

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

Original Paper

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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 exiting; 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

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Table 1. Cases associated with EURO 2020 and other ERP events in overlapping period by event

Date	Event	Cases 3–7 days before onset (England)	Cases 2 days before onset (England)	Total unique cases ^a
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

^aCases which attended both 2 and 3–7 days before onset are counted once.

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 Grange Festival (opera) in Hampshire and The British Open Golf at Sandwich, Kent. The non-pharmaceutical interventions included in the ERP varied, but all included a requirement to demonstrate immunity (through full vaccination with an approved vaccine or prior infection within 180 days) to COVID-19, or a negative lateral flow test taken within 48 h of the event, checked on entry through the NHS COVID-19 app [6].

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.

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. Keywords were used to include individuals who reported camping in these locations during the (extended) event period.

Individuals were deemed to have attended an event whilst potentially infectious if they did so in the period from 2 days prior to onset of symptoms, or (if asymptomatic) test, onwards and to have potentially contracted COVID-19 at an event if they attended between 3 and 7 days prior to the onset of symptoms or test.

Individuals were counted once per date at each event for event date analysis and once per event for overall event and demographic analyses. As individuals may have attended events on multiple dates, sums of cases attending multi-day events may not match total counts of cases at those events.

To provide a review of general levels of activity in England in the same period, all activity events and household visitor events (in which a close contact attends the home of a positive case during the period when the case may be infectious) reported to contact tracing by all cases in England during the period 8th June 2021 to 19th July 2021 were counted, split by event category.

Overall prevalence in the English population, as calculated by the national Coronavirus Infection Survey [2], is provided for comparison.

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

Table 2. Cases associated with EURO 2020 and other ERP events in overlapping period

Event	Date day/month	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	14 000
Cricket: 3rd ODI Bristol CG	04/07	10	10	1.06	50	8000
Cricket: England vs. NZ	10/06	24	4	0.19	70	16 000
Cricket: England vs. NZ	11/06	21	8	0.19	70	16 000
Cricket: England vs. NZ	12/06	17	8	0.19	70	16 000
Cricket: England vs. NZ	13/06	5	0	0.22	70	7000
Cricket: Pakistan ODI Lords	10/07	135	72	1.06	100	31 000
Download Festival	18/06	55	8	0.22		10 000
Download Festival	19/06	53	3	0.22		10 000
Download Festival	20/06	42	22	0.39		10 000
Download Festival	21/06	16	19	0.39		10 000
EURO 2020	13/06	4	6	0.22	25	22 000
EURO 2020	18/06	40	17	0.22	25	22 000
EURO 2020	22/06	52	23	0.39	25	22 000
EURO 2020	26/06	44	23	0.39	50	43 000
EURO 2020	29/06	449	179	0.61	50	43 000
EURO 2020	06/07	699	154	1.06	75	67 000
EURO 2020	07/07	2092	375	1.06	75	67 000
EURO 2020	11/07	3404	2295	1.36	75	67 000
Goodwood Festival	08/07	38	14	1.06	75	35 000
Goodwood Festival	09/07	48	29	1.06	75	35 000
Goodwood Festival	10/07	58	57	1.06	75	35 000
Goodwood Festival	11/07	44	59	1.36	75	35 000
Goodwood Festival	12/07	2	1	1.36	75	35 000
Royal Ascot	15/06	19	4	0.22	30	12 000
Royal Ascot	16/06	14	0	0.22	30	12 000
Royal Ascot	17/06	6	5	0.22	30	12 000
Royal Ascot	18/06	11	2	0.22	30	12 000
Open Golf	11/07	1	1	1.36	80	32 000
Open Golf	12/07	3	1	1.36	80	32 000
Open Golf	13/07	4	0	1.36	80	32 000
Open Golf	14/07	3	8	1.36	80	32 000
Open Golf	15/07	23	20	1.36	80	32 000
Open Golf	16/07	24	29	1.36	80	32 000
Open Golf	17/07	22	21	1.36	80	32 000
Open Golf	18/07	17	21	1.57	80	32 000

(Continued)

Table 2. (Continued.)

Event	Date day/month	Cases 3–7 days before onset	Cases 2 days before onset	ONS weekly prevalence estimate (%)	Venue capacity (%)	Spectators
Wimbledon	28/06	27	13	0.61	50	21 104
Wimbledon	29/06	19	15	0.61	50	20 828
Wimbledon	30/06	23	13	0.61	50	21 511
Wimbledon	01/07	25	21	0.61	50	21 291
Wimbledon	02/07	34	14	0.61	50	21 166
Wimbledon	03/07	40	18	0.61	50	23 755
Wimbledon	04/07	5	2	1.06		
Wimbledon	05/07	81	33	1.06	75	29 031
Wimbledon	06/07	52	15	1.06	81	28 668
Wimbledon	07/07	69	17	1.06	100*	26 436
Wimbledon	08/07	58	28	1.06	100*	20 310
Wimbledon	09/07	102	25	1.06	100*	24 572
Wimbledon	10/07	79	39	1.06	100*	23 427
Wimbledon	11/07	67	51	1.36	100*	19 738

*Show court capacity.

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

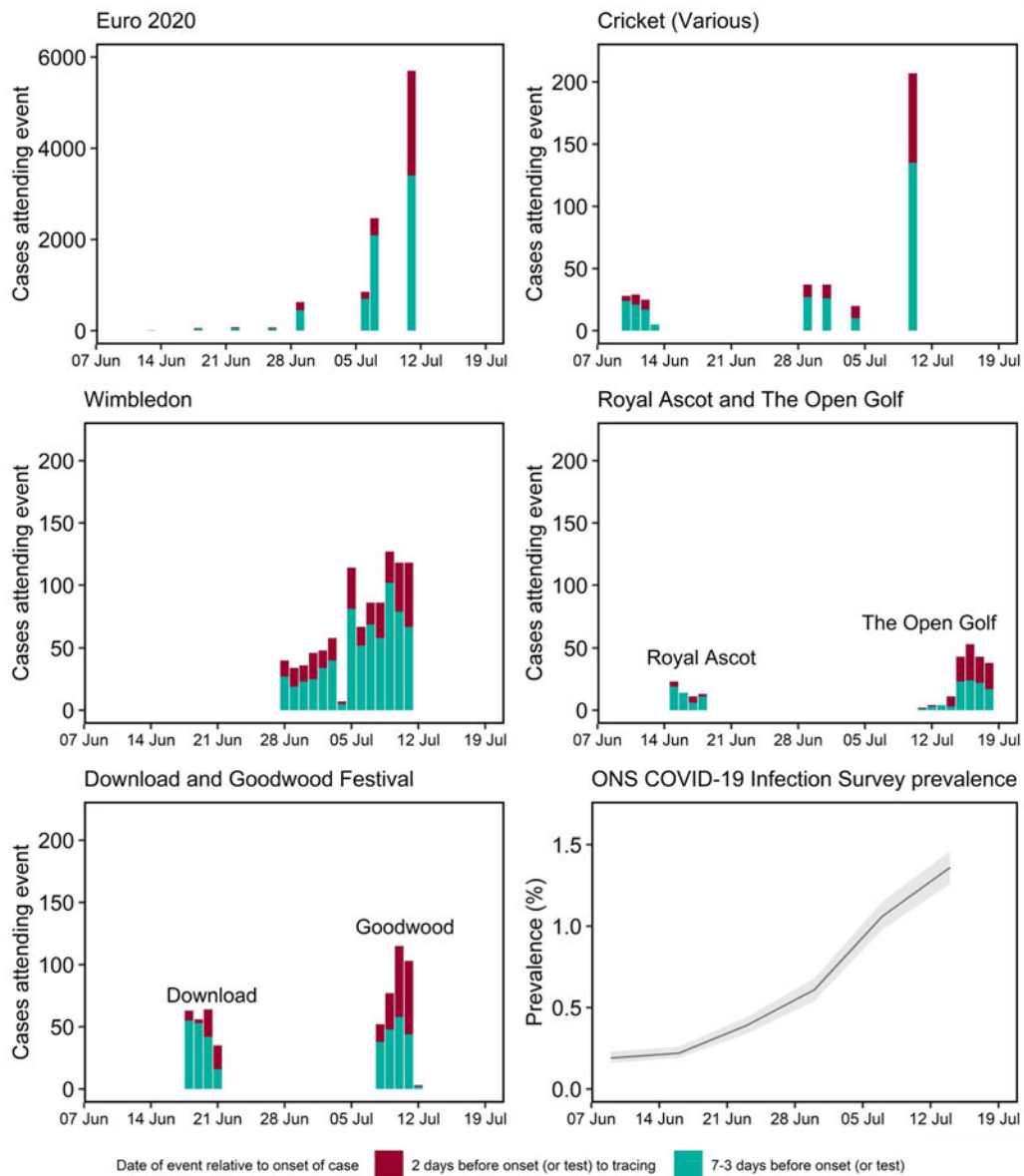


Fig. 1. COVID-19 cases reporting attendance at an ERP event by date of attendance and prevailing estimated COVID-19 prevalence.

Table 3. Positive cases by gender and age

Event ^a	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

^aRoyal Ascot omitted because of small case numbers.

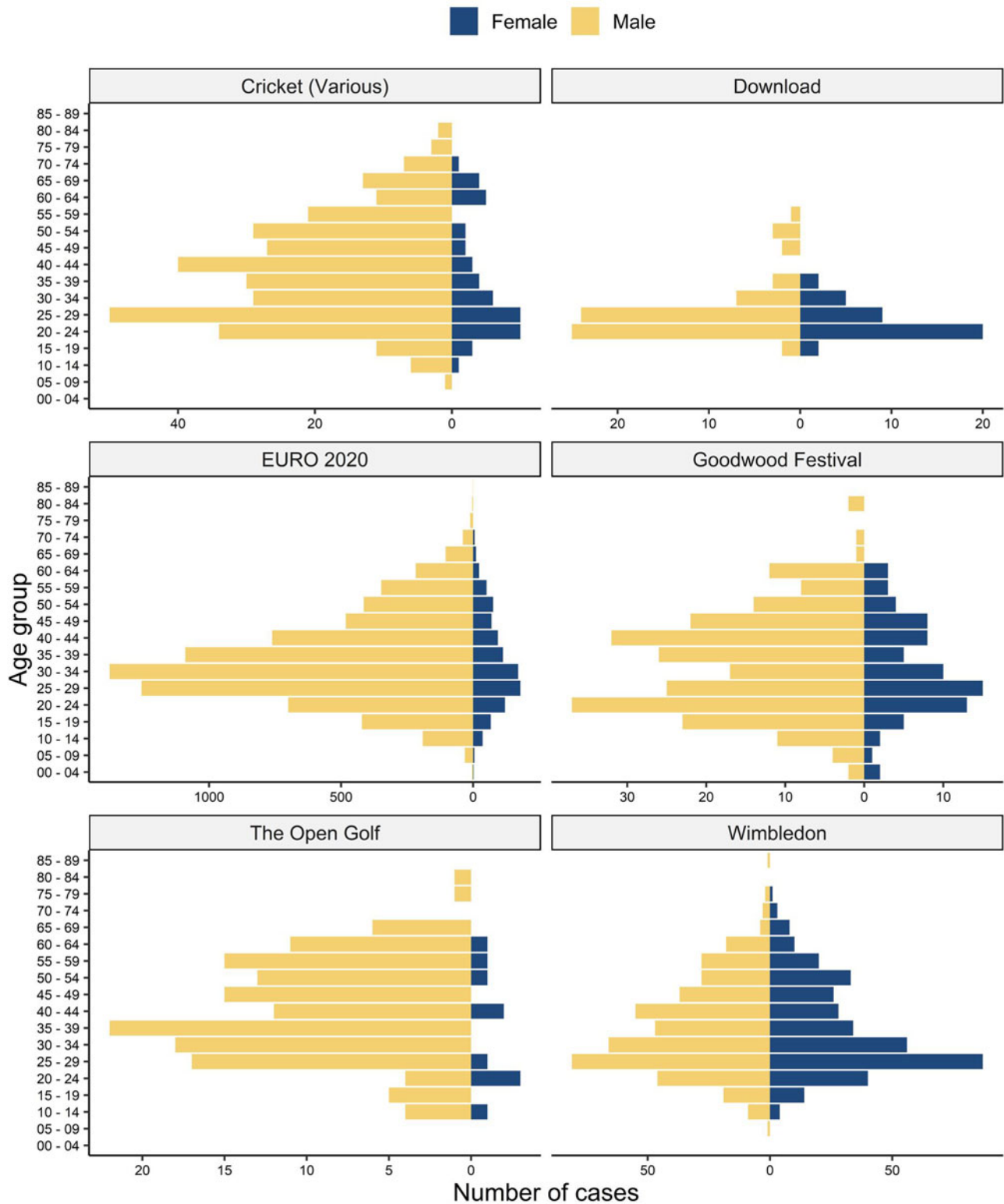


Fig. 2. Age and sex of COVID-19 cases reporting attendance at an ERP event 9th June–19th July.

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

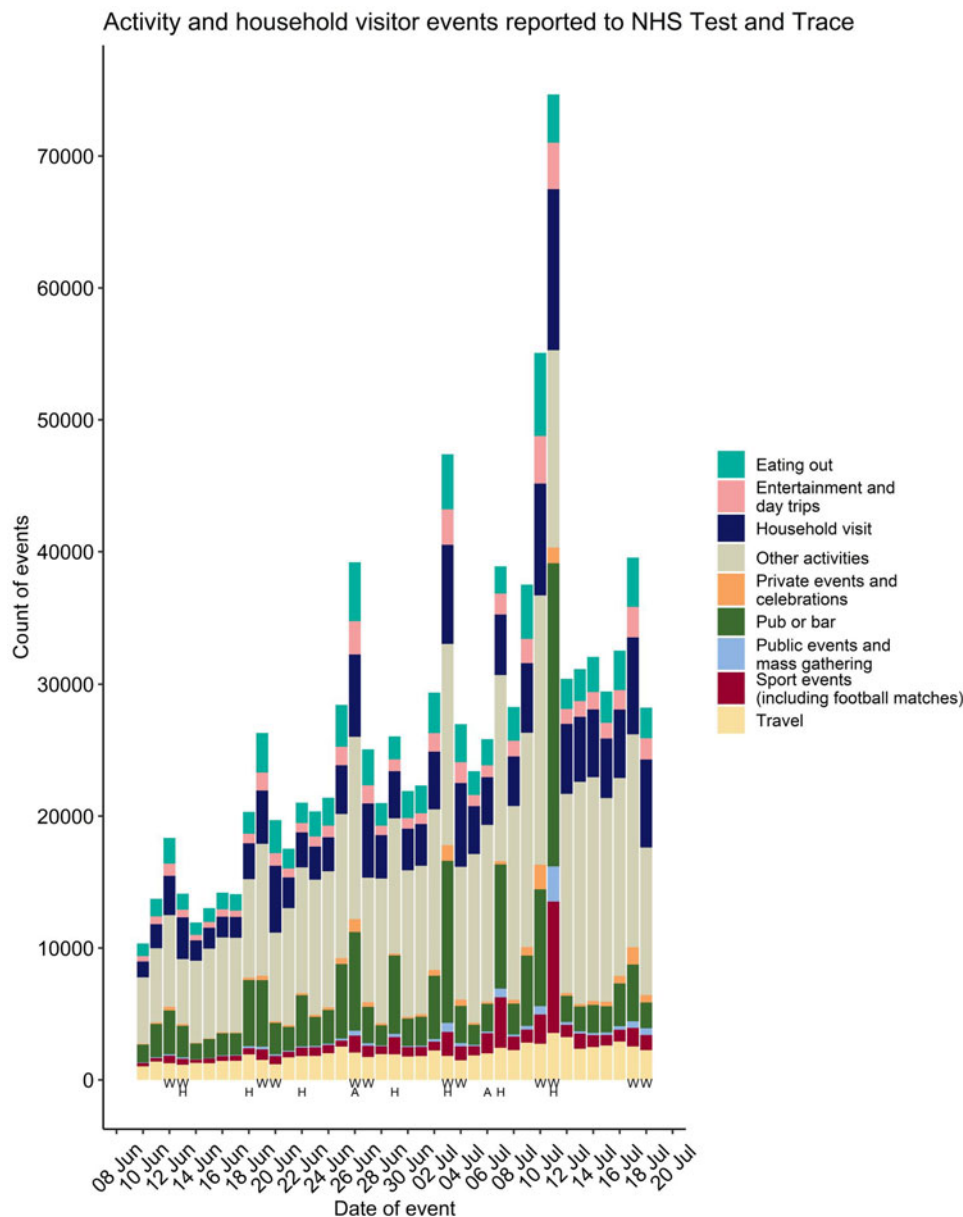


Fig. 3. Activity and household events reported to NHS Test and Trace by positive cases, weekends (W), holidays (H) and Euro match (A).

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>.

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

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