

1 **Reported COVID-19 Incidence in Wisconsin High School Athletes**

2 **During Fall 2020**

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24 **Contributorship Statement:**

25 Drs. Sasser, Watson, McGuine and Haraldsdottir, Ms. Goodavish and Mr. Biese conceptualized
26 the study, data collection, data analysis and interpretation, drafted the manuscript, and approved
27 the final manuscript as submitted. Ms. Stevens contributed to the data collection, data analysis
28 and interpretation, reviewed the manuscript and approved the final manuscript as submitted.

29 **ABSTRACT**

30 **Introduction:** The purpose of this study was to describe the reported incidence of COVID-19 in
31 Wisconsin high school athletes in September 2020, and to investigate the relationship of
32 COVID-19 incidence with sport and face mask use.

33 **Methods:** Surveys were sent to athletic directors of all Wisconsin high schools regarding sports
34 during September 2020. The association between reported case rates in athletes in each county
35 and the county general population were evaluated with a weighted linear model. Multivariable
36 negative binomial regression models evaluated the associations between COVID-19 incidence
37 and sport type and face mask use by players, adjusting for the county COVID-19 incidence for
38 each school.

39 **Results:** 207 schools that had reinitiated sport reported 270 COVID-19 cases among 30,074
40 players, for case and incidence rates of 809 cases per 100,000 players and 32.6 cases per 100,000
41 player-days, respectively. The case rates for athletes in each county were positively correlated
42 with the case rates for the county's general population ($\beta=1.14\pm 0.20$, $r=0.60$, $p<0.001$). One
43 hundred fifteen (55%) of cases were attributed to household contact, 85 (41%) to contact outside
44 sport or school, 5 (2.4%) to school contact, and 1 (0.5%) to sport contact. No difference was
45 identified between team and individual sports (incidence rate ratio (IRR)=1.03 [95% CI=0.49-
46 2.2], $p=0.93$) or between non-contact and contact sports (IRR=0.53 [0.23-1.3], $p=0.14$), although
47 the difference between outdoor and indoor sports approached statistical significance (IRR=0.52
48 [0.26-1.1], $p=0.07$). 84% of schools required face masks while playing. For those sports with
49 >50 participating schools, there were no significant associations between COVID-19 incidence
50 and face mask use in cross country (IRR=0.71 [0.2-2.2], $p=0.52$), football (IRR=1.6 [0.6-5.1],

51 p=0.404), boys soccer (IRR=2.3 [0.5-17], p=0.31), or girls volleyball (IRR=1.4 [0.3-6.6],
52 p=0.64).

53 **Conclusions:** Incidence of reported COVID-19 among athletes was related to background
54 county incidence and most cases were attributed to household and community contact. Although
55 not statistically significant, reported COVID-19 incidence may be lower in outdoor sports. Face
56 mask use did not have a significant benefit, which may be due to relatively low rates of COVID-
57 19 and the small number of schools that did not report using face masks.

58

59 **Keywords:** adolescent; infection; pediatric; SARS-CoV-2

60 INTRODUCTION

61 The COVID-19 pandemic has caused unprecedented changes to the daily lives of people
62 of all ages globally. Sports throughout the country have been shut down or altered in varying
63 ways depending on the local county or state ordinances. In Wisconsin, youth sports were
64 effectively canceled by the Safer At Home order in March 2020.¹ With the order overturned by
65 the Wisconsin Supreme Court in May 2020, counties throughout the state instituted their own
66 restrictions.^{2,3} Youth sports were restarted in certain counties around the state during the summer
67 of 2020, while others did not reinstate.⁴

68 There has been a dearth of information regarding the risk of COVID-19 infection and
69 sport participation. However, it is widely accepted that transmission of the SARS-CoV-2 virus
70 that causes COVID-19 is related to direct exposure to respiratory droplets and airborne
71 transmission.^{5,6} Longer periods of time in close proximity to infected individuals may increase
72 transmission risk, and high intensity exercise may potentiate the spread of respiratory droplets,
73 according to the United States Center for Disease Control and Prevention (CDC).⁵ National,
74 state, and local regulations have all suggested an associated higher transmission risk with contact
75 sports, indoor sports and team sport participation.⁷ Little direct evidence from sports exists to
76 support this. Media reports of COVID-19 transmission within youth sports are a cause for
77 concern, although it is often unclear whether the risk is due to sport participation or gatherings
78 peripheral to or separate from the sports arena.^{8,9} A recent study in a soccer club from
79 Washington state found physically distanced youth soccer training to be safe and did not
80 contribute to COVID-19 spread among child and adolescent participants.¹⁰ Another preprint
81 publication regarding club soccer players nationwide found no difference in reported COVID-19
82 incidence among athletes participating in contact versus non-contact soccer.¹¹ Finally, a third

83 preprint study of data collected from high school athletic directors nationwide found that,
84 although COVID-19 incidence was higher among indoor sports, very few cases of COVID-19
85 were reportedly attributable to sport contact and the overwhelming majority were attributed to
86 household and community contacts.¹²

87 Several recommendations to minimize COVID-19 risk in youth sports have been
88 published since the onset of the pandemic by various academic organizations, public health
89 agencies, and national sport governing bodies.^{7,13,14,15,16} However, because little data is directly
90 available for sport contexts, these recommendations are largely based on inpatient COVID-19
91 data, case studies, and expert opinion. Risk mitigation recommendations vary widely and the
92 debate around facemask use while playing sports continues.¹⁷ The CDC and American Academy
93 of Pediatrics (AAP) recommend against the use of facemasks during play if they inhibit
94 breathing, become wet, or become a choking hazard, but strongly recommend the use of
95 facemasks any time while not in the act of playing a sport.^{14,18} Therefore, the purpose of this
96 study is to describe the incidence of reported COVID-19 in high school sports in Wisconsin and
97 to understand the associations between COVID-19 incidence and sport type as well as face mask
98 use among athletes.

99

100 **METHODS**

101 **Study Design**

102 All procedures performed in this study were deemed exempt from by the Institutional
103 Review Board of the University of Wisconsin-Madison. In collaboration with the Wisconsin
104 Interscholastic Athletics Association (WIAA), surveys were distributed to all high school athletic
105 directors on October 1, 2020. In addition to school name and location, athletic directors were

106 asked whether they had restarted participation in sports since the initial COVID-19 restrictions in
107 the spring of 2020. Those schools that reported reinitiating sports were asked to provide the
108 specific sports and the date of restarting, number of athletes, number of practices and games, and
109 number of COVID-19 cases among athletes within each sport, as well as the reported sources of
110 infections (if known) during the month of September 2020. Schools were asked about their type
111 of instruction during September (virtual or in-person) and whether they required the use of face
112 masks for players while playing. Schools were included if they had any sport that had restarted
113 participation during September 2020.

114 **Statistical Analysis**

115 Data were initially evaluated using descriptive statistics, including estimates of central
116 tendency (mean, median) and variability (standard deviation, interquartile range, range) for
117 continuous variables, and counts and percentages for categorical variables. Reported COVID-19
118 case rates were expressed as the number of reported cases per 100,000 players ($\text{cases} / \text{total}$
119 $\text{number of players} * 100,000$) overall and for each sport. Duration of participation for each sport
120 at each school was determined as the difference in days between the date of restarting and
121 October 1, 2020, and player-days was determined as the product of the number of participating
122 players and duration. Reported COVID-19 incidence rates were expressed as the number of
123 reported cases per 100,000 player-days ($\text{cases} / \text{total number of player-days} * 100,000$) overall
124 and for each sport, with confidence intervals calculated using an exact method.

125 In addition, the number of cases, total population, case rate and incidence rate during
126 September were determined for each county in which a respondent high school was located from
127 publicly available online information from the local health authority. In order to determine
128 whether background county COVID-19 case rates were associated with reported COVID-19 case

129 rates among high school athletes, the total number of athletes and reported COVID-19 cases
130 were aggregated by county. For those counties with >100 athletes, the relationship between
131 COVID-19 case rates among high school athletes and the general population were evaluated with
132 a linear model weighted for the total population of each county.

133 For those sports with data from 50 or more schools, the relative risk of each sport was
134 evaluated using a mixed effects negative binomial regression model to predict the number of
135 COVID-19 cases for each team with local incidence, instructional delivery type, and sport as
136 fixed effects, the log of player-days as an offset, and school as a random effect, yielding an
137 incidence rate ratio (IRR) with “Cheer / Dance” as the reference (since this represented the
138 median unadjusted incidence rate). To evaluate the relationship between reported COVID-19
139 incidence and sport characteristics, a multivariable negative binomial regression model was
140 developed to predict the number of cases, with local incidence, sport location (indoor, outdoor),
141 sport contact (contact, non-contact), sport type (team, individual), and school instructional
142 delivery type as covariates, and the log of player-days as an offset.

143 To evaluate the association between overall COVID-19 incidence and reported face mask
144 use, incidence rates and 95% confidence intervals were calculated within each sport with greater
145 than 50 reporting schools for those reporting face mask use or not. Separate multivariable
146 negative binomial regression models were then developed to predict the number of cases, with
147 local incidence, instructional delivery type, and face mask use (yes/no) as covariates, and the log
148 of player-days as an offset. Coefficients from the models were exponentiated to represent IRRs
149 for binary variables and Wald confidence intervals were generated. Significance level was
150 determined *a priori* at the 0.05 level and all tests were 2-tailed. All statistical analyses were
151 performed in R.

152

153 **RESULTS**

154 Two hundred forty-four schools submitted complete survey responses, of which 207 had
155 restarted a fall sport. These schools represented 30,074 student-athletes that had participated in
156 16,898 practices and 4,378 games. One hundred eighty-seven schools (90.3%) reported utilizing
157 in-person instruction during September 2020. Among the schools that had restarted participation,
158 270 cases of COVID-19 were reported, yielding a case rate of 892 cases per 100,000 athletes and
159 an incidence rate of 32.6 (95% CI = 28.9-36.8) cases per 100,000 player-days. From September 6
160 to October 4, 2020, 2390 cases of COVID-19 were reported among 14-17 year-olds in
161 Wisconsin, for a case rate of 1067 cases per 100,000 people and an incidence of 38.1 cases per
162 100,000 person-days.¹⁹ Of the cases with a reported known source, 115 (55%) were attributed to
163 household contact followed by community contact outside sport or school (85, 41%), school
164 contact (5, 2.4%), sport contact (1, 0.5%) and other (3, 1.4%). For those sports with greater than
165 50 participating schools, the incidence rate ranged from 13.3 (Tennis – Girls) to 45.2 cases per
166 100,000 player-days (Football), as shown in Figure 1 (full data available in Supplemental Table
167 1).

168 When aggregated by county, the case rates for athletes in each county were significantly
169 and positively correlated with the case rates for their respective county's general population
170 ($\beta=1.14\pm0.20$, $r=0.60$, $p<0.001$; see Figure 2). The IRRs for specific sports, adjusted for state
171 COVID-19 incidence, instruction delivery type and school repeated measures are shown in
172 Figure 3. The IRRs for school instructional delivery and sport characteristics are shown in Table
173 1. One hundred seventy-three schools (84%) reported face mask use by players while playing
174 sports. Unadjusted incidence for teams with and without reported face mask use within each

175 sport with greater than 50 respondent schools are shown in Figure 4. After adjusting for local
176 county COVID-19 incidence and school instructional delivery, face mask use was not associated
177 with a decreased COVID-19 incidence in football, girls' volleyball, boys' soccer or cross country
178 (Table 2).

179

180 **DISCUSSION**

181 In this statewide survey study of high school athletes, we did not identify a statistically
182 significant association between COVID-19 incidence and sport type after adjusting for local
183 virus incidence and school instructional delivery. Girls' tennis, girls' golf and cross country
184 reported the lowest adjusted incidence rates of COVID-19, while football reported the highest.
185 Nonetheless, the confidence intervals around these estimates were wide, perhaps due to the
186 relatively low incidence of COVID-19 in Wisconsin during this period. There were no
187 independent, statistically significant differences in reported COVID-19 incidence between indoor
188 versus outdoor sports, contact versus non-contact sports, or individual versus team sports.
189 However, indoor and contact sport classification approached significance, suggesting that this
190 relationship may become clearer with a larger sample during a period of higher COVID-19
191 incidence. In fact, a recent preprint publication among high school athletes nationwide
192 demonstrated this relationship over a longer time period when background COVID-19 rates were
193 higher throughout the country.¹²

194 We found that case rates of reported COVID-19 in high school athletes were significantly
195 related to the case rates of their respective county's general population, and very similar to the
196 overall COVID-19 incidence rate among 14-17 year olds in Wisconsin during roughly the same
197 time frame. In addition, 96% of the cases among athletes had a reported source of infection from

198 household and community contacts, and only 1 (0.5%) from a known sport contact. This may
199 suggest that the background, local COVID-19 incidence may have a greater effect on overall
200 COVID-19 incidence among high school athletes than participation in a specific sport or type of
201 sport.

202 Reported face mask use among the sports with the largest number of respondent schools
203 (football, girls' volleyball, boys' soccer, and cross country) did not have a significant
204 relationship with COVID-19 incidence. While this is similar to the findings among outdoor
205 sports in a recent nationwide sample of high school athletes, it is in contrast to the finding from
206 that study that facemask use was associated with decreased COVID-19 incidence among indoor
207 sports.¹² The overwhelming majority of the respondent schools in the present study (84%)
208 reported facemask use while on the field or court. Together with the relatively low background
209 COVID-19 incidence rates during September, this may have limited our ability to identify a true
210 relationship between mask use and reported COVID-19 incidence.

211 Similarly, we did not find a relationship between COVID-19 incidence and type of
212 instructional delivery (in-person, virtual). Of the cases with a reported known source, only 2.5%
213 were attributed to a school contact. This is consistent with prior reports that schools have not
214 been significant contributors to the spread of COVID-19.²⁰ However, 90% of our respondent
215 schools reported in-person instruction, making it difficult to fully evaluate the role of in-person
216 school instruction in COVID-19 incidence among high school athletes. Nonetheless, we included
217 school instruction type within our adjusted models in order to account for this as a potential
218 confounder. Importantly, it should be recognized that this study cannot account for transmission
219 or incidence of COVID-19 among attendees at high school sporting events beyond the
220 participants. This represents an important potential contributor to community COVID-19 risk,

221 and risk mitigation procedures should continue to be prioritized to protect both athletes and
222 attendees.

223

224 **Limitations**

225 This study has several limitations. We are unable to verify the information provided by
226 athletic directors through a separate independent source. Local, county-level daily COVID-19
227 case data was often not available for adolescents or children, so our adjusted models could only
228 account for the population-level background incidence from each county. Nonetheless, we found
229 that reported case rates from our sample and the case rates from the county general populations
230 were highly related. It is difficult to fully interpret comparisons of COVID-19 cases reported by
231 athletic directors and those collected by public health agencies, but we have included public
232 health data to add context for our findings and to adjust our incidence models. As mentioned
233 above, the incidence of COVID-19 was relatively low during September 2020 in Wisconsin, and
234 this may have limited our ability to detect statistically significant associations in some cases.
235 Reported sources of infection were provided by the schools themselves and it is unknown
236 whether these represent the results of formal contact tracing by local health authorities. Finally,
237 this data represents information regarding athletes from a single state and may not be
238 generalizable to other populations.

239

240 **Conclusions**

241 After adjusting for local county COVID-19 incidence, no statistically significant
242 differences in reported COVID-19 incidence were identified between sports or sport types
243 among Wisconsin high school athletes during September 2020. Reported COVID-19 case rates

244 among athletes were highly correlated with case rates for the general population for their
245 respective counties, and incidence rates among athletes were very similar to those of 14-17 year
246 olds in Wisconsin in general. Most cases among athletes were attributed to household and
247 community contact with very few attributed to school or sport contacts. Further research is
248 warranted to better define the risk factors for COVID-19 transmission during adolescent sport
249 participation and the relative benefits of different risk mitigation strategies.

250

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330

331 Figure Legends.

332

333 Figure 1. Unadjusted incidence rates of COVID-19 during September 2020 for various sports
334 from Wisconsin high schools. Incidence rate is shown as reported cases per 100,000 player-days
335 for those sports with greater than 50 schools reporting restarting. Red, dashed line represents the
336 COVID-19 incidence rate among 14-17 year-olds in Wisconsin from 9/6 to 10/5/2020 (data
337 extracted from <https://www.dhs.wisconsin.gov/covid-19/cases.htm#youth> on 2/5/2021).

338 Figure 2. Reported COVID-19 case rates for Wisconsin high school athletes and the general
339 population of their respective counties during September 2020. Size of points scaled to
340 population of each county and dashed line represents a line of equality. Solid line and shaded
341 area represent regression line and 95% confidence interval from linear model weighted for
342 population of each county. r = correlation coefficient.

343 Figure 3. COVID-19 incidence rate ratios during September 2020 for Wisconsin high school
344 sports, adjusted for local (state) COVID-19 incidence, instructional delivery type and repeated
345 measures from the same school. Includes those sports with greater than 50 schools reporting
346 participation, with Cheer/Dance as reference. * $p < 0.05$.

347 Figure 4. Unadjusted COVID-19 incidence rates reported among Wisconsin athletes in
348 September 2020, comparing teams with or without reported face mask use, within each sport.
349 Includes those sports with greater than 50 reporting schools.

350

351 Table 1. Incidence rate ratios for reported COVID-19 cases among Wisconsin high schools in
352 fall 2020 by school instructional delivery and sport characteristics.

| | IRR (95% CI) | p |
|---|------------------|-------|
| School instructional delivery (in-person) | 1.33 (0.74-2.4) | 0.34 |
| Outdoor | 0.52 (0.26-1.1) | 0.072 |
| Team | 1.03 (0.49-2.2) | 0.93 |
| Non-Contact | 0.53 (0.23-1.26) | 0.14 |

353 ^aIncidence rate ratios and Wald confidence intervals from a mixed effects negative binomial
354 regression to predict COVID-19 cases with local incidence, instructional delivery type, and sport
355 characteristics as fixed effects, school as a random effect and log(player-days) as an offset; CI =
356 Confidence Interval; IRR=Incidence Rate Ratio.

357

358 Table 2. The association of reported face mask use with COVID-19 incidence within each sport
359 among Wisconsin high school athletes during September 2020.^a

| | IRR (95% CI) ^a | p |
|--------------------|---------------------------|-------|
| Cross Country | 0.706 (0.24-2.2) | 0.524 |
| Football | 1.58 (0.57-5.1) | 0.404 |
| Soccer - Boys | 2.34 (0.52-17) | 0.307 |
| Volleyball - Girls | 1.37 (0.3-6.6) | 0.641 |

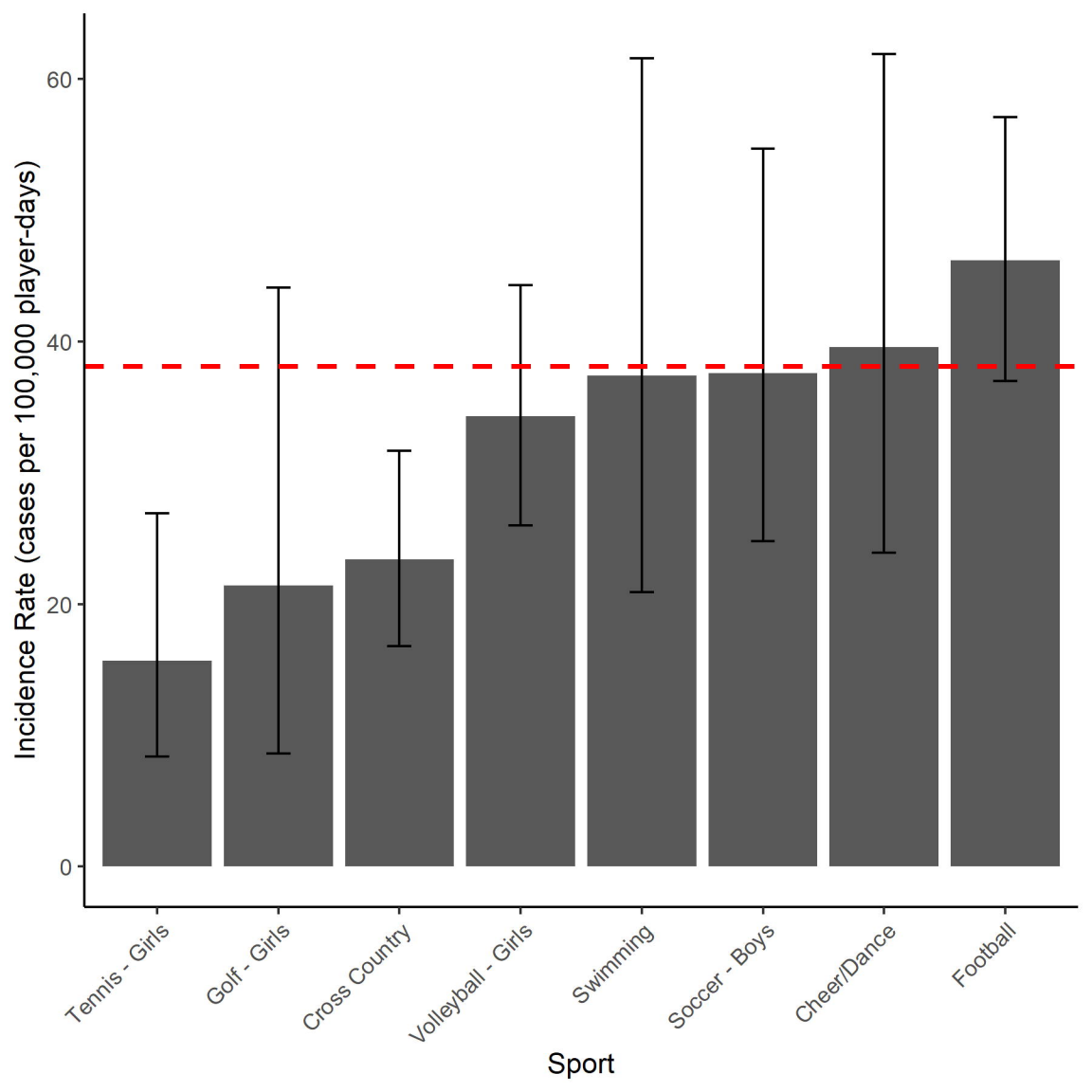
360 ^aIncidence rate ratios and Wald confidence intervals from separate multivariable negative
361 binomial regression models within each sport to predict COVID-19 cases with local incidence,
362 instructional delivery type, and face mask use (yes/no) as fixed effects, and log(player-days) as
363 an offset. CI = Confidence Interval; IRR=Incidence Rate Ratio.

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High School Cases per 100,000 Athletes

$r = 0.602$
 $p < 0.001$

