



Original Research

# Exploring Age and Sex Patterns for Rehabilitation Referrals After a Concussion: A Retrospective Analysis



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## KEYWORDS

Concussion education;  
Mild traumatic brain  
injury;  
mTBI;  
Rehabilitation;  
Rehabilitation care

**Abstract Objective:** To explore patterns of postconcussion care at a level 1 trauma center.

**Design:** Retrospective cohort study.

**Setting:** U.S. level 1 trauma center and local satellite units.

**Participants:** Patients of any age with a concussion diagnosis that reported to level 1 trauma center and local satellite units between 2016 and 2018 (N=2417).

**Intervention:** Not applicable.

**Main Outcome Measures:** Age, sex, point of entry, rehabilitation referrals, and pre-existing comorbidity diagnosis.

**Results:** Patient age (mean [SD]) significantly differed among points of entry, from youngest to oldest: 26.0 (14.0) years in sports medicine, 29.3 (23.0) years in the emergency department, 34.6 (23.6) years at primary care providers, and 46.0 (19.7) years at specialty care departments. Sex also significantly differed among points of entry; emergency departments reported more men (55.6%), whereas the other points of entry reported more women (59.3%-65.6%). Patients

**List of abbreviations:** ADHD, attention deficit/hyperactivity disorder; ICD-10, *International Classification of Diseases* 10th Revision; LOC, loss of consciousness; OHSU, Oregon Health Science University; OR, odds ratio; OT, occupational therapy; Psych, psychology; PT, physical therapy; ST, speech therapy.

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were more likely to receive a referral from sports medicine (odds ratio [OR]<sub>unadjusted</sub>=75.05,  $P<.001$ ), primary care providers (OR<sub>unadjusted</sub>=7.98,  $P<.001$ ), and specialty care departments (OR<sub>unadjusted</sub>=7.62,  $P<.001$ ) than from the emergency department. Women were more likely to receive a referral (OR<sub>unadjusted</sub>=1.92,  $P<.0001$ ), regardless of point of entry. Lastly, patients with a preexisting comorbidity were more likely (OR<sub>adjusted</sub>=2.12,  $P<.001$ ) to get a rehabilitation referral than patients without a comorbidity.

**Conclusions:** Point of entry, age, sex, and preexisting comorbidities are associated with postconcussion care rehabilitation referral patterns. Improving concussion education dissemination across all entry points of a level 1 trauma center may standardize the postconcussion rehabilitation referral patterns, potentially improving the time to recovery from a concussion.

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There has been an increased focus on concussion awareness, because annually up to 1% of the population will sustain a concussion, with higher risk groups such as children and older adults exhibiting rates of up to 2%-6% annually.<sup>1</sup> Other estimates suggest that up to 40% of adults are affected by concussion at sometime within their life.<sup>2,3</sup> A concussion is defined as an acute brain injury resulting from mechanical energy transmission to the head from external physical forces, which is accompanied by a cascade of transient symptoms and neurologic abnormalities.<sup>4</sup> A concussion can occur during sport, during military service, or in everyday life (eg, fall or motor vehicle collision). The symptoms after concussion are heterogeneous, but commonly include balance and cognitive deficits, which can significantly decrease quality of life.<sup>5</sup>

Current evidence suggests that the incidence of concussion occurs in a bimodal age distribution, with the most commonly affected populations being young adult men who are involved in sport and motor vehicle collisions and older adult women who experience falls.<sup>1,2</sup> Despite this bimodal age distribution, most guidelines for concussion are aimed at younger populations, specifically those who sustained a sport-related concussion.<sup>6-9</sup> Comparatively, there is considerably less guidance on management of postconcussion care for middle-aged and older adults, which may affect where postconcussion care is sought.

After sustaining a concussion, a primary consideration is where to go for medical care. Timing of diagnosis and subsequent referrals, including rehabilitation, may play an important role in recovery and, therefore, health care point of entry might be an important decision. Given the heterogeneity of symptoms after concussion, there are no clearly identified point(s) of entry to receive postconcussion medical care.<sup>10</sup> Point of entry in pediatric populations after a concussion varies by age.<sup>11</sup> Over half of patients under age 4 entered via the emergency department, whereas more than three-quarters of patients aged 5-17 years entered via primary care providers.<sup>11</sup> Little is known regarding point of entry patterns of individuals  $\geq 18$  years.

One key recommendation from the Centers for Disease Control and Prevention is to assess known risk factors that impact concussion recovery, including a history of mood disorders (eg, depression and anxiety),<sup>12</sup> attention deficit/hyperactivity disorder (ADHD),<sup>13</sup> migraine headaches,<sup>14</sup> dizziness at onset of injury,<sup>15</sup> and higher symptom scores after injury.<sup>16</sup> It is unclear whether these risk factors are routinely

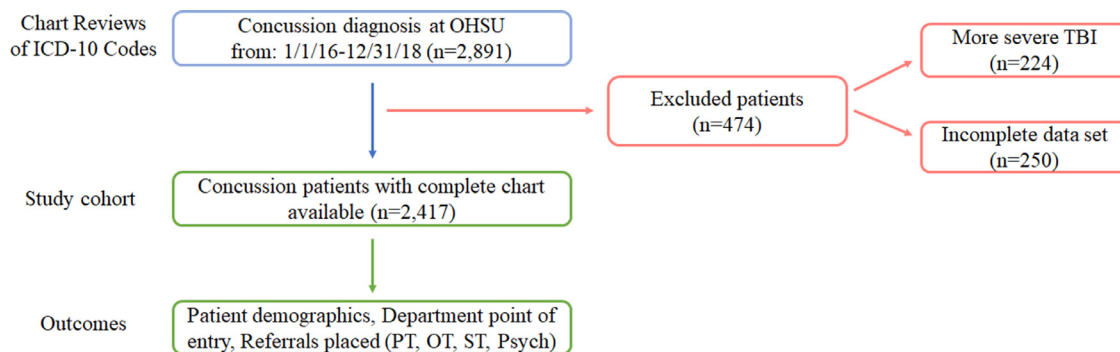
considered across all points of entry or only in specialized clinics, such as sports medicine, where more extensive concussion-specific training may occur. Importantly, assessing known evidence-based risk factors for prolonged recovery has implications for relevant referrals to improve outcomes and speed of recovery.

The aim of this retrospective study was to explore postconcussion care patterns at a level 1 trauma center. Specifically, we were interested in determining whether there was an association among demographic information (eg, age and sex) with point of entry into the medical system and whether point of entry was associated with referral patterns to rehabilitation (physical, occupational, and speech therapy and psychological) care. We also explored whether known risk factors for poor outcomes after concussion such as preexisting diagnoses of depression, anxiety, ADHD, migraine, and headaches or sex changed referral patterns for rehabilitation care.

## Methods

This retrospective study was approved by Oregon Health Science University (OHSU) Institutional Review Board. Collection of informed consent was not required because all data were deidentified and retrospective in nature. We extracted data from January 1, 2016, to December 31, 2018, for patients who came to OHSU after a concussion (figure 1). Data were extracted by the Oregon Clinical and Translational Research Institute Research Data Warehouse from Epic Clarity, via Epic.<sup>a</sup> Epic is an electronic health record system commonly used in hospitals and clinics across the United States. Epic Clarity is a data warehouse that captures and constructs data from Epic into a format that is reportable for analysis. The Research Data Warehouse leverages Epic's Clarity database, which contains data from individual EpicCare patient electronic medical records. The database query inclusion criteria were (1) between 1 and 89 years of age and (2) had a primary diagnosis of concussion according to International Classification of Diseases 10th Revision (ICD-10) codes S06.0 (concussion), S09.90 (unspecified injury of the head) and F07.81 (postconcussion syndrome). For code S06.0, we included concussion without loss of consciousness (LOC), LOC $\leq 30$  minutes, and LOC of unspecified duration.

Patients were excluded if any of the following were indicated in their primary diagnoses: more severe head injuries



**Fig 1** Patient Consolidated Standards of Reporting Trials diagram. The initial 2891 were populated by searching for specific ICD-10 codes for patients seeking care between January 1, 2016, and December 31, 2018.

such as skull fracture, hospitalization that was associated with their concussion, or any positive findings on imaging (eg, hematoma, subdural, epidural). We excluded patients who were admitted to the hospital. To identify these patients, we sorted individual patients by all associated ICD-10 codes. Final exclusion was determined by this method and patients with specific ICD-10 codes (S02, S06.1-S06.9, S07, S08) were removed from the data set.

The query included demographic information (age and sex), initial point of entry into OHSU, preexisting comorbidities (depression, anxiety, ADHD, migraine, and headaches), and rehabilitation referrals. Point of entry was categorized into emergency department, primary care provider (pediatrics, family medicine, internal medicine, and women's health center), sports medicine, and specialty care departments (neurology, cardiology, pain center, trauma, and ophthalmology). The rehabilitation referrals that were extracted included physical therapy (PT), occupational therapy (OT), speech therapy (ST) and psychology (Psych; both psychology and neuropsychology).

## Statistical analyses

We used descriptive statistics (mean, [SD], median, frequency, percent) to characterize individuals seeking post-concussion care at OHSU. Logistic regression was used to test whether receiving a rehabilitation referral (any combination of PT, ST, OT, or Psych) was associated with point of entry, sex, age, and preexisting comorbidities. Chi-square, odds ratios, and 95% confidence intervals are reported. The majority of the analyses were designed and completed by a statistician (BHB) using STATA 16<sup>b</sup> software package.

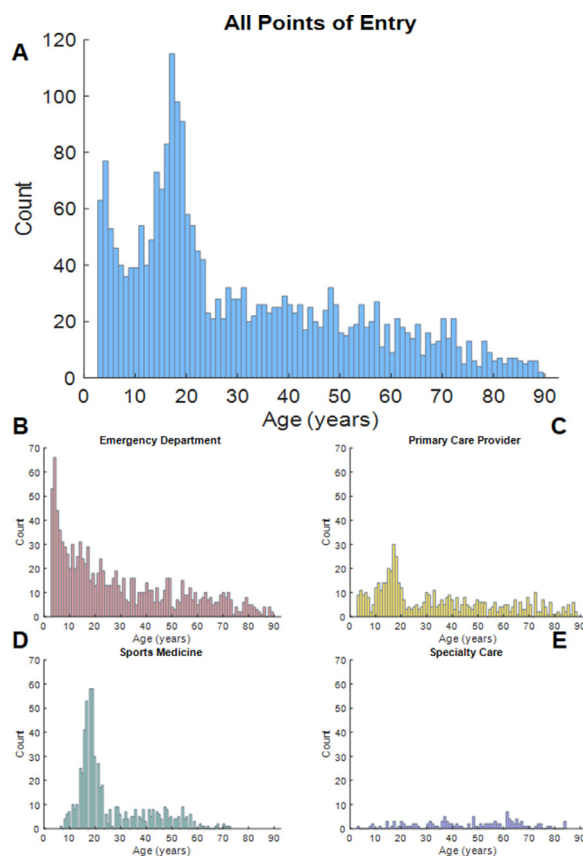
## Results

### Point of entry demographics

There were 4 primary points of entry identified for patients (N=2417) seeking care for a concussion at OHSU: emergency department, primary care provider, sports medicine, and specialty care departments. Of the 4 point of entry groups, the emergency department had the largest number of patients seeking postconcussion care (n=1137) and specialty care had the fewest (n=119). The primary care providers

saw 554 patients and sports medicine saw 607 patients seeking postconcussion care.

The majority of patients were 10-25 years old (figure 2A). The mean age was 30.5 years (SD=21.6). Patient age ranged from 3 to 89 years. The age distribution differed by point of entry (figures 2B-2E). Patients seeking postconcussion care with a point of entry in the emergency department or sports medicine tended to be younger (emergency department: mean=29.3 years, SD=23.0; sports medicine: mean=26.0 years, SD=14.0). The other points of entry were



**Fig 2** Histograms displaying the age distributions for (A) all points of entry (N=2417), (B) ED (n=1137), (C) primary care provider (n=554), (D) sports medicine (n=607), and (E) specialty departments (n=119).

more evenly distributed across age, though the average ages were older than for the emergency department and sports medicine patients (primary care provider: mean=34.6 years, SD=23.6; specialty care: mean=46.0 years, SD=19.7). Across all points of entry, more patients identified as female (53.8%) than male (46.2%). When sex was broken down by point of entry, the emergency department reported more men (55.6%), whereas the other points of entry reported more women (primary care provider 64.6%; sports medicine 59.3%; specialty care 65.6%). The distribution of sex by point of entry was statistically significant ( $\chi^2=80.4$ ,  $P<.0001$ ).

### Rehabilitation referrals: Point of entry, age, sex, clinical comorbidities

Logistic regression showed that point of entry significantly predicted whether a patient received a rehabilitation referral ( $\chi^2=755.4$ ,  $P<.0001$ ; table 1). Across all points of entry, PT referrals (n=319) were the most common, followed by OT (n=233), ST (n=185), and Psych (n=87). Using the emergency department as the reference group in a logistic regression, the majority of rehabilitation referrals were from the sports medicine point of entry. The sports medicine point of entry was responsible for 78.6% of rehabilitation referrals. Within the 648 sports medicine rehabilitation referrals, 38.0% were to PT, 28.4% to OT, 21.8% to ST, and 11.8% to Psych. Though not as likely as the sports medicine point of entry, patients whose point of entry was their primary care provider or specialty care also had significantly higher odds of receiving a rehabilitation referral compared to patients whose point of entry was the emergency department (see table 1). Sex was significantly associated with receiving a rehabilitation referral ( $\chi^2=35.0$ ,  $P<.0001$ ; see table 1 and figure 3), with women more likely to receive a rehabilitation referral than men. Age was not a significant factor for receiving a rehabilitation referral ( $\chi^2=0.51$ ,  $P=.47$ ).

Headache, anxiety, and depression were the 3 most common preexisting comorbidities in this cohort (table 2). Women (58.8%) were significantly more likely to be diagnosed with a preexisting comorbidity than men ( $\chi^2=78.9$ ,  $P<.0001$ ), whereas men (54.6%) were more likely to be diagnosed with preexisting comorbid ADHD than women. The primary care provider point of entry group had the highest percentages of preexisting comorbidity diagnoses, except for preexisting migraine comorbidity (specialty care point of entry group). After controlling for sex in a logistical regression, patients with a comorbidity had

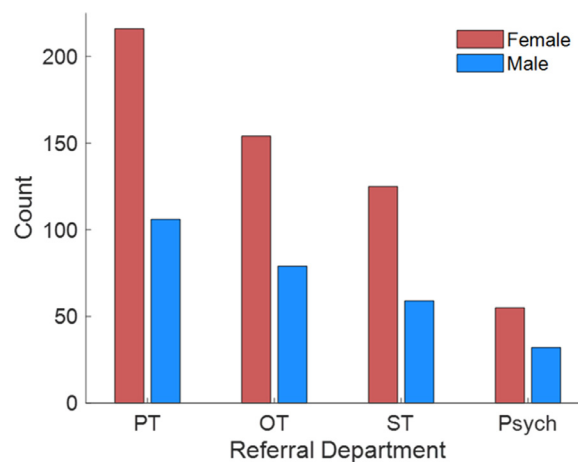


Fig 3 Rehabilitation referral type by sex. Sex counts for type of rehabilitation referral, regardless of point of entry.

higher odds of receiving a rehabilitation referral (see table 1).

### Discussion

In this retrospective study, age and sex differed with regard to where patients entered OHSU seeking postconcussion care, which affected the odds of receiving a rehabilitation referral. Beyond point of entry, these associative results highlight the roles that sex and preexisting comorbidity diagnoses have on postconcussive rehabilitation referral patterns. These findings underscore the importance of clear and consistent referral guidelines for clinicians across disciplines.

The age distribution of patients seeking postconcussion care at OHSU differed by point of entry. Patients who entered through the emergency and sports medicine departments were younger than those who entered through primary care providers and specialty care. Older adults more often received postconcussion care through their primary or specialty care clinics. Across all 4 points of entry, the mean age was <46 years, which showed that the population seeking postconcussive care at OHSU is relatively young, unlike other studies that suggest higher rates of emergency department visits by older adults than middle-aged adults.<sup>3,17-19</sup> These discrepancies in the frequency of older adults seeking medical attention after concussion may be explained in

Table 1 Odds ratios for rehabilitation referrals

	Odds Ratio	95% Confidence Interval	P Value
Sex (ref=male)	1.92	1.54-2.39	<.0001
Point of entry (ref=ED)			
Primary care provider	7.98	4.67-13.61	<.0001
Sports medicine	75.05	45.87-122.79	<.0001
Specialty care	7.62	3.64-15.99	<.0001
Comorbidity diagnosis (ref=no comorbidity)*	2.12	1.70-2.66	<.0001

NOTE. Separate logistic regression models were run for sex (unadjusted), point of entry (unadjusted), and comorbidity (adjusted for sex).

\* Comorbidity OR collapsed across types of comorbidity.

**Table 2** Preexisting comorbidity of patient cohort

	Total (N=2417)	Emergency Department (n=1137)	Primary Care Provider (n=554)	Sports Medicine (n=607)	Specialty (n=119)
Headaches, n (% total; %F)	811 (32.7; 64.0)	275 (24.2; 49.8)	243 (43.9; 74.9)	224 (36.9; 67.4)	50 (42.0; 72.0)
Anxiety, n (% total; %F)	546 (22.0; 69.6)	172 (15.1; 61.1)	204 (36.8; 77.5)	119 (19.6; 64.7)	33 (27.7; 72.7)
Depression, n (% total; %F)	515 (20.8; 71.3)	175 (15.4; 64.0)	189 (34.1; 79.9)	91 (15.0; 64.8)	34 (28.6; 76.5)
Migraine, n (% total; %F)	305 (12.3; 74.8)	74 (6.5; 64.9)	114 (20.6; 84.2)	63 (10.4; 71.4)	42 (35.3; 69.1)
ADHD, n (% total; %F)	152 (6.1; 45.4)	47 (4.1; 36.2)	56 (10.1; 44.6)	35 (5.8; 48.6)	10 (8.4; 80.0)

NOTE. Count and percentage totals are for all patients with that comorbidity. The second percentage is specific to women in the cohort with that comorbidity.

several ways. First, the median age of Portland, Oregon, residents is 37.1 years,<sup>20</sup> a younger population that our sample represents. Second, many studies use categorical bins to report across age groups, whereas we used age as a continuous variable, potentially yielding different trends.<sup>3,17-19</sup> Another possibility is whether concussion is coded as the primary reason or diagnosis for the visit.

In our data set, older adults were not seen as frequently as younger adults across any point of entry. In older adults, falls are the leading mechanism for injury, including concussions.<sup>2</sup> Importantly, fear of loss of independence is a significant factor in not seeking medical care after a fall in older adults.<sup>21,22</sup> In addition to fear of loss of independence, older adults could be financially disincentivized to seek care after a fall.<sup>23</sup> One study found that older adults who experience a head injury in the home were half as likely to seek postinjury care than those sustaining an injury in the community or sporting events.<sup>24</sup> These disincentivizing factors for older adults contrast the younger populations, especially athletes, who may be required to seek postconcussion care for clearance to return to sport/school. Most concussion-based medical guidelines establish clear postconcussive clinical requirements that must be met in order for patients to be cleared to return to academic and athletic activities.<sup>6-9</sup> Indeed, collegiate student athletes are more likely to seek medical care postconcussion when concussion-specific education is provided by their institution.<sup>25</sup> Better dissemination of concussion education material should be a priority, especially where didactic education can help supplement the lack of experience.<sup>26</sup> Though efforts to increase cross departmental education and awareness are ongoing,<sup>27</sup> a clear understanding of how effective these efforts are remains unknown.

In addition to age, sex was a significant factor in the point of entry after a concussion. The emergency department was the only point of entry that reported more men seeking postconcussion care, whereas the remaining 3 points of entry reported significantly more women seeking postconcussion care. This aligns with the literature that suggests that women have higher rates of general medical care utilization and significantly higher mean number of visits to primary care providers and diagnostic services.<sup>28</sup> Further, female athletes seek postconcussion care at higher rates than male athletes.<sup>29</sup> Connected to this sex difference in seeking postconcussion care is the fact that women report more concussion-related symptoms and are diagnosed with concussion more often than men.<sup>30,31</sup> There are no established reasons

why women have more concussions or more severe concussions than men, although factors including hormones and musculature have been discussed as possibilities.<sup>32,33</sup> Perceived severity of concussion and prolonged symptoms are established factors in seeking care,<sup>24</sup> which may provide some explanation for the sex discrepancies reported herein. In this study, sex had a significant association with preexisting comorbidity diagnosis, which aligns with the literature regarding comorbidity diagnoses patterns.<sup>34-37</sup> Aside from ADHD, women were significantly more likely to be diagnosed with depression, anxiety, headache, and migraines than men in our cohort. Increased likelihood of these comorbidities in women aligns with previous literature, highlighting the need to factor the presence of comorbidities into postconcussion care.<sup>32,33</sup>

Like age and sex, preexisting comorbidity was a factor in point of entry.<sup>38</sup> Primary care providers were the most frequent point of entry for patients with any preexisting diagnosis of headache, ADHD, anxiety, and depression, and patients previously diagnosed with migraines sought postconcussion care at a specialty department point of entry. Although both the primary care providers and specialty care departments issued rehabilitation referrals more often than the emergency department, rehabilitation referrals from these 2 entry points were negligible compared to sports medicine. Preconcussion psychiatric (eg, depression and anxiety) and headache/migraine diagnoses are known risk factors for worse functional and postconcussive outcomes.<sup>12,14</sup>

Point of entry, sex, and preexisting comorbidity all affected rehabilitation referrals after a concussion diagnosis. Of the 4 points of entry, 78.6% of rehabilitation referrals came from the sports medicine clinic. Of the patients who did not enter through sports medicine, only 7% received a rehabilitation referral. This particular finding may be a result of the established postconcussion guidelines set for younger athletes (high school and collegiate). Our sports medicine group recently implemented an age limit ( $\leq 60$  years old), which artificially limits access to the most specialized group in postconcussion care. This age limit results in less specialized postconcussion care for older adult populations compared to younger populations. The odds of receiving a rehabilitation referral for postconcussion care are minimal outside of the sports medicine point of entry, resulting in the younger population being more likely to receive rehabilitation referrals. Recent evidence suggests that early physical therapy and aerobic exercise can

decrease recovery time postconcussion.<sup>39-41</sup> Promoting symptom-limited aerobic exercise as an integral part of concussion rehabilitation is a departure from the previously held belief that prolonged rest is the best approach to post-concussion care.<sup>8,42,43</sup> Emphasizing the importance of rehabilitation referrals to medical professionals might improve concussion recovery timeline for all patients.

### Limitations

This retrospective investigation is not without limitations. Due to the method of data extraction, we were unable to extract important information about the concussion, such as date, mechanism, and symptom reporting. Furthermore, we could not account for patient socioeconomic factors (eg, finances, insurance, etc) that could have influenced point of entry. Another limitation relates to how different clinicians coded (ICD-9/10) the concussive event in patient files, which may have reduced the true number of patients seeking post-concussive care. This study does not delineate among non-elite and elite athletes or military personnel, so interpretations should be limited to a broad population that may include these groups. Finally, because the data presented are specific to a level 1 trauma center and local satellite units in the United States, the results may not be generalizable to all geographic and clinical care settings.

### Conclusions

This retrospective analysis sheds light on the roles of age, sex, and preexisting comorbidities on postconcussion care rehabilitation referral patterns. Rehabilitation referrals may decrease recovery time and address important preexisting comorbidities that may otherwise be overlooked during the postconcussion care visit. There is significant variability in postconcussion care, particularly for older adults where the guidelines are not clear.<sup>3,17,19</sup> Point of entry into the medical system appears to affect postconcussion care. This work highlights the need for streamlined postconcussion care. Increasing the dissemination of standardized concussion education materials to medical professionals across all disciplines may reduce the variability of postconcussion care patterns. More work is needed on prospectively following patients through the recovery process to determine the most efficacious postconcussion care for any age, sex, and preexisting comorbidity.

### Suppliers

- a. EpicCare; Epic Systems Inc.
- b. STATA 16; StataCorp.

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