

## Preprint version

# 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. The events were part of the ERP. This additional public health analysis from routine contact tracing data was not part of the pre-registered protocols and analysed as part of daily public health analysis.

We used contact tracing data routinely collected through telephone interviews and online questionnaires, recording postcodes and location types attended in the potentially infectious (day -2 to day 0) and potentially acquired (day -3 to day -7) time periods, 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 and Trace. This included both individuals who were potentially infectious (3,071) and those who acquired their infection during the time of the tournament (6,784). This is in contrast with the All England Lawn Tennis Championships at Wimbledon (and other events), 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 circumstances (once in a generation experience for many) 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 indoors spaces such as bars and pubs where people may congregate to watch events. It is also important to minimise the risk of transmission from aerosol exposure related to singing and chanting in large groups by improving ventilation 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 3 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). Key findings from the phase 1 events were that outdoor spaces are generally lower risk than indoor spaces. (2) 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 and drink concessions, entry or exit points and corridors where ventilation is poorer and there could be crowding during intervals and at ingress and egress; reduced face covering compliance was associated with higher attendance levels, 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). (3, 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 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 (13 June to 11 July 2021): 8 EURO 2020 football matches at Wembley Stadium, f5 international cricket matches at various locations (details in Supplementary File [Table 1](#)), 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 (NPIs) 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 hours of the event, checked on entry through the NHS COVID-19 app. (6) This additional public health analysis from

routine contact tracing data was not part of the pre-registered protocols and analysed as part of daily public health analysis.

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

Positive COVID-19 results from PCR or supervised LFD tests were automatically reported to NHS Test and Trace electronic system, and cases were contact traced either online by the individual or over the phone with an agent. Contact tracing data was analysed to identify cases that reported activities potentially associated with an event in the ERP.

For each case, data was 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, the data were filtered to detect reported cases who matched using the following 3 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 (for example, 'Ascot') appeared in the free text description.
- 3a. Activity: The activity was reported in a category which was relevant to the ERP event (for example, horse races), OR
- 3b. Keyword: The free text description contained a keyword relating to the event (for example, 'racing').

In this analysis 8 events or groups of events which were part of the ERP were identified: Cricket (England versus New Zealand test match and 4 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 1](#).

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 to 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 and household visitor episodes (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 8 June 2021 to 19 July 2021 were counted, split by event category.

Overall prevalence in the English population, as calculated by the national Coronavirus Infection Survey (7), 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 3 criteria. 3,714 cases reported attending ERP events during their infectious period (from 2 days before onset or test onwards) and 7,396 cases attended during the period when they acquired their infection (between 3 to 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 associated with each event. 6,376 cases were identified as attending EURO 2020 football events at Wembley during the period they were likely to have acquired COVID-19, and 3,036 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 8 events took place over variable durations of time: some on consecutive days and others on intermittent occasions. [Table 2](#) reports the number of cases identified by day of event. Particularly high numbers were identified at the Euro 2020 Final on 11 July, with close to half of all cases associated with the Euros coming from this date. The total number of cases who attended during the period when they likely acquired their infection included the Wembley Semi Final (7 July) and Final were both high at 2,092, and 3,404 respectively. The number of cases who attended the Final and were potentially infectious was 2,295. [Figure 1](#) shows the cases 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 to 43). Overall, most cases who 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 9 June to 19 July 2021. [Figure 3](#) shows the types of events reported each day (data available in Supplementary [Table 3](#)); 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 (11 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 2,000 at the EURO 2020 final despite event goers requiring a COVID pass for entry; this was in contrast with much lower infectious cases detected at other events occurring in the same month.<sup>(8)</sup> This raises questions on the utility of individuals self-reporting tests in reducing the prevalence of COVID infection at rare or special occasion 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 attendees at Wimbledon were reported to be largely compliant with the crowd management measures in place, at the 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. At both venues alcohol was served, but at Wembley attendees were not allowed to take this into the seated accommodation. At both venues the compliance with risk mitigation measures was variable. However, the initial reports from research teams indicate that the Wembley spectators became less compliant with mitigation such as face coverings as the tournament progressed. 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.<sup>(9)</sup>

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. Further analysis of movement strategies will be reported as part of ERP phase 3 reports.(5)

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 versus England quarter-final (3 July in Rome), for the England versus Denmark semi-final (7 July) and for the England versus Italy final (11 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 (for example, football, golf) were more likely to have higher male and younger demographic attending. The age distribution also likely reflects the impact of vaccination; by 11 July 2021, more than 80% of those over 50 years were fully vaccinated and less than 30% of those under 40 years were fully vaccinated.(3)

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 8pm, 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, 12, 13)

## Conclusions (287 words)

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 (14) where 2,632 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. (15) 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 to consider such as face coverings when travelling to and from events and minimising crowding in poorly ventilated indoors spaces such as bars and pubs where people may congregate to watch events. It is also important that individuals are informed to reduce the risk of transmission from aerosol exposure related to shouting and chanting in large groups by improving ventilation in enclosed spaces..

Other risk mitigation measures at high community prevalence include 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. Promoting vaccination and the wearing of face coverings for those attending events will also reduce the risk of transmission associated with the journey to and from the event and associated social activities. Finally, event organisers should consider measures to manage the density of crowds in areas such as hospitality and concessions on the concourses, and entry and exit points to the event.

## 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)

The database, collation and analyses were developed as part of their COVID-19 public health work by colleagues within the Field Epidemiology Service, PHE and DCMS

Tom Rodden, Sam Lister, and Theresa Marteau provided helpful comments on the manuscript.

No specific funding was made available for the study.

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

Date	Event	Cases 3 to 7 days before onset (England)	Cases 2 days before onset (England)
10 June to 11 July	International cricket	253	123
13 June to 11 July	Euros 2020	6,376	3,036
15 June to 19 June	Royal Ascot	39	11
18 to 20 June	Download Festival	48	33
28 June to 11 July	Wimbledon tennis	582	299
11 to 18 July	The Open Golf	64	100

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

Event	Date	Cases 3 to 7 days before onset (England)	Cases 2 days before onset (England)	ONS weekly prevalence estimate <a href="#">(3)</a>	Venue capacity	Spectators
Cricket: First ODI Emirates	29 June 2021	27	10	0.61%	50%	7,500
Cricket: Second ODI Kia Oval	1 July 2021	26	11	0.61%	50%	14,000
Cricket: Third ODI Bristol CG	4 July 2021	10	10	1.06%	50%	8,000
Cricket: England versus New Zealand	10 June 2021	24	4	0.19%	70%	16,000
Cricket: England versus New Zealand	11 June 2021	21	8	0.19%	70%	16,000
Cricket: England versus New Zealand	12 June 2021	17	8	0.19%	70%	16,000
Cricket: England versus New Zealand	13 June 2021	5	0	0.22%	70%	7,000
Cricket: Pakistan ODI Lords	10 July 2021	135	72	1.06%	100%	31,000
Download Festival	18 June 2021	41	8	0.22%		10,000
Download Festival	19 June 2021	39	3	0.22%		10,000

<b>Event</b>	<b>Date</b>	<b>Cases 3 to 7 days before onset (England)</b>	<b>Cases 2 days before onset (England)</b>	<b>ONS weekly prevalence estimate (3)</b>	<b>Venue capacity</b>	<b>Spectators</b>
Download Festival	20 June 2021	34	22	0.39%		10,000
EURO 2020	13 June 2021	4	6	0.22%	25%	22,000
EURO 2020	18 June 2021	40	17	0.22%	25%	22,000
EURO 2020	22 June 2021	52	23	0.39%	25%	22,000
EURO 2020	26 June 2021	44	23	0.39%	50%	43,000
EURO 2020	29 June 2021	449	179	0.61%	50%	43,000
EURO 2020	6 July 2021	699	154	1.06%	75%	67,000
EURO 2020	7 July 2021	2,092	375	1.06%	75%	67,000
EURO 2020	11 July 2021	3,404	2,294	1.36%	75%	67,000
Goodwood Festival	8 July 2021	37	14	1.06%	75%	35,000
Goodwood Festival	9 July 2021	46	29	1.06%	75%	35,000
Goodwood Festival	10 July 2021	56	57	1.06%	75%	35,000
Goodwood Festival	11 July 2021	42	59	1.36%	75%	35,000
Royal Ascot	15 June 2021	19	4	0.22%	30%	12,000
Royal Ascot	16 June 2021	14	0	0.22%	30%	12,000
Royal Ascot	17 June 2021	6	5	0.22%	30%	12,000
Royal Ascot	18 June 2021	11	2	0.22%	30%	12,000
The Open Golf	11 July 2021	1	1	1.36%	80%	32,000
The Open Golf	12 July 2021	3	1	1.36%	80%	32,000
The Open Golf	13 July 2021	4	0	1.36%	80%	32,000
The Open Golf	14 July 2021	3	8	1.36%	80%	32,000
The Open Golf	15 July 2021	23	20	1.36%	80%	32,000

Event	Date	Cases 3 to 7 days before onset (England)	Cases 2 days before onset (England)	ONS weekly prevalence estimate (3)	Venue capacity	Spectators
The Open Golf	16 July 2021	24	29	1.36%	80%	32,000
The Open Golf	17 July 2021	22	21	1.36%	80%	32,000
The Open Golf	18 July 2021	17	21	1.57%	80%	32,000
Wimbledon	28 July 2021	27	13	0.61%	50%	21,104
Wimbledon	29 June 2021	19	15	0.61%	50%	20,828
Wimbledon	30 June 2021	23	13	0.61%	50%	21,511
Wimbledon	1 July 2021	25	21	0.61%	50%	21,291
Wimbledon	2 July 2021	34	14	0.61%	50%	21,166
Wimbledon	3 July 2021	40	18	0.61%	50%	23,755
Wimbledon	4 July 2021	5	2	1.06%		
Wimbledon	5 July 2021	81	33	1.06%	75%	29,031
Wimbledon	6 July 2021	52	15	1.06%	81%	28,668
Wimbledon	7 July 2021	69	17	1.06%	100%*	26,436
Wimbledon	8 July 2021	58	28	1.06%	100%*	20,310
Wimbledon	9 July 2021	102	25	1.06%	100%*	24,572
Wimbledon	10 July 2021	79	39	1.06%	100%*	23,427
Wimbledon	11 July 2021	67	51	1.36%	100%*	19,738

\* On show courts

**Table 3. Positive cases by gender and age**

Note: Royal Ascot is omitted because of small case numbers.

<b>Event</b>	<b>Female (percent)</b>	<b>Male (percent)</b>	<b>Unspecified or not known (percent)</b>	<b>Age quartile 25%</b>	<b>Age quartile 50%</b>	<b>Age quartile 75%</b>
Cricket (various)	13.6	84	2.4	26	37.5	50
Download Festival	33.8	66.2	0	22	25	29
EURO 2020	11.7	84.9	3.4	27	33	43
Goodwood Festival	25	73.4	1.6	23	32	44.5
The Open Golf	6.3	90.6	3.1	31	41	54
Wimbledon	42.6	52	5.4	27	34	46

Figure 1. COVID-19 cases reporting attendance at an ERP sporting or cultural event, by date of attendance, and overall estimated COVID-19 prevalence during the same period

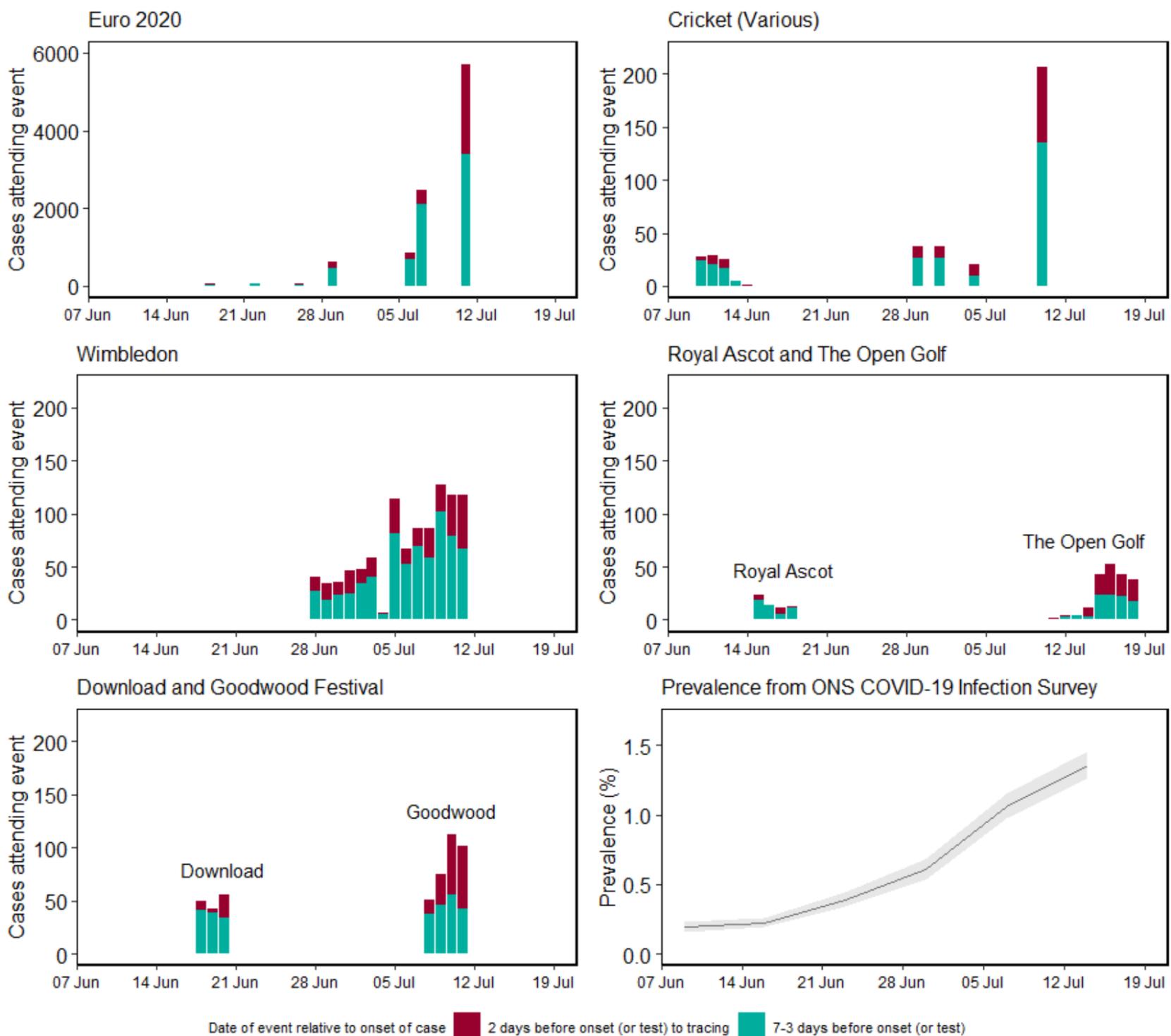


Figure 2. Age and sex of COVID-19 cases reporting attendance at selected ERP sporting or cultural events, 9 June to 19 July

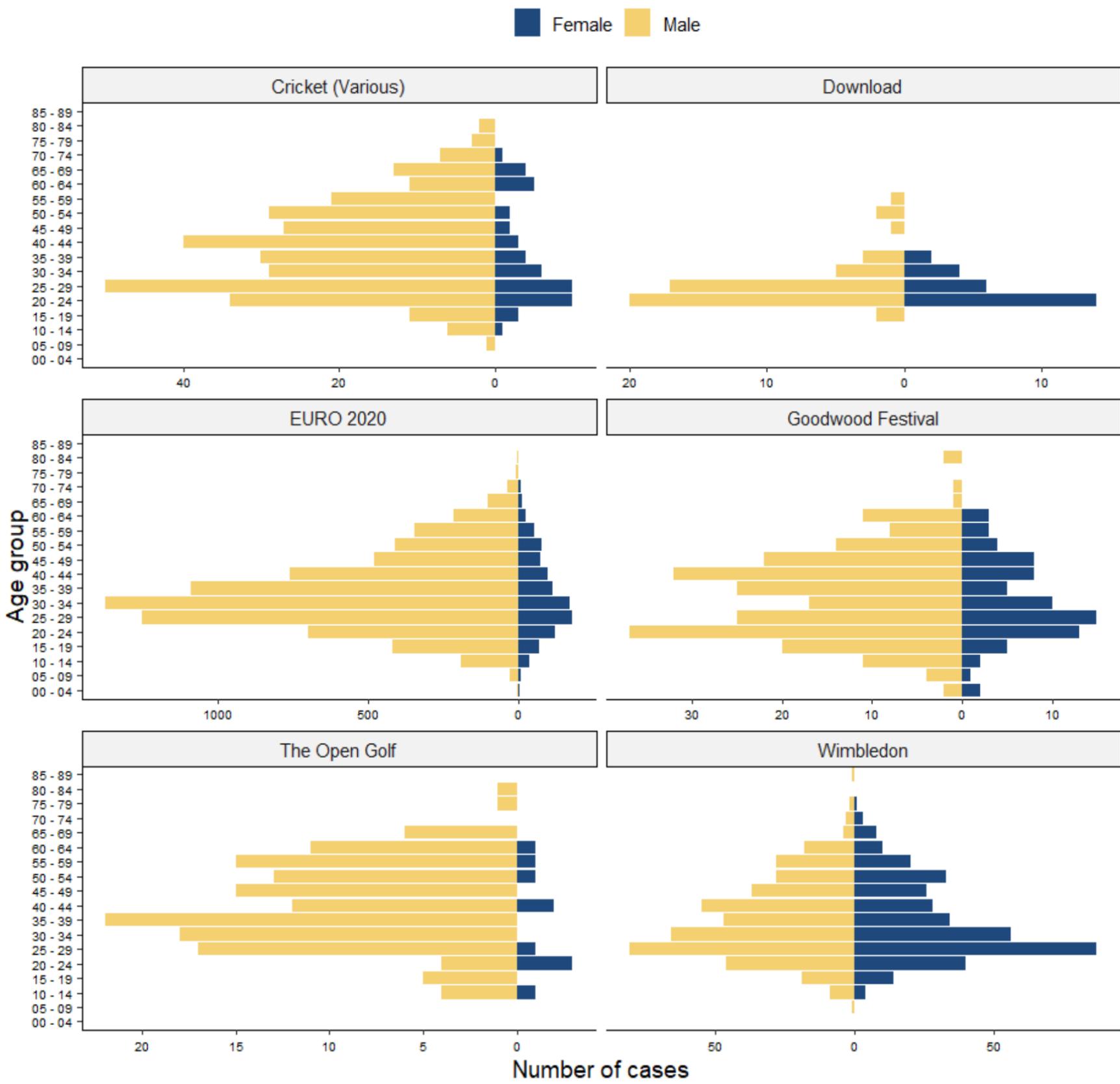


Figure 3. Activities and household visitors reported to NHS Test and Trace by positive cases by date of activity or visit, 9 June to 19 to July

Abbreviations

W = weekend

H = England Euro 2020 game

A = Other Euro 2020 game at Wembley stadium

