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## High school students who experienced a concussion are more likely to report indicators of depression: A cross-sectional examination using the 2017 Vermont Youth Risk Behavior Survey

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## **Introduction**

In 2014, U.S. emergency departments treated an estimated 812,000 children (age 17 or younger) for traumatic brain injuries (TBI) caused by concussions. Research linked TBIs to changes in thinking, sensation, and emotion<sup>1</sup>. Adolescents reporting one or more TBI events had significantly higher odds of reporting psychological distress. Concussions often lead to post-concussion syndrome (PCS), which increases the risk of anxiety, depression, and poor academic performance.

Current research focuses primarily on military populations and sports-related injuries, making it difficult to generalize findings to broader populations<sup>2</sup>. Studies are also generally short, and follow up post-three months of injury is rare.<sup>3</sup> Additionally, literature on youth concussions and psychological distress primarily relies on parent reporting, rather than youth self-reporting.<sup>4</sup>

The Youth Risk Behavior Surveillance (YRBS) dataset offers a unique opportunity to evaluate potential associations between concussion and depression indicators reported by youth. The objective of this research was to analyze any relationship between recent concussion and depressive indicators in an adolescent population.

## **Methods**

### **Study Design and Data Source**

The Vermont YRBS is a voluntary survey conducted every two years and covers health behavior questions regarding unintentional injuries, violence, physical activity, nutrition, weight status, tobacco use, alcohol, other drug use, and sexual behaviors.<sup>5</sup> Responses from the 2017 Vermont YRBS were used to examine the relationship between concussion status and depression indicators in high schoolers.

### **Subjects and Sample Size**

In 2017, 20,653 of 26,692 high schoolers ] (77%) from 69 of 70 (99%) eligible high schools participated in Vermont YRBS.<sup>6</sup>

### **Procedure**

The University of Vermont Institutional Review Board reviewed this project and determined that it qualifies as exempt from additional review. This study relied on previously determined CDC exclusion criteria for the YRBS without further exclusion.<sup>7</sup> The primary predictor was concussions in the previous year, examined as a dichotomous variable (no concussions or one or more concussions) and as a continuous (0 through 4 or more concussions) variable. The outcome of interest was categorical depression status, whereby any individual reporting at least one symptom of depression was considered a case. Depression indicators included endorsement of any of the following in the past year: feeling sad or hopeless for two weeks or more, engaging in self-harm, planning suicide, and attempting suicide. Substance use was also considered and calculated by summing categorical endorsement of the use of nine substances for each participant, creating a score ranging from 0 to 9.

## **Statistical Analysis**

Data analysis was not weighted given the high participation level. Unadjusted percentages and 95% confidence intervals between participants with a concussion(s) and depression indicators are presented in the findings. Bivariate logistic regression was performed to elucidate associations between categorical concussion status and dichotomous depression indicators. A sensitivity analysis was run using an identical bivariate logistic regression model with a continuous concussion variable. All analyses were adjusted for subject age, sex, grade, and substance use score, which have previously been utilized as covariates in analyses examining concussion and mental health.<sup>8,9,10</sup>

Recognizing that the magnitude of the association between concussion status and depression indicators could vary based on substance use, tests for effect modification of the categorical substance use variable were conducted. Bivariate logistic regression, including an interaction term between concussion status and substance use score and all covariates, was conducted, and the p-value for the interaction term was interpreted. Hill's criteria were considered to assess evidence of a causal relationship. All analyses were run using SPSS.

## **Results**

### **Descriptive Statistics**

Of the study population, 49.1% were female, and the majority was white (83.3%). Approximately one-quarter of the study population was distributed in each of the four high school years. Additionally, 63.8% were between 14 and 16 years, and 35.7% were 17 years or older. 17.9% (3,638 participants) reported experiencing one or more concussion events in the previous year. 62.6% of the population reported no substance use in the past 30 days, while 37.3% of the study population reported using one or more substances.

Among the study population, 68.4% reported no depression indicators over the past year, while 31.6% reported one or more indicators.

Overall, females had lower odds of reporting a recent concussion than males (OR=.77, 95% CI: .71, .83), and females had substantially higher odds of reporting at least one depression symptom compared to males.

## **Bivariate Logistic Regression**

### **Categorical Concussion Status Regression Model**

Logistic regression analysis using a dichotomous concussion variable revealed that the odds of reporting one or more depression indicators were greater for individuals reporting at least one concussion in the past year compared to individuals not reporting any recent concussions, controlling for age, sex, grade in school, and categorical substance use score (OR=1.27, 95% CI: 1.16, 1.40). Odds of reporting one or more depression indicators increased based on categorical substance use score when controlling for covariates (OR=1.47, 95% CI: 1.44, 1.51). Moreover,

males had lower odds of reporting depression indicators than females, controlling for binary concussion status and other covariates (OR=.33, 95% CI: 0.31, 0.35, Table 1).

**Continuous Concussion Status Sensitivity Analysis**

Considering the effects of multiple concussions, a subsequent sensitivity analysis demonstrated that the odds of reporting one or more depression indicators increased 12.4% with each additional concussion up to the four-concussion study maximum, controlling for age, sex, grade in school, and categorical substance use score (95% CI: 1.07, 1.18; Table 1).

**Table 1. Logistic Regression Output: Dichotomous and Continuous Concussion Variable**

	<b>Dichotomous Concussion Variable OR (95% CI)</b>	<b>Continuous Concussion Variable OR (95% CI)</b>
<b>Concussions</b>	1.273 (1.158,1.399)*	1.124 (1.069,1.181)*
<b>Age</b>	1.004 (0.945,1.065)	1.003 (0.944, 1.064)
<b>Sex</b>	0.329 (0.306,0.354)*	0.329 (0.306, 0.354)*
<b>Grade</b>	0.958 (0.896,1.024)	0.958 (0.896, 1.024)
<b>Substance Use</b>	1.474 (1.438,1.511)*	1.474 (1.438, 1.511)*
<b>Constant</b>	1.531*	1.56*

OR=Odds Ratio, \*p<.001

**Discussion**

Logistic regression results using recent concussion history as a dichotomous variable indicated higher odds of reporting one or more depression indicators, controlling for covariates. This suggests a significant increase in odds of depression indicators in high schoolers reporting one or more concussions within the past year.

Sensitivity analysis results using concussion history as a continuous variable indicated higher odds of reporting one or more depression indicators for each additional concussion up to four concussions within the past year. This suggests a modest increase in risk of depression indicators for each additional concussion.

This research may support prioritizing concussion avoidance strategies for youth and demonstrates the need to develop screening, monitoring, and treatment for youth with post-concussion depression.

These findings bolster previous results relating concussions and depressive indicators. Population-based research conducted on 2009 Nevada YRBS data suggested higher odds of

reporting one or more depression indicators for individuals reporting a concussion within the last year compared to individuals who did not (OR=1.48, 95% CI: 1.12, 1.94). The study also concluded that students with concussions could have an increased risk of depressive indicators, indicating that concussion follow-ups should include a psychological evaluation.<sup>11</sup>

A limitation of this research is the cross-sectional study design, which hinders the ability to draw causal conclusions in relation to the observed associations. Additionally, a risk of data inconsistency is important to consider in a self-report survey setting, as respondents may not be able to accurately report their health history. Finally, the study utilized data from Vermont YRBS, a largely homogenous population, and thus conclusions may not be applicable to more diverse populations.

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