doi: 10.4085/1062-6050-0305.23

Descriptive Report of Injuries Sustained by Secondary School Baseball Players Categorized by Community-Level of Socioeconomic Status

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Acknowledgements: Data for this research was provided by Datalys Center for Sports Injury Research and Prevention, Inc., and specifically through the NATION project. We are grateful to all of the athletic trainers who support NATION through their data collection efforts. Athletic trainers who contribute to NATION provide a valuable resource of information that is used to support the health and safety of secondary school athletes. NATION is supported by the National Athletic Trainers' Association Research & Education Foundation and the Central Indiana Corporate Partnership Foundation (Indianapolis, IN) in collaboration with BioCrossroads (Indianapolis, IN). All content of this manuscript is the responsibility of the authors and does not necessarily reflect the views of the agencies who have supported this research.

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Abstract

Context: Baseball is a popular sport in the United States, with widespread play among secondary school student-athletes. Baseball-related injuries may vary based on community-level socioeconomic status of schools. **Objective:** To describe the injuries sustained by secondary school baseball players from schools categorized by community-level socioeconomic status. **Design:** Cross-sectional study design. **Setting:** Data (2014/15-2018/19 academic years) were obtained from the National Athletic Treatment, Injury, and Outcomes Network (NATION-SP). **Participants:** Secondary school baseball athletes. **Main Outcome Measures:** Frequencies and percentages of injuries, injury rates, and competition/practice injury rate ratios (IRR) were reported by the community-level socioeconomic status (ie, affluent, average wealth, disadvantaged) where each school is located. **Results:** NATION-SP captured 320 baseball injuries across 140,619 total athlete exposures (AEs), for an overall injury rate of 2.4/1,000 AEs. Of those, 52% occurred among athletes in 24 schools situated in affluent communities, 15.6% occurred in 12 schools from average wealth communities, and 32.5% occurred in 12 schools located in disadvantaged communities. The largest injury rate was schools located in disadvantaged communities (3.3/1000 AE), followed by affluent (2.3/1000 AE) and average wealth (1.4/1000 AE) communities. On average, schools from affluent and disadvantaged communities had higher injury rates during competition than during practice (affluent: IRR=1.5, 95% CI=1.11, 2.05; disadvantaged: IRR=1.6, 95% CI=1.12, 2.41). Frequencies of many injury characteristics were consistent in schools across community-level socioeconomic status with contact, sprain/strain, and non-timeloss ranking highest in terms of injury mechanism, diagnosis,

and time loss, respectively. Shoulder/clavicle was most frequent body part injured in schools in average and disadvantaged wealth communities, and ankle was most frequent in schools in affluent communities. **Conclusions:** Baseball athletes playing in schools located in disadvantaged wealth communities had the largest overall injury rate, followed by schools in affluent, and average wealth communities. Across most injury characteristics, a consistent trend emerged regardless of community-level disadvantage, with the highest baseball injury rates resulting from contact mechanisms, diagnosed as sprains or strains, and classified as non-time-loss injuries. While many injury patterns are consistent across socioeconomic communities, examining injuries through the lens of community-levels of disadvantage provides insight into subtle differences that could information targeted prevention strategies or resource needs.

Key Words: High School Athletics, Concentrated Disadvantage, Injury Rates, Throwing, Resource Distribution

Abstract Word Count: 300

Body Word Count:

Key Points: Athletic healthcare underutilizes contextual factors such as community-level socio-economic status, or concentrated disadvantage, to address access and resource needs within communities served.

Introduction

Baseball has long been considered America's past-time and continues to be one of the most popular sports in secondary school athletics.[1] Over the past 25 years, injury risks and rates in secondary school baseball have been well-documented.[2-5] While these reports have increased the knowledge of injury trends in baseball, including sport specialization and injury risk,[4, 6-8] few studies have explored injuries in relation to the social determinants of health and their role in contributing to the health and well-being of populations. Social determinants of health include factors related to economic stability, healthcare and education access and quality, and neighborhoods and built environment characteristics. Geographic regions, such as where children are raised and go to school, are an important social determinant of health. The varied experiences and opportunities of athletes reared in communities of advantage or disadvantage may predispose them to different levels of injury risk over time.[9, 10] For example, having more money to invest in sports and leisure may equate to greater sport specialization and higher training volume for some athletes and fewer opportunity and ability to participate for others.[11] Additionally, resources, such as athletic training access, proximity to advanced sports medicine practitioners, and barriers to accessing health care (eg, time, money, transportation), in secondary schools located in advantaged or disadvantaged communities may differ[12-14] which could impact injury reporting and diagnosis. Understanding the impact of community-level socioeconomic status on injury trends may serve as a critical first step in promoting care that is equitable for all athletes.

One of the challenges with exploring community-level socioeconomic status is that it is a latent construct that is not directly observed, yet is a powerful driver of many social, emotional, and physical health outcomes. Concentrated disadvantage is a widely used measure of community-level socioeconomic status that incorporates the complex and synergistic effects of

socioeconomic factors such as poverty, income, education, employment and other important communal characteristics to compare relative social vulnerability from one community or neighborhood to another.[15-17] Concentrated disadvantage is therefore a robust measure of the wealth or disadvantage in a geographic area that influences individual outcomes, neighborhood resources, and public school policies and resources. Notably, health and well-being of a community are correlated with the socioeconomic status of the community, with pronounced disparities between those living in higher socioeconomic areas compared to those in lower socioeconomic areas.[18-20] Among adolescents from communities that are more socioeconomically disadvantaged, lower well-being has been observed[21-24] which speaks to the influence these communities have on the lives of the people who live in them.

Efforts to explore socioeconomic factors in athletic healthcare are beginning, with studies largely examining impact on access to athletic training services[12, 13, 23, 25, 26] or sports specialization, or describing injury characteristics.[11, 27-29] Further, a limitation with the current body of evidence is that studies regarding socioeconomic factors have largely focused on individual-specific measures of socioeconomic status, such as percentage of students receiving free or reduced lunch, as opposed to a composite measure that includes a variety of influential community-level factors that creates a more realistic and meaningful picture of the advantage or disadvantage of communities and the lived environment. Focus on the context of communities, such as the neighborhood and built environment of each secondary school, is the essence of social ecologic theory and social determinants of health that contribute to inequities in populations.[16] Additionally, most studies have not analyzed the impact of community-level of advantage or disadvantage at the level of a single sport. Assessments at the single sport level provides consideration of the specific nuances of a sport and may illuminate different injury

trends unique to that sport. Therefore, the purpose of this study was to describe the characteristics of injuries sustained by secondary school baseball players by community-level socioeconomic status, a measure of the concentrated disadvantage of a community.

Methods

Design and Sample

Exposure and injury information from 48 U.S. secondary school baseball teams participating in the National Athletic Treatment, Injury, and Outcomes Network Surveillance Program (NATION-SP) during the 2014/15 through 2018/19 academic years were evaluated for this descriptive epidemiology study. The methods of NATION-SP have been reviewed and approved by the Western Institutional Review Board (Puyallup, WA) and are described elsewhere.[30] Briefly, ATs at participating institutions contributed exposure and injury data using their clinical Electronic Medical Record (EMR) systems. [30] An exposure was any organized secondary school-sanctioned baseball practice or competition event in which student-athletes present were at risk for injury due to their participation. For each exposure event, ATs reported student-athlete participation counts and whether the event was a practice or a competition.[30] The exposure data collected were used to estimate at-risk exposure time as athlete-exposures (AEs), defined as one student-athlete participating in one school sanctioned baseball practice or competition event. A reportable injury was defined as an injury that 1) occurred as a result of participation in an organized secondary school-sanctioned athletic event for school sponsored baseball and 2) required attention from an AT or physician, regardless of time loss.[30] ATs were able to report multiple injuries occurring from one injury event. A time loss (TL) injury was defined as any injury evaluated or treated by an AT or physician in which an athlete returned the

day after or beyond with respect to the date of injury. A non-time loss (NTL) injury was any injury evaluated or treated by an AT or physician in which an athlete returned to participation on the date of injury. For both TL and NTL injuries, ATs documented the injury mechanism, body part injured, diagnosis, and days of injury time loss in addition to the related exposure information. [30] Injury mechanism was classified as contact, non-contact, overuse, illness/other, or not reported as documented in the patient record. Body part injured was characterized as an injury to the shoulder/clavicle, head/face, hand/fingers, thigh, or ankle. Injury diagnoses were defined as sprain/strains, contusions, or fractures. Time loss was characterized into non-timeloss to indicate no loss of playing time, or into one of the following time-loss categories: loss of 1-6 days, loss of 7 days or more, or not reported.

Index of Concentrated Disadvantage

An index of concentrated disadvantage was constructed using principal components analysis (PCA) of 7 variables from the 2012-2016 American Community Survey that were obtained through the National Historical Geographic Information System database (www.nhgis.org). These data were aggregated by zip code tabulation areas (ZCTA), which approximates area representations of United States Postal Service five-digit ZIP Code service areas that are widely used in neighborhood research.[31, 32] Variables collected from the American Community Survey included the proportion of the population that is African American, proportion of female-headed households, proportion of households receiving food stamps, households that received public assistance income in the past 12 months, proportion of households below the federal poverty line, median household income (mean centered), and proportion of individuals with educational attainment at the high school level or higher. The process used to generate the index of concentrated disadvantage was previously described and

reported by Robison et al.[16] The constructed index explained 61% of the total variance of the seven variables, which is comparable to other socioeconomic status research.[17, 32] The concentrated disadvantage index was then matched to the ZIP code of each participating secondary school to estimate the socioeconomic status of the community in which the school was located. Schools were placed into 3 categories named affluent, average wealth, and disadvantaged wealth based on their standardized concentrated disadvantage index z-scores ($z > 1.96$; $-1.96 < z < 1.96$; and $z < -1.96$, respectively). This categorization represents the community-level socioeconomic status of the participating secondary schools.

Statistical Analysis

Injury frequencies, proportions, and rates (per 1,000 AEs) with associated 95% confidence intervals (CIs) for injury mechanism, body part injured, injury diagnosis, and time loss were examined by affluent, average wealth, and disadvantaged wealth community-level socioeconomic status categories. Injury rate ratios (IRRs) were used to examine differential injury rates by event-type within a community-level socioeconomic status, with 95% CIs excluding 1.0 considered as statistically significant. The concentrated disadvantage index was created using PCA methods in the 'psych' package using varimax rotation in R version 4.2.1.[33] All other analyses were conducted using SPSS 24 (IBM Corporation, Armonk, NY).

Results

NATION-SP captured 320 baseball injuries across 140,619 AEs, for an overall injury rate of 2.4/1,000 AEs between the 2014/15 and 2018/19 academic years. Of those, 166 (52.0%; IR=2.3/1,000 AEs) occurred in the 24 schools located in affluent communities, 50 (15.6%;

IR=1.4/1,000 AEs) in the 12 schools located in average wealth communities, and 104 (32.5%; IR=3.3/1,000 AEs) in the 12 schools located in disadvantaged wealth communities. Schools located in affluent and disadvantaged wealth communities had higher IRs during competition (affluent: n=86, IR=2.8/1,000 AEs, IRR=1.5, 95% CI=1.11,2.05; disadvantaged: n=52, IR=4.3/1,000 AEs, IRR=1.6, 95% CI=1.12,2.41) than practice (affluent: n=80, IR=1.9/1,000 AEs; disadvantaged: n=52, IR=2.7/1,000 AEs) whereas injury rates in schools located in average wealth communities did not exhibit differences by event type (competition: n=20, IR=1.9/1,000 AEs; practice: n=30, IR=1.2/1,000 AEs; IRR=1.6, 95% CI=0.90, 2.78).

The Table presents frequencies and rates according to the injury characteristics of injury mechanism, body part injured, diagnosis, and time loss across community-level socioeconomic status. The top rate for most injury characteristics was the same across community-level socioeconomic status with contact, sprain/strain, and non-timeloss ranking highest in terms of injury mechanism, diagnosis, and time loss, respectively (Table). For body part injured, schools located in average wealth and disadvantaged wealth communities saw the highest frequencies of shoulder/clavicle injuries and ankle injuries were the most frequent in schools located in affluent communities.

Discussion

This is the first study to describe injury characteristics of second school baseball athletes across levels of school community-level socioeconomic status, an important step in exploring the impact of social determinants of health on athletic populations and communities. Schools located in communities of wealth disadvantage had the largest overall injury rate (3.3/1000 AE),

followed by schools in affluent (2.3/1000 AE) and average (1.4/1000 AE) wealth communities. Further, both schools located in affluent and disadvantaged wealth communities saw greater injury rates in baseball competitions when compared to baseball practices, while there was no difference of rate of baseball injury in schools located in average wealth communities by event type. While overall injury rates by mechanism, body part, diagnosis, and time loss were relatively low, the most common injury characteristic within most of these categories was consistent across community-level socioeconomic status groups. Exploring factors such as the built environment, including schools, neighborhoods, and levels of community disadvantage, may help identify potential contributors to injury occurrence among baseball athletes. The finding that the overall baseball injury rate was not the same across the school community-level socioeconomic status groupings should be further explored because there may be something occurring that varies these baseball athletes' injury risk. For example, there are characteristics of baseball as well as realities of wealth advantaged and disadvantaged communities that warrant discussion. Examining these findings through a baseball-specific lens may provide a fuller understanding of the data, and the following discussion presents ideas aimed at sparking interest in future hypothesis-driven research.

The injury rate for high school baseball players observed in this study, regardless of community-level socioeconomic status, was 2.4/1000 AEs. This value falls in the middle of rates reported in other descriptive epidemiology reports (0.98 - 5.44 injuries/1000 AEs),[2, 3, 5] and differences may partially be explained by reporting method and the years in which the data were collected. None of the communities in the current study reached a rate of injury as high as 5.44/1000 AEs, and the largest rate per community in this study was from schools in wealth disadvantaged areas (3.3/1000 AEs). Across most injury characteristics, a consistent trend

emerged regardless of community-level socioeconomic status, with the highest baseball injury rates resulting from contact mechanisms, diagnosed as sprains or strains, and classified as non-time-loss injuries. Shoulder/clavicle injuries were most frequent in average and disadvantaged wealth communities, and ankle injuries were most frequent in affluent communities, although shoulder and clavicle were a close second. Collectively, these data suggest that athletic trainers managing the healthcare of secondary school baseball athletes should be prepared to treat upper extremity injuries and sprains and advocate for ways to reduce the occurrence of contact injuries, particularly in controlled environments such as practice. Across schools in affluent and wealth disadvantaged communities, the rate of baseball injuries was higher during competition than practice but this was not observed in schools located in average wealth communities where the rates were not different. Higher rates of injury during competition have been reported in other epidemiology research,[34] which has been attributed to factors such as elevated play intensity, more aggressiveness and contact, and the competitive play environment.[34, 35] Further, the rates of injury were highest when the injury did not result in lost playing time, a finding consistent across other descriptive epidemiology studies.[3, 36] More research is needed to explore and better understand the factors associated with baseball injuries that allow continued play to determine if and how prevention strategies may reduce injury risk.

Across levels of community disadvantage non-time loss baseball injuries were more frequent, accounting for at least 40% of injuries, than injuries resulting in lost playing time. Loss of 1-6 days of play was the second most frequent for baseball players in schools located in affluent and disadvantaged wealth communities, although injuries resulting in 7 or more days of lost playing time was the second most frequent for baseball players in average wealth communities. From a large study conducted across 10 male and female sports, Powell and

Barber-Foss[37] reported that baseball injuries had the highest proportion (31%) of injuries resulting in more than 7 days of missed play when compared to the other sports. Findings from the current study suggest that at least 20% of baseball injuries reported resulted in 7 or more days of lost play, and baseball players from schools located in average wealth communities had 32% of injuries in this category which is closer to the report of Powell and Barber-Foss. Time to return to sport participation following injury is influenced by a variety of potentially interwoven factors, such as those related to injury location and severity, principles of tissue healing, clinician expertise and clinical decisions, return-to-play guidelines or practices, and access to healthcare. Exploration into the factors associated with time lost from play are needed. In the current study, all of the schools had access to an athletic trainer, although the model and availability of athletic training services likely varied.[38] Research suggests that schools with higher socioeconomic status,[13, 39] more students on free and reduced lunch,[25, 26] and higher sports medicine budgets[40] have greater access to ATs or athletic training services than schools with lower socioeconomic status, but whether this access influences return-to-play trajectories has not been studied in regards to the care of baseball athletes.

The frequency of specific body parts injured may be partially explained through physiologic factors that are attributed to when an athlete begins playing baseball and, in particular, specializes in the sport. In regards to the shoulder, less engagement in sport has been shown to influence osseous adaptations and range of motion in the throwing shoulder and has been linked to injury in baseball athletes. Additionally, the age and position when a baseball athlete begins throwing relative to skeletal maturity is related to humeral retroversion in the throwing arm,[41-43] which is hypothesized to have a protective role and allow more external rotation during the cocking phase for torque generation and performance gains. Baseball athletes

who do not engage in throwing until the time when the humeral physes begin to close, which is about age 14, are less likely to limit the physiological de-rotation of the humeral head and present with less humeral retroversion ultimately creating a situation of susceptibility to instability, pain, and injury.[44] In the current study, the highest frequency of injuries in baseball athletes from schools in disadvantaged and average wealth communities was shoulder/clavicle. Whether the players from schools in in these communities were impacted by age or position playing baseball is unknown. Interestingly, ankle injuries were the most frequent injury in players from schools located in affluent communities, and shoulder/clavicle was second most frequent. Studies in youth baseball tend to focus on the shoulder as an area of concern for developing athletes, yet no studies have explored injury patterns across community-level socioeconomic status and this is an area for future research.

Across levels of community disadvantage, about half of all injuries suffered by baseball players were due to some form of contact, with the other half split primarily between non-contact and overuse type injuries. High rates of contact injuries in baseball have been reported from high schools and emergency room data sources,[2, 45-47] and contact with baseballs, bases, bats, and player collisions are all contributing factors. Recommendation for use of protective equipment, such as facemasks,[2, 48] and rule changes, such as breakaway bases,[49, 50] have been made in efforts to reduce the frequency of baseball contact injuries. Overuse injuries tend to be more difficult to correctly record from a surveillance perspective given inconsistent definitions and variability in how people classify overuse injuries, such as coding as a mechanism of injury, an injury type, or both.[2, 51, 52] Collins and Comstock[2] reported that non-contact injuries, which in their study also included overuse injuries, made up 30% of injuries in high school baseball players. Overuse injury frequencies in the current study were upwards of at least 42% across levels of community

disadvantage when considering the categories overuse and non-contact injuries together. However, the rates of overuse injury in the current study were lower across all communities than those previously reported by Roos et al.[52] Given the descriptive nature of this study, the reason for higher frequency of contact injuries in these baseball communities is unknown and should be further explored. Efforts to reduce contact injuries should contribute to a safer baseball experience for athletes.

Across the community groups, sprains and strains accounted for at least 35% of injury diagnoses. In wealth disadvantaged communities, there was also a substantial percentage of contusion injuries. Previous research in high school baseball identifies sprains/strains and contusions as the top two most frequent diagnoses in high school baseball,[2] which aligns with the findings from affluent and disadvantaged wealth communities although fractures were the second most common injury diagnosis in average wealth communities. Athletic trainers working with baseball should consider injury prevention programs to minimize sprain and strain injuries, yet also be prepared to manage them if they happen.

A challenge with research exploring the impact of community-level disadvantage on populations is that the methods used to classify communities vary. Previous research investigating socioeconomic factors and youth athletes typically use an income-based estimate[12, 13, 28] compared to the geographical-based approach used in this study. While income based measures seem intuitive, they may be generated using a limited or even single source of information, such as state median household income, census poverty level, or percent of students who quality for free or reduced lunch.[12, 13, 25, 26, 28, 29] These measurements, therefore, only capture the economic aspect of socioeconomic status and overlook other critical social determinants of health of the built environment, including the educational levels within a

community and the social and community context of the neighborhood a secondary school is located.[53] The current study determined community-level disadvantage by using principal component analysis of community-based variables from the American Community Survey measured at the ZCTA of the school. This robust approach takes into consideration a variety of social determinants of health, including race, female-headed households, education attainment, and types of health insurance coverage, providing a more realistic and meaningful construct from which to classify populations or communities as affluent, average wealth, and wealth disadvantaged.[31, 32] A geographical-based lens, such as with concentrated disadvantage, allowed the exploration of the impact that the social determinants of health of the built environment has on people in a community. The variation in the overall injury rates across the communities suggests that built environment may play a role in influencing injury patterns in high school baseball players. Future research should consider this robust approach when examining injury rates and AT coverage in relation to socioeconomic factors because it provides an estimate that goes beyond simple differences in income and may better reflect the social determinants of health of the community that is being studied and described.

Limitations

Schools were included based on a sample of convenience and only schools with ATs were included. Consequently, it is not possible to determine if injury rates differ depending on access or level of access to an AT. Access may play a role in injury and return-to play patterns considering that when an AT is not present in a school, care is often provided to cover acute injuries, such as through emergency medical services,[14] which likely limits availability of on-site preventative medicine. Further, because all of the schools employed a ATs, it is possible that the inclusion criteria biased the sample towards wealthier communities with access to athletic

training services. Additionally, the employment status of each AT was unknown and it is possible that employment status could influence reporting of injuries.[38] However, as reported by Kerr et al,[38] schools with part-time athletic training employment models for care had lower injury rates than schools with full-time models, suggesting underreporting of injuries. Findings from the current study suggest that schools in disadvantaged wealth areas had the largest overall injury rate of all communities. If underreporting is a concern, due to factors such as employment model, then the rates in disadvantaged wealth communities are likely higher than reported in this study. However, while employment status of individual ATs may be an important factor, the current research is based on the theory that the community-level socioeconomic status is also a major social determinant of injuries in high school baseball players and provides a unique perspective of community wealth that is associated with injuries. The full impact of factors surrounding the socioeconomic influence in communities warrants further study.

Conclusion

This study is a descriptive report of baseball injuries suffered by players in schools located in affluent, average wealth, and disadvantaged wealth communities. While many injury patterns are consistent across socioeconomic communities, examining injuries through the lens of community-levels of disadvantage provides insight into subtle differences that could information targeted prevention strategies or resource needs. Healthcare should be designed to address the unique challenges and strengths that influence athletes in a community—ultimately aiming to reduce disparities in health outcomes and access to resources.

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Table 1. Injury Frequencies and Rates for Mechanism of Injury, Common Body Parts Injured, Common Diagnoses, and Time to Return-to-Play from Baseball Injury by Community-Level Socioeconomic Status

	Affluent Communities (N=166) Count (%)	Rate per 1000 AE	Average Wealth Communities (N=50) Count (%)	Rate per 1000 AE	Disadvantaged Communities (N=104) Count (%)	Rate per 1000 AE
Injury Mechanism						
Contact	82 (49.4)	1.1	27 (54.0)	.75	51 (49.0)	1.61
Non-Contact	38 (22.9)	.52	10 (20.0)	.28	21 (20.2)	.66
Overuse	36 (21.7)	.49	11 (22.0)	.30	27 (26.0)	.85
Illness/Other	5 (3.0)	.07	1 (2.0)	.03	3 (2.9)	.09
Not Reported	5 (3.0)	.07	1 (2.0)	.03	2 (1.9)	.06
Body Part Injured						
Shoulder/Clavicle	25 (15.1)	.34	9 (18.0)	.25	18 (17.3)	.57
Head/Face	16 (9.6)	.22	6 (12.0)	.17	5 (4.8)	.16
Hand/Fingers	13 (7.8)	.18	7 (14.0)	.19	14 (13.5)	.44
Thigh	9 (5.4)	.12	2 (4.0)	.06	10 (9.6)	.32
Ankle	29 (17.5)	.40	3 (6.0)	.08	7 (6.7)	.22
Diagnosis						
Sprain/Strain	66 (39.8)	.90	21 (42.0)	.58	37 (35.6)	1.17
Contusion	23 (13.9)	.32	3 (6.0)	.08	27 (26.0)	.85
Fracture	13 (7.8)	.18	6 (12.0)	.17	3 (2.9)	.09
Time Loss						
Non-Timeloss	76 (45.8)	1.04	25 (50.0)	.69	44 (42.3)	1.39
Loss of 1-6 Days	46 (27.7)	.63	7 (14.0)	.19	35(33.7)	1.11
Loss of $\geq$ 7 Days	43 (25.9)	.59	16 (32.0)	.44	21 (20.2)	.66
Not Reported	1 (0.6)	.01	2 (4.0)	.06	4 (3.8)	.13