Foul Ball Rates and Injuries at Major League Baseball Games: A Retrospective Analysis of Data from Three Stadiums

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Abbreviations:
EMS: Emergency Medical Services
FB: foul ball
FOIA: Freedom of Information Act
HCP: health care provider
MLB: Major League Baseball
PCR: patient care run sheet
PP: patient presentation
PPG: patient presentations/game
PPTT: patient presentations per 10,000 attendees
TH: transport to hospital
THG: transports to hospital/game
TTHR: transportation to hospital rate per 10,000 attendees

Abstract

Importance: This paper provides a large-scale, per Major League Baseball (MLB) game analysis of foul ball (FB) injury data and provides estimates of injury frequency and severity.
Objective: This study's goal was to quantify and describe the rate and type of FB injuries at MLB games.
Design: This was a retrospective review of medical care reports for patients evaluated by on-site health care providers (HCPs) over a non-contiguous 11-year period (2005-2016). Data were obtained using Freedom of Information Act (FOIA) requests.
Setting: Data were received from three US-based MLB stadiums.
Results: The review reported 0.42-0.55 FB injuries per game that were serious enough to warrant presentation at a first aid center. This translated to a patients per 10,000 fans rate (PPTT) of 0.13-0.23. The transport to hospital rate (TTHR) was 0.02-0.39. Frequently, FB injuries required analgesics but were overwhelmingly minor and occurred less often than non-FB traumatic injuries (5.2% versus 42%-49%). However, FB injured fans were more likely to need higher levels of care and transport to hospital (TH) as compared to people suffering other traumatic injuries at the ballpark. Contusions or head injuries were common. Finally, FB injured fans were often hit in the abdomen, upper extremity, face, or head. It was found that FB injuries appeared to increase with time, and this increase in injuries aligns with the sudden increase in popularity of smartphones in the United States.
Conclusions and Relevance: These data suggest that in roughly every two or three MLB games, a foul ball causes a serious enough injury that a fan seeks medical attention. This rate is high enough to warrant attention, but is comparable in frequency to other diagnostic categories. Assessing the risk to fans from FBs remains difficult, but with access to uniform data, researchers could answer persistent questions that would lead to actionable changes and help guide public policy towards safer stadiums.

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Introduction

Many popular sports are dangerous for the players; in baseball, this privilege is extended to the spectators. Over one-half of the balls hit by batters fly into the stands, injuring approximately 1,750 people annually in the United States.[1] Out of all major sports, baseball has the highest incidence of spectator accidents.[2]

In Boston's Fenway Park (Boston, Massachusetts USA), approximately 30 balls per game go into the stands, injuring a spectator every three-to-four games.[3] At the Braves' former Turner Field (Atlanta, Georgia USA), 1.6% of stray balls caused injury to a spectator.[4] Data compiled by the Elias Sports Bureau (New York USA) show the number of foul balls (FBs) per game has increased 10% since 2000.[5]

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Years Covered/ Location	Attendance	Total # Patients	FB Patients	Rate FB Injuries (PPTT)	% FB Injuries from Total Patients Treated	Source
2005-2015	35,062,604	13,198	686	0.20	5.2%	This Study
1997-1998; MLB Team	7,655,506	3,659	291	0.38	8.0%	Milsten 2003
2011-2012; Korean Baseball Team	4,996,633	448	190	0.38	42%	Oh, Joo, Han 2015

Table 1. Academic Literature Comparison of Foul Ball Injury Risk
Abbreviations: PPTT, patient presentation (reported as PPTT, where PPTT = patients per 10,000); FB, foul-ball related injuries; MLB, Major League Baseball.

Nevertheless, with a few notable exceptions, discussions of FB injuries are absent from the medical literature (Table 1).[6,7] This paper attempts to address this gap through a FB injury-specific analysis of Major League Baseball (MLB) data while providing estimates of injury frequency and severity.

Methods

Data Collection

A retrospective review of medical care reports for patients evaluated by on-site health care providers (HCPs) at three US-based MLB stadiums over a noncontiguous 11-year period (2005-2016) was performed (Table 2). There are 30 MLB stadiums, all with first-aid coverage provided by 24 private companies and six publicly funded agencies.

Not surprisingly, all 30 MLB teams would not share data. In order to proceed, Freedom of Information Act (FOIA) requests were sent to the six publicly funded first-aid agencies. The first-aid forms and Emergency Medical Services (EMS) patient care run sheets (PCRs) were requested, and from this smaller subset, four responded affirmatively. From the four affirmative FOIA responses, two sent usable data and two sent incomprehensible and incomplete data. Entities subject to FOIA are permitted to require that the requester pay administrative fees. Two of the first-aid operators did request fees (MLB #1 and MLB #2), and as a result, the principal investigator applied for and received a University of Massachusetts (Worcester, Massachusetts USA) Emergency Medicine Research Division Small Grant (US $1,570). The health care agency covering MLB #3 provided an annual summary report.

When available, researchers extracted: game date, age, gender, mechanism of injury, diagnosis, location of injury, abnormality of vital signs, specific treatment received, treatment category, and disposition. Attendance information was obtained from an online baseball reference; games lacking attendance data were dropped (MLB #1 = three games; MLB #2 = one game).[8] Double headers (two games played consecutively) were removed because some feature counts (eg, attendance and injury counts) could not be unambiguously associated with the correct game (MLB #1 = no games; MLB #2 = 15 games across eight dates).

Each MLB team was asked for protective netting data and declined to give any. Therefore, the square footage of netting was estimated via literature references and photogrammetry.[9,10]

Diagnostic Categories

The diagnostic categories outlined by Ranse, et al were used with the following changes: "syncope" replaced "faint" and "collapse;" "contusion" and "dizzy/lightheaded" were included, but there was no "other minor wounds;" "mental health" was used instead of the five sub-diagnoses; and "foreign body" was used instead of the eight sub-diagnoses.[11] The most immediate reason for care was considered the "chief complaint." The primary diagnosis was taken directly from the first-aid sheets. If no primary diagnosis was listed, the investigators assigned their best estimate based on the chief complaint and first-aid narrative.

Foul ball and flying bat injuries were combined into one number for ease of calculations ("FB"), but flying bats accounted for fewer than five percent of FB injuries. For comparison, all other traumatic injuries (eg, trip/fall, minor burns) occurring during a game, excluding FB patients, were examined. The data received did not specifically list if patrons were injured while chasing a FB or the ensuing scrum for that ball.

Statistical Methods

Foul ball injuries were evaluated by considering the rates of two different events: the number of patient presentations (PPs) to the first-aid center (based on log sheets) and the number of transportations to hospitals ([TH] based on EMS PCR sheets). For each category, two metrics were used to quantify risk rates: the rate of events per game (patient presentations per game, PPG; and transports to hospital per game, THG) and the rate of events per 10,000 attendees of the event (PPTT and TTHR).

Both MLB #1 and MLB #2 provided injury data per game whereas MLB #3 provided summary counts. Some games lacked corresponding medical events. There are two possible reasons for this: absence of injuries or missing data. The authors fit a zero-truncated negative binomial distribution to the games with non-zero patient presentations via maximum likelihood to impute the probability that a game generates no events. To compute PPTT and TTHR correctly, the attendance at zero-injury games needed to be counted. To that end, the mean attendance per game across all unobserved games for each year was computed. The authors weighted these means by the number of observed games in each year.

All data were tracked in a spreadsheet (Microsoft Excel, Version 16.55; Microsoft Corporation; Redmond, Washington USA). Software for web scraping, automated data extraction, data cleaning, and statistical analysis was developed by the authors and is publicly available.[12] The study was approved by the University of Massachusetts Chan Medical School (Worcester, Massachusetts USA) Institutional Review Board.

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		MLB #1	MLB #2	MLB #3
Years Data Obtained		2010-2014	2011-2016	2005-2012
Type of Data Available		First-aid log sheets. No EMS PCR sheets.	EMS PCR sheets. No first-aid log sheets.	Summary data. No first-aid log sheets or EMS PCR sheets.
Patient Ages (in years)		Range 1-100 Median 32	Range 1-91 Median 35	–
FB Patient Ages (in years)		Range 2-88 Median 37	Range 2-91 Median 42	–
Total # Fans Treated		6,197	1,132	5,869
Male/Female		–	46%/50% = M/F	–
FB Male/Female		–	50%/46% = M/F	–
Total # FB Injuries		211	130	345
Observed Games	# Games	383	289	640[a]
	# Fans	8,995,742	9,668,463	16,398,399[a]
Statistically Corrected	# Games	383.5	308.2	–
	# Fans	9,006,814	10,309,469	–
FB Injuries/Game	PPG	0.55	0.42	0.54
	THG	0.024	0.049	1.00
FB Injuries/10K Fans	PPTT	0.23	0.13	0.21
	TTHR	0.010	0.015	0.39
Games/FB Injury	Patient	1.8	2.4	1.9
	Hospital	43	21	1.0
FB% Total Patients		3.4%	11.5%	5.9%
Total # Traumatic Injuries		3,046 (49%)	472 (42%)	–
Estimated Netting		3,021.46 ft^2	3,500 ft^2	2,981.40 ft^2

Table 2. Patients Evaluated by On-Site Health Care Providers

Note: FB-related injuries include foul ball and flying bat injuries. Traumatic injuries include any trauma-related injury that occurred during a game, excluding FB related injuries. "–" = No data available. Observed and corrected game/attendance counts refer only to single games.

Abbreviations: FB, foul ball; MLB, Major League Baseball; PCR, EMS patient care run sheets; PP/G, patient presentation rate/game (reported as PPTT, where PPTT = patients per 10,000); THG/TTHR, transportation to hospital rate/game (reported at patients per 10,000).

[a] MLB #3 provided only summary data; therefore, the authors could not statistically correct for double-headers as was done with MLB #1 and #2.

Results

MLB #1 sent first-aid log sheets (with no ambulance PCR sheets) spanning 2010-2014. Log sheets described 6,197 PPs across 383 of the 408 actual home games. Of the PPs, 211 (3.4%) were FB injuries. Total attendance at these games was 8,995,742. None of these games were double-headers. Patient age ranged from one to 100 years, and median age was 32 years; patients with FB injuries ranged from two to 88 years, and median age was 37 years. Gender data were largely missing.

MLB #2 sent ambulance PCR sheets spanning 2011-2016. Incomplete first-aid log sheets and EMS call logs of patient refusals were also sent but were unusable as there was no way to deduplicate PPs from PCR sheets. The PCR sheets described 1,172 THs across 296 of the 476 actual home games played. Of the presentations, 136 were FB injuries. Total attendance at these games was 9,855,955. Removing double-headers reduced these numbers to 1,132 patient presentations across 289 games, of which 130 (11.5%) were FB injuries. Total attendance at these games was 9,668,463. Patient age ranged from one to 91 years, and median age was 35 years; patients with FB injuries ranged from two to 91 years, and median age was 42 years. MLB #2 HCPs saw 46% males and 50% female patients.

Per the Statistical Methods section, the authors estimated the probability of a zero-injury game (MLB#1 = 0.001395; MLB#2 = 0.062228), the expected number of zero-injury games (MLB#1 = 0.535; MLB#2 = 19.2), and the expected attendance at zero-injury games (MLB#1 = 20,689; MLB#2 = 33,279).

Alternatively, MLB #3 sent eight years of summary data (2005-2012) with 16,390,659 total attendance and 5,869 total number of patients treated (PPTT = 3.6). There were 345 patients treated for FB injuries (5.9% of the total patients; PPTT = 0.21). Transportation rates across all patients was a TTHR of 0.39.

In summary, MLB #1 had 0.55 FB patients per game (0.23 PPTT) and MLB #2 had 0.42 FB patients per game (0.13 PPTT). In practical terms, these data suggest that a FB injures someone seriously enough to seek medical attention approximately every other ball game and sends a fan to a hospital every 20-40 games. Furthermore, FB injuries will account for approximately 5.2% of all injured fans compared to non-FB traumatic cases at 42%-49%.

Discussion

Ballparks are aware of FB injuries and potential medical consequences for fans. Most (80%) fans are treated by on-site HCPs with

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		FB Injuries (211 Fans) MLB #1 2010-2014	Traumatic Injuries (3,046 Fans) MLB #1 2010-2014	FB Injuries (130 Fans) MLB #2 2011-2016	Traumatic Injuries (472 Fans) MLB #2 2011-2016	FB Injuries (345 Fans) MLB #3 2005-2012
Vital Signs	Abnormal	0.0%	0.0%	13.8%	8.9%	
	Normal	0.0%	0.0%	82.3%	55.3%	
	Not Listed	100.0%	100.0%	3.8%	35.8%	
Treatment	Analgesics	27.5%	17.5%	14.6%	2.3%	
	Not Listed/None	9.0%	6.2%	8.5%	86.7%	
	Other	2.4%	1.8%	7.7%	6.6%	
	Refused Care	4.7%	3.3%	26.9%	3.2%	
	Wound Care Only	56.4%	71.2%	42.3%	1.3%	
Level of Care	ALS	1.4%	0.1%	5.4%	2.5%	
	BLS	5.7%	0.9%	13.8%	8.1%	
	Minor	79.1%	89.7%	46.9%	0.6%	49%
	Not Listed/None	3.8%	2.5%	0.0%	84.5%	
	Refused Care	10.0%	6.7%	33.8%	4.2%	
Disposition	Hospital on Own (now)	0.9%	0.0%	6.2%	1.1%	
	Medium Attention (later)	0.5%	0.0%	6.9%	1.7%	
	Minor Issue (<18 years old)	1.4%	0.0%	10.0%	0.6%	
	Not Listed	68.7%	99.7%	0.0%	84.9%	
	Refused Transport	8.5%	0.0%	26.9%	1.3%	
	Refused Treatment	0.9%	0.0%	22.3%	4.2%	11%
	Return to Event	14.7%	0.0%	16.2%	1.9%	31%
	Transport to Hospital	4.3%	0.2%	11.5%	4.2%	11%

Table 3. Comparison of Summary Data: FB versus Trauma
Note: Trauma injuries do not include FB numbers. The 26.9% of MLB #2 FB injured who refused transport was most likely falsely elevated because MLB #2 only provided ambulance run sheets. These types of patient care sheets are used by prehospital providers who are trained to have a patient "sign a refusal" if they do not want to be transported to a hospital. Can't compare Column 1 and Column 2 in disposition category. Why is FB category so well documented? Medical-legal reasons?
Abbreviations: FB, foul ball; MLB, Major League Baseball.

the minority (6.1%) requiring hospital transport.[13,14] On average, 0.55 FB injuries per game lead to a first-aid center presentation and 0.42 FB injuries per game required hospital transportation. This translates to 5.2% of fan presentations (MLB#1-#3) were due to FB injuries.

Table 3 and Table 4 describe the distribution of diagnoses, treatments, and dispositions. When compared to patrons suffering other non-FB traumatic injuries, FB injured fans required higher levels of care, more frequent hospital transportations, but also refused medical attention more regularly. Nonetheless, though, despite FB injuries frequently requiring non-narcotic analgesics, most were overwhelmingly minor, and people returned to the event after treatment. In a past study, the majority of people injured by a FB also only required minor or basic care.[15] A greater proportion of FB injured fans suffered contusions or head injuries. Finally, FB injured fans were hit in the face and head most commonly, then abdomen and upper extremity.

If the stands are packed, are spectators more likely to be hit by a foul ball? Surprisingly, this does not seem to be the case. Performing a Poisson regression on PP counts for both MLB#1 and MLB#2 using log(attendance) as an exogenous variable yields P values for the beta coefficients of 0.209 and 0.252, respectively; this suggests that attendance was not a strong predictor of FB risk. For non-FB related traumatic injuries, on the other hand, attendance was highly predictive, with $P = 0.000$ in both cases. The authors hypothesize that as attendance increases, the bleachers fill up, but foul balls may be less likely to reach those areas. More broadly, this result suggests that risk should be measured per game (PPG/THG) rather than per spectator (PPTT/TTHR).

It is widely assumed that netting reduces FB injuries. The netting coverage during the study was estimated as MLB #1 = 3,021 ft^2, MLB #2 = 3,500 ft^2, and MLB #3 = 2,981.40 ft^2.[9,10] The amount of stadium netting increased in 2016 in response to a 2014 Bloomberg article.[4] This study's netting estimates are pre-2016 and too close in size to be able to draw statistical conclusions. However, Korean baseball stadiums have nearly twice the netting (6,125 ft^2 estimated) but a similar rate of FB injury (PPTT 0.38; Table 1).[4,6,16–22]

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		FB Injuries (218 Fans) MLB #1 2010-2014	Traumatic Injuries (2,927 Fans) MLB #1 2010-2014	FB Injuries (130 Fans) MLB #2 2011-2016	Traumatic Injuries (354 Fans) MLB #2 2011-2016
Diagnosis	Abdominal Pain	0.0%	0.1%	4.6%	0.0%
	Abrasion	0.9%	11.1%	0.0%	1.5%
	Alcohol Related	0.0%	0.2%	0.0%	3.8%
	Blister Wound	0.0%	16.9%	0.0%	0.0%
	Contusion	65.9%	5.7%	36.9%	15.3%
	Dizzy/Lightheaded	0.9%	0.3%	1.5%	7.4%
	Eye Injury	1.4%	1.0%	2.3%	3.6%
	Head Injury	9.5%	0.7%	26.2%	14.6%
	Heat Exhaustion	0.0%	0.8%	0.0%	11.9%
	Laceration	1.4%	28.2%	6.9%	9.5%
	Not Listed/None	14.7%	8.1%	0.0%	0.4%
	Other	3.8%	8.4%	10.0%	14.0%
	Sprain/Strain (Soft-Tissue)	0.9%	18.5%	10.0%	11.9%
	Syncope	0.5%	0.1%	1.5%	6.1%
Location of Injury	Abdomen	2.4%	0.1%	5.4%	0.0%
	Ankle	0.5%	2.7%	0.8%	5.1%
	Back	0.0%	4.3%	2.3%	2.1%
	Elbow	0.9%	1.1%	0.0%	0.0%
	Eye	1.9%	0.4%	3.8%	2.8%
	Face	13.7%	2.1%	19.2%	12.7%
	Foot	0.5%	6.9%	1.5%	1.9%
	Forearm	1.9%	0.7%	1.5%	1.1%
	Hand	8.5%	22.1%	17.7%	4.2%
	Head	10.9%	1.9%	23.1%	16.7%
	Knee	1.9%	7.5%	1.5%	1.9%
	Lower Leg	2.8%	2.7%	4.6%	5.3%
	Neck	0.9%	0.8%	1.5%	0.8%
	Not Listed	41.7%	42.9%	0.8%	35.8%
	Pelvis	1.4%	0.3%	0.0%	1.9%
	Shoulder	3.3%	1.2%	2.3%	1.1%
	Thigh	0.0%	0.2%	0.0%	0.0%
	Thorax	3.3%	0.3%	3.8%	0.8%
	Upper Arm	2.8%	1.3%	8.5%	4.9%
	Wrist	0.5%	0.8%	1.5%	0.8%

Table 4. Comparison of Summary Data: FB versus Trauma
Note: Trauma injuries do not include FB numbers. For the sake of brevity, less common diagnoses (<1%) were combined into "Other."
Abbreviations: FB, foul ball; MLB, Major League Baseball.

There is more to the FB story than just netting as fan distraction may be another factor. This phenomenon has been reported in the lay-press and during successful lawsuits against MLB.[5,23–27] MLB #1 FB injuries increased over the years studied (Figure 1). To rule out confounding factors, the rate of non-FB traumatic injuries was displayed, which remained constant. The timing of this phenomenon aligns with the sudden increase in popularity of smartphones in the United States.[28] It was not possible to draw conclusions from a single MLB team's data, but by examining multiple MLB teams in the same time period, future work could examine whether smartphone usage and any concomitant distraction correlated with increased FB injuries.

Limitations

The biggest limitations were incomplete data and MLB stadium information. Despite multiple attempts, first-aid operational details could not be obtained. Absent operational details, it could not be determined if FB cases could have been ignored, but this situation seems unlikely given the medico-legal nature of these injuries.

MLB #1 provided only first-aid room log sheets and MLB #2 provided EMS PCRs with unusable and incomplete first-aid log sheets. The lack of data was most evident for MLB #2, which may have produced an under-count of the PPs. MLB#2 provided an implausibly small number of first-aid log sheets, and

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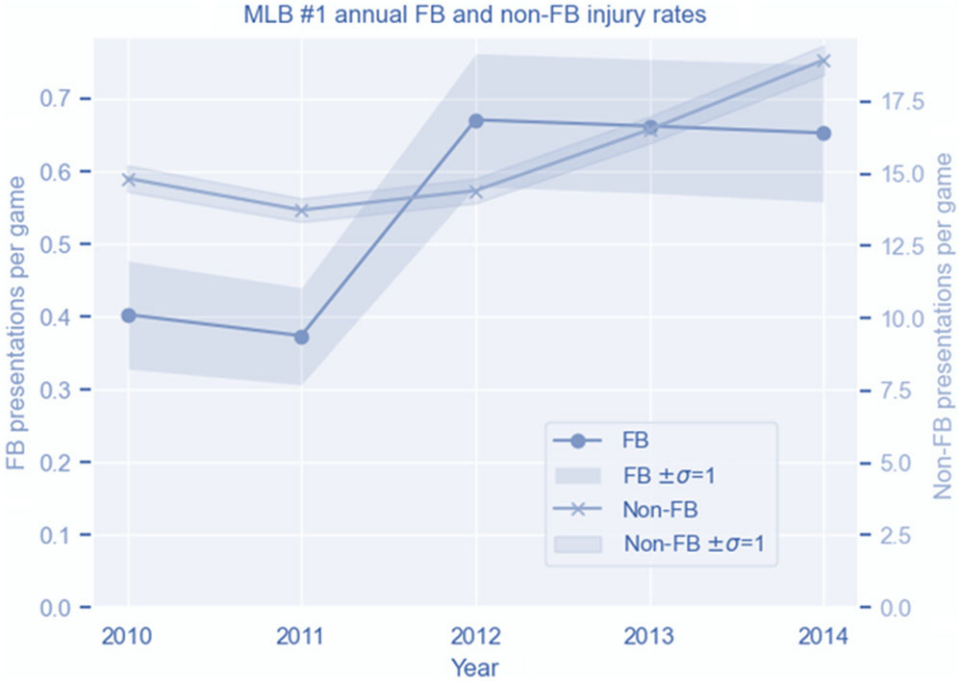

Figure 1. Foul Ball (FB) and Non-FB Injury Rates Across Time.

the operative assumption was that EMS PCRs were filled out every time an HCP encountered an injured fan.

Because only two MLB teams provided sufficient data for a full statistical analysis, team-specific effects could not clearly be identified. For example, understanding which factors most influence injury rates (ie, netting, lighting, seating, density, or distractions) would require a comparison across a larger number of stadiums.

Poor documentation, a known issue at mass gatherings, occurred here as well, especially on the MLB #2 PCR.[7,29] With MLB #2 providing only PCRs, that could bias the data towards a worse subset of injuries.

Conclusion

This introductory study produced data suggesting roughly every two or three MLB games, a FB causes an injury that requires medical attention. This rate is high enough to warrant attention but less frequent than other combined traumatic injuries.

Assessing the risk to fans from FBs remains difficult because of the adversarial nature of the data collection. With transparent and uniform data collection, researchers could rapidly and confidently answer basic risk questions and help guide public policy towards safer stadiums.

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