Published in final edited form as:

J Head Trauma Rehabil. 2021 ; 36(1): E40–E49. doi:10.1097/HTR.0000000000000603.

Lifetime History of Traumatic Brain Injury With Loss of Consciousness and the Likelihood for Lifetime Depression and Risk Behaviors: 2017 BRFSS North Carolina

Dana Waltzman, PhD, **Jill Daugherty, PhD, MPH**, **Kelly Sarmiento, MPH**

Division of Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia

Scott Proescholdbell, MPH

Division of Public Health, North Carolina Department of Health and Human Services, Raleigh, North Carolina

Abstract

Objective: Because of the growing concern about the potential effects of traumatic brain injuries (TBIs) on a child's developing brain and the potential impact of lifetime depression and risk behaviors associated with TBI, further exploration is warranted.

Setting and Participants: Data (N = 4917) from the 2017 North Carolina Behavioral Risk Factors Surveillance System (BRFSS).

Design: Cross-sectional.

Main Measures: Examine whether a lifetime history of TBI with loss of consciousness (LOC) or having a history of TBI with LOC prior to 18 years of age was associated with a greater likelihood of lifetime depression, current binge drinking, and current cigarette and e-cigarette smoking.

Results: Respondents with a history of TBI with LOC had 2.1 (95% CI, 1.6–2.8) times higher odds of lifetime depression and 1.7 to 1.8 (95% CI, 1.02–2.97) times higher odds of all risk behaviors than those without a lifetime history of TBI with LOC. There were no statistical differences between age of first TBI with LOC and lifetime depression, binge drinking, cigarette smoking, and e-cigarette use after controlling for key demographics.

Conclusion: These findings underscore the importance of increasing awareness among healthcare providers of the prevalence of lifetime depression and risk behaviors among individuals with a history of TBI and the need for improved screening and referrals to evidence-based services.

Corresponding Author: Dana Waltzman, PhD, Division of Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, 4770 Buford Hwy NE, Atlanta, GA 30341 (DWaltzman@cdc.gov).

The authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.headtraumarehab.com).

Keywords

age; health risk behaviors; LOC; TBI

TRAUMATIC BRAIN INJURIES (TBIs) are associated with a large number of injury-related deaths, hospitalizations, and disabilities each year.[1] In addition, a report from the Centers for Disease Control and Prevention (CDC) found that there were approximately 2.5 million TBI-related emergency department visits in the United States in 2014—an increase of more than 50% since 2006 (521.6 per 100 000 population in 2006 to 801.9 in 2014).[1] A TBI is caused by an impact or force to the head or body or a penetrating injury to the head that is associated with neurological dysfunction.[2] The severity of a TBI can range from "mild" (ie, a brief change in mental status or consciousness) to "severe" (ie, an extended period of unconsciousness or memory loss after the injury).[2]

Individuals with a TBI generally experience a constellation of short- or long-term symptoms that can affect thinking (ie, memory and reasoning), sensation (ie, sight and balance), language (ie, communication and understanding), and/or emotion (ie, depression, personality changes, and social inappropriateness).[3–5] Most individuals who sustain a mild TBI are often asymptomatic within 1 to 4 months,[6,7] whereas outcomes vary widely for those with greater TBI severity. However, there is emerging research that indicates that there may be ongoing effects from a TBI sustained during childhood while the brain is still developing.[8–11] For example, sustaining a TBI during childhood can increase a child's risk for adverse outcomes that can affect overall health and behaviors, such as self-regulation and social participation.[8,9,12] A TBI can also affect a child's ability to complete high school, be employed as an adult, and enroll in postsecondary education.[8,9,11,13–15]

While use of evidence-based practices has helped increase survival rates and quality of life for people living with TBI, certain health outcomes (such as depression) and behaviors (such as smoking and misuse of alcohol and other substances) can prolong or adversely affect a person's recovery from TBI.[16–19] Singh et al[18] conducted a 2-year prospective cohort study with more than 770 patients with TBI (of varying severities) and found that patients with depression had higher levels of postconcussion symptoms and worse psychosocial and global outcome ratings. Studies on smoking and excessive alcohol use following a TBI suggest that these behaviors may interfere with or occur as a way to cope with the neurobiological processes and dysfunction that occur during recovery from TBI.[20,21]

Excessive alcohol use (eg, binge drinking) and smoking are commonly initiated during adolescence.[22] In addition, signs of depression are prevalent among youth.[22] In 2017, a national school-based survey conducted by the CDC surveyed high school students regarding their self-reported health and behaviors. Findings from this survey demonstrated that 60.4% of students had had at least 1 drink of alcohol on at least 1 day during their life (ie, ever drank alcohol) and 13.5% of students reported binge drinking (≥4 drinks of alcohol in a row [for females] or ≥5 drinks of alcohol in a row [for males] within a couple of hours) on at least 1 day during the past 30 days.[22] In addition, 28.9% of students had tried cigarette smoking and 42.2% had used an electronic vapor product (including e-cigarettes, e-cigars, e-pipes, vape pipes, vaping pens, e-hookahs, and hookah pens) at some point previously.[22]

Alcohol contributes substantially to the morbidity of trauma patients, regardless of the type of injury. For example, in regard to TBI, studies have demonstrated the presence of alcohol in 35% to 81% of injured patients.[23,24] There is also evidence of an association between sustaining a TBI in youth and later risk behavior. One study found that in youth and adolescents aged 11 to 20 years, those who sustained a recent TBI (in the last 12 months) had 2 times greater odds of consuming alcohol and had 2.5 times greater odds of daily smoking than adolescents who never sustained a TBI.[25] In longitudinal birth cohort studies, sustaining a TBI during youth was associated with an increased risk of drinking to intoxication,[26] substance use (alcohol, tobacco, and cannabis),[27] and substance abuse and alcohol and drug dependence.[28]

Many adverse health risk behaviors initiated during childhood and adolescence can extend into adulthood and affect the health and safety of individuals in the long term.[22] Thus, because of the growing concern about the potential effects of TBIs on a child's developing brain and the potential impact of adverse health outcomes and risk behaviors (eg, binge drinking, smoking, and depression) associated with TBI, further exploration is warranted. To this end, using data from the 2017 North Carolina Behavioral Risk Factor Surveillance System (BRFSS), the goal of this article is to examine whether a person's lifetime history of TBI with loss of consciousness (LOC) and sustaining a TBI with LOC prior to 18 years of age is associated with a greater likelihood of reporting lifetime depression and/or current binge drinking, cigarette smoking, or e-cigarette use.

METHODS

Study population

The BRFSS[29] is a state surveillance system and is designed to make inference on a state noninstitutionalized population, aged 18 years and older. The BRFSS collects data on participants' health, use of preventive services, healthcare access, and health-related behavioral risk factors. The BRFSS employs a complex sampling design[30]; it uses a stratified random digit dialing method to collect a landline and cellphone sample. Final sample weights were products of base weights and adjustments of ranking on demographic variables. BRFSS data are de-identified and are considered exempt from human subjects review by the CDC's institutional review board. Data for this study only examined North Carolina BRFSS respondents, as only a few states incorporate a module that asks TBI-related questions. Data from the states that included a TBI module in 2017 cannot be combined because of differences in the TBI-related questions. In 2017, 4917 adults in North Carolina completed the BRFSS using a landline or cellphone (see Figure 1).

Traumatic brain injury

The TBI optional module included questions on the lifetime history of TBI. All respondents who completed the core sections of the BRFSS ($N = 4917$) received the following prompt:

For these next questions, please think about injuries you have had during your entire lifetime, especially those that affected your head or neck. It might help to remember times you went to the hospital or emergency room. Think about injuries you may have received

from a car or motorcycle wreck, bicycle crash, being hit by something, falling down, being hit by someone, playing sports, or an injury during military service.

This prompt was followed by the questions, “Thinking about any injuries you have had in your lifetime, were you ever knocked out, or did you lose consciousness?” and “How old were you the first time you were knocked out or lost consciousness?” On the basis of self-reported injury, lifetime history of TBI with LOC, and age of first TBI with LOC, questions were dichotomized as yes/no and less than 18 years and 18 years or older, respectively. Like the Ohio BRFSS TBI state module,[31] lifetime history of TBI was limited to TBIs with LOC-only. LOC is more accurately self-reported with certainty than other symptoms (such as confusion or disorientation) and indicates a disruption of brain function.[32] In addition, some studies have indicated that TBI with LOC has more discriminative power than TBI without LOC.[33,34]

Lifetime depression and risk behaviors

The health variables examined include lifetime depression, current binge drinking, current smoking, and current e-cigarette smoking.

Lifetime depression was defined using the question, “Has a doctor, nurse, or other health professional ever told you that you have a depressive disorder (including depression, major depression, dysthymia) or minor depression?” This variable was dichotomized as yes/no.

Current binge drinking was defined by combining 2 questions. The first question asked, “During the past 30 days, how many days per week or per month did you have at least one drink of any alcoholic beverage such as beer, wine, a malt beverage, or liquor?” The second question was as follows: “Considering all types of alcoholic beverages, how many times during the past 30 days did you have 5 (for men) and 4 (for women) or more drinks on an occasion?” If a person responded that he or she did not consume any drinks in the past 30 days, he or she was not asked the follow-up questions. This combined variable was coded with 3 mutually exclusive levels: nondrinker, non–binge drinker, and binge drinker. No drinking was defined as a respondent who answered that he or she had no drinks in the past 30 days in response to the first question. Non–binge drinking was defined as a respondent who reported drinking at least 1 alcoholic beverage in the past 30 days but did not report consuming 5 or more drinks (for men) or 4 or more drinks (for women) on an occasion. Binge drinking was defined as a respondent who reported consuming 5 or more drinks (for men) or 4 or more drinks (for women) on 1 or more occasions in the past 30 days.

Current smoker was defined by using the questions, “Have you smoked at least 100 cigarettes in your entire life?” and “Do you now smoke cigarettes every day, some days, or not at all?” This variable was dichotomized as yes/no. If the respondent answered “no” to the first question or “not at all” to the second question, the respondent was defined as not being a current smoker. If the respondent answered “yes” to the first question and “every day or some days” to the second question, the respondent was defined as a current smoker.

Current e-cigarette user was defined by using the questions, “Have you ever used an e-cigarette or other electronic “vaping” product, even just one time, in your entire life?” and

"Do you now use e-cigarettes or other electronic "vaping" products every day, some days, or not at all?" This variable was dichotomized as yes/no. If the respondent answered "no" to the first question or "not at all" to the second question, the respondent was defined as not being a current e-cigarette user. If the respondent answered "yes" to the first question and "every day or some days" to the second question, the respondent was defined as a current e-cigarette user.

Statistical analysis

Descriptive statistics were calculated to describe the demographic characteristics of North Carolina adults. These statistics were limited to those who answered "yes" or "no" to the lifetime TBI with LOC question ($N = 3771$). To account for the complex design of the BRFSS, frequencies and weighted percentages were estimated and compared across subgroups using χ^2 tests, along with corresponding 95% confidence intervals (CIs). The bivariate statistics were limited to those who answered "yes" or "no" to the lifetime TBI with LOC question and the respective lifetime depression question or risk behavior. To determine the association between lifetime history of TBI with LOC, and age of first TBI with LOC, and lifetime depression and risk behaviors (ie, current binge drinking, current smoking, and current e-cigarette user), multivariable binomial logistic regressions were used to create models, using the "no outcome" conditions as the reference group and adjusting for the demographic characteristics that were significant in the χ^2 tests. In addition, multicollinearity between the demographic characteristics was assessed for each multivariable binomial logistic regression model. Separate analyses were conducted for lifetime depression and each risk behavior variables. The level of the tests were $\alpha = .05$. Because of 22% of respondents not answering the TBI with LOC question, a missing data analysis comparing respondents who did not answer this question with those who did were conducted on demographic characteristics and lifetime depression and risk behavior variables. In addition, since there were a lot of respondents who did not answer the question about income, analyses with and without income were conducted for the final models. All analyses were performed in SAS 9.4 (SAS Institute, Cary, North Carolina), taking the complex survey design into account.

RESULTS

Respondents to the TBI question were relatively evenly split as follows: males (47.4%) and females (52.6%) (see Table 1). About 11.8% of individuals indicated veteran status, and most of the individuals were non-Hispanic white (68.1%). A majority completed some college or higher (58.3%). A quarter of the individuals (24.4%) had a history of TBI with LOC. Among those who indicated they had a history of TBI with LOC, 49.9% sustained a TBI with LOC prior to 18 years of age and 50.1% first sustained a TBI with LOC when they were an adult (18 years or older). Approximately 21.2% of individuals reported lifetime depression, 14.0% re ported current binge drinking, 17.8% reported current smoking, and 4.5% reported current e-cigarette use.

All multivariable models were adjusted for the demographic characteristics that were significant in the χ^2 tests. There was no evidence of multicollinearity between the demographic variables for all the evaluated endpoints.

Lifetime depression

Unadjusted analyses demonstrate that lifetime depression was more common among females, non-Hispanic whites, nonveterans, those who were not married, those with less educational attainment, those who were unemployed, and individuals with lower incomes (see Supplemental Digital Content, available at: http://links.lww.com/JHTR/A349). Similarly, lifetime history of TBI with LOC was related to individuals' self-reported lifetime depression (see Table 2). Age and age of first TBI with LOC were not significantly associated with lifetime depression.

After adjustment for sex, race/ethnicity, veteran status, marital status, educational attainment, employment status, and annual income, lifetime history of TBI with LOC was associated with increased odds of reporting lifetime depression (adjusted odds ratio [AOR] = 2.1; 95% CI, 1.6–2.8; see Table 3).

Current binge drinking

Unadjusted analyses demonstrate that current binge drinking was more common among males, younger respondents, nonveterans, those who were not married, those with higher educational attainment, currently employed individuals, and individuals with higher incomes (see Supplemental Digital Content, available at: http://links.lww.com/JHTR/A349). In addition, there was a statistically significant relationship between individuals with a lifetime history of TBI with LOC and age of first TBI with LOC and current binge drinking (see Table 2). Race/ethnicity and veteran status were not statistically significantly related to binge drinking.

After adjustment for sex, age, veteran status, marital status, educational attainment, employment status, and annual income, lifetime history of TBI with LOC was associated with increased odds of reporting non–binge drinking (AOR = 1.3; 95% CI, 1.02–1.7) and binge drinking (AOR = 1.7; 95% CI, 1.2–2.4). Age of first TBI with LOC (<18 years vs ≥ 18 years) was not associated with non–binge drinking (AOR = 1.1; 95% CI, 0.7–1.8) or binge drinking (AOR = 1.7; 95% CI, 0.9–3.3; see Table 3).

Current smoking

Unadjusted analyses demonstrate that current smoking was more common among males, younger respondents, those who were not married, those with less educational attainment, and individuals with a lower income (see Supplemental Digital Content, available at: http://links.lww.com/JHTR/A349). Individuals with a lifetime history of TBI with LOC were more likely to report being a current smoker (see Table 2). Veteran status, race/ethnicity, employment status, and age of first TBI with LOC were not statistically significantly related to current smoking.

After adjustment for sex, age, marital status, educational attainment, and annual income, lifetime history of TBI with LOC was associated with increased odds of reporting current smoking (AOR = 1.8; 95% CI, 1.3–2.4; see Table 3).

Current e-cigarette user

Unadjusted analyses demonstrate that current e-cigarette use was more common among younger respondents, those who were not married, those with less educational attainment, those currently employed, and individuals with lower income (see Supplemental Digital Content, available at: http://links.lww.com/JHTR/A349). Similarly, current e-cigarette use was associated with a lifetime history of TBI with LOC (see Table 2). Sex, race/ethnicity, veteran status, and age of first TBI with LOC were not significantly related to reporting current e-cigarette use.

After adjustment for age, marriage, educational attainment, employment status, and annual income, lifetime history of TBI with LOC was associated with increased odds of reporting current e-cigarette use (AOR = 1.7; 95% CI, 1.02–2.97; see Table 3).

DISCUSSION

This study demonstrated that lifetime depression and current binge drinking, cigarette smoking, and e-cigarette use were all significantly associated with reporting a lifetime history of TBI with LOC in North Carolinians, even after controlling for important demographic factors. For example, the odds of an individual reporting being diagnosed with lifetime depression among those with a history of TBI with LOC was twice as high as the odds of those without a history of TBI with LOC. These findings are consistent with other research that has found increased odds of depressive disorder, binge drinking, and cigarette smoking among individuals with a lifetime history of TBI with LOC in an Ohio sample,[31] although a study examining individuals from Colorado did not find an association with the presence of a TBI, TBI severity, and problematic alcohol use.[35] There have been a dearth of studies examining a lifetime history of TBI and e-cigarette use and to our knowledge this is the first to report such a finding. On the contrary, there is a plethora of research that has examined potential physical, cognitive, and neurological symptoms that may linger in the long term after one has experienced a TBI,[36,37] but there has been less focus on mental health and alcohol misuse problems. Importantly, there are several evidence-based interventions to address depression,[38] alcohol misuse,[39] and smoking[40] that can be used for patients with TBI. To increase access to these interventions for people living with TBI, findings from this study, as well as those from previous studies, point to the importance of increasing awareness among healthcare providers of the increased prevalence of lifetime depression and risk behaviors among patients with TBI and the need for improved screening and referrals to services.[18,20,41]

Contrary to our hypothesis, this study did not find that sustaining a first TBI with LOC prior to 18 years of age versus after 18 years of age affected the odds of reporting lifetime depression or risk behaviors. However, Bogner et al[31] did find an association between both age groups and adverse health outcomes for a first TBI with LOC prior to or after 15 years of age. There are several potential reasons why we did not find an association between a TBI

with LOC prior to 18 years of age and lifetime depression or risk behaviors and why this result differs from those of previous studies. First, and most importantly, besides binge drinking, our estimates were not stable enough to test the association between age of first TBI and lifetime depression and other risk behaviors. Second, our bivariate analysis did find that age of first TBI with LOC was significantly related to current binge drinking (P = .0005), with 28.6% of individuals who binge drink having had a first TBI with LOC before 18 years of age compared with 14.8% of individuals who binge drink having had a first TBI after 18 years or age. However, after controlling for key demographics in the final model, this significant relationship was no longer present. This could be due to low power and sample size or because there are other demographics that account for the variation in binge drinking that was explained by age of first TBI with LOC. Ultimately, the bivariate relationship highlights that this topic warrants further study with a larger sample size to provide greater clarity. Third, this sample included respondents who live in North Carolina. It may be the case that national data with a larger sample size will demonstrate a relationship between age of first TBI and lifetime depression and risk behaviors. Fourth, our results likely differ from those of Bogner et al due to our definition of age of first TBI. Our study directly compared respondents with a TBI with LOC prior to 18 years of age with that after 18 years of age, whereas the study conducted by Bogner et al examined respondents with a TBI with LOC prior to or after 15 years of age with those without a history of TBI. This difference could have a major impact on the results. However, when we added a no TBI reference group to our analyses (see Supplemental Digital Content 2, available at: http://links.lww.com/JHTR/A349), we did find similar results to Bogner et al: both age groups were related to increased odds of lifetime depression and current smoking, whereas having a TBI prior to 18 years of age had increased odds of non–binge drinking and binge drinking compared with those without a history of TBI with LOC.

There are several limitations to this study. First, the TBI questions are biased toward more severe brain injuries due to asking about lifetime TBI with LOC. In addition, the prevalence of all individuals who have sustained a TBI with LOC is between 5.7% and 12%.[42–44] Therefore, individuals who experienced a TBI but did not lose consciousness would not have endorsed this question. It is not possible to know whether the associations that we found are also true for those with potentially less severe forms of TBI, and this presents an area for future research. Second, because of the retrospective and cross-sectional nature of the data, temporality and causality between TBI history and the onset of lifetime depression or risk behaviors are unknown and cannot be established. This is particularly true for the outcome of lifetime depression, for which it cannot be known whether the onset of depression or sustaining a TBI came first; this is less true for the risk behaviors that assessed current binge drinking, cigarette smoking, and e-cigarette use. Third, these data were collected among respondents in North Carolina and may not be generalizable to other US states. However, states that also have a BRFSS TBI module, such as Colorado[35] and Ohio,[31] demonstrate similar prevalence estimates. Fourth, there was a high percentage of missing data for the lifetime TBI with LOC question (eg, 22% of respondents did not answer the question, N = 1094). Respondents who did not answer this question compared with those who did were different on all demographic characteristics (except for income), as well as reported depression and current binge drinking. For example, respondents who had missing data at

the time of the survey were more likely to be male, have a college education or higher, and report lifetime depression compared with respondents who did answer the self-reported lifetime TBI with LOC question. Fifth, the analysis did not measure TBI severity or number of TBIs. Future studies may want to examine these measures as well.

CONCLUSION

In this study, a lifetime history of TBI with LOC was significantly more common among those who self-reported lifetime depression, current binge drinking, tobacco cigarette smoking, and e-cigarette use. Findings from this analysis suggest that monitoring of patients with a history of TBI with LOC for the development of substance use problems may be beneficial. In addition, healthcare providers can consider screening patients with a lifetime history of TBI with LOC for mental health and alcohol misuse problems and provide referrals for evidence-based services as needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The findings and conclusions reported in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

REFERENCES

1. Centers for Disease Control and Prevention. Surveillance Report of Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths—United States, 2014. Atlanta, GA: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, US Department of Health and Human Services; 2019.
2. Centers for Disease Control and Prevention. TBI: get the facts. https://www.cdc.gov/traumaticbraininjury/get_the_facts.html. Published 2017. Accessed October 3, 2017.
3. Marr AL, Coronado VG. Central Nervous System Injury Surveillance Data Submission Standards—2002. Atlanta, GA: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention; 2004.
4. National Institute of Neurological Disorders and Stroke. Traumatic brain Injury: Hope Through Research. Bethesda, MD: National Institutes of Health; 2002.
5. Centers for Disease Control and Prevention. Traumatic brain injury & concussion: potential effects. https://www.cdc.gov/traumaticbraininjury/outcomes.html. Published 2017. Accessed August 31, 2017.
6. Lumba-Brown A, Yeates KO, Sarmiento K, et al. Centers for Disease Control and Prevention guideline on the diagnosis and management of mild traumatic brain injury among children. JAMA Pediatr. 2018;172(11):e182853. [PubMed: 30193284]
7. Barlow KM, Crawford S, Stevenson A, Sandhu SS, Belanger F, Dewey D. Epidemiology of postconcussion syndrome in pediatric mild traumatic brain injury. Pediatrics. 2010;126(2):e374–e381. [PubMed: 20660554]
8. Centers for Disease Control and Prevention. Report to Congress: The Management of Traumatic Brain Injury in Children. Atlanta, GA: Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention; 2018.
9. Babikian T, Merkley T, Savage RC, Giza CC, Levin H. Chronic aspects of pediatric traumatic brain injury: review of the literature. J Neurotrauma. 2015;32(23):1849–1860. [PubMed: 26414654]

10. Babikian T, Satz P, Zaucha K, Light R, Lewis RS, Asarnow RF. The UCLA longitudinal study of neurocognitive outcomes following mild pediatric traumatic brain injury. J Int Neuropsychol Soc. 2011;17(5):886–895. [PubMed: 21813031]
11. Koskiniemi M, Kyykka T, Nybo T, Jarho L. Long-term outcome after severe brain injury in preschoolers is worse than expected. Arch Pediatr Adolesc Med. 1995;149(3):249–254. [PubMed: 7532073]
12. Narad ME, Moscato E, Yeates KO, Taylor HG, Stancin T, Wade SL. Behavioral health service utilization and unmet need after traumatic brain injury in childhood. J Dev Behav Pediatr. 2019;40(6):451–457. [PubMed: 31107769]
13. Nybo T, Sainio M, Muller K. Stability of vocational outcome in adulthood after moderate to severe preschool brain injury. J Int Neuropsychol Soc. 2004;10(5):719–723. [PubMed: 15327719]
14. Todis B, Glang A. Redefining success: results of a qualitative study of postsecondary transition outcomes for youth with traumatic brain injury. J Head Trauma Rehabil. 2008;23(4):252–263. [PubMed: 18650769]
15. Todis B, Glang A, Bullis M, Ettel D, Hood D. Longitudinal investigation of the posthigh school transition experiences of adolescents with traumatic brain injury. J Head Trauma Rehabil. 2011;26(2):138–149. [PubMed: 20631630]
16. Gupta D, Sharma D, Kannan N, et al. Guideline adherence and outcomes in severe adult traumatic brain injury for the CHIRAG (Collaborative Head Injury and Guidelines) study. World Neurosurg. 2016;89:169–179. [PubMed: 26806065]
17. Faul M, Wald MM, Rutland-Brown W, Sullivent EE, Sattin RW. Using a cost-benefit analysis to estimate outcomes of a clinical treatment guideline: testing the Brain Trauma Foundation guidelines for the treatment of severe traumatic brain injury. J Trauma. 2007;63(6):1271–1278. [PubMed: 18212649]
18. Singh R, Mason S, Lecky F, Dawson J. Prevalence of depression after TBI in a prospective cohort: the SHEFBIT study. Brain Inj. 2018;32(1):84–90. [PubMed: 29190146]
19. Graham DP, Cardon AL. An update on substance use and treatment following traumatic brain injury. Ann N Y Acad Sci. 2008;1141:148–162. [PubMed: 18991956]
20. Allen S, Stewart SH, Cusimano M, Asbridge M. Examining the relationship between traumatic brain injury and substance use outcomes in the Canadian population. Subst Use Misuse. 2016;51(12):1577–1586. [PubMed: 27484302]
21. Weil ZM, Corrigan JD, Karelina K. Alcohol abuse after traumatic brain injury: experimental and clinical evidence. Neurosci Biobehav Rev. 2016;62:89–99. [PubMed: 26814960]
22. Kann L, McManus T, Harris WA, et al. Youth risk behavior surveillance—United States, 2017. MMWR Surveill Summ. 2018;67(8):1–114.
23. Corrigan JD. Substance abuse as a mediating factor in outcome from traumatic brain injury. Arch Phys Med Rehabil. 1995; 76(4):302–309. [PubMed: 7717829]
24. Kolakowsky-Hayner SA, Gourley EV III, Kreutzer JS, Marwitz JH, Cifu DX, McKinley WO. Pre-injury substance abuse among persons with brain injury and persons with spinal cord injury. Brain Inj. 1999;13(8):571–581. [PubMed: 10901686]
25. Ilie G, Mann RE, Hamilton H, et al. Substance use and related harms among adolescents with and without traumatic brain injury. J Head Trauma Rehabil. 2015;30(5):293–301. [PubMed: 25427256]
26. Winqvist S, Jokelainen J, Luukinen H, Hillbom M. Parental alcohol misuse is a powerful predictor for the risk of traumatic brain injury in childhood. Brain Inj. 2007;21(10):1079–1085. [PubMed: 17852100]
27. Kennedy E, Heron J, Munafo M. Substance use, criminal behaviour and psychiatric symptoms following childhood traumatic brain injury: findings from the ALSPAC cohort. Eur Child Adolesc Psychiatry. 2017;26(10):1197–1206. [PubMed: 28314984]
28. McKinlay A, Grace R, Horwood J, Fergusson D, MacFarlane M. Adolescent psychiatric symptoms following preschool childhood mild traumatic brain injury: evidence from a birth cohort. J Head Trauma Rehabil. 2009;24(3):221–227. [PubMed: 19461369]

29. North Carolina State Center for Health Statistics, Department of Public Health. North Carolina Behavioral Risk Factor Surveillance System Survey Data. Raleigh, NC: North Carolina Health and Human Services; 2017.
30. Behavioral Risk Factor Surveillance System: Comparability of Data BRFSS 2017. Version 2. Atlanta, GA: Centers for Disease Control and Prevention; 2018.
31. Bogner J, Corrigan JD, Yi H, et al. Lifetime history of traumatic brain injury and behavioral health problems in a population-based sample. J Head Trauma Rehabil. 2020;35(1):E43–E50. [PubMed: 31033748]
32. Ruff RM, Iverson GL, Barth JT, Bush SS, Broshek DK; NAN Policy and Planning Committee. Recommendations for diagnosing a mild traumatic brain injury: a National Academy of Neuropsychology Education paper. Arch Clin Neuropsychol. 2009;24(1):3–10. [PubMed: 19395352]
33. Corrigan JD, Bogner J. Initial reliability and validity of the Ohio State University TBI Identification Method. JHeadTraumaRehabil. 2007;22(6):318–329.
34. Whiteneck GG, Cuthbert JP, Corrigan JD, Bogner JA. Prevalence of self-reported lifetime history of traumatic brain injury and associated disability: a statewide population-based survey. J Head Trauma Rehabil. 2016;31(1):E55–E62. [PubMed: 25931187]
35. Whiteneck GG, Cuthbert JP, Corrigan JD, Bogner JA. Risk of negative outcomes after traumatic brain injury: a statewide population-based survey. J Head Trauma Rehabil. 2016;31(1): E43–E54.
36. Rabinowitz AR, Levin HS. Cognitive sequelae of traumatic brain injury. Psychiatr Clin North Am. 2014;37(1):1–11. [PubMed: 24529420]
37. Ponsford J, Cameron P, Fitzgerald M, Grant M, Mikocka-Walus A. Long-term outcomes after uncomplicated mild traumatic brain injury: a comparison with trauma controls. J Neurotrauma. 2011;28(6):937–946. [PubMed: 21410321]
38. Centers for Disease Control and Prevention. Managing depression. https://www.cdc.gov/learnmorefeelbetter/programs/depression.htm. Published 2018. Accessed June 27, 2019.
39. Centers for Disease Control and Prevention. CDC's alcohol screening and brief intervention efforts. https://www.cdc.gov/ncbddd/fasd/alcohol-screening.html. Published 2018. Accessed June 27, 2019.
40. Centers for Disease Control and Prevention, Office on Smoking and Health. State and community resources. https://www.cdc.gov/tobacco/stateandcommunity/index.htm?s_cid=osh-stu-home-nav-006. Published 2018. Accessed June 27, 2019.
41. Leong Bin Abdullah MFI, Ng YP, Sidi HB. Depression and anxiety among traumatic brain injury patients in Malaysia. Asian J Psychiatr. 2018;37:67–70. [PubMed: 30144779]
42. Frost RB, Farrer TJ, Primosch M, Hedges DW. Prevalence of traumatic brain injury in the general adult population: a meta-analysis. Neuroepidemiology. 2013;40(3):154–159. [PubMed: 23257914]
43. Silver JM, Kramer R, Greenwald S, Weissman M. The association between head injuries and psychiatric disorders: findings from the New Haven NIMH Epidemiologic Catchment Area Study. Brain Inj. 2001;15(11):935–945. [PubMed: 11689092]
44. Anstey KJ, Butterworth P, Jorm AF, Christensen H, Rodgers B, Windsor TD. A population survey found an association between self-reports of traumatic brain injury and increased psychiatric symptoms. J Clin Epidemiol. 2004;57(11):1202–1209. [PubMed: 15567638]

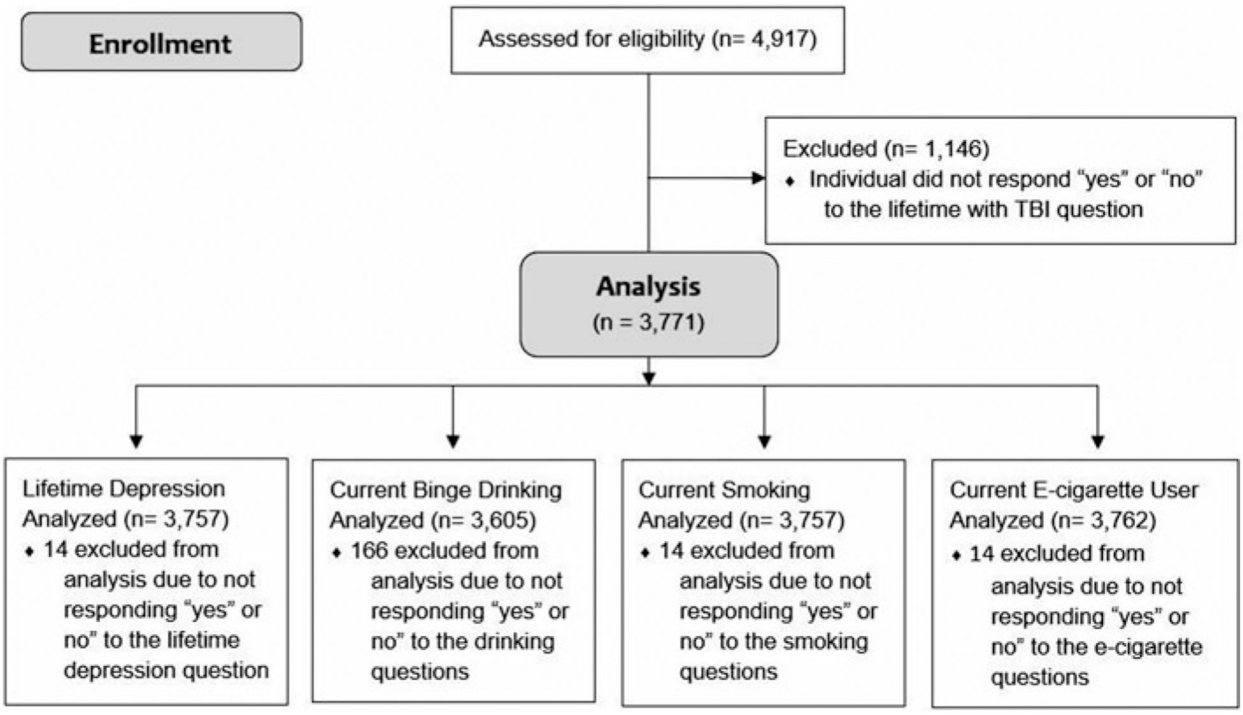

Figure 1.

CONSORT flow diagram of the statistical analysis of the respondents from the 2017 North Carolina BRFSS. BRFSS indicates Behavioral Risk Factors Surveillance System; TBI, traumatic brain injury.

J Head Trauma Rehabil. Author manuscript; available in PMC 2022 January 01.

TABLE 1

Demographic characteristics of adult North Carolinians, BRFSS, 2017[a]

	Lifetime history of TBI with LOC					
	Yes		No		Total	
Characteristic	***N***	**Weighted percentage**	***N***	**Weighted percentage**	***N***	**Weighted percentage**
Sex						
Male	497	57.1	1150	44.3	1647	47.4
Female	410	42.9	1712	55.7	2122	52.6
Age, y						
18–44	258	41.5	786	38.0	1044	38.8
45–64	378	37.6	1087	37.1	1465	37.2
65+	268	20.9	960	24.9	1228	23.9
Race/ethnicity						
Non-Hispanic white	669	75.0	1840	65.9	2509	68.1
Non-Hispanic black	144	17.0	624	22.8	768	21.4
Non-Hispanic other[b]	46	3.4	158	3.3	204	3.4
Hispanic	39	4.6	207	8.0	246	7.2
Veteran status						
Yes	174	16.6	345	10.3	519	11.8
No	733	83.4	2517	89.7	3250	88.2
Marital status						
Married	447	50.0	1486	52.4	1933	51.8
Divorced/widowed/separated	285	24.5	826	23.1	1111	23.4
Never married	145	20.9	465	20.2	610	20.4
A member of an unmarried couple	29	4.6	79	4.4	108	4.4
Educational attainment						
Completed high school or less	290	36.6	1081	43.3	1371	41.7
Some college	318	40.2	777	32.4	1095	34.3
Bachelor’s degree or higher	300	23.2	999	24.3	1299	24.0
Employment status						
Currently employed[c]	448	56.3	1414	54.2	1862	54.7

Characteristic	Lifetime history of TBI with LOC: Yes *N*	Yes Weighted percentage	No *N*	No Weighted percentage	Total *N*	Total Weighted percentage
Out of work/unable to find work	186	19.0	352	12.2	538	13.9
Homemaker/student/retired	272	24.7	1082	33.5	1354	31.4
Annual income						
<$25 000	239	28.5	690	29.1	929	29.0
$25 000–$50 000	196	26.7	614	26.6	810	26.6
>$50 000	335	44.8	1022	44.3	1357	44.4
Lifetime TBI with LOC						
Yes	NA	NA	NA	NA	908	24.4
No	NA	NA	NA	NA	2863	75.6
Age of first TBI with LOC[d]						
TBI <18 y old	NA	NA	NA	NA	397	49.9
TBI ≥18 y old	NA	NA	NA	NA	453	50.1
Lifetime depression						
Yes	270	30.6	501	18.2	771	21.2
No	636	69.4	2350	81.8	2986	78.8
Current binge drinker						
Nondrinker	412	44.1	1550	55.7	1962	52.9
Non-binge drinker	326	36.2	909	32.1	1235	33.1
Binge drinker	132	19.7	276	12.2	408	14.0
Current smoker						
Yes	220	25.5	394	15.4	614	17.8
No	684	74.5	2459	84.6	3143	82.2
Current e-cigarette user						
Yes	46	7.0	67	3.7	113	4.5
No	860	93.0	2789	96.3	3649	95.5

Abbreviations: AI/AN, American Indians/Alaska Natives; BRFSS, Behavioral Risk Factors Surveillance System; LOC, loss of consciousness; NA, not applicable; TBI, traumatic brain injury.

[a]The sample only includes individuals who responded to the lifetime TBI with LOC question (N = 3771).

[b]Includes those who answered that they were “non-Hispanic, black, Asian, AI/AN, other, or Hispanic.”

[c]Includes those who are self-employed.

[d]Total does not sum to 908 due to respondents who did not know their age of first TBI or refused to answer.

TABLE 2

Outcome characteristics by lifetime TBI with LOC exposure status among adult North Carolinians, BRFSS, 2017

	Lifetime depression (A/= 3757)[a]							
	Yes			No				
Characteristic	*N*	Weighted percentage or mean	95% CI	*N*	Weighted percentage or mean	95% CI	χ^2	*P*
Lifetime TBI with LOC							33.2	<.0001[b]
Yes	270	30.6	26.5–34.8	636	69.4	65.2–73.5		
No	501	18.2	16.2–20.1	2350	81.8	79.9–83.8		
Age of first TBI with LOC							0.20	.65
TBI <18 y old	107	29.3	23.2–35.5	289	70.7	64.5–76.8		
TBI ≥18 y old	145	31.3	25.2–37.4	307	68.7	62.6–74.8		

	Binge drinking (N = 3605)[c]										
	Nondrinker			Non-binge drinker			Binge drinker				
Characteristic	N	Weighted percentage or mean	95% CI	N	Weighted percentage or mean	95% CI	N	Weighted percentage or mean	95% CI	χ^2	P
Lifetime TBI with LOC										25.1	<.0001[b]
Yes	412	44.1	39.7–48.5	326	36.2	31.9–40.4	132	19.7	16.0–23.4		
No	1550	55.7	53.2–58.2	909	32.1	29.8–34.4	276	12.2	10.5–13.9		
Age of first TBI with LOC										17.3	<.001[b]
TBI <18 y old	152	36.4	30.1–42.7	147	36.0	29.7–42.2	85	27.6	21.4–33.8		
TBI ≥ 18 y old	222	48.6	42.1–55.1	167	39.0	32.7–45.3	42	12.4	8.1–16.7		

	Current smoker (N = 3757)[d]							
	Smoker			Nonsmoker				
Characteristic	N	Weighted percentage or mean	95% CI	N	Weighted percentage or mean	95% CI	χ^2	P
Lifetime TBI with LOC							25.1	<.0001[b]
Yes	220	25.5	21.6–29.5	684	74.5	70.5–78.4		
No	394	15.4	13.5–17.2	2459	84.6	82.8–86.5		
Age of first TBI with LOC							1.3	.25

Current smoker (N = 3757)[d]								
	Smoker			Nonsmoker				
Characteristic	N	Weighted percentage or mean	95% CI	N	Weighted percentage or mean	95% CI	χ^2	P
TBI < 18 y old	101	27.7	21.8–33.6	295	72.3	66.4–78.2		
TBI ≥ 18 y old	104	22.9	17.3–28.6	346	77.1	71.4–82.7		

Current e-cigarette user (N = 3762)[e]								
	Smoker			Nonsmoker				
Characteristic	N	Weighted percentage or mean	95% CI	N	Weighted percentage or mean	95% CI	χ^2	P
Lifetime TBI with LOC							7.1	<.01[b]
Yes	46	7.0	4.4–9.7	860	93.0	90.3–95.6		
No	67	3.7	2.6–4.8	2789	96.3	95.2–97.4		
Age of first TBI with LOC							…[f]	…[f]
TBI <18 y old	29	9.5	5.4–13.5	368	90.5	86.5–94.6		
TBI ≥18 y old	…[f]	…[f]	…[f]	…[f]	…[f]	…[f]		

Abbreviations: BRFSS, Behavioral Risk Factors Surveillance System; LOC, loss of consciousness; TBI, traumatic brain injury.

[a] Analyses limited to those who answered the lifetime TBI with LOC and depression questions.

[b] Results are P < .05.

[c] Analyses limited to those who answered the lifetime TBI with LOC and binge drinking questions.

[d] Analyses limited to those who answered the lifetime TBI with LOC and smoking questions.

[e] Analyses limited to those who answered the lifetime TBI with LOC and e-cigarette smoking questions.

[f] Estimates not presented because they are unstable due to small sample size and/or relative standard error more than 30%.

TABLE 3

Adjusted odds ratio and 95% CI for the relationship between TBI with LOC exposure and lifetime depression and risk behaviors among adult North Carolinians, BRFSS, 2017

	Lifetime depression[a]			Binge drinking[b]					
	Yes vs No			Non-binge drinker vs Nondrinker			Binge drinker vs Nondrinker		
Characteristic	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***	**OR**	**95% CI**	***P***
Lifetime TBI with LOC									
Yes vs No	2.1	1.6–2.8	<.0001[c]	1.3	1.02–1.7	.04[c]	1.7	1.2–2.3	<.01[c]
Age of first TBI with LOC[d]									
TBI <18 y old vs TBI ≥18 y old	…[e]	…[e]	…[e]	1.1	0.7–1.8	0.70	1.7	0.9–3.3	.11
				Current smoker[f]			Current e-cigarette user[g]		
				Smoker vs Nonsmoker			Smoker vs Nonsmoker		
Characteristic				**OR**	**95% CI**	***P***	**OR**	**95% CI**	***p***
Lifetime TBI with LOC									
Yes vs No				1.8	1.3–2.4	<.001[c]	1.7	1.02–2.97	.04[c]
Age of first TBI with LOC[d]									
TBI <18 y old vs TBI ≥18 y old				…[e]	…[e]	…[e]	…[e]	…[e]	…[e]

Abbreviations: LOC, loss of consciousness; OR, odds ratio; TBI, traumatic brain injury.

[a]Outcome adjusted for by sex, race/ethnicity, veteran status, marital status, educational attainment, employment status, and annual income.

[b]Outcome adjusted for by sex, age, veteran status, marital status, educational attainment, employment status, and annual income.

[c]Results are P < .05.

[d]Analyses limited to those who replied “yes” to lifetime TBI with LOC question.

[e]Estimates not presented because they are unstable due to small sample size and/or relative standard error more than 30%.

[f]Outcome adjusted for by sex, age, marital status, educational attainment, and annual income.

[g]Outcome adjusted for by age, marital status, educational attainment, employment status, and annual income.