EMG – Transmission Subgroup Consensus Statement on SARS-CoV-2 Transmission Risk at Festivals

Purpose of this Paper

This paper provides a short summary of the current knowledge around:

- The risks of transmission of COVID-19 infection at festivals, relative to other activities.
- What mitigations should be considered to reduce transmission risk at festivals.

Headlines

- Attending festivals is associated with an increased risk of COVID-19 transmission. Data from the UK and abroad suggest evidence of increased transmission associated with festivals, relative to indoor seated and unseated events. [medium confidence]
- Festivals are associated with a mixture of known transmission risks – e.g., large numbers of people often in close proximity; crowded public and private transport; audience demographics primarily young adult participants many of whom in summer 2021 had not been vaccinated; difficulties maintaining physical distancing during festival activities. [high confidence]
- Additional factors that may increase transmission risk at festivals include community prevalence community prevalence, ventilation where relevant, event duration, event type and activities. [medium confidence]

Evidence Summary

Caveats and limitations

The evidence summarised in this paper should be interpreted within the context of the COVID-19 situation and the underlying COVID-19 prevalence at any given time. Caution is advised when interpreting results as they may not generalise to other contexts. It should also be noted that a different epidemiological situation may have resulted in different results from the studies conducted, and new variants that are more transmissible and/or less responsive to vaccines than those encountered in our studies could change transmission risk. This paper was drafted prior to the introduction of the new Omicron variant of COVID-19 and so does not cover any information in relation to this variant.

Different events present different contexts of audience characteristics and vaccination coverage, levels of mixing, state of background virus transmission, security, operational and other challenges which impact the research conducted and the generalisability of results. All of these factors must be taken into account when considering the overall conclusions and the policy and public health implications of the programme. The studies undertaken at events were subject to a range of methodological and scientific limitations, and these must be considered when interpreting the findings.

The methodology used in the exploratory analysis (Appendix II) differs from the Self-Controlled Case Series (SCCS) study used for some Phase III ERP events (Appendix I). The exploratory analysis (Appendix II) compared the incidence of positive PCR tests for SARS-CoV-2 in those who reported attending festivals during their contact tracing period to NHS Test and Trace as a proportion of the reported festival attendance count, to the estimated incidence of the general population at the time. For the

SCSS study (Appendix I), data were obtained for a sample of people who both attended a Phase III ERP event and had any SARS-CoV2-2 test result recorded in NHS Test and Trace in the 16 days following attendance at the event. Individuals acted as their own controls, and within-person incidence rate ratios were calculated comparing the rate of positive testing for SARS-CoV-2 during high risk and baseline periods of time. The key difference is that the SCCS study (Appendix I), by using individuals as their own controls, provides a counterfactual based on the actual behaviour of festival goers, rather than comparing them to the general population.

Transmission risk

Festivals are large, highly social, often predominantly open air, events that bring people together for prolonged periods where physical distancing is difficult to maintain and where interacting closely with others (including strangers) is part of the attraction (1). Music festivals have become increasingly popular in recent years with attendance figures reaching 5.2 million in the UK in 2019. In general, festivals tend to preferentially attract young adults with low personal risk of developing severe consequences of COVID-19.

Available evidence shows that attending a festival leads to an increase in COVID-19 risk, even when mitigation measures such as pre-attendance testing are in place (2). NHS Test and Trace data and data from international studies are provided in Appendix II and Appendix III respectively. The Events Research Programme (ERP) was the most comprehensive structured programme of research of audiences returning to mass events conducted to date, and ERP findings are considered in this paper. Findings from the Government's ERP, including a summary of the Self Controlled Case Series study (SCCS), a summary of the Behavioural and Environmental study, and a capping document with an overview of the programme, its key findings and achievements are linked to in Appendix I.

It has not been possible to directly compare this increase in risk from festival attendance to that from attending other more common events such as going to concerts (28.5 million attendances in 2019), pubs, restaurants, work or education. Moreover, risk at mass gatherings is a function not only of attendance itself but also factors such as community prevalence, the proportion of attendees with immune protection, duration of event, social activities, ventilation of the venue and use of public transport beforehand (1; 3; 4). Since festival attendance is relatively rare (as a fraction of total population exposure) when compared to these other activities, festivals are unlikely to make a lasting contribution to overall population transmission at the national level, particularly during periods when these other activities are not curtailed. As festivals bring together large numbers of people from across wide geographical areas it is sensible to consider a range of mitigation measures at, and around these events (5; 6).

Exploratory analysis of UK festival data from the NHS Test and Trace contact tracing database (Appendix II) suggests there is a higher relative incidence of COVID-19 amongst those who attended festivals when compared to the general population in the period following the event. In particular, multi-day events with onsite accommodation/camping may have elevated incidence. However, this is not universal to all festivals analysed, and there were several limitations and caveats to this. The SCCS, which further measures the risk of COVID-19 infection associated with attending Phase III ERP events (Appendix I), found that attendance at the mainly outdoor unseated events studied (Goodwood, Latitude and Tramlines) was associated with a 1.7-fold increased risk of COVID-19 transmission amongst attendees (95% confidence interval between 1.52 and 1.89).

Mitigations

- **Risk Assessment:** The use of a suitable risk assessment framework provides festival organisers with an approach to enable the differential risks from all activities undertaken at the festival to be considered for each route of exposure (air, surface, person-to-person) (7; 8). For example, music festivals in England have been delivered from summer 2021 with risk assessments, in line with UK Government guidance on events and attractions. The majority of these festivals have implemented Covid-status certification The hierarchy of control approach helps to determine the most effective mitigation to use for each activity and each potential exposure route, and where necessary layers of protection can be developed.
- **Vaccine certification**: Although vaccinated individuals are less likely than others to be infectious (9), it is important to recognise that, whilst protection against severe disease is very high, protection against infection is incomplete and that breakthrough infections can still lead to onward transmission. Breakthrough infections in the vaccinated population are less than observed for the unvaccinated population (9). Emerging evidence shows that protection against infection wanes over time (10), the longer the duration since attendees last COVID vaccination, the less indicative vaccination status could be of protection against infection. For these reasons vaccine certification, per se, is likely to have a limited impact on reducing transmission at festivals [Medium confidence] (11). However, it should be noted that the introduction of vaccine certification has been linked to increased vaccine uptake (12) [Medium confidence]. Given higher vaccine complacency in certain groups, such as youth who perceive lower risks of infection, this intervention could be an additional policy lever to increase vaccine uptake and population level immunity (12).
- **Non-pharmaceutical interventions (NPIs)**: Each festival will comprise many opportunities for the virus to be transmitted. For example, queuing for drinks, use of toilets, the performance area, event viewing spaces, indoor spaces such as marquees, and crowding at the entrance and exit. As in all settings, physical distancing is likely to be the most effective way of avoiding transmission (7; 13), but the nature of festivals will make this difficult to achieve. Face coverings can provide source control for transmission from infected individuals but protection is incomplete and, unless wearing of face coverings is mandatory, uptake is likely to be very low given the current patterns of wearing in the UK population (13; 14). Improved messaging around the wearing of face coverings might increase patterns of wearing. Dispersed exit and entry to the events, as well as widely dispersed market stands, could reduce crowding and chances of transmission (6). Managing entry with staggered arrival times could also reduce the risk of transmission.
- **Testing:** In summer 2021, some festivals that included pre-entry screening were associated with transient increases in COVID transmission which resulted in a higher incidence in the local area over the following few weeks (15). This is likely due to a combination of people performing tests incorrectly (this occurs in general population and is not specific to festival attendees), with difficulty in enforcing testing, and limited sensitivity of the tests. The prolonged nature of festivals means that frequent testing is needed to identify incident cases during a festival. Given the limitations of vaccination in preventing transmission, strategies that limit testing to the unvaccinated will also fail to prevent entry of some infectious people. It would also be beneficial to encourage attendees to use LFTs in the days after attending a festival so they could pick up if they had caught COVID-19 at the festival and promptly self-isolate to avoid passing the infection on.

- **Transport to/from/at event**: Shared transport to and from festivals presents a potential setting for transmission. This transmission risk may be reduced through appropriate ventilation and mask use.
- **Contact tracing**: Although people often attend in groups which will facilitate contact tracing, wider social networks at festivals are likely to be complex, which may complicate wider identification of contacts who may have had close contact. It would be desirable to increase the ability to identify people attending an event (rather than ticket purchasers).
- **Hand hygiene**: Regular hand hygiene is likely to play a role in reducing transmission, although less so than ventilation in mass gathering events (4). However, it is important to ensure easy access to hand hygiene materials considering other infections that are transmitted easily through contact route of transmission.
- **Ventilation**: Many festivals are open air which provides natural ventilation, but attention needs to be paid to ensuring adequate ventilation in all settings within a festival, including enclosed tents, toilets, backstage, and other areas. ERP found good quality ventilation, for given occupancy levels, was observed in nearly all of the spaces monitored. It was found that high crowding can be maintained without significant negative impact on air quality, in settings which have very high levels of natural ventilation. Risk is increased with prolonged and repeated exposure to poor air quality, insufficient ventilation, reduced distancing between individuals or limited compliance with face covering. This may particularly impact staff at events and additional mitigations should be considered for staff. Event organisers should consider their ventilation strategy, occupancy, operations, space utilisation, and people movement outcomes within an overall risk assessment tailored to each setting within a festival (16).
- **Education**: Those who are clinically vulnerable need to know that festivals pose an increased risk of acquiring COVID-19 so they can make informed decisions about whether to attend and consider mitigation measures if they do. Festival goers need to be aware of the higher risk of transmission and the risk this poses to vulnerable contacts outside of the festival, and similar advice applies to other mass gathering events. Measures such as avoiding contact with vulnerable people for 10 days after the festival, accompanied by testing before visiting vulnerable people, can reduce this risk.
- **Communication strategy**: For whichever measures are implemented (E.g., Face coverings, hand hygiene, testing, contact tracing) a communication strategy is required that engages festivalgoers in the mitigation plan (1), including the following elements:
    1. Communicate rationale and sufficient practical information;
    2. Draw upon knowledge of festival goers' shared identities to promote and reinforce protective behaviours as group norms; and
    3. Co-production of a plan of mitigation measures with festivalgoers.

References

1. *Re-opening live events and large venues after Covid-19 'lockdown': Behavioural risks and their mitigations.* **Drury, J, et al.** 2021, Safety Science, Vol. 139, p. 105243.

2. **DCMS.** Science Note - A self-controlled case series study to measure the risk of SARS-CoV-2 infection associated with attendance at an Events Research Programme event. 2021.

3. *Predicting COVID-19 Transmission to Inform the Management of Mass Events: a model-based approach.* **Donnat, C, et al.** 2021, JMIR Public Health and Surveillance.

4. *The risk of indoor sports and culture events for the transmission of covid-19 (restart-19).* **Mortiz, S, et al.** 2020, medRxiv.

5. *Conducting mass gathering events during the COVID-19 pandemic: A case study of Kumbh Mela 2021 as a potential 'super spreader event'.* **Shuklaa, S, et al.** 2021, J Travel Med.

6. *Living with COVID-19: mass gatherings and minimizing risk.* **Murakami, M, et al.** 7, 2021, QJM: An International Journal of Medicine, Vol. 114, pp. 437-439.

7. **EMG/SPI-M/SPI-B.** EMG, SPI-M and SPI-B: Considerations in implementing long-term 'baseline' NPIs, 22 April 2021. 2021.

8. **HSE.** Risk assessment during the coronavirus (COVID-19) pandemic. 2021.

9. *The impact of SARS-CoV-2 vaccination on Alpha and Delta variant transmission.* **Eyre, D W, et al.** 2021, medRxiv.

10. **SAGE.** SAGE 95 minutes: Coronavirus (COVID-19) response, 9 September 2021. 2021.

11. **SPI-B/SPI-M/EMG.** Considerations for potential impact of Plan B measures, 13 October 2021. 2021.

12. *The impact of mandatory COVID-19 certificates on vaccine uptake: Synthetic Control Modelling of Six Countries.* **Mills, Melinda C and Rüttenauer, Tobias.** 2021, medRxiv.

13. **EMG.** Application of physical distancing and fabric face coverings in mitigating the B117 variant SARS-CoV-2 virus in public, workplace and community. 2021.

14. **ONS.** Coronavirus (COVID-19) latest insights: Lifestyle. 2021.

15. **JUNIPER.** *COVID-19 regional variation: Large events.* s.l. : Unpublished, 2021.

16. **DCMS.** Science Note - Emerging findings from studies of indicators of SARS-CoV-2 transmission risk at the Events Research Programme: environment, crowd densities and attendee behaviour. 2021.

17. *Safe management of full-capacity live/mass events in COVID-19 will require mathematical, epidemiological and economic modelling.* **Harris, M, et al.** 2021, Journal of the Royal Society of Medicine.

Appendix I: The Events Research Programme

Findings from Phases II and III of the government's Events Research Programme (ERP) can be found at: https://www.gov.uk/government/publications/events-research-programme-phase-ii-and-iii-findings

This webpage includes links to:

- a summary of the Self Controlled Case Series study;
- a summary of the Behavioural and Environmental study; and
- a capping document with an overview of the programme, its key findings and achievements.

The overview of the Events Research Programme and key Phases II and III findings as taken from the capping document linked above:

1.1 Objectives of the ERP

The Events Research Programme (ERP) was the most comprehensive structured programme of research of audiences returning to mass events conducted to date. The objectives of the ERP were to build evidence on the risks associated with events-related transmission routes of the COVID-19 virus; characteristics of events and surrounding activities; and the extent to which risk mitigation measures could be effectively implemented and address these risks.

The UK government's roadmap out of lockdown, published in February 2021, committed to exploring how large-scale events could return safely with reduced or no social distancing from Step 4 onwards, accounting for the variable levels of risk at different events, as identified by the Scientific Advisory Group for Emergencies (SAGE). As part of that, the ERP was established to deliver this work, conducting pilot events across different settings and sectors to aid understanding and inform approaches to reduce transmission risks.

1.2 Structure of the ERP

Phases I, II and III

The ERP consisted of three phases. Phase I ran from 17th April to 15th May 2021, and consisted of nine pilot events, some running across multiple days, in a variety of indoor and outdoor settings, with variations of seated, standing, structured and unstructured audience styles, cultural and sport activities, proportion of occupied venue capacity and a range of participant numbers. The pilot selection was based on event settings that would provide data and transferable learning that could be generalised across many settings. The findings from Phase I were published on 25th June and can be found here.

Phases II and III of the ERP were designed to build on the findings from Phase I and ran from 10 June to 25 July 2021. These pilot events provided the opportunity to generate further evidence, particularly around transmission risk as well as around the implementation and operational considerations of the findings from Phase I. Additionally, there was a particular focus on testing the NHS COVID Pass, and other certification of test results and vaccination status in real world settings. Phases II and III also aimed to further develop the scientific and analytical approaches from Phase I and to provide additional data that could be pooled across different events to increase statistical power to the evidence already generated.

See the full list of pilot events from Phases I-III.

Science framework

The programme design drew upon a science framework for studying events that was developed by a working group led by the Scientific Advisory Group for Emergencies (SAGE) sub-group, the Environmental Modelling Group (SAGE-EMG). Researchers collected large amounts of data as parts of published protocols before, during, and after these events, including environmental data through high-resolution monitoring, observational and self-reported data on behaviour, testing and wider public health data.

The programme was overseen by an independently-chaired Science Board, led by Dame Theresa Marteau, and with representation from departmental Chief Scientific Advisers and with other leading government and independent experts (see Science Board membership). See also the Science Board Statement, conflicts of interest, and protocols for the studies.

Specific provisions of the Health Protection (Coronavirus, Restrictions) (Steps) (England) Regulations enabled the Secretary of States for DCMS and DHSC, considering advice from the Chief Medical Officer or Deputy Chief Medical Officer, to disapply restrictions or requirements contained in a number of different Coronavirus regulations to allow these events to take place during a period of restrictions.

1.3 Scope

The ERP began during Step 2 of the government's Roadmap, when large events were still prohibited and interventions to contain COVID transmission in place. The ERP was the largest science-based programme in the UK, outside of clinical trials, to inform innovative policy and its implementation during the COVID-19 pandemic. Between April and July, a total of 31 pilot events were conducted in England across a range of settings and sectors, with over two million participants involved in an ERP event, in a comprehensive programme not attempted previously. It allowed for new levels of scientific research into mass events, and a number of firsts, including bringing audiences back to 100% capacity in some events, hosting the first nightclub event in the UK and music festival in the Northern Hemisphere since the beginning of the pandemic, and facilitating what was at that point in time the largest gathering of spectators with pre-event testing anywhere in the world.

Events included the FA Cup Final, the BRIT Awards, the British Formula 1 Grand Prix, The Wimbledon Tennis Championships, UEFA EURO 2020, Latitude Festival, theatrical performances and nightclub events. The UK was among the first to pilot such events, and at such a scale to help shape the route back to events with audiences fully reopening.

The ERP has advanced the understanding of the risk of transmission of COVID-19 at large events, and has explored how to mitigate against this. Internationally, the programme has generated the most extensive evidence base to inform the running of events to minimise the risk of transmission. The programme used a collaborative approach involving leading university research teams, a crowd dynamics consultancy, independent scientific and ethics advisers working in partnership with 8 government departments and agencies, national and local public health leads, events industry stakeholders and 27 local authorities. The ERP gave the opportunity to evaluate on the basis of 'real life', albeit within the context of a global pandemic.

The novel combination of environmental and behavioural research was carried out to assess and mitigate the risk of transmission. This included the installation of over 750 temporary cameras capturing over 9300 hours of video footage with over 275,000 individual data points extracted, alongside the monitoring of 179 individual spaces using 370 CO2 monitors, which logged data every

two minutes. The self controlled case series method, is an existing epidemiological study design, however was innovatively applied within the ERP to measure the risk of transmission associated with attending an event. See Section 2.2 for limitations of these studies.

The programme also piloted the use of the NHS App to evidence COVID status at large events explored the operational challenges of delivering events in a more COVID secure manner. This work supported the development of government guidance and its COVID-19 policy for the reopening of events and attractions.

1.4 Link to previous publications

Findings from Phase I of the programme.

The ERP Reporting Dashboard, which captures detailed management information from all ERP events from Phases I-III, includes a breakdown of NHS Test and Trace data associated with ERP events. As stated, this NHS Test and Trace data cannot be directly attributed to transmission occurring at a specific ERP event or venue itself, but can inform the impact on population health of staging events.

2.1. Purpose

Phases II and III of the ERP set out to build on findings from Phase I. As per this Science Board statement, Phase II was implemented with the primary research aim of resolving the question: what is the impact on risk of transmission of events held at full capacity, without social distancing, with entry conditional upon pre-event negative lateral flow test (LFT) results? The primary research question for Phase III was: What is the impact on risk of transmission of events held indoors or outdoors at or close to full capacity, without social distancing? The later phases of the programme also allowed further exploration of the logistics of running events (including testing the NHS COVID Pass) and the implementation of mitigation measures to reduce risk.

2.1. Limitations and interpretation

The ERP focused on the measures that might help the safe return of large events and closed settings. As set out in the ERP's Terms of Reference, the programme was not responsible for advising on the timing of progression through the steps of the roadmap. This progression was decided by Ministers as part of the overall approach to reopening.

Findings from the ERP should be interpreted within the context of the COVID-19 situation and the underlying COVID-19 prevalence at any given time. Caution is advised when interpreting results as they may not generalise to other contexts. Phases II and III of the ERP were set against a background of rising infection rates driven by the Delta variant (B.1.617.2), plus an increasingly vaccinated population, and results should be considered through this lens. It should also be noted that a different epidemiological situation may have resulted in different results from the studies conducted, and it is possible that we see new variants arise that are more transmissible and possibly less responsive to vaccines than those encountered in our studies, which could change transmission risk. Different events present different contexts of audience characteristics and vaccination coverage, levels of mixing, state of background virus transmission, security, operational and other challenges which impact the research conducted and the generalisability of results. All of these factors must be taken into account when considering the overall conclusions and the policy and public health implications of the programme. The overall transmission risk from attending an event also includes potential exposures outside the venue, including travel to and from the event and any associated activities (e.g., visits individuals make to bars and restaurants). The self-controlled case

series study does incorporate this end-to-end transmission risk however it is not in the scope of the environmental and behavioural study, which considers risk within the event venue.

The studies undertaken at events were subject to a range of methodological and scientific limitations, and these must be considered when interpreting the findings. These are described in detail in the protocols published on gov.uk and evidence likely generated by the programme summarised in the Science Board statements. Results presented here should be read in conjunction with the documented limitations. Similarly, the results for the environmental and self controlled case study should be interpreted in the context of the limitations described in the science notes.

2.3. Findings - Environmental and Behavioural studies

The Environmental and Behavioural studies were used to further understand transmission risk at ERP events as a result of environment, crowd densities and attendee behaviour, as detailed in the published research protocols. See also the full Science Note.

The studies investigated factors associated with risk of transmission of COVID-19 at events using high resolution monitoring, both distributed throughout each venue and following individual attendee journeys. Data collected during the studies included, among others, CO2 measurements, airflows, occupancy levels, crowd density estimates and adherence with mitigations (e.g., face coverings, crowd movement) across a wide range of events.

The studies demonstrate that environmental and behavioural risk factors associated with COVID-19 transmission at events are complex and contextual. The studies assessed air quality by measuring CO2 across 179 spaces in ten venues, as CO2 is mainly present in exhaled breath and can identify spaces with poor air quality from overcrowding or insufficient ventilation. Poor air quality in events with multiple occupants indicates a higher airborne transmission risk. The studies observed good air quality, for the given occupancy levels, in nearly all venues, however there were situations leading to poor air quality in some spaces: mostly due to pockets of overcrowding but occasionally due to ventilations strategies needing improvement. Key measures of average and maximum CO2 levels and peak crowd densities varied significantly between different events and during them. The maximum recorded CO_2 values were below 1500 ppm in 161 of the spaces monitored, and where they were higher this usually did not persist for longer than 1-2 hours. The average CO_2 levels during an entire event were below 800 ppm in 170 out of 179 monitored spaces.

Air quality studies were complemented by studies focusing on attendee behaviour during the event. Studies showed that increasing the number of people in a given space reduces the ability to physically distance and increases the risk of close contact with others. Adherence to safety measures including physical distancing and face covering usage were higher at events or locations within an event where they were required rather than discretionary.

Individual risk while attending an event is dependent on social interactions, on the interaction with the environment, and on the individual journey through an event. It is not yet possible to directly quantify the passive risk of inhaling aerosol particles that carry the virus from ambient air. However, risk is increased with prolonged and repeated exposure to poor air quality, insufficient ventilation, reduced distancing between individuals or limited compliance with face covering. It was found to vary significantly among venues and even within the same event, implying that customers can choose lower risk environments and behaviours to reduce their personal risk. Risk assessments and possibly additional mitigations should be considered separately for staff.

Analysis of the data from ERP continues and further investigation of key risk factors will be used for further modelling and to inform policy guidance. Venues and event organisers should consider their ventilation strategy, occupancy, operations, space utilisation, and people movement within an overall risk assessment tailored to each venue. Appropriate mitigations, such as an enhanced ventilation strategy, must be part of a hierarchy of controls including face coverings and reducing crowding.

2.4. Findings - Self Controlled Case Series study

The Self-Controlled Case Series study was used to further measure the risk of COVID-19 infection associated with attending Phase III ERP events held at or close to full capacity without social distancing, as detailed in the published research protocol. See also the full Science Note.

In a self-controlled case series each person acts as their own control. Data were obtained for a sample of people who both attended a Phase III ERP event, and had any COVID-19 test result recorded in NHS Test and Trace in the 16 days following attendance at the event. The proportion of attendees for whom attendance data were available varied from approximately 3% at some events to greater than 90% at others. The rate of positive testing for COVID-19 was compared within person, between a 7-day high risk period following attendance at an event with the subsequent 7-day period when infection risk is assumed to be unaffected by attendance at the event. The rate for negative testing was also calculated to determine any bias in testing trends over the observation period.

Approximately 1.7% of attendees, for whom data were available, tested positive for COVID-19 during their 16-day study period. The results tend to show that there was little evidence of increased transmission by attendance at the following categories of events: mainly outdoor seated, mainly outdoor partially seated or the indoor seated theatre events studied. Caution is needed when interpreting these findings. For example, some theatre events were run at or below 50% of normal full capacity and involved low numbers of attendees meaning we were unable to rule out a potentially important increased risk of transmission. Bearing in mind the findings of the environmental and behavioural studies these results may not generalise to other contexts where venue characteristics and individual/crowd behaviour may be different.

Attendance at the mainly outdoor unseated events studied (Goodwood, Latitude and Tramlines) was associated with a 1.7-fold increased risk of COVID-19 transmission amongst attendees (95% confidence interval between 1.52 and 1.89). For context, the risk of infection in the baseline period was ~0.9% for Latitude attendees in the study; a 70% increase would take this risk to 1.53%. This confidence interval means the estimate of 70% is robust due to the large number of attendees (over 2000) at these events. Reasons for this difference in transmission risk are likely to be multifactorial and could include behaviour whilst at the event, overall event size and duration or mode of travel to and from the event. It should also be noted that these results are set against the background of a particular epidemiological situation, and the possibility remains that new variants arise that are more transmissible and possibly less responsive to vaccines than those encountered in our studies, which would change transmission risk.

Across all events, where attendee COVID-19 vaccination status was self-reported, 87% of people with a positive COVID-19 test result during the study period were unvaccinated

2.5 NHS App trial and COVID-status Certification Learnings

COVID-status certification was piloted in all three phases of the ERP, with Phase I using testing protocols only (demonstration of a negative lateral flow test). The NHS COVID Pass was introduced for the EUROs games in Phase II as a means for certification, alongside using a vaccination letter ordered from 119 or nhs.uk to verify COVID status, and this method was used for all Phase III events (as per this work statement). In Phase II (EUROs only) and III individuals were required to show proof of:

- a negative test (lateral flow) taken within 24-72 hours of entry to a venue (in Phase III it was 48 hours)
- vaccination (two doses of a U.K. approved vaccine plus two weeks); or
- natural immunity from a prior positive PCR test (up to 180 days post PCR test)

The above protocols are consistent with voluntary certification, which is currently available for use by organisations via the NHS COVID Pass (accessible via the NHS App and NHS.UK and letter via NHS.UK or by calling 119) for organisations in England to use to help limit the risk of transmission in their venues and events.

The government has set out that if data suggests that further measures are necessary to protect the NHS, 'Plan B' could be enacted, in which mandatory vaccine only certification would be introduced in certain settings (as per the policy paper published here, which sets out the rationale for vaccine only certification, and the proposal for how it would be implemented in Plan B).

Testing of the NHS COVID Pass generated insights on user journey and communications, as well as testing infrastructure, experience of organisers and operational delivery at venues. Insights from the wider testing of certification through the ERP have informed the proposal for mandatory vaccine certification in a Plan B scenario, as set out in the policy paper.

These pilots found compliance with certification protocols improved with clearer and more consistent communications, which aided the avoidance of confusion. They demonstrated the importance of having properly trained stewards who are equipped to rapidly and accurately verify COVID status, in order to minimise queuing and associated safety and security concerns, and the findings from the ERP have been used to inform the government's plans for mandatory certification in 'Plan B'.

Appendix II: Exploratory analysis of NHS Test and Trace data of UK festival attendance

Exploratory analysis of UK festival data

Several UK festivals were selected for exploratory analysis using NHS Test and Trace contact tracing system database. The festivals included a number enrolled in the Events Research Programme (ERP)[1]. Additional festivals were selected to reflect a range of different factors of interest – number of attendees, type of location (e.g., city-based; festival site), age-range of target audience, and duration of event including those with overnight accommodation at the festival.

Cases were identified as those who had a PCR positive test for COVID-19 and reported attending the festival during their contact tracing period to NHS Test and Trace. Cases were associated with specific events using date, geographical and activity filters to match them to the selected festivals. These filter definitions were reviewed to ensure cases were attributed to the correct festival, and not to events or festivals occurring at the same location immediately before or after the festival of interest.

Attendance events were categorised as either **backward** or **forward events**: backward events occurred in the 7 to 3 days preceding symptom onset (or date of test), representing the period cases most likely to have acquired their infection; forward events occurred in the 2 days preceding symptoms onset/date of test, to the date of contact by NHS Test and Trace, representing the period where a case could have infected others.

The same methodology for case selection as the ERP[2] was used, with two minor alterations. Camping events reported during the case's backwards (acquisition) period were additionally included, and days before or after the festival (when attendees or staff may have arrived early or left late) were excluded from the case date filter, with only official festival dates selected for case ascertainment. This was to allow an accurate comparison with the general population incidence, to calculate a relative risk incidence (method described below).

Case incidences at the festivals were calculated using estimated unique attendee figures, either from the ERP dashboard or collated from event organisers via the Department for Digital, Culture, Media and Sport (DCMS). Event organisers were asked for attendance figures derived from their data sources which most accurately reflected the number of unique individual attendees at their events. Event organisers may have used different data sources (e.g., ticket sales; other attendance estimates). To provide a relative risk incidence, the incidence in the general population was estimated using the Coronavirus (COVID-19) Office for National Statistics (ONS) Infection Survey[3]. This survey provides estimated incidence per 10,000 population per day over a particular date range. As this was a daily incidence, this was multiplied by the number of event days to provide a comparative incidence rate to the festivals. Days before and after the official festival dates were not included – the number of cases on these dates were a small percentage of the overall case numbers, likely due to relatively small attendance pre/post-festival. To include these cases would require a corresponding increase of the comparator ONS general population incidence by a day or two, representing a significant increase (e.g., from 2 days to 3, the ONS incidence would be 50% larger). This would bias the relevant ratio significantly, therefore the camping-only dates were excluded from case ascertainment and relative incidence calculation. This allowed the case rate to be as comparable as possible.

The incidence rate for cases reporting festival attendance during their backwards contact tracing period reflects cases who are likely to have acquired their infection during the days which the

festival occurred. The ONS date range selected for the comparative baseline incidence rate was 4 days after the festival date range. This is so that both populations (event cases, and ONS estimated cases) will have had their acquisition period during the same period. The ONS incidence within the date range for the duration of the festival of interest was used to compare incidence with cases reporting festival attendance during their forwards contact tracing period.

Relative incidence ratios

Exploratory analysis suggests there may be a higher relative incidence of COVID-19 amongst those who attended festivals during their acquisition period compared to the general population (Table 1). In particular, multi-day events with onsite accommodation/camping may have higher incidence. However, this was not consistent through all selected festivals, and there were several caveats to the analysis.

Relative incidence of COVID-19 cases who were in their infectious period whilst attending the festivals appear to be greater in some of the festivals of interest compared to the general population (Table 2). A similar pattern of higher relative incidence in multi-day events with on-site accommodation is present. This suggests festival attendees were more likely to be in an infectious period compared to the general population, and so potentially increase the general risk of transmission at festivals**.** Some of the festivals which have higher rates of cases during their forward contact tracing (infectious) period compared to the general population also have higher rates of cases compared to the general population during their backward contact tracing (acquisition) period. However, the same caveats and limitations in data are present and no causal link is implied.

Caveats

Some people infected with COVID-19 may not seek testing, if tested may not engage with contact tracing, and may not report their festival attendance. Therefore, incidence at festival events is expected to be underestimated and the degree of underestimation may vary between festivals.

The estimated number of unique attendees have been collated via event organisers, using the most applicable data available. Nevertheless, these may still represent best estimated figures due to the data limitations (e.g., ticket sale rather than confirmed attendance), and therefore may cause incorrect estimates of incidence at events.

Case search criteria were developed to ensure specificity for the festival of interest, but also sufficient sensitivity to include cases with varied descriptions for their backwards/forwards event which were very likely to be the festival of interest. This was reviewed with information from event organisers via DCMS, and assessed with sample case-level validation and review. For some festivals of interest, particularly those with closely linked ‘fringe’ events, or those occurring within a town or city rather than a dedicated site, this may mean some cases were included who may have not directly attended the festival of interest.

All the events which took place in August encouraged attendees to test after the event and, therefore, more cases may have been picked up as a result of increased post-event testing.

Self-reported festival attendance during the backwards (acquisition) contact tracing period does not necessarily indicate disease transmission for the case occurred at the festival. Cases reported through the NHS Test and Trace system cannot be directly attributed to a specific event. While it is possible that transmission happened while the individual was at or near an event, the transmission location cannot be concluded from these data. Transmission could have occurred in or outside the

event, for example on public transport or shared private transport to the event, within a household, or in a place unrelated to an event.

There may be confounding population differences between the ONS incidences and event attendees which have not been adjusted for – including age, location of residence, ethnicity, socioeconomic status, vaccine status.

[1] https://www.gov.uk/government/publications/information-on-the-events-research-programme
[2] ERP Reporting Dashboard explainer - GOV.UK (www.gov.uk)
[3]https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/datasets/coronaviruscovid19infectionsurveydata

Table 1 Incidence for cases reporting attendance at festivals during their backward contact tracing period, compared to estimated national incidence

Event characteristics				Event incidence	National incidence	Comparison (relative risk)	
	Size of event[1]	**Onsite accommodation?**	**Month (2021)**	**Incidence per 10,000 event population**	**ONS incidence rate for event period per 10,000 population**	**Relative incidence ratio**	**95% confidence interval**
A	Small	Yes	June	62.9	15.6	**4.03**	*3.15 - 5.15*
B	Small	Yes	July	48.3	54.8	0.88	*0.76 - 1.03*
C	Large	Yes	July	244.0	39.3	**6.21**	*5.83 - 6.61*
D	Large	Yes	July	211.3	29.5	**7.17**	*6.70 - 7.68*
E	Large	No	August	15.3	41.2	0.37	*0.32 - 0.43*
F	Small	Yes	August	35.7	20.6	**1.73**	*1.46 - 2.06*
G	Small	No	August	4.0	10.3	0.39	*0.17 - 0.87*
H	Large	No	August	59.3	41.2	**1.44**	*1.27 - 1.63*
I	Large	Yes	August	227.1	41.2	**5.52**	*5.33 - 5.72*

[1]Number of unique attendees – small (≤38,000); large (38,000+).

All festivals analysed were multi-day events except event G, which was a single day festival.

Table 2 Incidence of cases reporting attendance at festivals during their forward contact tracing period, compared to estimated national incidence

Event characteristics				Event incidence	National incidence	Comparison (relative risk)	
	Size of event[1]	**Onsite accommodation?**	**Month (2021)**	**Incidence per 10,000 event population**	**ONS incidence rate for event duration per 10,000 population**	**Relative incidence ratio**	**95% confidence interval**
A	Small	Yes	June	32.4	9.2	**3.54**	*2.52 - 4.98*
B	Small	Yes	July	44.3	46.3	0.96	*0.82 - 1.12*
C	Large	Yes	July	108.3	47.9	**2.26**	*2.06 - 2.48*
D	Large	Yes	July	172.9	35.9	**4.81**	*4.47 - 5.19*
E	Large	No	August	12.1	44.8	0.27	*0.23 - 0.32*
F	Small	Yes	August	7.7	22.4	0.34	*0.24 - 0.50*
G	Small	No	August	4.7	11.2	0.42	*0.20 - 0.87*
H	Large	No	August	50.0	44.8	1.12	*0.97 - 1.28*
I	Large	Yes	August	187.3	44.8	**4.18**	*4.02 - 4.35*

[1]Number of unique attendees – small (≤38,000); large (38,000+).

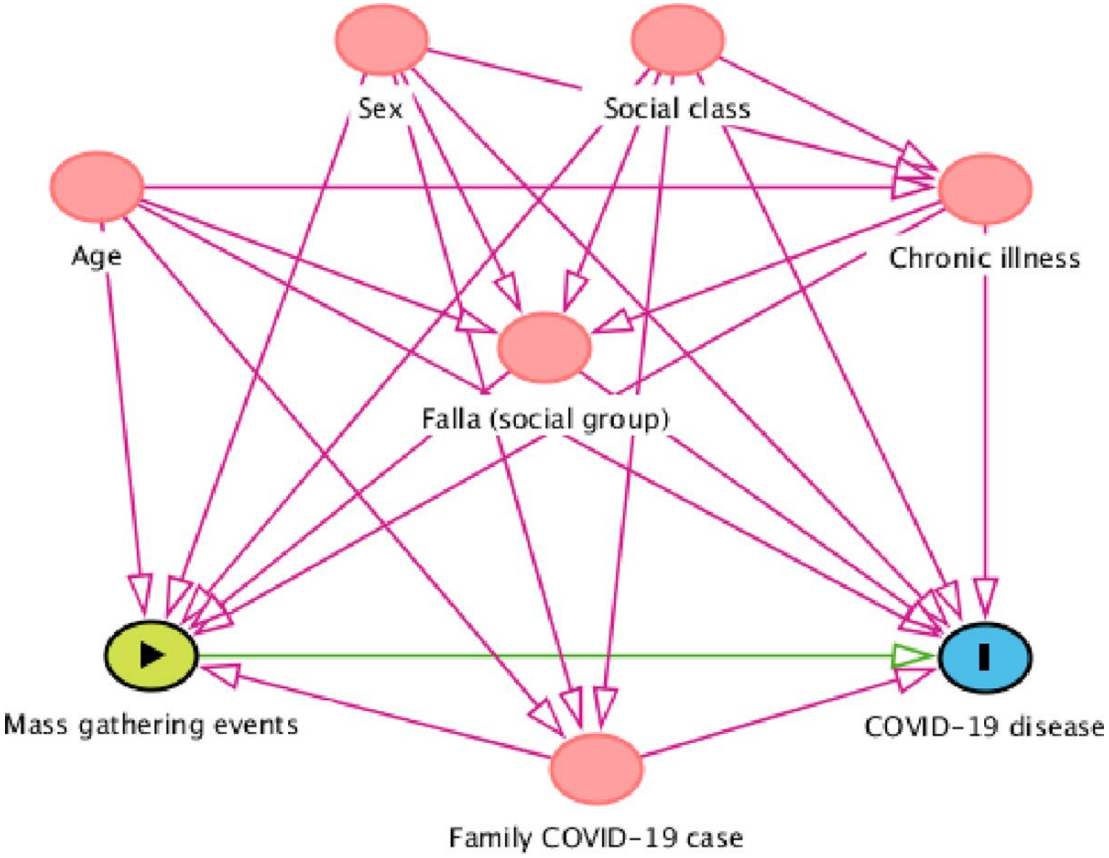
Appendix III: International evidence

We undertook a literature review using the Living Evidence on COVID-19, a database collecting COVID-19 related published articles from Pubmed and EMBASE and preprints from medRxiv and bioRxiv. Articles containing the words ((festival*) OR (mass gathering event) in the Title/Abstract published before 23 October 2021 examined for relevance. From 135 potentially relevant articles screened, we included 5 papers that included outbreak investigation or risk of infection during festivals.

1. **"Mass gathering events and COVID-19 transmission in Borriana (Spain): A retrospective cohort study" (Spain)**[1]

This was a population-based retrospective cohort study was carried out from May 14 to June 31, 2020 in Borriana, Spain. Participation in the Falles festival was extensive, since the population of Borriana, both adults and children, took part in many cultural, touristic, leisure, and dinner events, and many MGEs were held in February and March 2020. These MGEs may be considered as super-spreading events.

Those who had a family member with COVID-19 had a higher risk of SARS-CoV-2 infection (aRR = 1.71 95% CI 1.49–1.97). Additionally, the risk of contracting COVID-19 increased with higher body mass index (BMI), up to the group of 30 Kg/m2 or higher (aRR = 3.21 95% CI 1.29–7.98), and marginally with habitual alcoholic beverage consumption (aRR = 1.14 95% CI 0.99–1.32). DAGs were used to study potential confounders.



[1] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0256747

2. **COVID-19 Transmission due to Mass Mobility Before and After the Largest Festival in Bangladesh: An Epidemiologic Study (Bangladesh)[2]**

To explore the influence of one of the biggest festivals (Eid-ul-Adha) on the trend of COVID-19 infection, we analysed data from a week before the festival to 2 weeks following the festival. The infection rate (positive cases per million of the population) and the test positivity rate (positive cases among the total number of conducted diagnostic tests) of each day during this period were calculated both for the Mymensingh region and national level. Both the test positivity rate (TPR) and infection rates in the Mymensingh region demonstrated an increasing trend. The mean test positivity rate of the Mymensingh region on the week before the festival was 9.5%. It increased to a mean test positivity rate of 13% in the following week and further rose to a rate of 17% in the next week

3. **Conducting mass gathering events during the COVID-19 pandemic: A case study of Kumbh Mela 2021 as a potential 'super spreader event' (India)[3]**

The Kumbh Mela-2021 emerged as a potential super spreader event with an increase from 37 cases per day to 144 cases per day (276%) in the COVID-19 cases in Haridwar. An increase from 138 to 480 cases per day (236%) and from 45 600 to 92 754 cases per day (92%) was noted in Uttarakhand and India

4. **Mass gathering events and undetected transmission of SARS-CoV-2 in vulnerable populations leading to an outbreak with high case fatality ratio in the district of Tirschenreuth, Germany[4]**

We found that returning ski-travellers from Austria and Italy and early undetected community transmission likely initiated the outbreak which was then accelerated by Bavarian beer festivities.

5. **Why crowding matters in the time of COVID-19 pandemic? - a lesson from the carnival effect on the 2017/2018 influenza epidemic in the Netherlands[5]**

The increase of new cases for COVID-19 in the carnival region exceeded that in the non-carnival region about 1 week after the first case was reported, but these results warrant caution as for COVID-19 there were no cases reported before the carnival and social measures were introduced shortly after carnival.

[2] https://journals.sagepub.com/doi/10.1177/00469580211023464

[3] https://pubmed.ncbi.nlm.nih.gov/34609481/

[4] https://pubmed.ncbi.nlm.nih.gov/33046173/

[5] https://pubmed.ncbi.nlm.nih.gov/33023561/