Socioeconomic status and outcomes after sport-related concussion: a preliminary investigation

Scott L. Zuckerman, MD,^{1,2} Brian Holt Zalneraitis, BS,¹ Douglas J. Totten, BA,¹ Kolin E. Rubel, BS,³ Andrew W. Kuhn, BA,¹ Aaron M. Yengo-Kahn, MD,^{1,2} Christopher M. Bonfield, MD,^{1,2} Allen K. Sills, MD,^{1,2} and Gary S. Solomon, PhD^{1,2}

¹Vanderbilt Sports Concussion Center and ²Department of Neurological Surgery, Vanderbilt University School of Medicine, Nashville, Tennessee; and ³University of Indiana School of Medicine, Indianapolis, Indiana

OBJECTIVE. A significant proportion of patients experience long-term symptoms after sport-related concussion (SRC), and several factors have been associated with this protracted recovery. Limited data exist on the role of socioeconomic status (SES) on SRC outcomes. The objective in this study was to conduct a preliminary investigation to determine the effect of SES on outcomes after SRC in student-athletes treated at a regional sports concussion center.

METHODS. A retrospective cohort study of 282 middle school, high school, and collegiate student-athletes was conducted. An attempt was made to contact all patients seen at a comprehensive SRC center between January 2012 and May 2015 for in-depth interviews. Subsequent demographic data were collected. The SES was defined as follows: cost of living percentile, median income percentile, percentage of college graduates, percentage of homeowners, county type, and insurance status. Outcomes after SRC were defined as follows: days of symptom duration, days of missed school, and days of missed practice. Statistically controlled covariates included sex, race, age, body mass index, concussion history, neuropsychiatric history, and type of sport.

RESULTS. A total of 282 student-athletes consented and were studied. The median age was 15.8 years (range 11.6–22.2 years) and 61.4% of student-athletes were male. A previous concussion was incurred by 34.0% of student-athletes. Football was the most common sport (32.3%), followed by soccer (16.3%), and basketball (15.6%). The median symptom duration was 21 days (range 1–365 days); the median missed school days was 2 (range 0–90 days); and median for days of missed practice was 10 (range 0–150 days). After multivariate Cox regression analysis, no relationship between any of the 6 SES variables and symptom duration or missed practice was seen. However, individuals with private insurance had more missed days of school than those with public insurance (hazard ratio 0.46, 95% CI 0.26–0.83, $p = 0.009$).

CONCLUSIONS. In a preliminary study of middle school, high school, and collegiate student-athletes, SES had no impact on the outcomes of symptom duration and missed practice. However, for individuals with private insurance, the return to school was slower than for those with public insurance. This pilot study reveals the complex relationship between SES and SRC recovery, which demands further study with more accurate and validated assessments of SES.

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KEY WORDS socioeconomic status; sports-related concussion; traumatic brain injury; football; basketball; soccer; athletics; postconcussion syndrome; trauma

SPORT-related concussion (SRC) has surfaced as a public health concern in recent years. Approximately 1.6–3.8 million SRCs are reported annually,¹⁰ with an estimated 136,000 SRCs occurring in high school athletics alone.⁵ Additionally, 10%–15% of patients develop persistent symptoms following SRC.^{7,19,33} Given the po-

tential for long-term disability, it is important to determine factors that may predict a protracted recovery.

Currently, no diagnostic test exists to determine severity of injury after SRC; often the injury severity is assessed through symptom duration or time away from school or sport.²⁹ Several risk factors have been associated with re-

ABBREVIATIONS BMI = body mass index; EMR = electronic medical record; HR = hazard ratio; IQR = interquartile range; SES = socioeconomic status; SRC = sport-related concussion; TBI, mTBI = traumatic brain injury, mild TBI; VSCC = Vanderbilt Sports Concussion Center.

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covery time, including severity of symptoms, history of concussion, personal and family history of preinjury migraines and mood disorders, and sex.^{14,17,19} Other factors, such as socioeconomic status (SES), have yet to be investigated.

Socioeconomic status has been studied mostly in moderate and severe traumatic brain injury (TBI), in which lower SES has been generally associated with worse social outcomes,^{6,32} although the literature is mixed.²⁴ In one of the few studies specific to mild TBI (mTBI), lower SES significantly predicted a poor cognitive outcome at 3 months postinjury.²³ In relation to sports injuries, our search yielded no specific studies relating SES to SRC outcomes.

Given that SES is a novel factor in the study of SRC with limited to no data, the current objective was to conduct a pilot study examining the impact of SES on recovery after SRC among a cohort of middle school, high school, and collegiate student-athletes. Evaluating novel factors related to SES and SRC recovery may elucidate important trends and generate new hypotheses that demand rigorous scientific study.

Methods

A retrospective cohort study was conducted at a regional sports concussion center. The Vanderbilt Sports Concussion Center (VSCC) outcomes registry database was

launched in 2013 and data-collection efforts remain ongoing. Student-athletes across middle Tennessee and the surrounding states of Kentucky, Georgia, and Alabama who presented to the VSCC for treatment were included in the database. The current study was approved by our institutional review board.

Inclusion and Exclusion Criteria

A total of 699 patients who suffered SRC were seen at the VSCC between January 2012 and May 2015 by 5 interdisciplinary providers from adult and pediatric neurosurgery, neuropsychology, and sports medicine. As noted in Fig. 1, of the 699 patients with SRC, complete data were collected for 295 patients (42%). The population studied included middle school, high school, and collegiate student-athletes participating in team or individual sports. Student-athletes were excluded if they were not playing at these levels of competition or if they had a history of brain surgery, seizures, or meningitis. After exclusionary criteria were applied, our final cohort included 282 student-athletes. All concussions were diagnosed in accordance with the definition provided by the international Concussion in Sport Group (CISG) guidelines.¹⁵ Diagnoses were made by certified athletic trainers or team physicians based on the following on-field or sideline signs or symptoms: 1) lethargy, foginess, headache, dizziness,

FIG. 1. Flow diagram of final cohort.

nausea, visual problems, photophobia, or phonophobia; 2) alteration in mental status; 3) loss of consciousness; or 4) amnesia. Grading systems of concussion severity were not used, based on the aforementioned Concussion in Sport Group guidelines.¹⁵

Data Collection

In-depth phone interviews were completed to collect all SRC information. Each interview was standardized and similarly structured. All patients and families were contacted a minimum of 3 months after the injury to allow for symptom resolution. In addition to interviewing the concussed student-athlete, a parent or guardian was also interviewed for each patient younger than 18 years or when available. Collateral information was obtained because most patients were adolescents or teenagers (i.e., in middle school or high school) and not all SRC information may have been readily known due to loss of consciousness or amnesia surrounding the event. Multiple contacts were often required per patient to obtain complete data. If the patient was still symptomatic during the interview, additional contacts were made until symptoms had resolved or 1 year had passed postinjury.

Several data points were collected for each patient, including demographic information, medical history, family history, acute injury characteristics, and symptom duration. The institutional electronic medical records (EMRs) were used to cross-validate already gathered data. Any discrepancies between patient interviews and the EMRs were resolved with additional patient contacts. All data were maintained in a de-identified database.

For the current study, the extracted demographic, family, and past medical information included the following: sex, race, age, body mass index (BMI), concussion history, and neuropsychiatric history, including attention deficit disorder and/or learning disorders, depression or anxiety, psychiatric disorders, or any positive history of such findings in any parent, sibling, or child. The SRC event data included mechanisms of injury (described below). Clinical outcome data included duration of symptoms and achievement of asymptomatic status.

Socioeconomic Status

The literature on SES determination is vast and be-

yond the scope of this study. Based on the TBI and sports medicine literature, we chose to study factors including education, employment, income, and general family environment.^{4,11,12,20,22,30,31} Although these specific factors may not represent an ideal definition of SES, these variables and information were available in all patients. Unfortunately, the socioeconomic variables included in this study were not obtained directly from the patients and families themselves due to the original registry design. Thus, surrogate measures had to be used. The SES was defined a priori as 6 different variables: cost of living percentile,¹¹ median income percentile,¹ percentage of college graduates,¹ home ownership,⁴ county setting,⁸ and insurance status.^{12,22} All variables except insurance status were based on the patient's zip code at the time of injury. Insurance status was gathered from the EMR. Continuous percentage variables were transformed into categorical variables for ease of data analysis. Description of each variable is presented in Table 1.

Outcomes

Three main SRC outcomes of interest were assessed: symptom duration, missed school, and missed practice. Each outcome variable was measured in days as a continuous variable. Symptom duration was defined as the student-athlete experiencing self-reported symptoms attributable to the initial injury. Missed school was defined as the number of school days missed. If a student-athlete suffered an SRC during the summer months while out of school, missed school was not included. Missed practice was counted as the number of team practices missed that was attributable to the initial injury. In our practice, athletes are always returned to school prior to return to sport.

Statistical Analyses

For all descriptive analyses, continuous variables were reported as a median with corresponding interquartile range (IQR) and overall range, and binary count variables with number (%). Five of the 6 exposures of interest were categorical, with insurance status coded as binary. All 3 outcomes of interest (symptom resolution, return to school, and return to practice) were continuous and measured in days. The study period for each patient was 365 days. Patients who did not achieve symptom resolution by

TABLE 1. Definitions of variables used to test SES

Exposure	Definition	Source
1. Cost of living	Average cost of basic living expenses for each given area to assess both participants' wealth/income & geographic setting.	Marcin et al., 2003
2. Median income	Income level earned by any given household, w/ half of the homes in the area earning more & half earning less.	Adler & Newman, 2002
3. Percent college graduates	Percentage of the population in the area that graduated from college, for use in determining education attainment.	Adler & Newman, 2002
4. Home ownership	Percentage of homes in the area that are owned by their occupants, for use in determining wealth/income.	Collins et al., 2016
5. County setting	Assessment of the type of geographic setting based on city size.	Ingram & Franco, 2014
6. Insurance status	Determination of study participants' insurance status as either private or public (government provided).	Max et al., 2005; Penson et al., 2001

365 days were censored by design. These censored patients were included in the analysis without achieving the outcome.

In addition to Kaplan-Meier failure plots, univariate and multivariable Cox regression models were conducted to estimate the relationship between each of the 6 SES exposures to the 3 outcomes. Several modifying factors were included as covariates in each model: age, sex, race, BMI, concussion history, psychiatric history, and sport. The hazard function was defined as the instantaneous risk of achieving the event of interest at time (t) in the subset who still had symptoms. Indicator variables were used for each exposure category. For each Cox regression model, all hazard ratios (HRs) with 95% CIs not containing 1.0 were considered statistically significant. All statistical analysis was performed in STATA version 14 (StataCorp LP).

Results

Patient Demographic Data

The majority of student-athletes were male (61.4%), and football was the most represented sport (32.3%). The median BMI was 22.1, ranging from 14.7 to 45.2. Approximately one-third (34.0%) of the study group had a history of at least 1 SRC prior to the current event. Migraines were the most prevalent comorbidity (18.4%), and 35.6% of student-athletes had a positive family psychiatric history. The majority of student-athletes competed at the high school level (69.5%), followed by middle school (20.2%) and collegiate (10.3%) athletes. All demographic data, each of the 6 SES domains, and the 3 outcomes are summarized in Table 2.

Regression Analysis

All univariate and multivariable Cox regression models are seen in Tables 3–5. Kaplan-Meier failure plots of symptom duration, missed school, and missed practice—measured in days—are seen in Figs. 2–4. For the outcomes of symptom duration and missed practice, none of the Cox regression models revealed a significant trend on univariate or multivariable testing (Tables 3 and 5). However, for the outcome of missed school, insurance status was found to be significant. The return to school for those with private insurance was more likely to be slower than for those with public insurance, both on univariate (HR 0.52, 95% CI 0.31–0.87; $p = 0.013$) and multivariable testing (HR 0.46, 95% CI 0.26–0.83; $p = 0.009$) (Table 4). This trend is seen graphically in Fig. 5. After log-rank test, this trend was confirmed; student-athletes with private insurance missed significantly more school than student-athletes with public insurance ($\chi^2 = 7.63$, $p = 0.0057$). Of those with public insurance, the mean and median of missed school days were both 2.0, ranging from 0 to 8 days, with an SD of 2.1. Of those with private insurance, the mean and median missed school days was 5.2 and 2.0, respectively, ranging from 0 to 90 days, with an SD of 10.6.

Discussion

In the evaluation of student-athletes after SRC, several factors that modify recovery have been postulated, yet

TABLE 2. Characteristics of the 282 student-athletes

Characteristic	Value
Demographic data	
Male	173 (61.4)
Race	
White	241 (85.5)
Non-white	41 (14.5)
Age in yrs	
Median (IQR)	15.8 (14.3–18.3)
Min–max	11.6–22.2
BMI	
Median (IQR)	22.1 (20.4–25.1)
Min–max	14.7–45.2
Previous concussion	96 (34.0)
Neuropsychiatric history	
LD/ADHD	30 (10.6)
Depression/anxiety	11 (3.9)
Migraine	52 (18.4)
Illicit substance abuse	8 (2.8)
Family psychiatric	100 (35.5)
Family migraine	56 (19.9)
Competition level	
Middle school	57 (20.2)
High school	196 (69.5)
Collegiate	29 (10.3)
Sport	
Football	91 (32.3)
Soccer	46 (16.3)
Basketball	44 (15.6)
Baseball/softball	17 (6)
Lacrosse	18 (6.4)
Cheerleading	15 (5.3)
Volleyball	10 (3.6)
Rugby	4 (1.4)
Wrestling	12 (4.3)
Other	25 (8.9)
Exposure	
Cost of living percentile	
0–50	72 (25.5)
51–70	103 (36.5)
>70	107 (37.9)
Median income percentile	
0–59	77 (27.3)
60–79	114 (40.4)
≥80	91 (32.3)
College graduates	
0%–20%	100 (35.5)
21%–47%	100 (35.5)
≥48%	82 (29.1)

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TABLE 2. Characteristics of the 282 student-athletes

Characteristic	Value
Exposure (<i>continued</i>)	
Home ownership	
0%–71%	98 (34.8)
71.1%–80%	63 (22.3)
>80%	121 (42.9)
County setting	
Large central metro	85 (30.1)
Large fringe metro	164 (58.2)
Small/medium metro	33 (11.7)
Insurance	
Private	255 (90.4)
Public	27 (9.6)
Outcomes	
Symptom duration, days	
Median (IQR)	21 (11–61)
Min–max	1–365
Missed school, days	
Median (IQR)	2 (0–5)
Min–max	0–90
Missed practice, days	
Median (IQR)	10 (4.5–20)
Min–max	0–150

ADHD = attention deficit/hyperactivity disorder; LD = learning disorder; max = maximum; min = minimum.

Unless otherwise specified, the values represent the number of patients (%).

little has been studied about the importance of SES. In our preliminary study from the VSCC, several different surrogates of convenience for SES were selected to evaluate their impact on SRC outcomes. No SES surrogates were found to correlate with duration of symptoms and return to sport. However, individuals with private insurance took longer to return to school than those with public insurance. Results from our pilot investigation may generate new hypotheses for future investigations.

Recovery after SRC is a complex process. When communities of parents, teachers, and coaches are heavily involved in the rehabilitation of a student-athlete, community-level intervention may potentially improve outcomes. It has been well studied that after moderate and severe TBI, children from lower-SES families develop more behavioral and social problems, with lower achievement than their advantaged counterparts.^{6,13,24–26} SES has previously been defined in many ways. One study used a Socioeconomic Composite Index composed of annual family income, social resources, and maternal education,²⁵ similar to our study. However, most of this prior research was performed in young children (< 10 years old) who sustained a severe TBI. It is difficult to extrapolate these findings to a concussion population due to different injury severities, multiorgan system involvement, and varying stages of brain development.

With respect to more mild brain injuries, Rabinowitz

et al.²³ evaluated predictors of persistent dysfunction in adolescents and young adults with mTBI compared to orthopedic and uninjured controls. Interestingly, the authors found that SES (defined by the aforementioned Socioeconomic Composite Index) correlated with 3-month cognitive recovery but did not predict symptom endorsement. The authors postulated that lower SES was a marker of decreased cognitive reserve, and those with less cognitive reserve were more susceptible to cognitive declines. In a similar evaluation, Olsson et al.²¹ evaluated 150 children and their parents after mTBI and found that child symptom burden at 6 and 18 months was predicted by preinjury parent distress, which may be intertwined with SES. Conversely, McNally and colleagues¹⁶ evaluated 186 adolescents with mTBI compared to 99 orthopedic controls and found no relationship between life stressors or social resources and child symptom duration, similar to our findings. Although useful, these studies were not conducted in a sports population. The outcomes of interest after general mTBI (education, achievement, behavioral problems) are different from those after sport-specific injury (return to play, return to learn, symptom resolution, neurocognitive test scores, postural stability). Counseling from coaches and athletic trainers, a desire to return to sport, and sport-specific outcomes are subtle yet important factors that reinforce the uniqueness of sports concussions.

No prior studies were found in the literature that directly assessed the impact of SES on outcomes in an exclusively SRC population. In our pilot investigation, 6 rudimentary SES domains spanning education and income levels had no correlation with symptom duration and athletic participation. However, a relationship between insurance status and missed school was discovered, in which those with private insurance missed more school than those with public insurance.

It is possible that student-athletes with private health insurance were more likely to receive medical care by a concussion specialist who recommended cognitive rest, which led to a longer time away from school. One survey-based study of high school athletic trainers found that cognitive rest was most commonly recommended,⁹ but a similar study of emergency room discharge instructions found cognitive rest was prescribed in only 4% of cases.²⁸ A recent randomized controlled trial of 88 pediatric concussions seen in the emergency room (not exclusively due to sports) compared strict rest for 5 days versus usual care, consisting of 1–2 days of rest with a stepwise return to activity. Despite the intervention group reporting lower school attendance, no significant difference in neurocognitive and balance outcomes was seen, except that the group prescribed rest endorsed more postconcussive symptoms and slower symptom resolution time.²⁷

A second explanation of our findings is that those with public insurance, representing a lower socioeconomic group, returned to school as dictated by their symptoms, teachers, or parents, without seeing a health care professional. This return to school may have been appropriate, or may have been premature—the current study cannot determine either case. This latter example of students returning to school prematurely may be more common. Researchers from a family and sports medicine practice in

TABLE 3. SES as a predictor of symptom duration

SES Exposure	Univariate		Multivariable	
	HR (95% CI)	p Value	HR (95% CI)	p Value
Cost of living percentile				
0–50	Reference	Reference	Reference	Reference
51–70	0.98 (0.70–1.30)	0.779	1.09 (0.77–1.52)	0.636
>70	1.03 (0.76–1.40)	0.828	1.02 (0.73–1.43)	0.891
Median income percentile				
0–59	Reference	Reference	Reference	Reference
60–79	0.99 (0.74–1.33)	0.959	0.94 (0.68–1.29)	0.693
≥80	1.15 (0.85–1.57)	0.368	1.06 (0.76–1.47)	0.744
College graduates				
0%–20%	Reference	Reference	Reference	Reference
21%–47%	1.02 (0.77–1.36)	0.865	1.00 (0.73–1.35)	0.975
≥48%	1.11 (0.83–1.50)	0.478	1.09 (0.79–1.50)	0.601
Home ownership				
0%–71%	Reference	Reference	Reference	Reference
71.1%–80%	1.02 (0.74–1.41)	0.889	0.92 (0.64–1.32)	0.651
>80%	1.02 (0.77–1.33)	0.911	0.98 (0.73–1.32)	0.901
County setting				
Large central metro	Reference	Reference	Reference	Reference
Large fringe metro	0.93 (0.71–1.21)	0.584	0.89 (0.66–1.20)	0.457
Small/medium metro	1.04 (0.69–1.55)	0.865	0.85 (0.55–1.33)	0.486
Insurance status	1.08 (0.72–1.62)	0.704	0.87 (0.54–1.42)	0.583

TABLE 4. SES as a predictor of missed school

SES Exposure	Univariate		Multivariable	
	HR (95% CI)	p Value	HR (95% CI)	p Value
Cost of living percentile				
0–50	Reference	Reference	Reference	Reference
51–70	0.74 (0.52–1.08)	0.116	0.78 (0.53–1.16)	0.222
>70	0.80 (0.55–1.16)	0.236	0.77 (0.51–1.16)	0.213
Median income percentile				
0–59	Reference	Reference	Reference	Reference
60–79	0.82 (0.57–1.17)	0.268	0.83 (0.57–1.22)	0.341
≥80	0.91 (0.62–1.32)	0.608	0.88 (0.58–1.35)	0.565
College graduates				
0%–20%	Reference	Reference	Reference	Reference
21%–47%	0.79 (0.56–1.1)	0.176	0.77 (0.53–1.11)	0.160
≥48%	0.86 (0.59–1.25)	0.431	0.85 (0.57–1.29)	0.449
Home ownership				
0%–71%	Reference	Reference	Reference	Reference
71.1%–80%	1.30 (0.89–1.89)	0.179	1.27 (0.84–1.94)	0.258
>80%	1.14 (0.82–1.60)	0.430	1.15 (0.80–1.65)	0.442
County setting				
Large central metro	Reference	Reference	Reference	Reference
Large fringe metro	1.05 (0.76–1.45)	0.745	1.02 (0.70–1.50)	0.903
Small/medium metro	1.42 (0.89–2.29)	0.144	1.50 (0.89–2.53)	0.132
Insurance status	0.52 (0.31–0.87)	0.013*	0.46 (0.26–0.83)	0.009*

* Statistically significant ($p < 0.05$).

TABLE 5. SES as a predictor of missed practice

SES Exposure	Univariate		Multivariable	
	HR (95% CI)	p Value	HR (95% CI)	p Value
Cost of living percentile				
0–50	Reference	Reference	Reference	Reference
51–70	0.89 (0.64–1.22)	0.464	0.95 (0.66–1.36)	0.782
>70	1.04 (0.76–1.42)	0.812	1.00 (0.69–1.43)	0.993
Median income percentile				
0–59	Reference	Reference	Reference	Reference
60–79	0.82 (0.60–1.12)	0.206	0.83 (0.59–1.16)	0.263
≥80	1.11 (0.80–1.54)	0.534	1.02 (0.71–1.47)	0.914
College graduates				
0%–20%	Reference	Reference	Reference	Reference
21%–47%	1.01 (0.75–1.36)	0.938	0.94 (0.68–1.30)	0.707
≥48%	1.20 (0.87–1.64)	0.266	1.08 (0.77–1.52)	0.646
Home ownership				
0%–71%	Reference	Reference	Reference	Reference
71.1%–80%	1.05 (0.75–1.48)	0.758	0.96 (0.65–1.41)	0.822
>80%	1.02 (0.77–1.37)	0.871	1.00 (0.72–1.37)	0.985
County setting				
Large central metro	Reference	Reference	Reference	Reference
Large fringe metro	1.06 (0.80–1.41)	0.688	1.04 (0.76–1.43)	0.806
Small/medium metro	0.90 (0.59–1.38)	0.641	0.78 (0.49–1.24)	0.301
Insurance status	1.06 (0.70–1.61)	0.780	0.92 (0.57–1.51)	0.756

Canada retrospectively reported that 44.7% of 159 middle school, high school, and collegiate student-athletes were returned to school prematurely, which was defined as symptom recurrence upon return to learn.² However, does it mean that a student-athlete was returned to school too early if their symptoms returned, or could the appropriate policy have been followed, only for the student-athlete not to respond as previously thought? Even if we held the first proposed hypothesis—that those with private insurance received appropriate cognitive rest—our explanation would be challenged by the results of a recent observa-

tional study by Moor et al.,¹⁸ who measured adherence to postinjury treatment recommendations in 56 concussed adolescent student-athletes. Those who were less adherent to physical rest, mental rest, and school restrictions actually recovered faster than those who followed the prescribed recommendations. Despite speculation and proposed hypotheses, it remains unclear what group of patients receives the optimal post-SRC care. Future works are needed to discern the relationship between SES and how athletes are returned to school. Given the preliminary nature of our study and the surrogate measures used for

FIG. 2. Graph showing symptom duration. Figure is available in color online only.

FIG. 3. Graph showing missed school. Figure is available in color online only.

FIG. 4. Graph showing missed practice. Figure is available in color online only.

SES, we offer no concrete recommendations, but rather we hope to spark future research on the relationship of SES to SRC outcomes.

Limitations

As with any preliminary investigation, there are several study flaws that preclude definitive conclusions. The 2 most important biases concern generalizability and reliability. Although major efforts were made to contact patients and their guardians at multiple time points, we were only able to capture 42.2% of student-athletes, and due to other exclusion criteria, only 40.3% were analyzed. Unfortunately, no claims can be made regarding the remaining 59.7%. This immediately calls into question the representativeness of the study cohort. Because contact was made through telephone interviews, we inadvertently selected for patients who were more able and willing to enroll in the study. There may be additional heterogeneity within the remaining population that reflects different trends than the ones presented. We urge future investigators to obtain research data during the concussion provider visit to avoid these limitations in representativeness.

The second study flaw relates to using zip codes as a surrogate for SES. The optimal methodology to collect SES information is through direct patient interview. At the time of our registry design, although we asked many in-depth demographic, medical, and sport-specific questions, we failed to delve into the commonly used strategies for assessing SES. Furthermore, no validated questionnaires were used. Although some population-based information can be obtained through zip codes, their use is suboptimal in a study of a highly selected group of patients such as ours. When socioeconomic factors are determined by a thirdhand source such as zip codes, only generic conclusions can be made to spark further study. Recommendations for specific, targeted interventions are prohibited. Although 282 participants is low for a population-based study, in a more narrow SRC cohort, this number is quite reasonable.

Other weaknesses of the study deserve further mention. Student-athletes and their guardians may have been unable to remember specific SRC information months and sometimes years after their injury. However, collateral in-

FIG. 5. Graph showing missed school divided by private and public insurance. Figure is available in color online only.

formation was obtained on all patients when available, to counteract recall bias. Our study also represents trends in one region of the country, and sporting activities may not reflect regional trends found elsewhere. In general, this cohort (85% white and 90% with private insurance) reflects a fairly high SES and was obtained from a dedicated SRC clinic at an urban comprehensive medical center. Therefore, it may not reflect population trends in more rural and underserved areas. Last, the 6-part definition of SES used in this study may not have been ideal, and further studies might choose to use other standardized definitions.

Future Research

Despite the aforementioned limitations, an interesting finding pertaining to time away from school was found, which generates novel hypotheses for future study. The highest utility of this conclusion is not with interpreting the study results outright and disseminating it to coaches, parents, and children. Rather, this finding may represent an important phenomenon that warrants additional investigation with larger, prospective, and multiinstitutional research efforts. If the results are confirmed, this could have important implications for those treating concussed athletes everywhere. Does the quicker return to school among those with public insurance represent a more active rehabilitation process or a premature return to normal routine? The topic of active rehabilitation versus prescribed rest is a major area of interest in the SRC literature, and was the topic of a 2-day, multidisciplinary meeting of national experts in Pittsburgh, Pennsylvania.³ Strict brain rest may in fact exacerbate the effect of the inciting injury. The committee strongly recommended against the previously followed “cocoon” therapy. If results can be confirmed that SES leads to a longer duration of absence from school, this may be viewed as too much rest, and a more active approach may be superior.

Conclusions

The current pilot study sought to evaluate the impact of SES on SRC outcomes. No surrogate SES factors were found to correlate with duration of symptoms or return to sport; however, patients with private insurance took lon-

ger to return to school than those with public insurance. Given the exploratory nature of our study and novelty of associating socioeconomic factors with SRC outcomes, we urge future investigators to conduct further prospective trials with improved capture rates and reliable assessments of SES.

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Author Contributions

Conception and design: Zuckerman, Bonfield, Solomon. Acquisition of data: Zuckerman, Totten, Rubel. Analysis and interpretation of data: Zuckerman, Zalneraitis, Totten, Rubel, Yengo-Kahn. Drafting the article: Zuckerman, Zalneraitis, Totten, Kuhn, Yengo-Kahn. Critically revising the article: Zuckerman, Kuhn, Yengo-Kahn, Solomon. Reviewed submitted version of manuscript: Zuckerman, Zalneraitis, Kuhn, Bonfield, Sills, Solomon. Approved the final version of the manuscript on behalf of all authors: Zuckerman. Statistical analysis: Zuckerman. Administrative/technical/material support: Bonfield, Sills, Solomon. Study supervision: Bonfield, Sills, Solomon.

Supplemental Information

Previous Presentations

This project was presented in abstract and poster form on October 27, 2016, at the 5th International Consensus Conference on Concussion in Sport in Berlin, Germany.

Correspondence

Scott L. Zuckerman, Department of Neurological Surgery, Vanderbilt University School of Medicine, Medical Center North T-4224, Nashville, TN 37212. email: scott.zuckerman@vanderbilt.edu.