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To cite this article: Einat K. Brenner , Emily C. Grossner , Benjamin N. Johnson , Rachel A. Bernier , José Soto & Frank G. Hillary (2020) Race and ethnicity considerations in traumatic brain injury research: Incidence, reporting, and outcome, Brain Injury, 34:6, 799-808, DOI: [10.1080/02699052.2020.1741033](https://doi.org/10.1080/02699052.2020.1741033)

To link to this article: <https://doi.org/10.1080/02699052.2020.1741033>



Published online: 31 Mar 2020.



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Race and ethnicity considerations in traumatic brain injury research: Incidence, reporting, and outcome

Einat K. Brenner, Emily C. Grossner*, Benjamin N. Johnson, Rachel A. Bernier, José Soto, and Frank G. Hillary

Department of Psychology, Pennsylvania State University, State College, Pennsylvania, USA

ABSTRACT

Primary Objective: This study has three goals: to determine whether there is a higher rate of traumatic brain injury (TBI) for people of color (POC), whether TBI studies report racial/ethnic demographics, and whether there is a discrepancy in discharge destinations between Whites and POC. We examined whether 1) a higher percentage of POC would sustain head injuries than expected, 2) the majority of TBI studies examined (>50%) would not include racial/ethnic demographics, and 3) Whites would be discharged to further treatment over POC.

Research Design: Retrospective study and literature review.

Methods and Procedures: Data from the Pennsylvania Trauma System Foundation was used to determine the number of POC with TBI using χ^2 analysis, as well as where patients with TBI were being discharged using a configural frequency analysis. PubMed was used for the literature search to examine the frequency of reporting race/ethnicity in TBI literature.

Main Outcomes and Results: Results demonstrated that Blacks sustain more TBIs than would be expected ($p < .05$), the majority of scientific studies (78%) do not report racial/ethnic demographic information, and Whites are discharged to further care more often than POC.

Conclusions: These findings highlight differences in incidence and treatment of TBI between White individuals and POC, raising important considerations for providers and researchers.

ARTICLE HISTORY

Received 9 August 2019

Revised 2 March 2020

Accepted 7 March 2020

KEYWORDS

Race; ethnicity; brain injury; TBI; outcome

Racial and Ethnic Differences in Discharge Destination for Individuals with TBI

Traumatic brain injury (TBI) holds significant public health concern, as 1.4 million people sustain a TBI per year in the United States (1), with costs, estimated in 2013, of approximately 13.1 USD billion per year and total medical costs ranging from 63.4 USD to 79.2 USD billion per year (2). A disproportionately higher number of individuals with TBI is from racial/ethnic minority groups (3–5). This has also been documented in individuals with mild TBI (6), children with TBI (7), and older adults with TBI (8).

Not only are nonwhite individuals more likely to sustain a TBI, there are also differences in the experience of treatment within the healthcare system between ethnic minorities and White individuals in the United States, including differences in wait time to see a doctor, number of referrals for further services, number of therapy hours, functional outcomes, community integration, level of disability, and time to return to work following injury (9,10). Additionally, minority groups have been shown to receive discrepant care in terms of where they are discharged for follow-up care. Minority groups have also been shown to be less likely to receive inpatient rehabilitation following TBI than Whites (11). Blacks and Hispanics are more likely to report depression following TBI and often have more severe psychologically traumatic, somatic, and cognitive symptoms (12), which may potentially require additional treatment post-injury. Other work has shown that

Asian and Black individuals have a higher risk of mortality than Whites following TBI (13,14). Taken together, this demonstrates that minority groups are sustaining head injuries at higher rates than majority individuals, yet they report less effective medical care from professionals and suffer more extreme consequences of injury, which could have downstream consequences for vocational outcome and quality of life. Given that ethnic minorities will comprise approximately 45% of the population within the next 30 years (15), it is vital to understand the racial/ethnic disparity in prevalence rates and outcome after TBI in order to ensure the quality of care for a growing population.

The study of the impact of race and ethnicity on outcome in TBI is complex and likely influenced by a number of covarying factors, with the most important being socioeconomic status. While inequalities in racial health status are well documented, the relationship between socioeconomic status and race is still being investigated. However, the unique impact of race on health outcomes over and above the influence of SES has been documented (16). Furthermore, potential differences in access to insurance among patients sustaining a TBI further complicates the examination of racial and ethnic differences in treatment and recovery. Insured patients overall have been found to have longer hospital and ICU stays (17). Following TBI, it is more common for insured patients to be sent to inpatient rehabilitation than uninsured patients. However, after controlling for insurance status,

Whites have been shown to be more likely to receive rehabilitation services than Black, Hispanic, or Asian patients with TBI (11,18). Among those with private insurance, Whites are still more likely to be discharged to rehabilitation programs than Blacks (11). Thus, even when considering the influence of insurance and the role of socioeconomic status, racial differences continue to play a strong role in determining standards of patient care.

Despite the evidence that nonwhite individuals are sustaining TBI at a higher rate than White individuals and receiving inadequate care, minority individuals are underrepresented in empirical studies of TBI. It has been demonstrated that there is a systematic bias in studies of long-term outcome of TBI in that socioeconomically disadvantaged groups, such as racial and ethnic minorities, may be less able to follow-up and continue participation in studies (19). This is not true for only studies on TBI, but of psychological studies in general. Research conducted in the United States has relied primarily on results from White samples, leading to a general lack of ethnic/racial representation in the literature (20). From 1970 to 1989, 14,542 articles were published in six prominent psychology journals and only 526 articles were published on African Americans (21). Similarly, the Journal of Counseling Psychology examined articles in their journal from 1976 to 1986 and found that 53 of the 934 articles published had a racial/ethnic minority focus (22). Most recently from 1990 to 1999, reports of race and ethnicity in 3 counseling journals increased from 26% of the articles in 1990 to 85% in 1999 (23). Over this 10 year period, 78.2% of the participants were White, 6.7% were Black, 6.6% were Hispanic, and 5.8% were Asian/Pacific Islander (23). While these kinds of studies have not been conducted in TBI research specifically, there is a notable positive trend in reporting and including racially and ethnically diverse samples in psychological research, but it is unclear if these efforts mirror the changing demography in the United States, and whether this trend is being realized in TBI research. Failure to represent changing demographics in our science creates important challenges to external validity and the ability to generalize clinical findings to all groups.

With this background as context, the present study had three goals. First, we examined whether people of color (POC) sustained more moderate-severe head injuries than expected based on the Pennsylvania State Census. We examined this by comparing population data to actual rates of injury reported in a comprehensive database of Pennsylvania trauma injuries (Pennsylvania Trauma Outcome Study [PTOS]) for the years 2010 to 2016. Consistent with the literature, we hypothesized that there would be a higher percentage of minority individuals sustaining head injuries compared to what would be expected given the prevalence of minority individuals from the Pennsylvania State Census. Second, we examined the representation of POC in the human TBI literature for a similar window of time. Again, given evidence from a broader psychological literature (not yet examined in TBI), we investigated whether the majority of empirical TBI studies would not include racial and ethnic participant demographics, as POC populations are rarely studied and reported in this literature. Lastly, in order to understand whether Whites and POC receive comparable medical care following TBI, we

examined the relationship between race/ethnicity and discharge destination after TBI. We hypothesized that there would be a higher proportion of Whites receiving follow-up care when controlling for additional factors, such as insurance type and patients' functional status. To address these hypotheses we combine analysis of a comprehensive TBI database with a prospective literature search.

Methods

Pennsylvania trauma outcome study dataset

To test hypotheses 1 and 3, we used existing clinical data gathered between January 1, 2010 to December 31, 2016 as part of the PTOS, a trauma registry that was formed by the Pennsylvania Trauma Systems Foundation (PTSF). This database contains information about thousands of trauma cases of all injury types that occurred in the state of Pennsylvania, from the moment emergency services came into contact with the injured individual until the day they were discharged. The database was founded in 1985 and contains data from PTSF-accredited trauma centers. In order to gain accreditation, hospitals are reviewed by the PTSF board of directors who follow guidelines put forth by the American College of Surgeons, Committee on Trauma. Continued accreditation across years depends on continued compliance with the foundation guidelines, and each center is responsible for the quality of its data. The PTSF has processes in place for quality control prior to integration into the database (24).

The PTOS database included individuals from every county across Pennsylvania. In our analyses, we retained data from hospitals that had data collected for each year between 2010 and 2016. We also excluded 11 hospitals due to the fact that they did not have an ethnicity variable coded to distinguish between Hispanic and Non-Hispanic.

The following variables, defined in the following sections, were used for this study: injury type (ICD-10-CM codes), race, ethnicity, Glasgow Coma Scale (GCS) score, payor type (with regard to financing care), functional status at discharge (FSD), and discharge destination.

Injury type

For our study, using ICD-10-CM codes, individuals with injuries coded as S802 (skull fracture) or S06 (intracranial injury) were retrospectively selected for analysis because these injuries are indicative of intracranial trauma (25). This yielded 81,881 individuals in the dataset who had head injuries as their primary injury type.

Race/ethnicity

Existing racial categories in the database were White, Black, Asian, and "Other." Of note, "Other" in the database was described as American Indian, Alaskan Native, Asian/Pacific Islander, or "some other race." Existing ethnic categories were listed as Hispanic and non-Hispanic.

Glasgow coma scale score (GCS)

GCS scores were listed for each individual. GCS scores range from 3 to 15, with scores of 3–8 indicating severe head injury,

9–12 indicating moderate brain injury, and 13–15 indicating mild head injury (26). While GCS was assessed at multiple time points for each patient in the database, GCS here refers to the GCS score upon admission. Typically, a 24-h GCS score (i.e., GCS assessed 24-h post-injury) is standard practice for individuals with TBI so that secondary factors such as intoxication or resuscitation do not influence the assessment of deficit (27), but the admission time was the closest approximation to this timeframe in the dataset.

Payor type

Insurance payor types, as coded in the database, were Medicare, Medicaid, commercial, third-party, or self-pay. We distilled these insurance types into 1) medical assistance (MA), which combined Medicare and Medicaid, 2) private (i.e., commercial), and 3) third party.

Functional status at discharge (FSD)

In the PTOS database, FSD includes ordinal ratings from 1 to 4 on five separate functional domains: feeding, locomotion, expression, transfer mobility, and social interaction (28). Using this scale, if an individual receives a rating of 1, this connotes complete dependence, and a rating of 4 connotes independence. Using the method outlined by Wang and colleagues (29), we subtracted the summed ratings of each of the five domains from 20 to create a “functional impairment score,” where a score of 0 indicated no functional impairment and 15 indicated maximal impairment. A score of 0 to 5 was considered “mild,” 6 to 10 was “moderate,” and 11 to 15 was “severe” impairment (29). Coding the data as such is consistent with previous research, and facilitated groupings for subsequent analyses (see *Discharge Destination* analysis). For the purposes of analyses, “mild” was coded as 1, “moderate” as 2, and “severe” as 3.

Discharge destination

Discharge destinations included: rehabilitation center, homeless, home, skilled nursing facility, Pennsylvania trauma center, other hospital (e.g., not an accredited trauma center), burn center, psychiatric facility, legal authority, drug or alcohol rehabilitation, other supervised residential facilities, against medical advice, transitional care unit, out of state trauma center, long-term acute care center, hospice, and foster care. Specifically, rehabilitation centers refer to facilities that aim to return the patient to their level of functioning prior to the trauma or bring them to the most functional state possible. Skilled nursing facilities offer long-term care to patients whose functions return very slowly, very slightly, or not at all. Other supervised residential facilities refer to progressive care facilities, personal care homes, shelters, boarding homes, or halfway houses (24).

Literature search

For study Goal 2, a literature search was conducted to examine the inclusion of race and ethnicity in published studies of TBI from January 1, 2006 to December 31, 2017 in order to represent the years of data in the PTOS database to present day. The focus of the search was on the relative frequency of reporting racial or ethnic demographic information in studies of

individuals sustaining TBI. Using PubMed, “traumatic brain injury AND humans” was used as the search criteria, with exclusion terms of “concussion” and “sports.” Additional PubMed filters used included, “free full text articles” and articles written in English, and omitted “ages birth-12 years,” “pharmaceutical trials,” and “reviews.” Of note, “concussion” and “sports” were excluded as search terms because consensus statements define TBI and sports-related concussion differently (30), and the first intervention for sports-related concussion often occurs at the level of the athletic trainer or other team personnel rather than the emergency department. Overall, this yielded 5,059 reports. Search results were sorted by publication date. Of the years 2006 to 2017, 2006 had the fewest number of articles ($N = 113$). To maintain a consistent number of articles reviewed per year, we used Google’s random number generator to select 50 articles from the list of all PubMed IDs for each given year. The number of published articles that met our requirements varied each year, ranging from 113 to 720, and 50 represented approximately 50% of the number of published reports meeting our search requirement for the year with the fewest published articles. This yielded 600 articles (50 articles per year for 12 years), which were coded as (1) race/ethnicity not specified (coded “Race Not Specified”) (2), description included the percentage of White participants only, or Whites vs. Nonwhites (coded “Whites Specified”), or (3) both White and additional racial/ethnic groups specified (i.e., Hispanic, Black, Asian, Pacific Islander, Native American (coded “POC specified”). Of note, no articles only specified POC and not White participants.

Data analysis plan

Goal 1: prevalence

In order to examine whether people of color (POC) are more represented in the head injury population, we utilized chi-square goodness-of-fit tests to compare PTOS race prevalence data to Pennsylvania census data from the United States Census Bureau. Importantly, race and ethnicity were defined in the same manner in both the PTOS database and the Census, with race categorized as White, Black, Asian, and Other and ethnicity defined as Hispanic or Non-Hispanic. We conducted this analysis for the years 2010 and 2016 to provide context for the identical years analyzed in the PTOS dataset.

Goal 2: literature search

From the literature search, the 600 coded articles were examined to broadly determine how published studies in the TBI literature report race and ethnicity. The methods sections, participant descriptions, and descriptive tables were examined in order to code articles for (1) race/ethnicity not specified (2), specified Whites only, or (3) specified POC. The frequencies of the coded articles were plotted and percentages for each group of coded articles were calculated.

Goal 3: discharge destinations

In order to examine the relationships between both race/ethnicity and discharge destination after TBI, using 45,658 cases of individuals sustaining head injuries in the PTOS dataset who were discharged to one of the six destinations

Table 1. Mean functional status at discharge (FSD) and the frequency of individuals discharged to each destination.

Discharge Destination	Average FSD	Frequency
Home	1.03	32,052
Rehabilitation Center	1.46	9,584
Skilled Nursing Facility	1.59	7,806
PA Trauma Center	2.25	282
Long Term Care Acute Care Center	2.66	578
Hospice	2.73	534

FSD categories are as follows: mild FSD = 1, moderate FSD = 2, severe FSD = 3.

outlined in Table 1, we conducted a configural frequency analysis (CFA; 31) to determine the likelihood of discharge destination based on racial and ethnic group, functional status at discharge (FSD), and insurance type. Further exclusions included cases with missing race and ethnicity data ($N = 1,362$) and cases with missing FSD criteria ($N = 20,373$), yielding 23,923 cases for analysis.

CFA is a person-centered non-parametric technique akin to chi-square contingency table analysis that detects patterns or “configurations” among a set of categorical variables that occur significantly more or less often than chance (31). Whereas standard contingency table analysis evaluates the significance of the *global chi-square* (which compares the distributions of responses across the set of *all* categories of observations in one variable against those of another), CFA tests the significance of *local chi-squares*, determining whether or not *each* possible configuration of responses in a contingency table is observed more often (a “type”) or less often (an “antitype”) than expected. We used CFA to determine the likelihood of each configuration of the six variables of interest compared to what is expected by chance. Given that CFA allows testing of many configurations in a contingency table simultaneously ($k = 432$ in our data), all tests were bias-corrected for Type I error using a Bonferroni correction (31) and given the sample size, only those findings with at least a small effect size were interpreted ($\phi \geq .10$).

Results

Goal 1: prevalence

Using a chi-square goodness-of-fit test, the results indicated that, based on race, there was a significantly different pattern of head injuries sustained in the PTOS dataset than would be expected given the Pennsylvania population for both 2010 ($\chi^2(3) = 18.21, p < .001$) and 2016 ($\chi^2(3) = 28.34, p < .001$). Specifically in 2010, Black individuals sustained more head injuries than would be expected given their representation in the state of Pennsylvania, while Asian individuals sustained fewer head injuries than would be expected. White individuals sustained about the same proportion of head injuries as would be expected. In 2016, this pattern persisted with Black and Asian individuals, but White individuals sustained slightly fewer head injuries than would be expected given their representation in the population (Figure 1).

Goal 2: literature search

Articles were coded as “did not specify race or ethnicity,” “specified White participants only,” or “specified multiple races and ethnicities.” Seventy-eight percent of the coded articles did not specify race or ethnicity ($N = 468$), 7.5% specified White participants only ($N = 45$), and 14.5% specified multiple races and ethnicities (specified POC) ($N = 87$). Figure 2a demonstrates the breakdown of the coded articles from the sample with race reported in less than 50% of all papers on average. Figure 2b demonstrates the breakdown of the coded articles over time from 2006 to 2017, as well as the total number of articles that met search criteria per year.

Goal 3: discharge destinations

Description of discharge destinations

The frequency of individuals discharged to each destination was calculated, along with the mean FSD for each discharge destination. This allowed us to examine how many individuals were sent to each discharge destination and what severity of injuries is typically served at each of the destinations. Discharge destinations that were not relevant to our population or question (i.e., burn unit, legal authority) were excluded from analysis, as well as destinations that had fewer than 1% of individuals discharged to them. Excluded from the analysis were: burn unit ($N = 18$), psychiatric facility ($N = 474$), legal authority ($N = 491$), drug and alcohol facility ($N = 79$), foster care (= 230), homeless (= 90), against medical advice (= 913), out-of-state trauma center (= 136), transitional care unit (= 283), other hospital (= 233), and other supervised residential facility (= 670). Table 1 lists the discharge destinations that were used in the subsequent analysis, along with the average FSD for that destination and the frequency of individuals discharged there. An average FSD of 1 is indicative of mild impairment in functioning, 2 is indicative of moderate impairment in functioning, and 3 is indicative of severe impairment in functioning at discharge. For example, home (average FSD = 1.03) is a common discharge destination for mild impairment, PA trauma center (average FSD = 2.25) is a likely destination for moderate impairment, and hospice (average FSD = 2.73) is likely for individuals with severe impairment.

Configural frequency analysis of discharge destinations

Several patterns emerged from the results of the CFA. For individuals with mild FSD, both White and Hispanic individuals were more likely than expected to be discharged home and Whites were less likely to be discharged to a skilled nursing facility. For those with moderate FSD, White individuals with both MA and private insurance were more likely than all others to be discharged to higher levels of care. Specifically, Whites with MA were more likely to be sent to skilled nursing facilities, and Whites with both MA and private insurance were more likely to be sent to rehabilitation centers. Whites with either MA and private insurance were

Expected & Observed Racial Composition in Moderate-Severe TBI

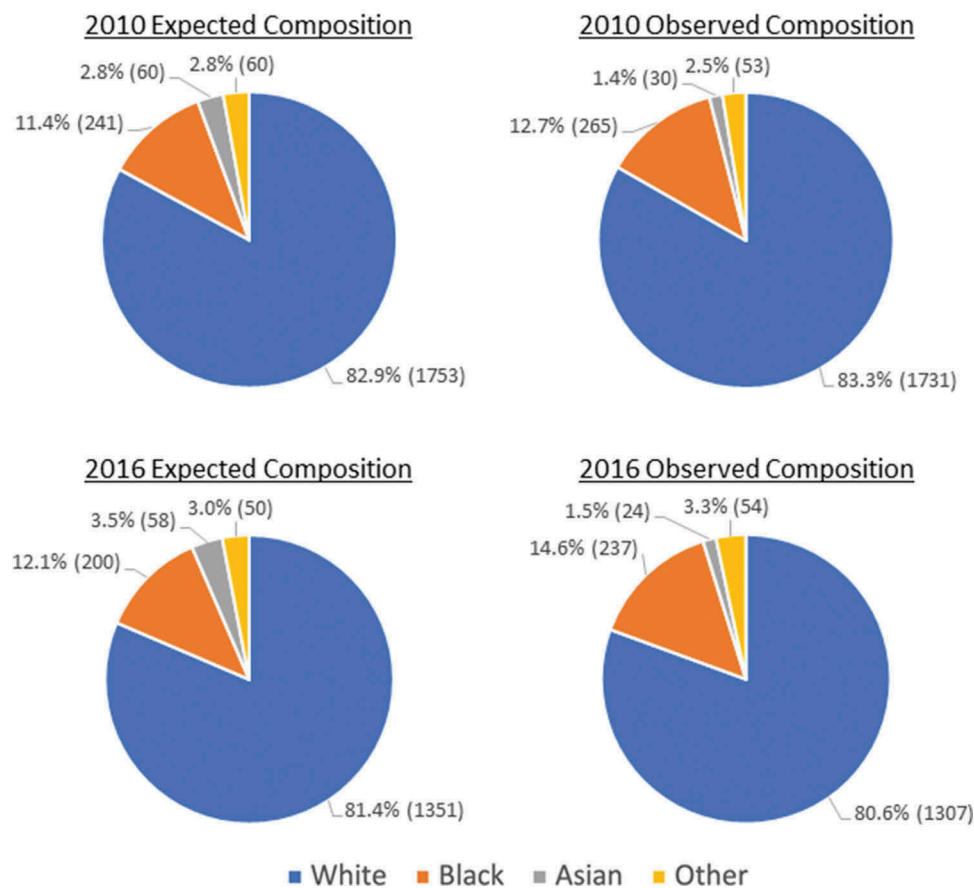


Figure 1. Depictions of the observed breakdown of people of different races who actually sustained a moderate-severe TBI in the PTOS dataset compared to the breakdown of the expected frequency of people of different races with TBI given Pennsylvania Census data in 2010 and 2016.

less likely to be sent home. For those with severe FSD, White individuals were overall more likely to receive extended care. Specifically, White patients with MA were more likely to be sent to skilled nursing facilities, long-term acute care units, and hospice, while those with private insurance were more likely to be discharged to long-term acute care units or trauma centers. White individuals with MA or private insurance were less likely than individuals in other racial groups to be sent home (Table 2).

Discussion

This study examined the relationship between racial/ethnic minority status and the incidence of TBI and clinical outcome following TBI. Specifically, we were interested in determining whether minority individuals are sustaining a significant proportion of head injuries, whether the scientific literature reflects a greater focus on racial and ethnic minorities given the reported imbalance, and whether these individuals are receiving comparable care to their White counterparts. The following discussion further explores the findings of each of these points.

Goal 1: examining relative rates of TBI in POC

The first goal of this study was to examine whether racial and ethnic minority groups sustain TBI at a rate equivalent to their distribution in the population, as measured by the Pennsylvania data from the United States Census Bureau. Results showed that in both 2010 and 2016, more Black individuals sustained moderate to severe TBI than expected given PA census data. This is consistent with previous literature noting that racial and ethnic minorities make up a disproportionate number of patients with TBI (3,5). By contrast, our results indicated that Asian individuals are less likely to sustain TBI resulting in hospitalization than expected. There exists minimal information about the incidence rate of TBI in Asian populations in the United States, but one study conducted in Hawai'i found that Asian individuals have a higher incidence rate of TBI, as well as less favorable outcomes (32). It should be noted that multiple studies have found that there is an increased mortality rate in Asian populations following TBI (13,14,33), so regardless of prevalence, this population is crucial to study.

One potential reason for the discrepancy between our findings and previous literature could be due to some

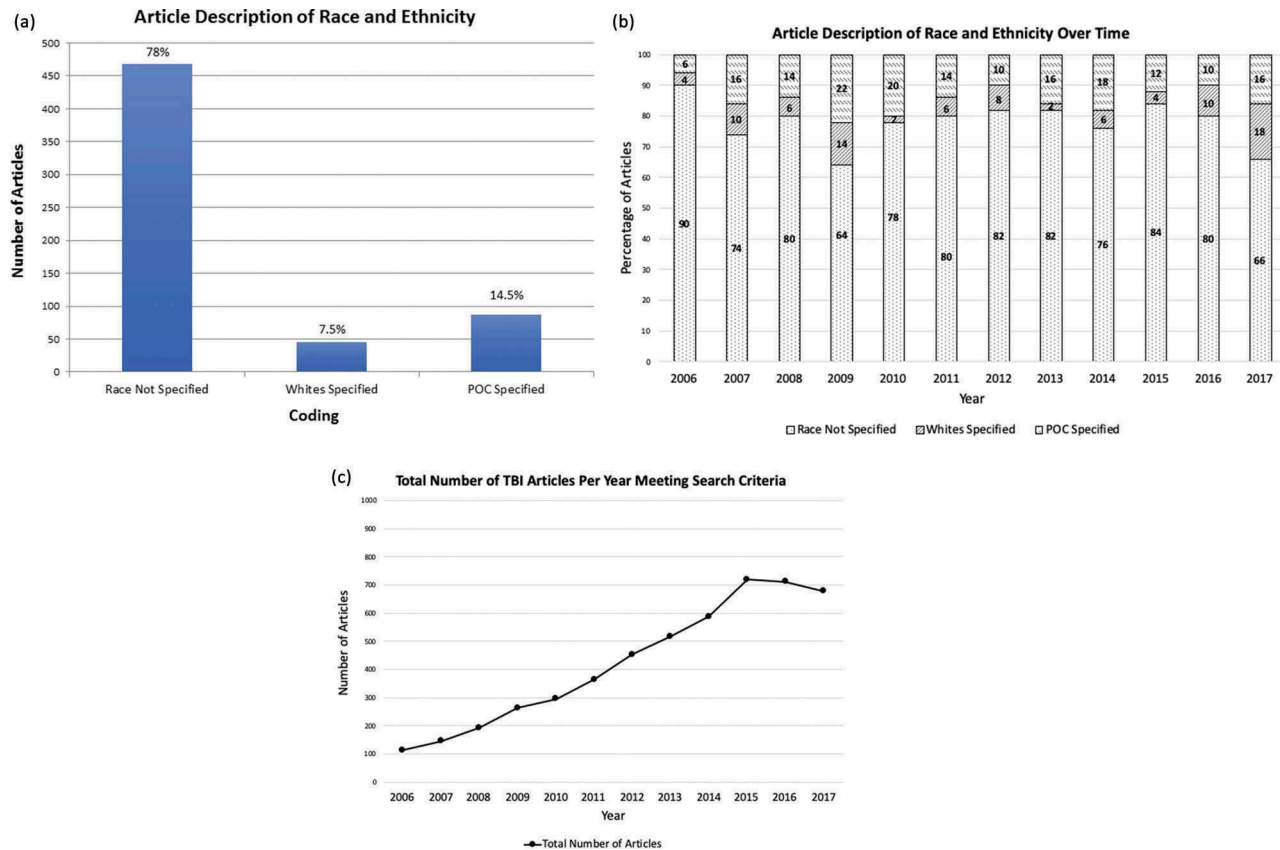


Figure 2. (a). Breakdown of literature search articles and the frequency of descriptions of race and ethnicity of the participant sample. Articles were coded as (1) race/ethnicity not specified (coded “Race Not Specified”) (2), description included the percentage of White participants only, or Whites vs. Nonwhites (coded “Whites Specified”), or (3) both White and additional racial/ethnic groups specified (i.e., Hispanic, Black, Asian, Pacific Islander, Native American (coded “POC specified”). Of note, no articles only specified POC and not White participants. (b). Left: Percentage of articles per year coded as Race Not Specified, Whites specified, and POC specified. Right: Total number of TBI articles from PubMed per year meeting search criteria.

Table 2. Configural frequency analysis results.

Race/Ethnicity	Insurance Type	Discharge Destination	Likelihood	Observations (N)	Effect Size (ϕ)
Mild FSD					
Hispanic	3rd Party	Home	+	178	0.10
White	Private	Home	+	13994	0.19
White	Private	Skilled Nursing Facility	-	814	0.14
Moderate FSD					
White	MA	Skilled Nursing Facility	+	1658	0.31
White	MA	Rehab	+	1052	0.13
White	Private	Rehab	+	848	0.10
White	Private	Home	-	191	0.14
White	MA	Home	-	323	0.13
Severe FSD					
White	MA	Skilled Nursing Facility	+	737	0.16
White	MA	Long-Term Acute Care Unit	+	179	0.18
White	MA	Hospice	+	329	0.36
White	Private	Long-Term Acute Care Unit	+	184	0.20
White	Private	PA Trauma Center	+	92	0.14
White	MA	Home	-	117	0.11
White	Private	Home	-	25	0.12

“MA” = medical assistance; “+” indicates a higher likelihood of a given discharge location than expected due to base rates, given one’s race/ethnicity and type of insurance; “-” indicates lower likelihood of a given discharge location than expected due to base rates, given one’s race/ethnicity and type of insurance.”

ambiguity of the category “Asian.” In the United States, the racial category of “Asian” is relatively new and dates back to only the 1970s–1980s. Prior to the 1990 United States Census, demographic information on “Asian” was not available and racial categories of “Chinese,” “Japanese,” and “Filipino” were the only descriptions available (34). Additionally, individuals of Middle Eastern, Indian, or South Asian descent, for example, might identify themselves as either “Asian” or “Other” (35). It may be that our racial description of Asian encompasses a much more heterogeneous group of individuals than other more long-standing and well-established racial descriptions (i.e., White, Black). Such heterogeneity might give rise to discrepant findings between our study and others exploring TBI in Asian samples. Unfortunately, more granular racial descriptions were not available in the PTOS dataset so we could not explore this possibility further.

Goal 2: examining descriptions of POC in TBI literature

Given literature that shows that POC is disproportionately affected by TBI, the second goal of the study was to examine the frequency of reporting race/ethnicity in the TBI literature. We found that 78% of studies examined did not report specific information concerning the race and/or ethnicity of their samples. Another 7.5% reported the percentage of White individuals in their samples, but did not

specify the demographics of the rest of their participants. Importantly, this trend did not change significantly between 2006 and 2017, which demonstrates that the scientific community still fails to adequately report racial/ethnic demographic variables. Although it has been the case that samples in research be overly-representative of White participants who may have more time and resources to participate in studies (20), these findings reveal two important points. First, they show that even when researchers make an effort to recruit POC for their studies, this information is not disclosed. For instance, some studies noted that they collected race/ethnicity data yet did not specifically report it, which does not allow researchers to know who the results are generalizable to. Second, and critically, reviewers are much less likely to require reporting of race/ethnicity in a sample than they do sex, age, and education of a sample. If this reporting practice is not enforced, researchers may not even collect these data. On the whole, it is important to characterize samples using race/ethnicity data, as it provides vital descriptive data for further work examining how socioeconomic or other societal factors interact with race/ethnicity in TBI outcomes. Based upon this literature search, we argue for standardization in reporting race/ethnicity characteristics of a sample in addition to the more common demographic descriptors (e.g., age, sex, education).

Goal 3: examining discharge destinations for Whites and POC

Lastly, we examined whether differences in discharge destination would be observed across various racial and ethnic groups. To accomplish this goal, we sought to examine patterns of significant results among the types and antitypes in the CFA output to determine if racial/ethnic categories were associated with specific discharge destinations.

We used CFA to examine the proportionate frequencies of distinct racial/ethnic categories, functional status at discharge, and insurance type in the sample. For individuals with *mild* FSD, there was no consistent pattern across CFA results. Hispanic individuals with third party insurance and White patients with private insurance were more likely to be sent home. White individuals with private insurance were also less likely to be discharged to a skilled nursing facility. This is likely due to the fact that these individuals all displayed mild difficulties in functional status, leading to a likely discharge home instead of to further care. However, when examining those with moderate or severe FSD, the CFA established more consistent patterns across groups. For those with *moderate* FSD, White patients were more likely to receive extended care via rehabilitation centers or skilled nursing facilities and they were also significantly *less* likely to be sent home. At the same time, when examining *severe* FSD, White patients were again more likely to receive extended care, via skilled nursing facilities, long-term acute care units, trauma centers, and hospice care. Regardless of if they had MA or private insurance, they were again less likely to be sent home than individuals of any other racial or ethnic categories.

On the whole, White individuals are more likely to have their dysfunction recognized, *regardless of functional deficit*. When White patients presented with a less observable deficit after injury (i.e. mild FSD), they were able to return home more often than most other groups. At the same time, White individuals who experienced at least moderate functional difficulty were more likely to be discharged to further treatment, regardless of insurance type. While the reasons for this are not entirely clear, it may be the case that residual symptoms following injury in POC are not diagnosed or attended to in the same manner as they are in White individuals. This finding is consistent with prior work (36) and could potentially be due to factors such as human bias (37) or failing to recognize cultural differences in expression of suffering and dysfunction (38), leading to a possible unequal implementation of care.

To date, much of this literature has focused on differences in outcome following brain injury, noting that people of color experience worse long-term deficits (1,33). Our results show that discrepancy in discharge destinations, regardless of insurance or FSD, is another important factor that may play a role in observed outcome differences following brain injury. Previous studies examining differences in discharge following injury have noted that Hispanic patients who sustain a TBI are discharged home more frequently than their White counterparts (39). Hispanic and Black individuals are also less likely to be discharged to rehabilitation facilities and for less time than majority individuals, regardless of insurance type (9,11,14). Our additional examination into discrepancies in discharge destinations presents as a crucial possible point of intervention in order to decrease discrepancies in care: discharge decisions.

Limitations

There are several limitations to our study that require consideration. The first is that the PTOS database represents clinical cases occurring only in Pennsylvania, as opposed to data from across the United States. However, Pennsylvania includes two large metropolitan areas, Philadelphia and Pittsburgh, as well as smaller cities, college towns, and a large number of rural areas and farmlands. Furthermore, according to 2018 U.S. Census data, in Pennsylvania, 82.1% of the population is White and 11.9% is Black while in the United States as a whole, 76.6% of individuals are White and 13.4% are Black (40). Similarly, in Pennsylvania, 7.3% of individuals identified as Hispanic or Latinx and 76.5% identified as White non-Hispanic, while in the United States, 18.1% identified as Hispanic or Latinx and 60.7% identified as White non-Hispanic (40). These numbers indicate that Pennsylvania may be relatively representative of the United States, although people who identify as Hispanic may be underrepresented in this sample.

Secondly, information regarding specific benefits and disadvantages of the different discharge destinations is not entirely known. Broadly, as we outlined in Table 1, it is understood that these treatment facilities are representative of different types of injury and dysfunction. However, we are unable to determine whether some treatment facilities are “better” than others in

terms of extended care. While we do not aim to make claims about White patients receiving “better” care than nonwhite patients, the findings indicate an overall trend of majority of individuals being discharged to further treatment than POC.

Furthermore, as with many studies examining race and ethnicity, some of the categorizations may be ambiguous for individuals of certain races/ethnicities or those who are multi-racial. The PTOS dataset allowed individuals to identify “Other” as their race, but this does not allow for a determination as to how these individuals would choose to self-identify had the options not been presented in a forced-choice manner. For example, it has been demonstrated that the term “Hispanic” is now thought of as synonymous to a racial category (41). Multiple studies have demonstrated that Hispanic/Latinx individuals who do not identify with either White or Black are more likely to choose “other” as their presented race (42,43), particularly when these individuals have darker skin, are second generation in the United States, and have experienced racial discrimination (41). In fact, there are compelling arguments to suggest that race is a social construct and not a biological phenomenon (44,45).

Additionally, the PTOS database does not include variables measuring socioeconomic status, education level, and English proficiency. Additional factors we were unable to examine and could influence patient care and outcome include the level of acculturation (46), social support (47), attitudes and beliefs about rehabilitation (48), and patient mistrust (49). All of these variables could likely interact and influence the discharge destination of patients. Lastly, due to the retrospective and cross-sectional nature of the study, we cannot determine the causes for differences in discharge destination or injury prevalence.

Conclusions

The findings in each of the three goals of this study demonstrate discrepancies in prevalence, study, and treatment of TBI in White versus nonwhite individuals. We first demonstrated that Black individuals in Pennsylvania are more likely than expected to sustain head injury given their prevalence in the state’s population. Next, a review of the literature revealed that, although it has been historically documented that psychological research heavily recruits White individuals (20), racial and ethnic identities of study participants are still largely omitted from the sample descriptions in TBI studies. Therefore, even though POC may be recruited and involved in studies, they are not identified. This omission in demographic reports may disincentivize researchers from recruiting underrepresented groups by normalizing lack of representation. Lastly, our CFA demonstrated meaningful patterns of discrepancy in care, where, broadly, White individuals were significantly more likely to receive further care and less likely to be sent home following moderate or severe head injuries.

Overall, these findings add to an existing literature documenting differences in the incidence and treatment of TBI between White individuals and POC, highlighting the importance of recognizing that race/ethnicity may influence incidence and treatment of TBI. Steps should be taken to ensure that TBI awareness, prevention, and treatment are

provided equally and in a culturally informed manner to patients regardless of race/ethnicity. In general, the CDC recommends a public health model for TBI prevention, including the surveillance of head injury, identifying risk and protective factors, developing evidence-based interventions, and disseminating interventions appropriately (50). Specifically in regard to attaining this goal for minority groups, community navigators, who are trained and culturally competent healthcare workers, can be used to help reduce healthcare disparities by helping to improve communication between patients and healthcare professionals (51). Additional steps that can be taken in order to reach this goal may include continued diversity training to the large variety of professionals engaged in TBI patient care. This diversity training may benefit from being ongoing and continually updated with information specifically regarding discrepancies in care and outcome as it relates to TBI patients. With regard to research, increased reporting of participant demographics, possibly with increased enforcement at the level of journal editors, peer-reviewers, and grant agencies would clarify the generalizability of findings and advance understanding of multicultural influences on TBI (52). Further research should be conducted into the possible implementation of policies to improve diversity in the TBI literature as well as to ensure equality of patient care.

Disclosure statement

The authors report no conflict of interest.

Funding

Pennsylvania Trauma Systems Foundation.

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