

Original Research

Influence of High School Socioeconomic Status on Athlete Injuries during the COVID-19 Pandemic: An Ecological Study

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Background

It is presently unclear how the cessation of high school sport has affected injury incidence at different socioeconomic levels. The COVID-19 pandemic may have disproportionately affected athletes of lower socioeconomic status, potentially increasing injury risk in this population.

Purpose

To 1) Describe athlete injury incidence prior to and during the 2019-2020 and 2020-2021 school years in high school athletes by socioeconomic status; 2) Investigate the association between socioeconomic status and injury incidence in high school athletes.

Study Design

Ecological Study

Methods

High schools were matched between the 2019-2020 and 2020-2021 school years. All athletes from all sports were included. High school socioeconomic status was determined by the school district median household income. Socioeconomic strata were defined as <\$30,000, \$30,000-50,000, \$50,001-100,000, and >\$100,000. Injury incidence proportion with 95% confidence interval (95% CI) was calculated for each academic year. Mixed effects negative binomial models with robust errors were performed to assess the association between the incidence proportion ratio and high school median household income. Six states and 176 high schools were included (2019-2020: 98,487 athletes; 2020-2021: 72,521 athletes).

Results

Injury incidence increased in three of four socioeconomic strata during the 2020-2021 year (<\$30,000: 2019-2020: 15.6 (13.1-18.1), 2020-2021: 26.3 (23.1-29.6); \$30,000-50,000: 2019-2020: 7.8 (7.1-8.6), 2020-2021: 14.9 (13.8-15.9); \$50,001-100,000: 2019-2020: 15.1 (14.7-15.4), 2020-2021: 21.3 (20.9-21.8); >\$100,000: 2019-2020: 18.4 (18.1-18.8), 2020-2021: 17.3 (16.8-17.7)). An association was observed between injury incidence ratio and log median high school household income in 2019-2020 [1.6 (1.1-2.5)] but not 2020-2021 [1.1 (0.8-1.6)] school years.

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Conclusions

Athletes from lower socioeconomic high schools reported increased injury incidence compared to higher socioeconomic high schools during the 2020-2021 academic school year. These results highlight the increased COVID-19 pandemic vulnerability in athletes from lower socioeconomic high schools. High school sport stakeholders should consider how abrupt sport stoppage can affect lower socioeconomic athletes.

Level of Evidence

2

INTRODUCTION

There are over 15 million high school students in the United States, with over eight million participating in high school sports yearly.^{1,2} High school sports play a pivotal role in student health and wellbeing, including cardiovascular fitness,^{3,4} psychological wellbeing,^{5,6} academic performance,⁷⁻⁹ and quality of life.¹⁰⁻¹² However, participating in high school sport poses inherent risk. High school athletes suffer an estimated 1.4 million injuries per year and sustain as high as 4.6 injuries and 0.7 severe injuries per 1000 athletes exposures.^{13,14} These injuries result in 2.5 million high school athletes eliciting emergency department services,¹⁵ and costing \$44.7 million in human capital and \$144.6 million in comprehensive costs annually as reported in 2007.¹⁶

Abrupt cessation of practice and game play can increase injury risk in high school athletes.^{17,18} This increased injury risk is related to decreased cardiovascular fitness and conditioning, reductions in strength, and decreased sport specific training.¹⁸⁻²⁰ During the spring and summer of 2020, the SARS-CoV-2 coronavirus and the resultant disease, coronavirus disease (COVID-19) pandemic stemmed an abrupt stoppage of high school sport training, practice, and competition.^{21,22} The prolonged cessation from high school training and sport resulted in overall decreases in physical activity, running, and individual sport specific practice.²³⁻²⁶ The return to high school sport during the subsequent academic school year may have exposed high school athletes to abrupt increases in training and competition load,¹⁸⁻²⁰ predisposing these athletes to increased injury incidence and subsequent medical burden.^{24,25}

There is a distinct relationship between an individual's living environment and physical activity.²⁷ Availability and access to parks, running trails, and sport and recreational facilities have demonstrated improved physical activity habits, sport participation, and overall physical health in adolescents and adults.²⁸⁻³¹ However, socioeconomic status can influence access to recreational and park facilities, with cost, safety, weather, and quality and density of recreational facilities identified as potential barriers.^{28,32-34} Individuals and families of lower socioeconomic status have also demonstrated decreased physical activity habits, irrespective of race or urban or rural settings.^{35,36} Further, high school athletes from lower socioeconomic levels reported decreased weekly organized practice hours and months training compared to higher socioeconomic level athletes.³⁷ During the COVID-19 pandemic, people of lower socioeconomic status were disproportionately affected by

infection prevalence³⁸ and less healthcare resources.³⁹ High school athletes of lower socioeconomic may also have been disproportionately affected.²⁶ In a survey of 13,000 high school athletes, male and female athletes from lower socioeconomic backgrounds reported decreased physical activity and higher anxiety and depression compared to athletes of higher socioeconomic status.²⁶ This highlights a clinical and research gap concerning the current understanding of the impact of socioeconomic status on athlete injury risk when returning to sport following high school sport cessation.

It is presently unclear how the cessation of high school practice and game play has affected injury incidence in adolescent athletes. Socioeconomic status can influence physical activity,^{35,36} and recreational and leisure resources.^{28,32-34} Further, the COVID-19 pandemic may have disproportionately affected athletes of lower socioeconomic status,^{26,38,39} potentially increasing injury risk in this population. These data can inform sports medicine clinicians, educators, and policy makers on understanding the secondary effects of the COVID-19 pandemic, specifically high school injury burden at different socioeconomic strata. Therefore, the purpose of this study was to 1) Describe athlete injury incidence prior to and during the 2019-2020 and 2020-2021 school years in high school athletes by socioeconomic status; 2) Investigate the association between socioeconomic status and injury incidence in high school athletes.

METHODS

STUDY DESIGN

An ecological study investigating the influence of high school socioeconomic status on athlete injury incidence over an academic year was performed, with the high school level used as the unit of analyses. The Strengthening the Reporting of Observational Studies in Epidemiology for Sport Injury and Illness Surveillance (STROBE-SIIS) were followed.⁴⁰ Informed consent was not required as this was a retrospective study. This investigation was approved by the University Institutional Review Board.

DATA COLLECTION

Athletes presenting with any illness or injury reported to their school athletic trainer (AT) and were documented as presenting with a time-loss problem during a team-sponsored practice or game. AT sport coverage was based on the school's sport participation population, not on socioeco-

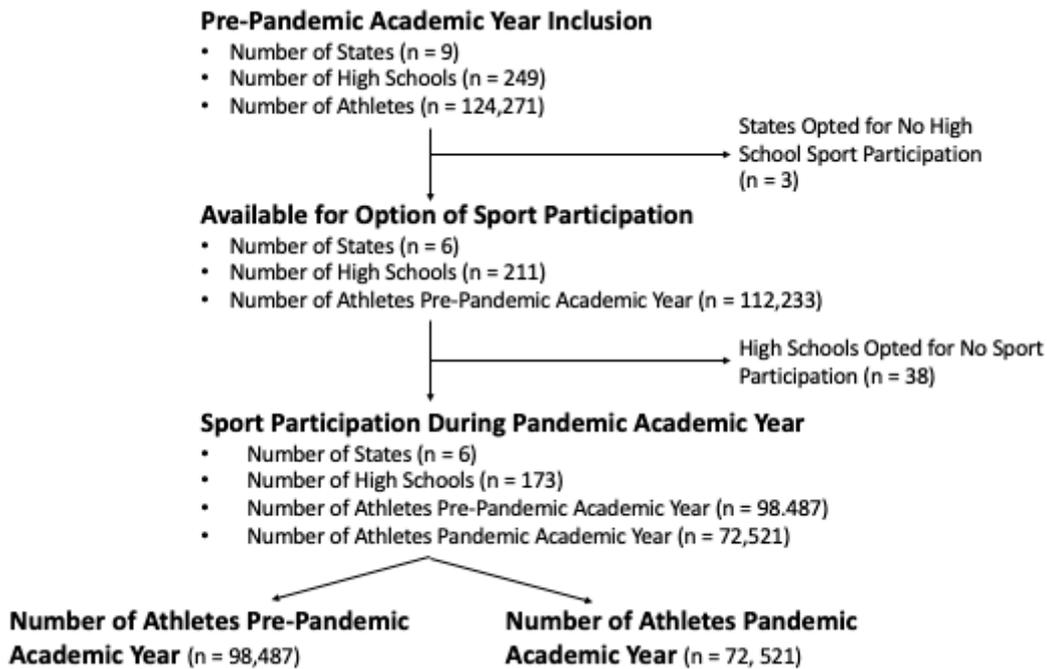


Figure 1. Participant Flow Chart

conomic status. Internal validity data checks were performed by the regional athletic trainer supervisor and the regional and national quality control supervisors on a quarterly basis.

PARTICIPANTS

High school athletes, from six states (Alabama (AL); Delaware (DE); Illinois (IL); Maryland (MD); Michigan (MI); Pennsylvania (PA)) were included in this study. High schools were matched between the 2019-2020 and 2020-2021 academic school years. Matching was based on the high school participating in athletics during the 2020-2021 academic school year. If the high school did not report or participate in high school athletics during the 2020-2021 year, they were excluded from the analyses (Figure 1). This resulted in 176 high schools rostered in the Players Health Rehab System for participating sports over the two-year study. Athlete health was monitored by the full-time athletic trainer assigned to each school by ATI Physical Therapy.

EXPOSURE DEFINITION

The main exposure was year of the pandemic, defined as athlete participation training, practices, or games on academic year 2020-2021. An athlete-exposure (AE) was defined as one athlete participating in one practice or competition where a player was at risk of sustaining an injury.^{41,42}

OUTCOME

An injury was defined as tissue damage or other derangement of normal physical function occurring during any training session or competition that resulted in at least one

day lost to training and/or competition and that required medical attention.^{40,43} Athlete complaints that resulted in cessation of a competition or training session but the athlete returned to training or competition the same session or following day were recorded as zero days of time loss and did not result in a recorded injury.⁴⁰ Injured body segments and body parts were defined by the Orchard Sports Injury Classification System.⁴⁴ Injury severity calculated as overall time loss, with further injury severity stratified by 7-28 (moderate) and 28+ (severe) days.⁴⁰ The AT documented the injury or illness in the Players Health Rehab system. The documentation included the injury or illness date, athlete sex, sport of participation, body part, problem type, the participation status of the athlete, athlete phase of recovery and days until return to sport. Total data missingness was 3%, for a more complete description of missingness, please refer to the statistical analyses section.

EXPLANATORY VARIABLE

High school socioeconomic status was determined by the median household income for the school district. Median household income was determined through federal public reports on National Center for Education Statistics. For epidemiological calculations, median household income was stratified into <\$30,000, \$30,000 to \$50,000, \$50,001 to \$100,000, and >\$100,000 based on previous public health research.⁴⁵

CONFOUNDERS

Self-identified gender, state, and sport were identified as confounders. Due to the large number of sports played, sport was collapsed into four categories: collision (American football, lacrosse, wrestling, ice hockey, rugby), field

and court (basketball, field hockey, soccer, tennis, volleyball, gymnastics, softball, baseball), individual (track and field, swimming, mixed rifle, mixed skiing, golf, dance, diving, cross country, bowling, archery, rowing, cheerleading), and other. These sport collapsed categories are also alternatively known as collision, contact, and non-contact sports. Other was utilized for non-descript sport records.

STATISTICAL ANALYSES

All data were assessed for missingness prior to analyses (Gender: 0%; Age: 0%; Date of Injury: 3%; Sport: 1.7%; Body Part: 1.6%; Return to Play: <0.1%; Pain: <0.1%) with data demonstrating minimal missingness. Complete case analyses were performed. Participant statistics were described using mean (standard deviation) for continuous normally distributed variables, median (25th quartile, 75th quartile) for non-normally distributed continuous variables, and frequencies and percentages for categorical variables. Distributions were assessed through visual inspection and normal plots. Injury incidence proportion (also known as cumulative incidence) with 95% confidence interval (95% CI) was calculated as new injuries per 100 athletes for each academic year, overall and by state, gender, severity, sport, and body part.⁴⁶ A mixed effects negative binomial model with robust errors were performed to assess the association between the incidence proportion ratio and high school median household income. Random effects were modeled at the high school level. Model fixed effects were controlled for gender, state, and percentage of male and female high school athletes compared to male and female school population. An offset of the log of male and female high school athlete participation was included. Due to the changes in injury incidence between the academic school years, academic school years were stratified. Sensitivity analyses included: 1) Including only severe injuries; 2) Including socioeconomic status as an ordinal variable, with \$50,000 to \$100,000 set as the reference; 3) Stratified by state. All analyses were performed in R version 4.01 (R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>), using the *nanian* package for missingness assessment⁴⁷ and the *GLMMadaptive* package for mixed effects negative binomial modelling.⁴⁸

RESULTS

A total of 98,487 athletes (Female: 43,250; Male: 55,239) participated in high school sport in the pre-pandemic academic year and 72,521 athletes (Female: 32,968; Male: 39,554) in the pandemic academic year. The median high school family income was \$92,143 (\$70,596, \$113,692) with a range of \$25,500 to \$193,100. A total of three (2%) high schools reported a median high school family income of <\$30,000, 10 (6%) \$30,000 to \$50,000, 99 (57%) \$50,001 to \$100,000, and 61 (35%) > \$100,000.

A total of 15,477 injuries were reported in the pre-pandemic academic year compared to 14,057 injuries during

the pandemic academic year. Median injury time loss stratified by socioeconomic status is reported in [Table 1](#). For injury incidence stratified by socioeconomic status, gender, severity, sport, and state, please refer to [Table 2](#), [Table 3](#), and [Table 4](#).

ASSOCIATION OF INJURY INCIDENCE RATIO AND HIGH SCHOOL SOCIOECONOMIC STATUS

Unadjusted [2.3 (95% CI: 1.4, 3.7)] and adjusted [1.6 (95% CI: 1.1, 2.5)] injury incidence increased for every unit of log median high school household income in the 2019-2020 academic school year. Unadjusted injury incidence decreased by a ratio of 0.7 (95% CI: 0.5, 1.0) for every increase of log median high school household income in the 2020-2021 academic school year. Adjusted injury incidence demonstrated no association between injury incidence ratio of 1.1 (95% CI: 0.8, 1.6) log median high school household income in the 2020-2021 academic school year. For full models refer to Appendix A. For results of actual and predicted injury counts, please refer to [Table 4](#).

SENSITIVITY ANALYSES

No relationship was observed between severe injury incidence and log median high school household income for the 2019-2020 academic school year 1.1 (95% CI: 0.8, 1.6) nor the 2020-2021 academic school year 0.7 (95% CI: 0.5, 1.0). Moderate injury incidence increased by a ratio of 1.6 (95% CI: 1.1, 2.4) for an increase of log median high school household income in the 2019-2020 academic school year. No relationship was observed between moderate injury incidence and log median high school household income for the 2020-2021 academic school year [1.1 (95% CI: 0.7, 1.6)]. When stratifying by median high school household income, no relationship was observed for the 2019-2020 academic school year. When stratifying by state, Alabama, and Pennsylvania demonstrated similar results, while Delaware, Illinois, Maryland, and Michigan observed no relationship for the 2019-2020 and 2020-2021 academic school years.

DISCUSSION

The main findings of this study were that while there was an overall 26% reduction in high school sport participation, different socioeconomic strata demonstrated different participation reductions, with lower socioeconomic strata demonstrating a smaller decrease in participation (<\$30,000: 11%; \$30,000 to \$50,000: 5%; \$50,001 to \$100,000: 40%; >\$100,000: 24%). Lower socioeconomic strata reported greater increases in pandemic injury incidence, ranging from 69% to 91%, compared to higher socioeconomic strata ranging from 41% increase to a 6% decrease in injury incidence. Athletes of lower socioeconomic status that participated in collision sports demonstrated an increase in injury incidence ranging from 159% to 213%, with the highest socioeconomic strata demonstrating only a 10% increase in injury incidence during the pandemic academic school year. A unit increase in median high school household income was associated with a

Table 1. Injury Incidence Proportion Stratified by Socioeconomic Status and by Gender and Severity

	Injury IP		Identified Gender IP				Injury Severity IP					
			Male		Female		Minor		Moderate		Severe	
	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21
Overall 19-20: n: 98,487 20-21: n: 72,521	15.7 (15.5, 15.9)	19.4 (19.1, 19.7)	17.0 (16.7, 17.3)	23.4 (23.0, 23.8)	14.0 (13.7, 14.4)	14.5 (14.2, 14.9)	4.1 (3.9, 4.2)	4.9 (4.7, 5.0)	4.9 (4.7, 5.0)	7.8 (6.6, 8.0)	6.8 (6.6, 6.9)	6.5 (6.3, 6.6)
<\$30,000 19-20: n: 806 20-21: n: 717	15.6 (13.1, 18.1)	26.3 (23.1, 29.6)	17.8 (14.3, 21.4)	41.9 (36.9, 46.9)	12.7 (9.2, 16.2)	9.4 (6.3, 12.4)	5.0 (3.5, 6.5)	5.9 (4.1, 7.6)	3.5 (2.2, 4.7)	7.1 (5.2, 9.0)	7.2 (5.4, 9.0)	13.1 (10.6, 15.6)
\$30,000 to \$50,000 19-20: n: 5,114 20-21: n: 4,882	7.8 (7.1, 8.6)	14.9 (13.8, 15.9)	7.2 (6.5, 8.0)	16.2 (14.9, 17.5)	4.0 (3.3, 4.8)	12.2 (10.6, 13.9)	1.6 (1.3, 2.0)	3.3 (2.8, 3.9)	1.7 (1.2, 3.0)	5.8 (5.1, 6.5)	4.6 (4.0, 5.1)	5.7 (5.0, 6.3)
\$50,001 to \$100,000 19-20: n: 49,079 20-21: n: 34,310	15.1 (14.7, 15.4)	21.3 (20.9, 21.8)	16.0 (15.5, 16.4)	25.2 (24.5, 25.8)	13.9 (13.5, 14.4)	15.3 (14.7, 15.8)	4.1 (3.9, 4.2)	5.5 (5.3, 5.8)	4.6 (4.4, 4.8)	8.6 (8.3, 8.9)	6.4(6.2, 6.6)	7.0 (6.8, 7.3)
>\$100,000 19-20: n: 40,882 20-21: n: 31,226	18.4 (18.1, 18.8)	17.3 (16.8, 17.7)	20.0 (19.5, 20.5)	20.2 (19.6, 20.8)	15.5 (15.0, 16.0)	13.3 (12.7, 13.8)	4.6 (4.4, 4.8)	4.1 (3.9, 4.3)	6.0 (5.7, 6.2)	7.1 (6.8, 7.4)	7.9 (7.6, 8.1)	5.7 (5.5, 6.0)

IP = Incidence Proportion
 Incidence proportion is per 100 athletes
 All incidence proportion is reported with 95% confidence intervals
 19-20 = Pre-pandemic academic school year
 20-21 = Pandemic academic school year

Table 2. Injury Incidence Proportion by Stratified by Sport and Socioeconomic Status

	Collision		Field & Court		Individual		Other	
	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21
Overall 19-20: n: 98,487 20-21: n: 72,521	5.4 (5.2, 5.5)	8.7 (8.5, 8.9)	5.3 (5.1, 5.4)	8.1 (7.9, 8.3)	2.5 (2.4, 2.6)	3.2 (3.1, 3.4)	2.9 (2.8, 3.0)	0.5 (0.4, 0.6)
<\$30,000 19-20: n: 806 20-21: n: 717	5.7 (4.1, 7.3)	15.6 (13.0, 18.3)	5.3 (3.8, 6.9)	8.6 (6.6, 10.7)	2.3 (1.3, 3.4)	2.0 (0.9, 2.9)	2.2 (1.2, 3.3)	0.1 (0.0, 0.4)
\$30,000 to \$50,000 19-20: n: 5,114 20-21: n: 4,882	3.0 (2.5, 3.4)	6.4 (5.7, 7.1)	2.9 (2.4, 3.3)	5.3 (4.7, 6.0)	0.9 (0.6, 1.1)	2.3 (1.9, 2.8)	1.1 (0.8, 1.4)	0.8 (0.5, 1.1)
\$50,001 to \$100,000 19-20: n: 49,079 20-21: n: 34,310	5.0 (4.8, 5.2)	9.4 (9.1, 9.7)	5.3 (5.1, 5.5)	21.3 (20.9, 21.8)	2.1 (1.9, 2.2)	2.9 (2.8, 3.1)	2.8 (2.6, 2.9)	0.3 (0.2, 0.4)
>\$100,000 19-20: n: 40,882 20-21: n: 31,226	6.2 (6.0, 6.4)	6.8 (6.5, 7.1)	5.6 (5.4, 5.9)	6.6 (6.3, 6.9)	3.3 (3.2, 3.5)	3.4 (3.2, 3.6)	3.3 (3.1, 3.5)	0.5 (0.4, 0.6)

IP = Incidence Proportion
 Incidence proportion is per 100 athletes
 All incidence proportion is reported with 95% confidence intervals
 19-20 = Pre-pandemic academic school year
 20-21 = Pandemic academic school year

Table 3. Injury Incidence Proportion by Stratified by State and Socioeconomic Status

	Alabama		Delaware		Illinois		Maryland		Michigan		Pennsylvania	
	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21	19-20	20-21
Overall 19-20: n: 98,487 20-21: n: 72, 521	7.4 (7.0, 7.8)	30.6 (29.9, 31.2)	22.4 (21.7, 23.2)	16.2 (15.4, 17.2)	11.0 (10.7, 11.4)	21.2 (20.5, 21.9)	29.0 (28.2, 29.7)	7.2 (6.7, 7.7)	18.0 (17.4, 18.7)	17.6 (17.0, 18.3)	15.6 (14.9, 16.3)	14.3 (13.7, 15.0)
<\$30,000 19-20: n: 806 20-21: n: 717	8.2 (5.8, 10.6)	22.1 (18.7, 25.5)	28.4 (23.3, 33.5)	44.7 (35.5, 51.8)								
\$30,000 to \$50,000 19-20: n: 5,114 20-21: n: 4,882	29.7 (26.7, 32.7)	21.2 (18.8, 23.4)	16.2 (13.8, 18.6)	13.5 (11.2, 15.8)	5.8 (5.0, 6.6)	12.3 (11.0, 13.6)						
\$50,001 to \$100,000 19-20: n: 49,079 20-21: n: 34,310	4.7 (4.3, 5.1)	30.2 (29.4, 30.9)	22.9 (22.0, 23.7)	17.0 (16.1, 18.0)	9.3 (8.8, 9.7)	25.2 (23.8, 26.6)	34.4 (33.2, 35.6)	9.3 (8.5, 10.2)	13.4 (12.5, 14.3)	12.9 (12.0, 13.9)	22.6 (21.1, 24.1)	17.0 (15.6, 18.4)
>\$100,000 19-20: n: 40,882 20-21: n: 31,226	15.7 (14.5, 16.9)	30.4 (28.9, 32.0)			15.1 (14.5, 15.6)	22.4 (21.4, 23.5)	25.5 (24.6, 26.4)	5.8 (5.2, 6.4)	21.4 (20.5, 22.4)	20.7 (19.7, 21.6)	14.7 (13.9, 15.6)	14.3 (13.6, 15.1)

IP = Incidence Proportion
 Incidence proportion is per 100 athletes
 All incidence proportion is reported with 95% confidence intervals
 19-20 = Pre-pandemic academic school year
 20-21 = Pandemic academic school year

Table 4. Injury Incidence Proportion by Stratified by State and Socioeconomic Status.

	Actual Injury Count 19-20	Predicted Injury Count 19-20 (95% CI)	Actual Injury Count 20-21	Predicted Injury Count 20-21 (95% CI)
Overall	15,477	15,376 (11,096, 22,099)	14,057	12,096 (9,640, 17,533)
Severe Injuries	6,665	6,597 (4,877, 9,078)	4,690	4,426 (3,092, 6,341)
Moderate Injuries	4,784	4,744 (3,402, 6,560)	5,655	5,056 (3,510, 7,286)
Stratified household income	15,477	15,375 (10,720, 22,381)	14,057	13,255 (9,401, 18,975)
Alabama	1,191	1,186 (698, 2,039)	5,843	5,478 (4,492, 6,796)
Delaware	2,347	2,331 (1,767, 3,067)	1,153	1,048 (492, 3,258)
Illinois	3,783	3,775 (1,931, 8,762)	2,522	2,497 (1,613, 4,109)
Maryland	4,302	4,149 (2,663, 6,408)	806	788 (478, 1,288)
Michigan	2,178	2,173 (1,654, 2,973)	2,126	2,125 (1,610, 2,902)
Pennsylvania	1,191	1,186 (698, 2,039)	1,607	1,622 (1,073, 2,472)

95% CI = 95% Confidence Interval
 19-20 = Pre-pandemic academic school year
 20-21 = Pandemic academic school year

60% increase in injury incidence in the 2019-2020 academic school year; but no association was observed for the pandemic academic school year.

Lower socioeconomic strata demonstrated increased injury incidence during the 2020-2021 academic school year, with the highest socioeconomic strata of \$100,000+ median household income demonstrating similar injury incidence between school years. Further, lower socioeconomic males demonstrated the greatest increase in injury incidence. These differences in injury incidence may be related to recreational and sport facility access. Lower socioeconomic people have less access and quality of recreational and sport facilities.²⁸⁻³¹ People from lower socioeconomic strata generally have increased fear of violence^{28,32-34} and increased barriers to performing physical activity and exercise.^{35,36} Concerning high school athletes, athletes from lower socioeconomic strata have demonstrated reduced training time per week.³⁷ During the prolonged cessation of high school sport, athletes from lower socioeconomic strata may have had reduced access and time to train and practice sport compared to higher socioeconomic athletes, providing increased deconditioning and loss of sport specific skill, subsequently increasing injury incidence.

Lower socioeconomic collision sport participants demonstrated a two to three times increase in injury incidence during the 2020-2021 academic school year, while the highest socioeconomic strata demonstrated similar col-

lision injury incidence between the 2019-2020 and 2020-2021 academic school years. High school collision sports such as football, lacrosse, and wrestling have previously demonstrated the greatest injury incidence, compared to field and court and individual sports.^{13,14} Collision sports also require further physical preparation beyond general fitness and strength, due to athlete to athlete collisions.⁴⁹⁻⁵¹ The repetitive physical trauma involved in collision sport requires physical adaptations to handle the high impact forces involved in tackles and blocking.^{49,50} This supports previous research where decreased off season and preseason training demonstrated greater injury incidence in collision sports,^{51,52} suggesting a truncated preseason predisposes an athlete to greater musculoskeletal injury risk in this population compared to other sports.

A proportional association was observed between injury incidence and median high school household income in the 2019-2020 academic school year after controlling for confounders. These results support previous research concerning socioeconomic status and injury incidence.^{53,54} One study observed that low material wealth was a protective effect against sport injuries.⁵⁵ However, this study examined adolescent injuries in 35 countries, and specific comparisons of sport participation was not performed. As many countries do not provide school sponsored sports, socioeconomic status can be a barrier to sport participation in many countries.^{56,57} However, in this study, sport participation

in relation to overall high school population was controlled for, and these athletes solely participated in sport within the United States, decreasing the transferability of this literature to this study's findings. A possible explanation is that lower socioeconomic high school athletes are more prone to decreased injury reporting compared to higher socioeconomic high school athletes.^{37,58} Lower socioeconomic athletes may have greater fear of losing playing time, differences in self-regulation, or health care access outside of school athletics.³⁷ However, injury under reporting may be for only minor or moderate injuries. Within the sensitivity analyses, severe injury incidence ratios were similar between socioeconomic strata. The similar severe injury incidence between strata may be due to the nature of severe injuries, which can cause greater limits on sports performance and function compared to moderate or minor injuries.⁴⁰ These greater physical and sport specific limitations may be associated with a greater propensity of lower socioeconomic status high school athletes to report these injuries. However, further research is needed to investigate these potential discrepancies.

No association between median household income and injury incidence was observed for the 2020-2021 academic school year. As stated previously, higher socioeconomic strata demonstrated similar injury incidence between the academic school years; however, lower socioeconomic strata reported an increased in injury incidence. The conflicting findings between socioeconomic status and injury incidence ratios between the pre-pandemic and pandemic academic school years may be related to secondary effects related to COVID-19 vulnerability.^{38,39} The increased injury incidence in lower socioeconomic strata may have negated the injury underreporting effect during the pandemic academic school year. Further qualitative and quantitative research into barriers and facilitators of injury reporting and risk are needed within these populations to understand potential solutions to socioeconomic athlete injury discrepancies.

LIMITATIONS

Due to the nature of high school sport and resource availability, it was not possible to collect more granular exposure data such as practice or competition minutes. This precludes injury rate calculations, decreasing the clinical usefulness of these incidence and model results. COVID-19 infection rates changed throughout the reporting period, and were different for the included states, decreasing the precision of these results. The included states reported different prevalence of high school socioeconomic strata, biasing the results towards the null. Recruitment was based on athlete coverage by the sports medicine organization and sport participation during the 2020-2021 academic year, increasing risk of recruitment bias and non-response bias. There are inherent yearly fluctuations in injuries at the high school and state level. This study only had access

to one year of injury data prior to the COVID-19 pandemic, decreasing the precision of these results. Due to the ecological nature of this study, individual injury history, strength, range of motion, balance, and sport experience were not available, resulting in unmeasured confounding that could bias these results. Causality cannot be inferred from these data, with future causal study design required to understand the cause and effect of abrupt prolonged sport stoppage.

CONCLUSION

Lower socioeconomic high schools reported increased injury incidence compared to higher socioeconomic high schools during the 2020-2021 academic school year. This relationship was most pronounced in males and within collision sports. The highest socioeconomic high school strata reported similar injury incidence between academic school years, suggesting greater access and time to exercise, training, and sport practice during the abrupt high school sport stoppage. Increased high school socioeconomic status was associated with a statistically significant increased injury incidence within the 2019-2020 but not the 2020-2021 academic school years. These results highlight the secondary downstream COVID-19 pandemic associations and the increased potential pandemic vulnerability in lower socioeconomic high school athletes. Sports medicine clinicians, high school administrators, and policy makers need to consider the magnified effect abrupt stoppage from high school sport practice and competition can incur in lower socioeconomic high school athlete injuries when designing return to sport protocols. Expanded preseason and inquiries into previous training and practice habits may be required for more vulnerable high school athletes when returning to sport.

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CONFLICTS OF INTEREST

None

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SUPPLEMENTARY MATERIALS

Appendix

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