compared with all other age groups ($p = 0.001$). There were no significant differences in injury mechanism between age groups ($p = 0.34$). The average time from mTBI to first medical evaluation at the HIC was approximately 317 days. There were no significant differences in time from mTBI to medical evaluation at the HIC between age groups ($p = 0.87$). There were no differences in mTBI characteristics or associated injuries between age groups as shown in Table 3.

Predictors of Severity of Post-mTBI Symptoms

In general, age was found to be a significant predictor of the severity of several symptoms experienced post-mTBI, with middle-aged patients reporting more severe symptoms compared with the oldest patient group. All age groups were more likely to report a severe headache and nausea/vomiting over not experiencing at all compared with patients >66 years old ($p < 0.05$ for all).

Table 2: mTBI time and mechanisms by age group

	16-25 years (n = 27)	26-35 years (n = 31)	36-45 years (n = 29)	46-55 years (n = 42)	56-65 years (n = 24)	66 + years (n = 14)	p value
Mean days since injury until seen at clinic	287 ± 263	346 ± 263	286 ± 229	306 ± 304	358 ± 234	352 ± 280	0.87
Season in which injury occurred (%)							0.22
Spring	33	19	17	22	46	14	
Summer	26	19	21	32	13	43	
Fall	26	36	21	29	21	21	
Winter	15	26	41	17	21	21	
Time in which injury occurred (%)							0.001*
6 AM-12 PM	33	9.1	25	21	28	69*	
12 PM-6 PM	24	14	46	53	39	23	
6 PM-12 AM	19	50	17	18	28	0	
12 AM-6 AM	24	27	13	8.8	5.6	7.7	
Injury mechanism (%)							0.34
Acceleration/deceleration	4.2	10	12	24	23	8.3	
Direct impact to head	67	53	56	46	41	33	
Fall >1 meter	17	10	16	15	9.1	17	
Ground level fall	8.3	23	12	12	23	33	
Other	4.2	3.3	4	2.4	4.5	8.3	
Category of injury (%)							0.10
Transportation	52	38	43	51	52	50	
Falls	15	31	39	34	33	43	
Violence	0	10	11	0	0	7.1	
Sports	33	17	7.1	15	9.5	0	

$p < 0.01$; †$p < 0.001$. Data were analyzed using chi-square analyses with Bonferroni post-hoc testing.

https://doi.org/10.1017/cjn.2016.441 Published online by Cambridge University Press

Table 3: mTBI characteristics by age group

	16-25 years (n = 27)	26-35 years (n = 31)	36-45 years (n = 29)	46-55 years (n = 42)	56-65 years (n = 24)	66 + years (n = 14)	p value
Anterograde amnesia (%)	22	33	28	9.5	21	7.1	0.70
Retrograde amnesia (%)	56	42	61	29	46	36	0.17
Loss of consciousness (%)	48%	32	45	50	46	71	0.55
Altered consciousness (%)	69	90	86	86	82	85	0.79
Seizure within 48 hours (%)	0	3.2	0	4.8	0	0	0.63
Vomiting within 48 hours (%)	23	24	27	6.2	5.0	15	0.49
Admitted to hospital immediately after injury (%)	36	17	31	28	35	43	0.54
Emergency room visit immediately after injury (%)	48	31	62	56	44	57	0.23
Associated injury (other than head and neck) (%)	71	52	62	74	77	86	0.26
Death or severe injury to others as a result of event (%)	8.7	0	7.4	0	0	7.7	0.26

*p < 0.01; †p < 0.001. Data were analyzed using chi-square analyses with Bonferroni post-hoc testing.

As shown in Figure 1, the middle-aged group (36-45 and 46-55 years) were particularly more likely to report experiencing severe symptoms compared with the oldest patients. The 36- to 45-year-old age group reported higher severity of headaches (odds ratio [OR], 5.56; 95% confidence interval [CI], 1.51-20.44; p = 0.01), nausea and vomiting (OR, 25.15; 95% CI, 2.72-233; p = 0.01), irritability (OR, 5.65; 95% CI, 1.57-20.31; p = 0.01), poor concentration (OR, 4.93; 95% CI, 1.36-17.81; p = 0.02), and taking longer to think (OR, 4.74; 95% CI, 1.30-17.20; p = 0.02) compared with patients >66 years of age. As shown in Figure 2, the 46- to 55-year-old age group reported higher severity of sleep disturbance issues (OR, 3.85; 95% CI, 1.09-13.60; p = 0.04), blurry vision (OR, 4.10; 95% CI, 1.16-14.4.4; p = 0.03), and light sensitivity (OR, 3.80; 95% CI, 1.09-13.19; p = 0.04) compared with the oldest age group. Also, the 55- to

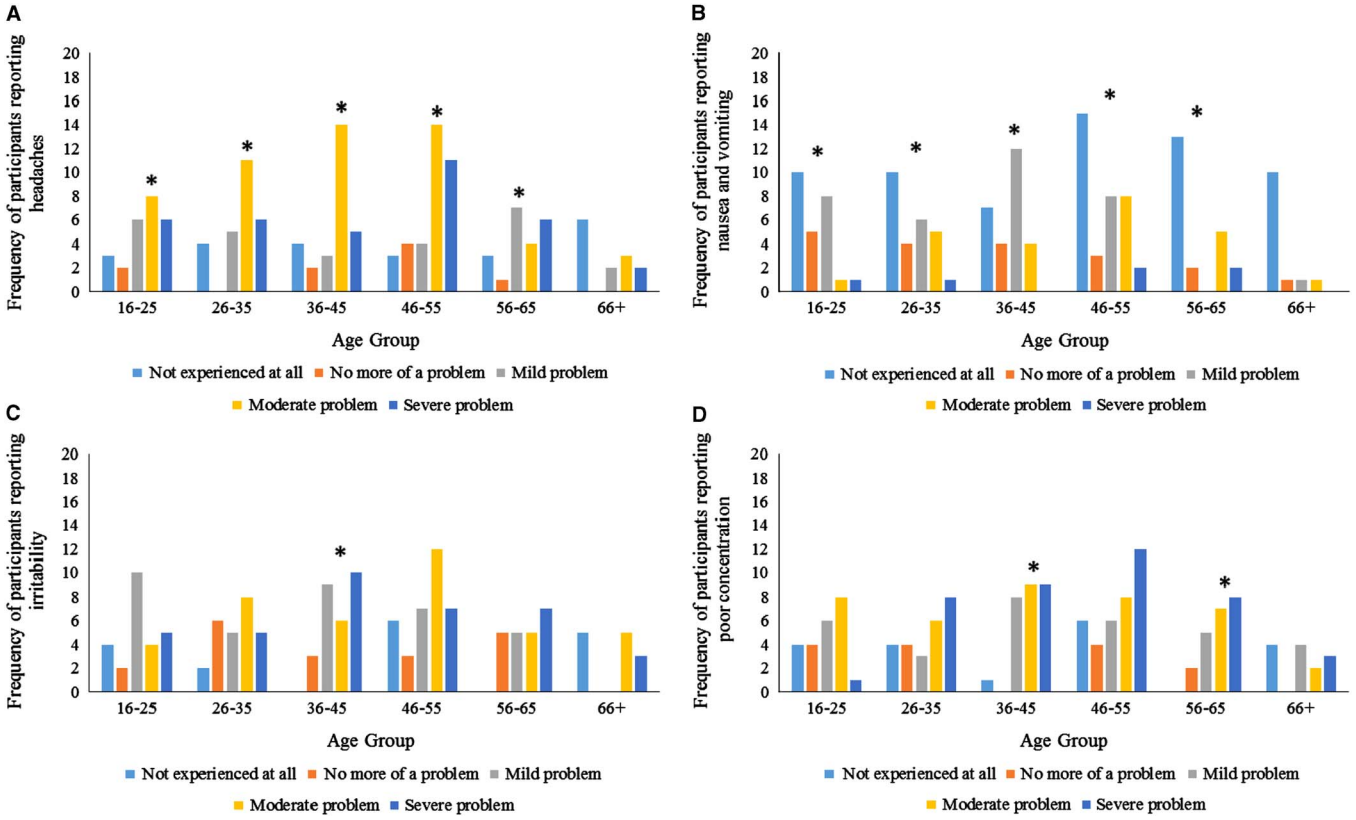

Figure 1: *All age groups reported significantly higher severity of headaches (A) and nausea and vomiting (B) compared with the 66+ year-old age group. The 36- to 45-year-old age group reported significantly higher severity of irritability (C) and poor concentration (D) post-mTBI compared with the 66+ year old age group. The 56- to 65-year-old age group also reported significantly higher severity of poor concentration post-mTBI compared with the 66+ year old age group. *p < 0.05 (ordinal logistic regressions).*

https://doi.org/10.1017/cjn.2016.441 Published online by Cambridge University Press

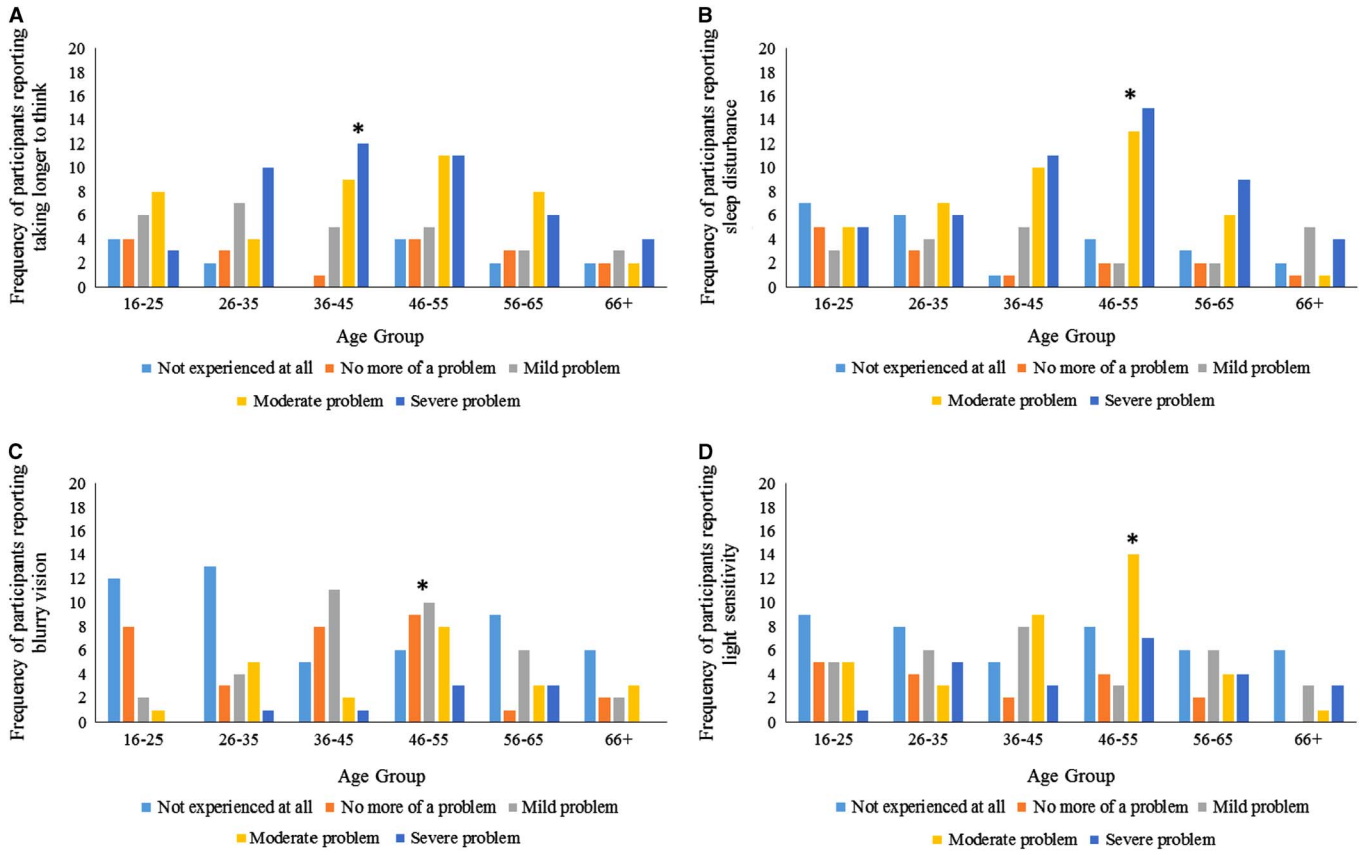

Figure 2: *(A) The 36- to 45-year-old age group reported significantly higher severity of taking longer to think post-mTBI compared with the 66+ year old age group. The 46- to 55-year-old age group reported significantly higher severity of sleep disturbances (B), blurry vision (C), and light sensitivity (D) post-mTBI compared with the 66+ year old age group. *p < 0.05 (ordinal logistic regressions).*

65-year-old age group reported higher severity of concentration issues post-mTBI compared with the oldest age group (OR, 5.01; 95% CI, 1.33-18.91; p = 0.02).

As days since the mTBI increased, patients were more likely to report severe headache, nausea and vomiting, sleep disturbance, fatigue, irritability, feeling depressed, feeling frustrated, memory changes, poor concentration, taking longer to think, blurry vision, and double vision ($p < 0.05$ for all).

Gender was a significant predictor of severity of noise sensitivity post-mTBI, with females being 2.04 times more likely (95% CI, 0.27-0.89, p = 0.02) to report severe symptoms compared to males.

Injury mechanism was not found to be a significant predictor for the severity of any of the symptoms and was removed from the ordinal regression model.

Predictors of RPQ Subscale Scores

The average RPQ-3 subscale score was 5.98 ± 4.14 and the average RPQ-13 subscale score was 27.7 ± 12.4. There were no differences between age groups in RPQ-3 subscale scores ($p > 0.05$). The middle-aged groups (36-45, 46-55, and 55-65 years) had significantly higher RPQ-13 subscale scores compared with patients >66 years of age, $F(5, 144) = 2.44$, $p = 0.04$. Days since injury were significant predictors for the RPQ-3 subscale score, $F(1, 145) = 5.45$, $p = 0.02$, $R^2 = 0.04$ and RPQ-13 subscale score, $F(3, 143) = 5.48$, $p = 0.001$, $R^2 = 0.10$.

Discussion

Our finding that 69% of mTBI in the elderly (>66 years) occurred in the morning from 6 AM to 12 PM is a new finding not reported in the literature. This result suggests that elderly patients may be at higher risk of mTBI when they wake up in the morning, which may be a result of medications or postural hypotension; however, further research is needed to validate this hypothesis.

We used a validated questionnaire (RPQ) to assess the severity of post-mTBI symptoms in patients at a level 1 tertiary care outpatient HIC. Our findings showed that age was significantly associated with higher severity of certain symptoms post-mTBI. Our study suggests that middle-aged individuals with mTBI (36-55 years) have a higher likelihood of reporting severe symptoms compared with elderly patients for several common mTBI symptoms. Middle-aged patients also had significantly higher RPQ-13 subscale scores, which have been associated with a greater impact on lifestyle, compared with patients >66 years of age.[25] Middle-aged patients may be experiencing more severe symptoms post-mTBI because of additional stressors: in our sample, 92% to 94% of the middle-aged patients were employed preinjury and approximately 39% to 44% were currently working at the time they were seen at the HIC, which was significantly higher compared with the older age groups. Also, a significant proportion of the middle-aged group (33%-46%) was also living with dependents (children <21 years), which was higher than all other age groups and may lead to financial and other

https://doi.org/10.1017/cjn.2016.441 Published online by Cambridge University Press

stressors, which may act to increase the severity of post-mTBI symptoms experienced by patients. Another important consideration is baseline functional status pre-mTBI: elderly patients may not perceive the post-mTBI symptoms to be a significant deviation from their regular functioning, whereas younger patients may experience a significant deviation from their regular functioning. Severity of symptoms may be related to the level of cognitive demands placed on patients following mTBI: for example, elderly patients may perceive fewer post-mTBI symptoms because of decreased cognitive demands during retirement, whereas younger patients may perceive more symptoms, which are further exacerbated by stressors and increased demands related to returning to work and school.[26] The association between age and the likelihood of reporting certain severe symptoms post-mTBI highlights the need for targeted management. This may include earlier referral to specialized services, rehabilitation programs, and more regular follow-up with family physicians for medical management for issues such as chronic headaches, nausea and vomiting, mood changes, and cognitive changes.

As days since the mTBI increased, patients were more likely to report severe headache, nausea and vomiting, sleep disturbance, fatigue, irritability, feeling depressed, feeling frustrated, memory changes, poor concentration, taking longer to think, blurry vision, and double vision. Also, days since mTBI was the only significant predictor of higher RPQ-3 and RPQ-13 subscale scores, which have been shown to have an impact on quality of life.[25] Days since mTBI is an important variable to consider: research has shown that up to 15% of patients experience persistent disabling problems and, even 1 year after injury, 22% are still below functional status.[17] Lengthy wait times to specialized services and treatment may contribute to the increased severity of symptoms experienced by patients.

Strengths of our study include the use of a validated screening tool for post-mTBI symptom severity and our exploration of various age ranges and the characteristics of patients with mTBI being seen at one of the largest outpatient head injury clinics in Canada. The study has several limitations. The data collected in this study were obtained through self-reporting and thus may be prone to recall bias, which may lead to overestimation or underestimation of symptom severity scores.[27] Other limitations include not having data regarding previous history of mTBI and post-mTBI depression or mental health conditions, which may impact symptom severity. Last, the population of this study is restricted to patients seen at a tertiary care centre in downtown Toronto and cannot be generalized to all mTBI patients.

Conclusions

These findings may have important implications for mTBI management based on age at time of mTBI. Health care providers may wish to consider risk factors that may lead to experiencing greater severity of post-mTBI symptoms and use this information to triage patients on the wait list and to offer earlier referrals to specialized services to manage chronic post-mTBI symptoms. Additional research on the differential effect of age on post-mTBI symptoms would be valuable and help guide clinical assessment and management.

Acknowledgments and Funding

The authors have no funding sources to report.

Disclosures

TH, CH, and DO do not have any disclosures.

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