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Patient Presentations in Outpatient Settings: Epidemiology of Adult Head Trauma Treated Outside of Hospital Emergency Departments

Cheryl K. Zogg, MSPH, MHS^{1,2,3}, R. Sterling Haring, DO, MPH^{2,3,4}, Likang Xu, MD, MS⁵, Joseph K. Canner, MHS³, Taylor D. Ottesen, BS¹, Ali Salim, MD, FACS^{2,6}, Adil H. Haider, MD, MPH, FACS^{2,6}, and Eric B. Schneider, PhD^{2,3,7,8}

¹Yale School of Medicine, New Haven, CT

²Center for Surgery and Public Health: Harvard Medical School, Harvard T.H. Chan School of Public Health, and the Department of Surgery, Brigham & Women's Hospital, Boston, MA

³Johns Hopkins Surgery Center for Outcomes Research, Department of Surgery, Johns Hopkins University School of Medicine, Baltimore, MD

⁴Department of Health Policy & Management, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

⁵National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, GA

⁶Division of Trauma, Burn, and Surgical Critical Care, Brigham & Women's Hospital, Boston, MA

⁷Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

⁸Department of Surgery, University of Virginia School of Medicine, Charlottesville, VA

Corresponding author: Cheryl K. Zogg, MSPH, MHS, Yale School of Medicine, 67 Cedar Street, Room 316 ESH, New Haven, CT 06510, Phone: (612) 810-2770, czogg@jhmi.edu.

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Abstract

Background: While deaths, hospitalizations, and emergency department visits for head trauma are well understood, little is known about presentations in outpatient settings. Our objective was to examine the epidemiology and extent of healthcare-seeking adult (18–64y) head trauma patients presenting in outpatient settings compared to patients receiving non-hospitalized emergency department care.

Methods: We used 2004–2013 MarketScan Medicaid/commercial claims to identify head trauma patients managed in outpatient settings (primary care provider, urgent care) and the emergency department. We examined differences in demographic and injury-specific factors, CDC-defined head trauma diagnoses, and extent of and reasons for post-index visit ambulatory care use within 30/90/180 days by index visit location as well as annual and monthly variation in head trauma trends. We used outpatient incidence rates to estimate the US nationwide outpatient burden.

Results: A total of 1.19 million index outpatient visits were included (emergency department: 348,659). Nationwide, they represented a weighted annual burden of 1.16 million index outpatient cases. These encompassed 46% of all known healthcare-seeking head trauma in 2013 (outpatient/emergency department/inpatient/fatalities) and increased in magnitude (+31%) from 2004–2013. One-fourth (27%) of office/clinic visits led to diagnosis with concussion on index presentation (urgent care: 32%). Distributions of demographic factors varied with index visit location, while injury-specific factors were largely comparable. Subsequent visits reflected high demand for follow-up treatment, increased concussive diagnoses, and sequelae-associated care.

Conclusions: Adult outpatient presentations of head trauma remain poorly understood. The results of this study demonstrate the extensive magnitude of their occurrence and close association with need for follow-up care.

Keywords

head trauma; traumatic brain injury; concussion; ambulatory; outpatient

Introduction

In 2013, head trauma in adults (aged 18–64y) was associated with 32,539 deaths, 133,990 inpatient hospitalizations, and 1,182,377 emergency department visits,¹ making it one of the leading causes of death and disability for patients of all ages.^{1–4} Surveillance of head trauma has changed the way that providers, policy makers, and loved ones of injured patients both approach and understand the extent and consequences of traumatic brain injuries, including an increased awareness of concussive sequelae that often extend beyond the observable span of the initial injury. In the United States, head trauma surveillance efforts have historically been centered around a traumatic brain injury pyramid (Figure 1A) created by the Centers for Disease Control and Prevention (CDC) in 2004.^{2–4,1} The pyramid classifies head injuries according to location of care in order of severity and anticipated burden size with deaths at the pyramid's peak, followed by inpatient hospitalizations, emergency department visits, and a collective group expected to be the largest in number that seek other types of care or receive no care. At the time of the pyramid's creation, the CDC noted that “[t]here is no estimate for the number of people with non-fatal TBI seen outside of an emergency

department or hospital setting.”^{3,4} More than a decade later, the epidemiology of head trauma treated in outpatient settings remains largely unknown, particularly for adult patients (Figure 1B). What information on outpatient presentations is available is almost entirely restricted to pediatric (<18y) and older adult (>64y) populations.^{5–10}

As a result, providers and policymakers have begun to call for improvements in surveillance and understandings of the epidemiology of head trauma, particularly minor head-injury and concussion.^{11–13} Emerging pediatric literature suggests that much of this burden is likely to be found in outpatient locations managed by primary care providers.^{5,14–18} Exclusion of such patients from ongoing surveillance efforts has the potential to underestimate conclusions and lead to suboptimal management of limited head trauma prevention, treatment, and provider training resources.¹⁹ In order to better understand the issue among adult patients, the objectives of this study were to:

1. Estimate the national burden of adult head trauma in patients seeking care as outpatients;
2. Define epidemiologic characteristics of the population, including demographic and injury-specific factors, CDC-defined head trauma diagnoses, and the extent of and reasons for post-index visit ambulatory care use within 30/90/180 days;
3. Examine temporal and seasonal variability.

Methods

Study population

We identified index outpatient visits with International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) diagnosis codes consistent with the CDC’s definition of traumatic brain injury^{2–4,1} using 2004–2013 Truven Health Analytics MarketScan Research Databases: Medicaid and Commercial Claims and Encounters.^{20,21} MarketScan provides unique longitudinal data, offering the largest national record of outpatient data inclusive of adults aged 18–64y.^{20,21} It incorporates information from adjudicated and paid insurance-claims filed by employment-based private insurance and the Centers for Medicare & Medicaid Services.^{20,21}

Inclusion/exclusion criteria are presented in eFigure 1. Index outpatient visits were defined as initial office/clinic or urgent care presentations with subsequent care received exclusively in ambulatory settings. Ambulatory settings were defined as presentation to either an outpatient setting or the emergency department without subsequent inpatient hospitalization. Index visits were excluded if they were: treated in locations other than outpatient settings; follow-up visits after initial delivery of inpatient care; referrals to higher levels of care, including any subsequent inpatient admission; or for patients aged <18 or >64y. We included index emergency department visits meeting the same criteria as a comparison. For patients with multiple visits, 180 days were required to have passed since a previous index visit in order to constitute a second index visit with no indication of follow-up care in the 30 days prior to the second visit. Unless otherwise denoted by missing indicator variables, visits for patients missing information were also excluded.

We grouped included index visits into three categories: urgent care, office/clinic, and emergency department. Demographic factors (age, sex, insurance, region, year), injury-specific characteristics (loss of consciousness derived from ICD-9-CM codes, Charlson Comorbidity Index, maximum-head Abbreviated Injury Scale, overall Injury Severity Score), variations in post-index visit ambulatory care use, and CDC-defined head trauma diagnoses were compared among office/clinic, urgent care, and emergency department settings using descriptive statistics. Comorbidity and injury severity scores were calculated using ICD-9-CM diagnosis and E-codes.

Trends in temporal and seasonal data

We used joinpoint regression to examine annual temporal trends.^{22–24} Joinpoint regression is a segmented linear-modeling technique that describes changing trends over successive segments of time and the amount of increase/decrease associated with each.^{23–25} Segment connections, termed joinpoints, are assigned by the model at places where changes in trend beyond a predetermined threshold occur. Slopes join linear segments between them and provide estimates of the annual percent-change during that period. An overall average annual percent-change is calculated as the weighted geometric-average of the segment slopes with weights set equal to the segment lengths.^{23–25} Up to two joinpoints were allowed. Temporal trends were examined by index visit location and type of insurance (private versus Medicaid). Outpatient seasonal trends were also examined by month from January 2010–December 2013. Variations were assessed overall and stratified by insurance.

National estimates of the outpatient burden

In order to obtain national estimates for 2013, we multiplied observed rates of (insurance-specific) office/clinic, urgent care, and emergency department visits per 100,000 adult MarketScan enrollees by the (insurance-specific) portion of the 2013 US adult population aged 18–64y.²⁶ We assumed rates of uninsured visits were equal to the national Medicaid rate (eTable 1).¹⁴ For the sake of comparison to previous research,¹⁴ sensitivity analyses assessed broadly defined alternative specifications in which the uninsured rate was set equal to 10%, 25%, 50%, and 150% of the Medicaid rate. Results ranged from 0.91–1.30 million index visits nationwide per year (eTable 2). A second set of sensitivity-analyses addressed the possibility of misclassification, adjusting 2013 estimates to account for 5%, 10% or 20% over- or underestimation (eTable 3). Extrapolation of uncertainty reported in US Census Bureau²⁶ data provided 90% confidence-intervals (CI). Provider time for index visits was calculated based on the average length of time (~7 minutes) anticipated for a routine office or emergency department visit.^{27,28} Statistical analyses were conducted using Stata Statistical Software: Release 14.1 and SAS/STAT: Release 9.4. The Johns Hopkins Institutional Review Board approved the study.

Results

National burden of adult outpatient head trauma

A combined total of 1.54 million index visits met inclusion criteria for the 2004–2013 time period. One-fifth ($n=348,659$; 23%) were managed in a hospital emergency department (Table 1). An additional 1% ($n=12,958$) were treated in an urgent care center, while

1,175,913 (77%) were managed in an office/clinic. The majority ($n=1.19$ million) consisted of outpatient visits to office/clinic settings or urgent care. Nationwide in 2013, previously unaccounted for adult outpatient index visits represented an estimated annual incidence of 1.16 million outpatient visits (90% CI: 1.14–1.18 million) and 134,900 hours of provider time (eTable 1). When ambulatory emergency department visits defined under the same criteria were included, the numbers increased to 1.64 million annual index visits (90% CI: 1.61–1.67 million) and 190,900 hours of provider time.

Epidemiologic characteristics of the observed (insured) population

Epidemiologic characteristics stratified by index visit location, including variations in demographic and injury-specific factors, CDC-defined head trauma diagnoses, and post-index visit ambulatory care use, are presented in Tables 1–3, eTable4, Figure 2A-B, and eFigure 2.

Demographic patient factors: In the emergency department, presentation of adult head trauma decreased as patients aged, dropping from 28% among adults aged 18–24y to 15% among adults aged 55–64y (Table 1). Urgent care visits also decreased with age, while the proportion of office/clinic visits remained close to young adult levels (18–24y: 24%, 55–64y: 20%). Adults aged 18–24y comprised the highest proportion of visits in both settings. In all three index visit locations, males presented more frequently than females (54%–58% versus 42%–46%). Insurance differences were most pronounced in urgent care (Medicaid: 7% versus private: 93%) and office/clinic settings (14% versus 86%). In the emergency department, Medicaid insured 50% of ambulatory head trauma patients.

Injury-specific patient factors: Most index visits presented as isolated (Injury Severity Score=4–8: emergency department 89%, urgent care 95%, office/clinic 86%), non-severe head-injuries (maximum head Abbreviated Injury Scale<3: 95%, 98%, 93%). The majority did not present with any pre-existing comorbidity (Charlson Comorbidity Index=0: 90%–99%). An additional 1% (urgent care) to 8% (emergency department) had a comorbidity index score of 1; 3% (urgent care) to 7% (office/clinic) were diagnosed with ICD-9-CM codes suggestive of loss of consciousness. Differences between emergency department and office/clinic visits were largely not clinically meaningful. Urgent care visits had less severe indications.

CDC-defined diagnoses: Most index visits, regardless of location, had a documented diagnosis of ‘unspecified head-injury’ (959.01: emergency department 82%, urgent care 69%, office/clinic 73%) (Table 2). In office/clinic settings, 30% of these visits were did not involve diagnosis with other recorded head trauma diagnoses on index presentation. In the emergency department, >50% of index visits did not have a second head trauma diagnosis recorded. One-fifth (ambulatory emergency department) to one-third (urgent care) were diagnosed with a concussion (850.x: emergency department 20%, urgent care 32%, office/clinic 27%). A combined 7% were diagnosed with ‘other or unspecified’ intracranial wounds (854.x: emergency department 6%, urgent care 3%, office/clinic 7%).

Post-index visit ambulatory care use: Outpatients originally presenting for management in office/clinic settings had an average of 4.6 subsequent ambulatory visits within 180 days of their index visit (1.2 visits within 30 days) (Table 3). Nationwide, this corresponded to nearly 7 million annual ambulatory visits (a number that includes index head trauma presentations plus all subsequent follow-up and routine medical care; Table 3). Emergency department index visits presented for an average of 4.5 post-index ambulatory visits within 180 days (1.1 visits within 30 days), resulting in approximately 3 million annual ambulatory visits nationwide. These numbers present a striking contrast to the US population-wide average of 1.3 all-cause ambulatory visits reported every 180 days for adults aged 18–64y in 2013 (an average of 0.2 visits in 30 days).²⁸

The 20 most prevalent primary diagnoses recorded among adult patients on subsequent ambulatory presentation within 30 and from 31–180 days are presented in eTable 4. Within 30 days, the most frequent diagnoses appear to correspond to follow-up head trauma care, presenting as outpatient visits for unspecified head-injury (21%), other or unspecified intracranial wounds (5%), and an increased percentage of patients diagnosed with a primary diagnosis of concussion (collectively 19%). Seventeen of the 20 most prevalent diagnoses were consistent with either head trauma follow-up or recovery (*e.g.*, contusions, open head wounds) and associated sequelae (*e.g.* headaches, post-concussion syndrome, documented changes in consciousness and activity). From 31–180 days, the relative frequency of routine forms of outpatient care (*e.g.*, routine medical/physical examinations, screening mammograms, influenza vaccinations) and presentations for other types of chronic (*e.g.*, hypertension/hyperlipidemia, diabetes mellitus) and acute (*e.g.*, acute pharyngitis) conditions became more common. Presentations related to head trauma follow-up and sequelae, however, remained among the most frequent primary diagnoses reported.

Temporal and seasonal trends

The overall observed annual rate of presentation for ambulatory treatment of head trauma increased by more than 31% across the study period, growing from 468 per 100,000 adult enrollees in 2004 to 614 in 2013 (eTable 5), an average annual percent-change of +4.0% (95%CI: +2.3–5.7%). Rates of ambulatory emergency department visits defined by the same criteria did not meaningfully change and actually trended toward decrease (2004: 175 versus 2013: 128; average annual percentage change –5.3% [95%CI: –9.8 to –0.5%]). Insurance-stratified emergency department trends indicated no change (private-insurance average annual percentage change: +0.3% [95%CI: –4.1% to +4.8%]; Medicaid average annual percentage change: –0.5%, [–3.4 to +2.6%]). Rates of outpatient presentation in office/clinic (average annual percentage change +6.9% [+4.3–9.5%]) and urgent care (+28.1% [+24.2–32.1%]) settings, in contrast, both increased. Urgent care use rose from a baseline of one visit per 100,000 adult enrollees in 2004 to nine per 100,000 in 2013. Office/clinic visits climbed from 292 per 100,000 in 2004 to 477 per 100,000 in 2013. Overall changes from 2004–2013 were primarily driven by a +65% relative increase in Medicaid office/clinic visits that spiked in 2012–2013 and a more constant +78% relative increase among privately-insured office/clinic visits.

Temporal trends stratified by index visit location and type of insurance are presented in Figure 2. Patients with private insurance (Figure 2A) and Medicaid (Figure 2B) both exhibited overall increases (average annual percentage change private: +6.0% [95%CI: +4.2–7.8%]; Medicaid: +4.3% [95%CI: +2.3–6.4%]). Similar results were observed when restricted to office/clinic settings (average annual percentage change private: +6.9% [95%CI: +4.3–9.5%]; Medicaid: +9.7% [95%CI: 5.4–14.2%]). In office/clinic settings from 2004–2013, annual outpatient presentation rates among Medicaid-insured patients were nearly twice as high as those among privately-insured patients. Within the emergency department, rates were upwards of six times as high.

Seasonal trends in the monthly rates of outpatient head trauma index visits are presented in eFigure 2 (values eTable 6). Akin to annual rates, monthly rates among Medicaid-insured outpatients were approximately twice as high as those among privately insured patients. Both groups demonstrated similar seasonal trends: relatively constant rates from February to October, a slight drop during November to December, followed by a peak during January each year. The size of seasonal fluctuations among Medicaid patients appeared more pronounced relative to smaller changes seen among privately insured patients. Patterns for overall outpatient trends were dominated by the larger volume of privately insured cases.

Discussion

This study of the epidemiology of outpatient head trauma used national data to demonstrate that nearly one-half (46%; Figure 1B) of all known healthcare-seeking visits for head trauma in adult patients occurred in non-hospital, non-emergency department settings in 2013, primarily in physician's offices/clinics. The observed sample of 1.02 million privately insured and 165,000 Medicaid outpatient index visits represents one of the largest populations examined to date and one of the first to consider the burden of adult head trauma in outpatient settings. When applied to the national US population in 2013, inclusive of uninsured patients,²⁶ previously unaccounted for treatment of adult head trauma in office/clinic and urgent care settings would have encompassed as many as 1.16 million initial physician visits and 134,900 hours of provider time among patients aged 18–64y.

The results build on what information is known about adult presentations for head trauma in outpatient settings. Prior to this work, in a 5-year assessment of data from National Ambulatory Medical Care Survey/National Hospital Ambulatory Medical Care Survey, 2005–2009, Mannix and colleagues⁵ identified 133 outpatient office/clinic visits for minor head-injury among adults aged 19–64y, weighted to represent 1,838,600 outpatient visits nationwide—an average of 367,700 visits per year. Trends reported for patients of all ages from 1995–2009 using the same data sources further suggest that age-adjusted rates of outpatient use for head trauma have increased from 277 (1995–1997) to 380 (2007–2009) index visits per 100,000 population over the span of 3 years.⁸ Our results concur, revealing that, among adult outpatients specifically, annual rates have increased from 292 to 477 office/clinic visits per 100,000 adult population between 2004–2013. In Ontario, Canada, work by Ryu *et al.*⁷ conducted among 876 potential mild head-injury cases aged 16y in 2001 demonstrated that inclusion of patients initially presenting to family physicians increased the incidence of identified ambulatory head trauma cases by a relative +22%.

Mimicking the dramatic increase in burden size when outpatient cases were included on a nationwide scale, they found that rates of identified index cases increased from 535 per 100,000 adult population based on ambulatory emergency department presentation alone to 653 per 100,000 adult population based on emergency department presentation or presentation to a family-medicine provider. A total of 25 family-medicine (outpatient) cases were included.⁷ Similar trends have also been reported among outpatient presentations for pediatric patients aged 18y.^{5,14–18} Akin to younger patients,^{14,17} findings among adults suggest that there could be a tendency for many mild head injury cases to preferentially present to outpatient instead of emergency department care.

Relative to index head trauma visits reported in MarketScan among pediatric patients,¹⁴ adult outpatient index visits occurred at a much lower rate (2013: 477 versus 1,071 index visits per 100,000 similarly-aged enrollees), exhibited less seasonal fluctuation, and pointed to inverted insurance-based trends in the relative rates of privately-insured versus Medicaid use (2013 pediatric: 1,204 privately insured versus 760 Medicaid-insured index visits per 100,000 similarly insured pediatric enrollees aged <18y; 2013 adult: 442 privately-insured versus 779 Medicaid-insured index visits per 100,000 similarly-insured adult enrollees). For both age groups, privately insured office/clinic visits constituted the majority of outpatient index cases and annual outpatient index visit rates increased from 2004–2013.¹⁴

In the emergency department, observed index visit rates among adult Medicaid patients closely mimicked those reported by the CDC for any head trauma-related emergency department presentation among adults with any form of primary payer.¹ Rates among privately insured patients were much lower. The extent to which this affects national estimates and changes in emergency department presentation over time can be appreciated in several ways: 1) While presumed reasonable to match uninsured use to Medicaid rates in an outpatient setting given the tendency for patients' ability to pay to influence injury-related utilization of outpatient care,^{14,29–31} application of the same standard to emergency department settings for the sake of consistency in this study represents an anticipated underestimate of uninsured emergency department use that likely explains much of the difference between CDC overall emergency department estimates¹ and those extrapolated from MarketScan rates (eTable 1); 2) emergency department estimates reported by the CDC on a national scale include all emergency department presentations, including those subsequently transferred/readmitted to higher levels of care and without exclusion for prior head trauma-related health-system use;¹ 3) Both datasets represent weighted administrative claims on which varying assumptions are based.³²

Changes among adults in the outpatient setting were primarily driven by increasing rates of office/clinic index visits (+63% relative change), among privately insured patients (+78%). Such findings are consistent with expectations based on emerging trends for concussion and mild head-injury observed in non-outpatient locations.^{12,13,33} Work by Coronado *et al.*³³ suggests that among all emergency department visits for patients aged 20y, including those with and without subsequent inpatient admission, bicycling and all-terrain vehicle use among males and bicycling and horseback-riding among females constitute the highest proportions of sports- and recreation-related head trauma. Within the workplace, data suggest important contributions from occupations that typically employ young adult males

involved in manufacturing and transportation industries as well as those with construction and farm jobs.^{34–38} Further research is needed to determine how outpatient injuries were sustained. Increasing trends in outpatient presentation are likely to be, at least partially, explained by increased awareness of the need for sports and recreational safety;^{39,40} increased pressure among providers to diagnose and report concussion and mild head-injury, which have historically been underdiagnosed;^{41–43} and increased visibility in the US media of the consequences of blast-related head trauma among returning veterans as well as ongoing discussions surrounding concussion prevalence in professional sport.⁸

Most patients were diagnosed with minor head-injuries; 75% with unspecified head-injury and 25% with concussion. Thirty percent of office/clinic index visits did not have a second head trauma diagnosis recorded during index presentation other than 959.01. The meaning of this code can be controversial with research suggesting that inclusion or exclusion could result in either over- or underestimation.^{5,44–46} Given that it is a part of the definition employed in surveillance by the CDC^{2–4,1} and that published studies have used it to denote mild head-injury and concussion,⁴⁷ we felt it important to include. It is possible that in a study of index outpatient and ambulatory emergency department visits part of the prevalence of this code could be due to clinicians' decision to reserve a definitive diagnosis while considering others in the differential, particularly if patients require follow-up care. Primary diagnoses on post-index visits within 30 days appear consistent with the assertion as does the higher isolated prevalence of the code among ambulatory emergency department index visits. Studies of concussion within the pediatric literature further suggest that part of the prevalence of the more non-descript code in ambulatory settings may also stem from a lack of "adequate training or infrastructure [among primary care and emergency medicine providers] to systematically diagnose and manage"⁴⁸ the increasing burden of concussion patients presenting for outpatient care.^{48–51} Recent surveys of primary care providers report that providers feel that they have insufficient training and have time to properly manage patients with head injury,⁴⁹ limiting adoption of best practices and potentially undermining the timely receipt of more specific diagnoses and care.

The study has limitations, several of which come from its reliance on a retrospective administrative database where completeness of information, lack of clinical detail (including more specific measures of altered mental status, imaging, and concussion symptomatology), and accuracy of reporting can be concerns. The study allowed for one of the first assessments of adult head trauma treated in outpatient settings using a large national sample of Medicaid and privately-insured cases. It did not, however, allow for direct assessment of uninsured patients who, while not expected to represent a large proportion of office/clinic or urgent care use, did represent 18% of the national adult population in 2013.²⁶ As a result of this prevalence, sensitivity-analyses reported in eTables 2–3 should be consulted when utilizing estimates presented in this work. Differences in data sources should be carefully considered. For example, while nationally weighted Nationwide Emergency Department Sample data used to capture emergency department visits are inclusive of uninsured patients (Figure 1B), they lack information on what happens to patients in the proceeding 30 and subsequent 180 days—factors used in this study to define a more conservative, robust ambulatory emergency department and outpatient head trauma population. Initial assessment of subsequent ambulatory use included all patient presentations, whether specifically related

to head trauma or not. Further research is needed to understand how head trauma-specific trajectories progress over time, relative to other patients, and beyond 180 days.

In conclusion, our findings suggest that nearly one-half of all healthcare-seeking adult patients with head trauma obtain treatment in non-hospital, non-emergency department settings, with most receiving care in physicians' offices/clinics. As annual rates of outpatient presentation among insured patients continue to increase, it will be essential to recognize and be able to address the unique health needs of adult patients. Declining trends in head trauma-related fatalities and inpatient admissions within this age group⁴ suggest that the burden of adult head trauma is shifting, moving toward less severe presentations and less centralized care avenues. As the trend progresses, expanded surveillance will be needed in order to provide data crucial to inform policy, prevention, and acute care, rehabilitation, and disability-support services required to improve the quality-of-life of this population. This data gap becomes particularly pronounced among adult head trauma patients whose needs have historically been overlooked in favor of programs designed to address the needs of younger and older patients. Increased reporting of and research about adult outpatient head trauma needs will help to enable the optimization of awareness and care for all patients at all levels of the head trauma pyramid and to focus attention on the part of the pyramid where the 'silent epidemic'^{1–4} persists.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Taylor C, Bell J, Breiding M, Xu L. Traumatic brain injury-related emergency department visits, hospitalization, and deaths— United States, 2007 and 2013. *MMWR Surveill Summ.* 2017;66(SS9): 1–16.
2. Langlois JA, Marr A, Mitchko J, Johnson RL. Tracking the silent epidemic and educating the public: CDC's traumatic brain injury-associated activities under the TBI Act of 1996 and the Children's Health Act of 2000. *J Head Trauma Rehabil.* 20(3):196–204.
3. Langlois J, Rutland-Brown W, Thomas K. Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations, and Deaths. Atlanta, GA; 2004.
4. Faul M, Xu L, Wald M, Coronado V. Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths 2002–2006. Atlanta, GA; 2010.
5. Mannix R, O'Brien MJ, Meehan WP. The epidemiology of outpatient visits for minor head injury: 2005 to 2009. *Neurosurgery.* 2013;73(1):129–34. [PubMed: 23615100]
6. Schappert SM, Burt CW. Ambulatory care visits to physician offices, hospital outpatient departments, and emergency departments: United States, 2001–02. *Vital Health Stat* 13 2006;(159): 1–66.
7. Ryu WHA, Feinstein A, Colantonio A, Streiner DL, Dawson DR. Early identification and incidence of mild TBI in Ontario. *Can J Neurol Sci.* 2009;36(4):429–35. [PubMed: 19650352]
8. Coronado V, McGuire L, Sarmiento K, et al. Trends in traumatic brain injury in the U.S. and the public health response: 1995–2009. *J Saf Res.* 2012;43(4):299–307.
9. Zemek RL, Grool AM, Rodriguez Duque D, et al. Annual and seasonal trends in ambulatory visits for pediatric concussion in Ontario between 2003 and 2013. *J Pediatr.* 2017;181:222–8. [PubMed: 27843008]

10. Taylor AM, Nigrovic LE, Saillant ML, et al. Trends in ambulatory care for children with concussion and minor head injury from Eastern Massachusetts between 2007 and 2013. *J Pediatr*. 2015;167(3):738–44. [PubMed: 26116471]
11. Bruns J, Hauser WA. The epidemiology of traumatic brain injury: A review. *Epilepsia*. 2003;44(Suppl 1):2–10.
12. Voss JD, Connolly J, Schwab KA, Scher AI. Update on the epidemiology of concussion/mild traumatic brain injury. *Curr Pain Headache Rep*. 2015;19(7):32. [PubMed: 26049775]
13. Laker SR. Epidemiology of concussion and mild traumatic brain injury. *PM R*. 2011;3(10 Suppl 2):S354–8. [PubMed: 22035677]
14. Zogg C, Haring R, Xu L, et al. The Epidemiology of pediatric head injury treated outside of hospital emergency departments. *Epidemiology*. 2018 [Epub ahead of print].
15. Taylor AM, Nigrovic LE, Saillant ML, et al. Trends in ambulatory care for children with concussion and minor head injury from Eastern Massachusetts between 2007 and 2013. *J Pediatr*. 2015;167(3):738–44. [PubMed: 26116471]
16. Bryan MA, Rowhani-Rahbar A, Comstock RD, Rivara F, Seattle Sports Concussion Research Collaborative. Sports- and recreation-related concussions in US youth. *Pediatrics*. 2016;138(1):e20154635. [PubMed: 27325635]
17. Arbogast KB, Curry AE, Pfeiffer MR, et al. Point of health care entry for youth with concussion within a large pediatric care network. *JAMA Pediatr*. 2016;170(7):e160294. [PubMed: 27244368]
18. Macpherson A, Fridman L, Scolnik M, Corallo A, Guttman A. A population-based study of paediatric emergency department and office visits for concussions from 2003 to 2010. *Paediatr Child Health*. 2014;19(10):543–6. [PubMed: 25587234]
19. Corrigan JD, Selassie AW, Orman JAL. The epidemiology of traumatic brain injury. *J Head Trauma Rehabil*. 25(2):72–80. [PubMed: 20234226]
20. Truven Health Analytics. MarketScan Research Databases. 2016 <http://truvenhealth.com/your-healthcare-focus/analytic-research/marketscan-research-databases>. Accessed January 23, 2018.
21. Adamson D, Chang S, Hansen L. Health Research Data for the Real World: The MarketScan Databases; 2006.
22. Statistical Research and Applications Branch, National Cancer Institute. Joinpoint Trend Analysis Software, Version 4.2. 2015 <http://surveillance.cancer.gov/joinpoint/>. Accessed January 23, 2018.
23. Yu B, Huang L, Tiwari R, Johnson K, Feuer E. Technical Report #2007–02: Modeling Population-Based Cancer Survival Trends Using Joinpoint Survival Models. Atlanta, GA; 2007.
24. Dunn M, Zou J. Technical Report #2009–02: AAPC for the Jointpoint Connect-the-Dots Scenario. Atlanta, GA; 2009.
25. Martinze-Beneito M, Garcia-Donato G, Salmeron D. A Bayesian joinpoint regression with unknown break-points. *Ann Appl Stat*. 2011;5(3):2150–68.
26. Smith J, Medalia C, United States Census Bureau. Current Population Report, P60–250, Health Insurance Coverage in the United States: 2013. Washington, DC; 2014.
27. Tai-Seale M, McGuire TG, Zhang W. Time allocation in primary care office visits. *Health Serv Res*. 2007;42(5):1871–1894. [PubMed: 17850524]
28. National Center for Health Statistics, Centers for Disease Control and Prevention. Ambulatory Care Use and Physician Office Visits. 2017 <https://www.cdc.gov/nchs/fastats/physician-visits.htm>. Accessed January 23, 2018.
29. Ladha KS, Young JH, Ng DK, Efron DT, Haider AH. Factors affecting the likelihood of presentation to the emergency department of trauma patients after discharge. *Ann Emerg Med*. 2011;58(5):431–7. [PubMed: 21689864]
30. Baillargeon J, Paar D, Giordano TP, et al. Emergency department usage by uninsured patients in Galveston County, Texas. *Proc (Bayl Univ Med Cent)*. 2008;21(3):236–42. [PubMed: 18628970]
31. Lozano K, Ogbu UC, Amin A, Chakravarthy B, Anderson CL, Lotfipour S. Patient motivators for emergency department utilization: A pilot cross-sectional survey of uninsured admitted patients at a university teaching hospital. *J Emerg Med*. 2015;49(2):203–10. [PubMed: 26066991]

32. Taylor C, Greenspan A, Xu L, Kresnow M. Comparability of national estimates of traumatic brain injury-related medical encounters. *J Head Trauma Rehabil.* 2015;30(3):150–9. [PubMed: 25955702]
33. Coronado VG, Haileyesus T, Cheng TA, et al. Trends in sports- and recreation-related traumatic brain injuries treated in US emergency departments: The National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP) 2001–2012 *J Head Trauma Rehabil.* 30(3):185–97.
34. Wrona R The use of state workers' compensation administrative data to identify injury scenarios and quantify costs of work-related traumatic brain injuries. *J Saf Res.* 2006;37(1):75–81.
35. Colantonio A, Mroczek D, Patel J, Lewko J, Fergenbaum J, Brison R. Examining occupational traumatic brain injury in Ontario. *Can J Public Heal.* 2010;101(Suppl 1):S58–62.
36. Colantonio A, McVittie D, Lewko J, Yin J. Traumatic brain injuries in the construction industry. *Brain Inj.* 2009;23(11):873–8. [PubMed: 20100123]
37. Wei W, Liu M, Fergenbaum J, Comper P, Colantonio A. Work-related mild-moderate traumatic brain injuries due to falls. *Brain Inj.* 2010;24(11):1358–63. [PubMed: 20715899]
38. Chang VC, Guerriero EN, Colantonio A. Epidemiology of work-related traumatic brain injury: A systematic review. *Am J Ind Med.* 2015;58(4):353–77. [PubMed: 25731875]
39. Jung CS, Zweckberger K, Schick U, Unterberg AW. Helmet use in winter sport activities--attitude and opinion of neurosurgeons and non-traumatic-brain-injury-educated persons. *Acta Neurochir (Wien).* 2011;153(1):101–6. [PubMed: 20532575]
40. Harmon KG, Drezner JA, Gammons M, et al. American Medical Society for Sports Medicine position statement: Concussion in sport. *Br J Sports Med.* 2013;47(1):15–26. [PubMed: 23243113]
41. Stuart B, Mandelco B, Wilshaw R, Beckstrand RL, Heaston S. Mild traumatic brain injury: Are ED providers identifying which patients are at risk? *J Emerg Nurs.* 2012;38(5):435–42. [PubMed: 21774974]
42. National Center for Injury Prevention and Control. Implementing Return to Play: Learning from the Experiences of Early Implementers. Atlanta, GA; 2015.
43. Kirschen MP, Tsou A, Nelson SB, Russell JA, Larriviere D, Ethics, Law, and Humanities Committee, a Joint Committee of the American Academy of Neurology, American Neurological Association, and Child Neurology Society. Legal and ethical implications in the evaluation and management of sports-related concussion. *Neurology.* 2014;83(4):352–58. [PubMed: 25008394]
44. Chan L, Doctor J, Temkin N, et al. Discharge disposition from acute care after traumatic brain injury: The effect of insurance type. *Arch Phys Med Rehabil.* 2001;82(9):1151–4. [PubMed: 11552183]
45. Powell JM, Ferraro J V, Dikmen SS, Temkin NR, Bell KR. Accuracy of mild traumatic brain injury diagnosis. *Arch Phys Med Rehabil.* 2008;89(8):1550–5. [PubMed: 18597735]
46. Carroll CP, Cochran JA, Guse CE, Wang MC. Are we underestimating the burden of traumatic brain injury? Surveillance of severe traumatic brain injury using centers for disease control International Classification of Disease, ninth revision, Clinical Modification, traumatic brain injury codes. *Neurosurgery.* 2012;71(6):1064–70. [PubMed: 22922677]
47. Collins C, Yeates KO, Pommering T, et al. Direct medical charges of pediatric traumatic brain injury in multiple clinical settings. *Inj Epidemiol.* 2014;1(1).
48. Zonfrillo MR, Master CL, Grady MF, Winston FK, Callahan JM, Arbogast KB. Pediatric Providers' Self-Reported Knowledge, Practices, and Attitudes About Concussion. *Pediatrics.* 2012;130(6):1120–5. [PubMed: 23147981]
49. Arbogast KB, Curry AE, Metzger KB, et al. Improving primary care provider practices in youth concussion management. *Clin Pediatr (Phila).* 2017;56(9):854–65. [PubMed: 28521519]
50. Reisner A, Burns TG, Hall LB, et al. Quality improvement in concussion care: Influence of guideline-based education. *J Pediatr.* 2017;184:26–31. [PubMed: 28233546]
51. Itriyeva K, Feinstein R, Carmine L. Pediatric providers' attitudes and practices regarding concussion diagnosis and management. *Int J Adolesc Med Health.* 2017 [Epub ahead of print].

*There is no estimate for the number of people with non-fatal traumatic brain injury seen outside of an Emergency Department or hospital setting.

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Figure 1.

(a) Head trauma pyramid conceptualized by the U.S. Centers for Disease Control and Prevention in 2004. (b) National burden of deaths, hospitalizations, and emergency department visits among adults aged 18–64y, United States, 2013.⁴ The 2013 estimated national burden of index outpatient visits ($n=1.16$ million) represented 46.1% of CDC-reported deaths/hospitalizations/emergency department visits plus the estimated number of index outpatient visits ($1,155,915/[1,155,915 + 1,182,377 + 133,990 + 32,539]$). Deaths represent Record-Axis Condition codes collected by the CDC's National Center for Injury Prevention and Control, non-fatal inpatient hospitalizations were taken from the Agency for Healthcare Research and Quality's (AHRQ's) Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample, and non-hospitalized Emergency Department visits were taken from the AHRQ's HCUP Nationwide Emergency Department Sample—consistent with methods currently employed by the CDC.⁴

Figure 2.

Observed annual rates of healthcare-seeking head trauma presentation per 100,000 (insured) adult enrollees, United States, 2004–2013 and joinpoint-regression results (overall and stratified by index visit location) among (a) privately insured and (b) Medicaid patients. Percentages and p-values represent modeled average annual percentage change. ED indicates emergency department.

Table 1.

Demographic/Injury-specific factors stratified by index visit location, United States, MarketScan 2004–2013

	Ambulatory		Emergency Dept.		Urgent care		Office/Clinic	
	No.	%	No.	%	No.	%	No.	%
Demographic factors								
Age in years								
18–24	97,291	28	3,612	28	278,737	24		
25–34	72,159	21	2,866	22	202,914	17		
35–44	63,587	18	2,479	19	211,219	18		
45–54	63,249	18	2,174	17	244,504	21		
55–64	53,372	15	1,828	14	238,539	20		
Sex								
Male	145,051	42	5,487	42	536,260	46		
Female	203,608	58	7,471	58	639,653	54		
Insurance								
Private	174,525	50	11,993	93	1,012,053	86		
Medicaid	174,134	50	965	7	163,860	14		
Region^a								
Northeast	34,773	20	1,345	11	156,715	16		
Midwest	38,499	22	1,894	16	261,541	26		
South	62,943	36	4,322	36	397,714	39		
West	36,402	21	4,369	36	177,757	18		
Unknown	1,908	1	63	0.5	18,326	2		
Year								
2004	28,675	8	173	1	47,687	4		
2005	31,065	9	181	1	44,589	4		
2006	26,362	8	266	2	43,777	4		
2007	23,561	7	391	3	78,128	7		
2008	27,246	8	698	5	96,912	8		
2009	38,786	11	1,256	10	140,625	12		
2010	41,761	12	1,505	12	149,777	13		
2011	40,820	12	2,038	16	186,327	16		
2012	43,393	12	3,177	25	213,395	18		
2013	46,990	14	3,273	25	174,696	15		
Injury-specific factors								
Loss of consciousness								
No	329,253	94	12,636	98	1,095,822	93		
Yes	19,406	6	322	3	80,091	7		
Charlson Comorbidity Index								
0	314,363	90	12,783	99	1,080,431	92		
1	29,303	8	160	1	84,208	7		
2	4,993	1	15	0.1	11,274	1		

	Ambulatory Emergency Dept.		Urgent care		Office/Clinic	
	No.	%	No.	%	No.	%
Max. head Abbreviated Injury Scale						
1	6,360	2	233	2	21,433	2
2	326,505	94	12,461	96	1,076,218	92
3	10,023	3	164	1	48,103	4
4	4,784	1	73	0.6	25,234	2
5	798	0.2	17	0.1	3,762	0.3
6	189	0.1	10	0.1	1,163	0.1
Overall Injury Severity Score						
<4	6,360	2	233	2	21,433	2
4–8	309,931	89	12,312	95	1,009,072	86
9–15	25,431	7	306	2	110,033	9
16–24	5,618	2	79	1	29,569	3
25	1,319	0.4	28	0.2	5,806	1
Overall index visits (total)	348,659	23	12,958	1	1,175,913	77

^a MarketScan Medicaid databases do not include region information. Results are shown for privately insured patients.

Percentages might not sum to 100% due to rounding.

Table 2.

Variations in head trauma diagnoses on index presentation stratified by index visit location, United States, MarketScan 2004–2013

	Ambulatory Emergency Dept.		Urgent care		Office/Clinic visit	
	No.	%	No.	%	No.	%
Presenting diagnosis^a						
Unspecified head-injury	286,017	82	8,936	69	859,350	73
Concussion	67,836	20	4,189	32	313,959	27
Other or unspecified intracranial wound	22,457	6	324	3	83,362	7
Closed fracture base of skull	4,819	1	65	0.5	25,691	2
Other closed skull fracture	3,505	1	44	0.3	16,848	1
Closed fracture vault of skull	1,522	0.4	45	0.3	8,002	1
Intracranial hemorrhage	810	0.2	26	0.2	4,792	0.4
Cortex/Cerebral contusion or laceration	525	0.2	18	0.1	4,018	0.3
Closed fracture skull/face	295	0.1	8	0.1	2,289	0.2
Injury to optic chiasm/pathway/visual cortex	65	<0.1	15	0.1	2,378	0.2
Open fracture vault of skull	95	<0.1	7	0.1	1,414	0.1
Other open skull fracture	104	<0.1	1	<0.1	741	0.1
Open fracture base of skull	87	<0.1	2	<0.1	463	<0.1
Open fracture of the skull or face	28	<0.1	6	<0.1	458	<0.1
Overall index visits (total)	348,659	23	12,958	1	1,175,913	77

^aEach visit had multiple diagnoses; diagnoses are not mutually excluded.

Table 3.

Average (mean) number of subsequent ambulatory visits per index ambulatory head trauma presentation among adults aged 18–64y, United States, 2010–2013 and extrapolated 2013 national burden of post-index visits (routine and injury-related) within 0–30, 31–90, and 91–180 days (national estimates inclusive of uninsured patients).

Average number of post-index visits per patient				
Index visit location		Within 30 days	Within 31–90 days	Within 91–180 days
Ambulatory emergency department	--	1.2	1.5	0.7
Urgent care	--	0.9	1.2	0.6
Office/clinic	--	1.1	1.5	0.9
2013 National burden of post-index visits				
	Index visits	Within 30 days	Within 31–90 days	Within 91–180 days
Ambulatory emergency department	479,015	519,033	714,875	939,679
Urgent care	14,788	13,264	18,020	22,757
Office/clinic	1,141,165	1,397,073	1,726,734	2,168,098
Outpatient (urgent care, office/clinic)	1,155,915	1,402,282	1,737,491	2,181,951