Public health impact of mass sporting and cultural events in a rising COVID-19 prevalence in England

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Abstract

A subset of events within the UK Government Events Research Programme (ERP), developed to examine the risk of transmission of COVID-19 from attendance at events, was examined to explore the public health impact of holding mass sporting events. We used contact tracing data routinely collected through telephone interviews and online questionnaires, to describe the potential public health impact of the large sporting and cultural events on potential transmission and incidence of COVID-19. Data from the EURO 2020 matches hosted at Wembley identified very high numbers of individuals who tested positive for COVID-19 and were traced through NHS Test & Trace. This included both individuals who were potentially infectious (3036) and those who acquired their infection during the time of the Final (6376). This is in contrast with the All England Lawn Tennis Championships at Wimbledon, where there were similar number of spectators and venue capacity but there were lower total numbers of potentially infectious cases (299) and potentially acquired cases (582). While the infections associated with the EURO 2020 event may be attributed to a set of socio-cultural circumstances which are unlikely to be replicated for the forthcoming sporting season, other aspects may be important to consider including mitigations for spectators to consider such as face coverings when travelling to and from events, minimising crowding in poorly ventilated indoor spaces such as bars and pubs where people may congregate to watch events, and reducing the risk of aerosol exposure through requesting that individuals avoid shouting and chanting in large groups in enclosed spaces.

Introduction

The UK Government Events Research Programme (ERP) [1] was developed by the UK government at the request of the Prime Minister to examine the risk of transmission of COVID-19 from attendance at events and explore ways to enable people to attend a range of events safely, through the study of a combination of testing, certification, non-pharmaceutical, behavioural and environmental interventions. The programme completed three phases of transmission and related studies incorporating a range of indoor and outdoor settings across cultural, sporting and business events. Phase 1 and 2 occurred at lower community COVID-19 prevalence (typically 1 in 500 to 1 in 1500) [2]. Key findings from the phase 1 events were that outdoor spaces are generally lower risk than indoor spaces [3]. The ERP phase 1 studies also demonstrated using CO2 monitoring linked to crowd movement data that higher risk areas could be readily identified such as indoor spaces related to toilets, food/drink concessions, entry/exit points and corridors; face covering compliance varied with attendance level and was lower in hospitality areas, when congregating in groups, in circulation zones and while entering; and reduced social distancing compliance was linked with higher attendances and less effective crowd management strategies.

At the start of the phase 3 events on 13 June 2021, the England 7-day case rate was 43.5 per 100,000 and rose rapidly to a peak on 19 July 2021 at 543.3 per 100,000 of the population, owing to the rapid expansion and transmission of the Delta variant (Phylogenetic Assignment of Named Global Outbreak (Pango) lineage designation B.1.617.2) [4]. In phase 3 of the ERP, the events included increasingly higher numbers of attendees at higher capacity venues with later events moving towards full capacity [5]. The EURO 2020 matches at Wembley Stadium on 13th, 18th, 22nd, 26th, 29th June, 6th, 7th and 11th July, whilst not at full capacity attracted large numbers of fans in and around the venue many travelling...
nationally via coaches and public transport and were coupled with a relaxation of infection control measures.

The following sporting and cultural events were studied as part of the ERP and took place on dates overlapping with those of the EURO 2020 tournament (13th June–11th July 2021): eight EURO 2020 football matches at Wembley Stadium, five international cricket matches at various locations (details in Supplementary File Table S1), Download Festival (live music festival) in Leicestershire, Goodwood Festival of Speed motorsport event in West Sussex, Royal Ascot race meeting in Berkshire, All England Lawn Tennis Championships at Wimbledon, The Open Golf, All England Lawn Tennis Championships at Wimbledon and The Grange Festival (opera). Fewer than 10 mentions of The Grange Festival were identified; these were excluded from further analysis. Details of each event and search terms used are available in Supplementary Materials Table S1.

Download Festival and Goodwood Festival of Speed allowed visitors to camp at the venues overnight, including the final night of each event. The following day (Download Festival: 21st June, Goodwood: 12th July) was included in the search to capture individuals still at the venue on those days following the events.

We used contact tracing data routinely collected through telephone interviews and online questionnaires, to describe the potential public health impact of the large sporting and cultural events on transmission and incidence of COVID-19.

Methods
In line with all positive COVID-19 test results in England at the time, positive COVID-19 results from PCR or supervised LFD tests were automatically reported to NHS Test and Trace electronic system, and cases either self-completed contact tracing or over the phone with an agent [7]. Contact tracing data were analysed to identify cases that reported activities potentially associated with an event in the ERP. Results were generated using the data available as of 17th August 2021.

For each case, data were collected on the types of activity reported, dates of attendance, locations and any further information recorded in a free text description. To find cases who had attended an ERP event, this information was filtered using all of the following three criteria:

(1) Date: The activity occurred within the date range of the ERP event.
(2) Location: The postcode reported for the activity undertaken matched a postcode (or postcode part) of the ERP event venue, or a keyword associated to location (e.g. ‘Ascot’) appeared in the free text description.
(3) Activity: The activity was reported in a category which was relevant to the ERP event (e.g. horse races), or
(4) Keyword: The free text description contained a keyword relating to the event (e.g. ‘racing’).

In this analysis, eight events/groups of events which were part of the ERP were identified: Cricket (England vs New Zealand test match and four one day international matches), Download (music) Festival, EURO 2020 (football), Goodwood Festival of Speed (motorsport), Royal Ascot (horse racing), The Open Golf, All England Lawn Tennis Championships at Wimbledon and The Grange Festival (opera). Fewer than 10 mentions of The Grange Festival were identified; these were excluded from further analysis. Details of each event and search terms used are available in Supplementary Materials Table S1.

Findings
Our primary analysis identified cases who reported activities during contact tracing which matched ERP events in this analysis on all three criteria. In total, 3714 cases reported attending ERP events during their infectious period (from 2 days before onset or test onwards) and 7396 cases attended during the period

| Date       | Event                        | Cases 3–7 days before onset (England) | Cases 2 days before onset (England) | Total unique cases |
|------------|------------------------------|---------------------------------------|-------------------------------------|--------------------|
| 10/06–11/07| international cricket        | 253                                   | 123                                 | 374                |
| 13/06–11/07| Euros 2020                   | 6376                                  | 3036                                | 8772               |
| 15/06–19/06| Royal Ascot                  | 39                                    | 11                                  | 49                 |
| 18/06–21/06| Download Festival            | 65                                    | 52                                  | 105                |
| 28/06–11/07| Wimbledon tennis             | 582                                   | 299                                 | 855                |
| 08/07–12/07| Goodwood Festival            | 168                                   | 157                                 | 321                |
| 11/07–18/07| The Open Golf                | 64                                    | 100                                 | 159                |

*Cases which attended both 2 and 3–7 days before onset are counted once.
Table 2. Cases associated with EURO 2020 and other ERP events in overlapping period

| Event | Date      | Cases 3–7 days before onset | Cases 2 days before onset | ONS weekly prevalence estimate (%) | Venue capacity (%) | Spectators |
|-------|-----------|----------------------------|--------------------------|-------------------------------------|--------------------|------------|
| Cricket: 1st ODI Emirates | 29/06 | 27 | 10 | 0.61 | 50 | 7500 |
| Cricket: 2nd ODI Kia Oval | 01/07 | 26 | 11 | 0.61 | 50 | 14000 |
| Cricket: 3rd ODI Bristol CG | 04/07 | 10 | 10 | 1.06 | 50 | 8000 |
| Cricket: England vs. NZ | 10/06 | 24 | 4 | 0.19 | 70 | 16000 |
| Cricket: England vs. NZ | 11/06 | 21 | 8 | 0.19 | 70 | 16000 |
| Cricket: England vs. NZ | 12/06 | 17 | 8 | 0.19 | 70 | 16000 |
| Cricket: England vs. NZ | 13/06 | 5 | 0 | 0.22 | 70 | 7000 |
| Cricket: Pakistan ODI Lords | 10/07 | 135 | 72 | 1.06 | 100 | 31000 |
| Download Festival | 18/06 | 55 | 8 | 0.22 | 10000 |
| Download Festival | 19/06 | 53 | 3 | 0.22 | 10000 |
| Download Festival | 20/06 | 42 | 22 | 0.39 | 10000 |
| Download Festival | 21/06 | 16 | 19 | 0.39 | 10000 |
| EURO 2020 | 13/06 | 4 | 6 | 0.22 | 25 | 22000 |
| EURO 2020 | 18/06 | 40 | 17 | 0.22 | 25 | 22000 |
| EURO 2020 | 22/06 | 52 | 23 | 0.39 | 25 | 22000 |
| EURO 2020 | 26/06 | 44 | 23 | 0.39 | 50 | 43000 |
| EURO 2020 | 29/06 | 449 | 179 | 0.61 | 50 | 43000 |
| EURO 2020 | 06/07 | 609 | 154 | 1.06 | 75 | 67000 |
| EURO 2020 | 07/07 | 2092 | 375 | 1.06 | 75 | 67000 |
| EURO 2020 | 11/07 | 3404 | 2295 | 1.36 | 75 | 67000 |
| Goodwood Festival | 08/07 | 38 | 14 | 1.06 | 75 | 35000 |
| Goodwood Festival | 09/07 | 48 | 29 | 1.06 | 75 | 35000 |
| Goodwood Festival | 10/07 | 58 | 57 | 1.06 | 75 | 35000 |
| Goodwood Festival | 11/07 | 44 | 59 | 1.36 | 75 | 35000 |
| Goodwood Festival | 12/07 | 2 | 1 | 1.36 | 75 | 35000 |
| Royal Ascot | 15/06 | 19 | 4 | 0.22 | 30 | 12000 |
| Royal Ascot | 16/06 | 14 | 0 | 0.22 | 30 | 12000 |
| Royal Ascot | 17/06 | 6 | 5 | 0.22 | 30 | 12000 |
| Royal Ascot | 18/06 | 11 | 2 | 0.22 | 30 | 12000 |
| Open Golf | 11/07 | 1 | 1 | 1.36 | 80 | 32000 |
| Open Golf | 12/07 | 3 | 1 | 1.36 | 80 | 32000 |
| Open Golf | 13/07 | 4 | 0 | 1.36 | 80 | 32000 |
| Open Golf | 14/07 | 3 | 8 | 1.36 | 80 | 32000 |
| Open Golf | 15/07 | 23 | 20 | 1.36 | 80 | 32000 |
| Open Golf | 16/07 | 24 | 29 | 1.36 | 80 | 32000 |
| Open Golf | 17/07 | 22 | 21 | 1.36 | 80 | 32000 |
| Open Golf | 18/07 | 17 | 21 | 1.57 | 80 | 32000 |

(Continued)
when they acquired their infection (between 3 and 7 days prior to symptom onset or test). Of all of these cases, 244 attended more than one event.

Table 1 describes the total number of cases identified as attending each event. In total, 6376 cases were identified as attending EURO 2020 football events at Wembley during the period they were likely to have acquired COVID-19, and 3036 during the period they were likely infectious. Numbers in both categories increased substantially at the later matches, especially the Final. A smaller number of cases were identified at other events, such as the All England Lawn Tennis Championships at Wimbledon where there were similar numbers of spectators and venue capacity, but the total numbers of potentially infectious (n = 299) or acquired cases (n = 582) were much lower.

The eight events took place over variable durations of time: some on consecutive days and others on intermittent occasions. Table 2–C reports the number of cases identified by day of event. Particularly high numbers were identified at the Euro 2020 Final on 11th July, with close to half of all cases associated with the Euros coming from this date. The total number of cases who attended the Wembley Semi Final (7th July) and Final during the period when they likely acquired their infection was both high at 2092 and 3404 respectively. The number of cases who attended the Final and were potentially infectious was 2295. Figure 1 shows the case numbers per event per day. It should be noted that ONS-estimated prevalence was lower at the start of the study period (Panel 6) and that time trends within the data should be interpreted with caution.

Age and sex distributions are reported in Table 3. At EURO 2020 matches, 85% of cases were male, and the median age was 33 (IQR: 27–43). Overall the majority of cases which reported attending ERP events were male, but this varied by event. Cases identified at The Open Golf were 91% male, while at Wimbledon 52% were male. Age also varied by event, and this can be seen in age-sex pyramids in Figure 2. The pyramids show that while Download Festival and Wimbledon had a younger demographic amongst cases, a larger proportion of cases identified as attending The Open Golf, cricket events and Goodwood Festival of Speed were older.

As a secondary analysis, we identified and counted all types of activities reported by all cases in England during the period 9th June to 19th July 2021. Figure 3 shows the types of events reported each day (data available in Supplementary Table S3); spikes in activity can be seen on the days of England EURO 2020 football matches whether at home or away. Increases were seen in activities relating to bars and pubs, eating out and sports events on match dates. A large number of public and mass gatherings were also reported on the day of the EURO 2020 final (11th July).

**Discussion**

The increasing number of reported cases across all events reflects the increasing community prevalence of COVID-19 during that period. Both the EURO 2020 matches at Wembley and the All England Lawn Tennis Championships were mass spectator sporting events taking place on multiple days within a short period of time at an outdoor stadium in Greater London. There were similar numbers of spectators and high capacity in the stadia, reaching 75% for the later EURO 2020 matches and 100% on Centre Court at the Wimbledon final. Both required evidence of vaccination or negative LFD or natural immunity as a condition of entry. There are very markedly different numbers of positive cases reported as associated with these events, with those associated with the Wimbledon event more comparable with those reported from the other ERP events running concurrently, and with the numbers testing positive within the wider community at that time. This suggests that the EURO 2020 matches generated a level of COVID-19 transmission over and above that which would be more commonly associated with large crowds attending an outdoor sporting event with measures in place to mitigate transmission.

The number of potentially infected persons attending Wembley stadium increased as the tournament progressed, reaching more than 2000 at the EURO 2020 final despite event goers requiring a COVID pass for entry [8]. This raises questions on
Fig. 1. COVID-19 cases reporting attendance at an ERP event by date of attendance and prevailing estimated prevailing COVID-19 prevalence.

Table 3. Positive cases by gender and age

| Event*           | Female (per cent) | Male (per cent) | Unspecified or not known (per cent) | Age quartile 25% | Age quartile 50% | Age quartile 75% |
|------------------|-------------------|-----------------|-------------------------------------|------------------|------------------|------------------|
| Cricket (Various)| 13.6              | 84              | 2.4                                 | 26               | 37.5             | 50               |
| Download Festival| 36.2              | 63.8            | 0                                   | 23               | 25               | 29               |
| EURO 2020        | 11.7              | 84.9            | 3.4                                 | 27               | 33               | 43               |
| Goodwood Festival| 24.6              | 73.8            | 1.6                                 | 22               | 32               | 44.2             |
| The Open Golf    | 6.3               | 90.6            | 3.1                                 | 31               | 41               | 54               |
| Wimbledon        | 42.6              | 52              | 5.4                                 | 27               | 34               | 46               |

*Royal Ascot omitted because of small case numbers.
the utility of individuals self-reporting tests in reducing the prevalence of COVID infection at rare or special events and the longer term deliverability of self-testing as an option to mitigate disease transmission.

Research teams present at each of these events have verbally reported stark differences in crowd and spectator behaviour (personal communication from Dr Aoife Hunt, formal report in preparation). Whilst the Wimbledon crowds were well managed and largely compliant with the required risk mitigation, the initial reports from research teams indicate that spectators at the Wembley stadium became less compliant with mitigation such as face coverings as the tournament progressed. To manage
the orderly ingress of spectators for the higher (75%) capacity events, spectators were admitted earlier than usual and alcohol was served within Wembley Stadium. The concourse areas became densely populated with shouting, chanting and boisterous behaviour with close contact in these areas before and during the semi-final and final matches lasting at least 1–2 h within the stadium indoor areas and many more hours outside. In addition to this, the carbon dioxide levels reported from the concourse areas were higher than those recorded at other high-risk settings in the ERP events, including the densely crowded areas at the Download music festival, and will have compounded the risk associated with the high numbers of spectators potentially infectious at the event itself (personal communication from Dr Liora Malki-Epshtein UCL, formal report in preparation). Finally, the public disorder offences occurring at EURO 2020 have been widely reported, including an undefined number of ticketless fans who gained entry to the stadium. Public disorder in and around the stadium meant that COVID-19 status checks were suspended for the Final [9].

The EURO 2020 events had an increasing impact on a national scale which was not observed for other events within the ERP, suggesting that there were additional factors associated with these events and that the risk of COVID transmission was not mitigated by the control measures in place for entry to the event itself. There was increasing national interest as the tournament progressed, as this was the first time an English team were in an international final for 55 years generating a sense of the final stages being a ‘once in a generation’ occasion. This will not be replicated for all sport tournaments taking place over the winter, nor for all football matches. However, previous crowd behaviours associated with football fans has underpinned the methods used to manage these crowds including the legislation in place.
governing alcohol consumption within football stadia. In general, terms, this has the effect of concentrating people into as few areas as possible while crowd management strategies often hold groups until they can be moved en masse in a controlled manner. To mitigate the risk of transmission of COVID-19, it would be preferable to dissipate the crowds across as wide an area as possible and manage the movement over long periods of time, as happened at other events including the Wimbledon tennis championships.

In addition to the cases associated directly with Wembley stadium, there was a noticeable national impact on COVID-19 case rates for key games including the Ukraine vs. England quarter-final (3rd July in Rome), for the England vs. Denmark Semi-final (7th July) and for the England vs. Italy final (11th July), reflecting that in the later stages of the EURO 2020 tournament people came together across the country to watch the games and celebrate. There are higher proportions of events coded as pubs or bars on each of these dates compared to other dates for COVID-19 cases in England.

The case numbers associated with the events were detected using the routine reporting systems and were mainly from individuals who were symptomatic. As high proportions of cases, especially in young healthy individuals, are asymptomatic, this is likely to be an underestimate of the full impact of these events [10]. In addition, contact tracing is only undertaken for PCR test results and supervised LFD test results (those who are positive on home LFDs are requested to undertake an immediate PCR test) and recall bias of those contacted will vary. While there is no detailed age and sex breakdown for those who attended, it is highly likely that certain sports events in particular had a male and younger dominance. The age distribution also likely reflects the impact of vaccination; by 11th July 2021, those over 50 years were 80% fully vaccinated and under 40 were less than 30% fully vaccinated.

Contact tracing information can indicate events or locations individuals have attended while at risk of transmitting COVID-19 or places where transmission may have occurred. It is not possible to say with certainty how many individuals transmitted COVID-19 at an event or venue, nor exactly where an individual contracted the virus. The Euro Final match did not take place until 20.00 h, meaning that those attending may have been engaging in social activities during their journey to the match, and prior to entering the stadium itself. Transmission of infection may have occurred at the event itself or during any of the other reported activities associated with the event, of which attending a pub or restaurant is the most frequently reported.

Neither full vaccination nor a negative LFD test will completely eliminate the possibility of an infectious individual attending an event, but it should reduce the likelihood of someone transmitting highly infectious amounts of virus to a large number of individuals attending the event [11–14].

Conclusions

The EURO2020 tournament and England’s progress to the EURO final generated a significant risk to public health across the UK even when England played overseas. This risk arose not just from individuals attending the event itself, but included activities undertaken during travel and associated social activities. For the final and semi-final games at Wembley risk mitigation measures in place were less effective in controlling COVID transmission than was the case for other mass spectator sports events.

EURO2020-related transmissions have also been documented in Scotland [15], where 2632 individuals self-reported attending a EURO2020 event in the UK; and Finland, where 947 new SARS-CoV-2-positive cases were linked to travel to Moscow, Russia [16]. Whilst some of this may be attributed to a set of circumstances which are unlikely to be replicated for the forthcoming sporting season, other aspects may be important to consider including mitigations for spectators attending the venue to consider such as face coverings when travelling to and from events, minimising crowding in poorly ventilated indoor spaces such as bars and pubs where people may congregate either before entering the venue or to watch events, and reducing the risk of aerosol transmission through requesting that individuals avoid shouting and chanting in large groups in enclosed spaces. For larger events, it will be important to consider both the venue itself and other areas where fans without tickets for the venue will gather, and advice for the general population gathering in private homes or other locations in larger numbers than might otherwise be the case.

In particular, reducing the number of persons entering events or venues who are potentially infectious or at risk of severe disease or hospitalisation by promoting attendance by fully vaccinated individuals will be important whilst background prevalence rates remain at current levels. This will reduce the risk of transmission associated with the journey to and from the event and associated social activities. It will also be important that event organisers manage the density of crowds in areas such as hospitality and concessions on the concourses, and entry and exit points to the event.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0950268822000188.

Acknowledgements. The Events Research Programme was supported by UK government officers from the Department of Culture, Media and Sport (DCMS), Business Energy and Industrial Strategy (BEIS), Department of Health and Social Care (DHSC) and Public Health England (PHE) Data collection and analysis was undertaken by Anna Trefta, Jerlyn Peh and colleagues within the Field Epidemiology Service, PHE and DCMS Tom Rodden, Sam Lister, and Theresa Marteau provided helpful comments on the manuscript.

Data availability. The data supporting this paper have been made available in Supplementary material.

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