BMJ Open

COVID-safe behaviour before, during and after a youth mass gathering event: a longitudinal cohort study

Joanne A Rathbone [1], Mark Stevens [1], Tegan Cruwys [1], Laura J Ferris [2]

To cite: Rathbone JA, Stevens M, Cruwys T, *et al*. COVID-safe behaviour before, during and after a youth mass gathering event: a longitudinal cohort study. *BMJ Open* 2022;**12**:e058239. doi:10.1136/bmjopen-2021-058239

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-058239).

Received 11 October 2021
Accepted 24 June 2022

[1]Research School of Psychology, Australian National University, Canberra, Australian Capital Territory, Australia
[2]School of Business, The University of Queensland, Saint Lucia, Queensland, Australia

Correspondence to
Dr Joanne A Rathbone; joanne.rathbone@anu.edu.au

ABSTRACT

Objective As mass gathering events resume in the wake of the COVID-19 pandemic, there is a pressing need to understand (a) engagement in COVID-safe behaviour at these events and (b) how attending a mass gathering impacts subsequent behaviours. This study examined anticipated COVID-safe behaviour before, during, and after a youth mass gathering event.

Design Longitudinal cohort study.

Setting Self-report data were collected online at five timepoints from secondary-school graduates participating in celebrations linked to an annual week-long youth mass gathering event in Australia.

Participants Australian secondary-school graduates completed surveys before the event (N=397), on days 1 (N=183), 3 (N=158) and 5 (N=163) of the event, and 3 weeks after the event (N=140). Of those who completed the first survey, 72 indicated they would attend a primary mass gathering site where the largest mass gathering of graduates in Australia occurs in a typical (non-pandemic) year; 325 indicated they would be celebrating at other locations (ie, secondary sites).

Primary outcome measures Anticipated COVID-safe behaviour: physical distancing from friends and strangers and additional protective behaviours (hand hygiene and mask wearing).

Results At all timepoints, participants anticipated maintaining appropriate (>1.5 m) physical distance from strangers, but not from friends (<0.5 m). Attendees at the primary site reported less physical distancing from friends over time throughout the mass gathering, $\chi^2(4)=16.89$, $p=0.002$. Physical distancing from strangers, $\chi^2(4)=26.93$, $p<0.001$, and additional protective behaviours, $\chi^2(4)=221.23$, $p<0.001$, also declined across the mass gathering among both groups. These reductions in COVID-safe behaviour were significant and enduring, with all declines persisting at follow-up.

Conclusion It is critical that public health messaging and interventions emphasise the risks of disease transmission arising from other attendees who are known to us during mass gathering events, and that such messaging is sustained during and following the event to combat reductions in COVID-safe behaviour.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is the first study to examine COVID-safe behaviour before, during and after a mass gathering event during the COVID-19 pandemic.
⇒ This study used a longitudinal design and examined COVID-safe behaviour in situ.
⇒ This study measured anticipated rather than recalled COVID-safe behaviour, which mitigates recall bias.
⇒ This study did not include observational measures of COVID-safe behaviour.
⇒ This study used self-report measures that were not prevalidated.

As vaccination rates rise and countries begin to return to 'normal' in a post-COVID world, mass gathering events have resumed. This return of mass gatherings (ie, 'large numbers of people attending an event at a specific site for a finite time')[1] has been welcomed both because of the economic benefits they confer, and because they can boost the physical and psychological health of attendees—benefits that can persist even after the event has ended.[2–4] However, mass gatherings also pose substantial public health risks, not least because they provide a fertile environment for the transmission of contagious diseases like COVID-19.[1] In the coming months and years, COVID-safe behaviour at mass gatherings (eg, physical distancing, hand hygiene and face mask wearing) will be critical in mitigating the risks that these events pose—particularly as new variants emerge that may present new public health challenges.[5 6] Understanding patterns in COVID-safe behaviour during mass gatherings, and the consequences of attending such events for people's postevent behaviours, is, therefore, vital for the development of appropriate public health strategies.

The consequences that result when mass gathering attendees fail *en masse* to engage in COVID-safe behaviours were recently demonstrated by data collected during the European Championship football tournament (held between June and July 2021). Throughout the tournament, face masks were mandatory within stadiums (except

when spectators were seated) and physical distancing was advised.[7] Despite this, however, spectators were seen singing, shouting and celebrating without face masks and were unable or unwilling to physically distance.[8] On the day of the tournament final alone, NHS Test and Trace data indicated that over 2000 people in and around Wembley Stadium were known to be infectious with COVID-19, and over 3000 people contracted the virus.[9] This suggests that compliance with public health recommendations may diminish at mass gatherings. However, no empirical research has examined people's engagement in COVID-safe behaviour during mass gatherings. It is also unclear (a) whether attending such events has lasting consequences for COVID-safe behaviour and (b) whether people's behaviour during mass gatherings varies according to contextual factors, such as the people they are with. Previous research has found that people are more likely to take risks and less likely to be COVID-safe with ingroup members (ie, people they feel connected to, such as friends or family), compared with outgroup members.[10–12] This is because people use shared group membership as a heuristic for 'safety' and are, therefore, more likely to behave in ways that place their fate 'in the hands' of people they consider ingroup members.[10 13 14] To understand patterns of COVID-safe behaviour at mass gatherings, it may, therefore, be important to consider *who* people are more or less likely to be COVID-safe with at these events.

The present study sought to shed light on these questions, using longitudinal data on young people's predicted engagement in COVID-safe behaviours collected before, during and after a youth mass gathering that took place in Australia in 2020: Schoolies. This study focused on young people aged 16–19 years who were secondary-school graduates. In a typical (ie, non-pandemic) year, Schoolies involves tens of thousands of secondary-school graduates travelling to coastal locations for week-long celebrations that mark the end of their formal schooling years. The largest mass gathering of graduates typically occurs at the Gold Coast, Queensland. In the weeks prior to and during the 2020 Schoolies Week (21 November to 27 November), the risk of COVID-19 transmission in Queensland was relatively low (only 41 new cases were recorded between October and November 2020).[15] As a result, while official organised festivities traditionally held at the Gold Coast were disallowed (eg, concerts, beach parties), state borders were open and graduates were able to gather (spontaneously or in self-organised ways) and celebrate at the Gold Coast and other locations.[16] To mitigate the risk of COVID-19 transmission—with a particular focus on the Gold Coast as a primary celebration site and thus a high-risk setting—strong public health messaging encouraged COVID-safe behaviour among graduates prior to and during Schoolies (although no state-wide mandates, in relation to mask wearing or otherwise, were in place). The usual presence of police and support services were also deployed at the Gold Coast.[17] This context provided a unique opportunity to assess (a) anticipated COVID-safe behaviour at a mass gathering during the pandemic and (b) whether anticipated behaviour varied depending on who people were with. Moreover, this context allowed us to explore whether COVID-safety differed among graduates celebrating at the primary Schoolies site (ie, Gold Coast), compared with graduates celebrating at secondary sites that do not typically receive the same influx of graduates (ostensibly lower risk settings).

METHOD

Participants and design

We used a longitudinal design, examining Australian secondary-school graduates' COVID-safe behaviour at five timepoints before, during and after Schoolies Week. Participants were recruited online via paid advertising on Facebook and Instagram in the month prior to Schoolies Week. Advertisements targeted Facebook and Instagram users in Queensland Australia who were 16–19 years of age, and the advertisement text specified that 2020 secondary-school graduates were eligible to participate. Participants completed five online surveys (hosted on Qualtrics). The first of these was completed before Schoolies Week (baseline; T0) and was administered through the social media advertisements. Participants were then sent links to short follow-up surveys via SMS at four subsequent timepoints: day 1 of Schoolies Week (T1), day 3 (T2), day 5 (T3) and 3 weeks after Schoolies Week (T4). Participants received a AU$5 voucher for each survey they completed. Participants were considered eligible for inclusion in the analyses if they were secondary school graduate age (16–19 years) and responded correctly to an attention check item (asking them to choose response option 1 if they were paying attention), which was embedded within every questionnaire. Respondents who failed the attention check were excluded from analyses involving data from that questionnaire. Respondents were also excluded from all analyses if they provided responses to open response items in the T0 survey, which suggested they were not secondary-school graduates (eg, invalid email or mobile number). The recruitment method and data quality checks used in this study have been used successfully in previous research with secondary-school graduates attending Schoolies celebrations.

Outcomes

This study was part of a larger project on the Schoolies mass gathering. The full questionnaire is available on the Open Science Framework; link. The current study focused on three forms of COVID-safe behaviour: physical distancing from friends, physical distancing from strangers and additional protective behaviours (hand hygiene and mask wearing). To mitigate recall bias, we focused on anticipated rather than recalled behaviour. At T0 and T4, participants were asked to indicate how they anticipated behaving 'in the next month' to capture the time prior to (T0) and following (T4) the mass gathering

event. During the mass gathering event, participants were asked to indicate how they anticipated behaving 'this week' (T1, T2 and T3).

The measure of physical distancing from friends and strangers was adapted from Cruwys *et al*.[10] Participants were given the following instructions: 'social distance rules endorsed by the Australian government stipulate a distance of 1.5 m between yourself and others. But really it is you that decides how much distance you keep from different people. In the next month (T0 and T4)/this week (T1–T3)), how much distance do you think you would keep between yourself and the other persons listed below?'. Participants responded to this question in relation to (a) a friend, and (b) a stranger. Responses were recorded on a 7-point Likert scale where distance in metres was specified in 0.5 increments from 1 (no distance) to 7 (more than 2.5 m). Visual representations of physical distancing between two people were also included to aid clarity.

Additional anticipated protective behaviour was assessed using a 3-item measure developed for the purpose of this research: (In the next month/week), I will probably be… (1) taking hand sanitiser with me when I go out, (2) washing my hands regularly, (3) wearing a face mask when I can't social distance. Participants were asked to indicate their agreement with each item on a 7-point Likert scale (1=strongly disagree, 7=strongly agree). Responses were averaged to compute a composite measure of anticipated protective behaviour. The measure had adequate internal consistency at all timepoints (α_{T0}=0.69; α_{T1}=0.70; α_{T2}=0.67; α_{T3}=0.71; α_{T4}=0.72).

Participants' age, gender, postcode of residence and celebration site were collected. Postcodes were used to determine participants' Australian state of residency and the socioeconomic status (SES) of their area of residency. Neighbourhood SES was determined using the Index of Relative Socio-Economic Advantage and Disadvantage,[18] which ranges from 1 to 10, with high scores indicating that the participant is from an area with a relatively high level of advantage and low level of disadvantage.

Statistical methods

Change over time and differences in outcomes between participants celebrating at primary and secondary sites were examined using linear mixed-effects modelling in R (V.4.1.0) with packages *lme4* and *emmeans*.[19 20] The data had a nested structure consisting of time (level 1), participant (level 2) and site (ie, primary versus secondary; level 3). Three mixed-effects models were tested, predicting each of the three outcomes: (a) physical distancing from friends, (b) physical distancing from strangers and (c) protective behaviour. The null (or variance component) model, which included the model intercept and the participant intercept as a random factor, was first examined for each outcome. This enabled us to examine the intraclass correlation coefficients (ICCs), which indicated the extent to which there was clustering in participants' responses to each outcome, such that an individual participant's responses at each timepoint were more similar to each other than they were to other participants' responses. An ICC greater than zero confirmed that a multilevel analytical approach was appropriate and that a random intercept for participant should be included in each model to account for variability among participants.[21] Following confirmation, in each model, we specified fixed effects for time, site and the time ×site interaction term, and a random intercept for participant. Time was specified as a categorical variable with five levels (T0–T4). Significant effects of time were followed up with planned contrasts, which compared responses at T1–T4 to T0. The same planned contrasts were conducted separately for each site when following up significant time ×site interactions, and the interaction was examined for linear and non-linear patterns (up to the fourth degree) in each model. Multiple comparisons were adjusted for using the multivariate *t* distribution method.[19] Missing data were managed using restricted maximum likelihood, which uses all available data for all participants and provides unbiased estimates of variance components and SEs for fixed effects.[20 22]

Patient and public involvement

This study was part of a larger Psychology of Schoolies project examining psychological experiences of young people attending annual Schoolies celebrations. The project began in 2015 and has developed in consultation with community stakeholders, including local and state government, police, volunteer and emergency services. Community stakeholders provided feedback that informed study design but were not involved in recruiting participants or conducting the study. No participants or other members of the public were involved in the implementation of this study. In accordance with our institutional ethics approvals, participants were invited to provide their contact details to the research team for the purposes of receiving aggregate study findings. Results have been shared with our research partners and continue to be disseminated to the public through scientific journal publications.[13 23]

RESULTS

In total, 397 eligible graduates completed the T0 survey (M_{age}=17.34, range 16–19 years; M_{SES}=6.75, range 1.00–10.00; 77.3% female; 96.2% Queensland residents). Full participant characteristics at each timepoint are presented in table 1. Seventy-two participants indicated that they were celebrating Schoolies at the primary site (Gold Coast) and 325 indicated they were celebrating at secondary sites. Participants celebrating at the primary and secondary sites did not differ significantly in age ($t(101.51)$=1.46, p=0.148), gender ($\chi^2(2)$=0.69, p=0.707) or neighbourhood SES ($t(101.23)$=0.12, p=0.907) at T0. At follow-up, N=183 participants at T1 were included in the analysis, N=158 at T2, N=163 at T3 and N=140 at T4. Based on the exclusion criterion, 130 respondents'

Table 1 Participant characteristics at each timepoint

	All participants	Primary site	Secondary site
	M (SD)/n (%)	M (SD)/n (%)	M (SD)/n (%)
Time 0	N=397	N=72	N=325
Age	17.34 (0.50)	17.41 (0.50)	17.32 (0.50)
Gender			
Female	307 (77.3)	53 (73.6)	254 (78.2)
Male	88 (22.2)	18 (25.0)	70 (21.5)
Self-described as gender queer	1 (0.3)	0 (0.0)	1 (0.3)
Not specified	1 (0.3)	1 (1.4)	0 (0.0)
State of residency			
Queensland	382 (96.2)	65 (90.3)	317 (97.5)
New South Wales	3 (0.8)	2 (2.8)	1 (0.3)
Victoria	2 (0.5)	0 (0.0)	2 (0.6)
Northern Territory	2 (0.5)	1 (1.4)	1 (0.3)
South Australia	1 (0.3)	0 (0.0)	1 (0.3)
Not specified	7 (1.8)	4 (5.6)	3 (0.9)
Neighbourhood SES	6.75 (2.45)	6.78 (2.34)	6.74 (2.48)
Time 1	N=183	N=39	N=144
Age	17.35 (0.48)	17.39 (0.50)	17.32 (0.47)
Gender			
Female	144 (78.7)	28 (71.8)	116 (80.6)
Male	38 (20.8)	11 (28.2)	27 (18.8)
Self-described as gender queer	1 (0.6)	0 (0.0)	1 (0.7)
Not specified	0 (0.0)	0 (0.0)	0 (0.0)
State of residency			
Queensland	180 (98.4)	38 (97.4)	142 (98.6)
New South Wales	1 (0.6)	0 (0.0)	1 (0.7)
Victoria	0 (0.0)	0 (0.0)	0 (0.0)
Northern Territory	1 (0.6)	0 (0.0)	1 (0.7)
South Australia	0 (0.0)	0 (0.0)	0 (0.0)
Not specified	1 (0.6)	1 (2.6)	0 (0.0)
Neighbourhood SES	6.71 (2.50)	7.21 (2.28)	6.58 (2.55)
Time 2	N=158	N=30	N=128
Age	17.32 (0.47)	17.37 (0.49)	17.31 (0.47)
Gender			
Female	128 (81.0)	22 (73.3)	106 (82.8)
Male	29 (18.4)	8 (26.7)	21 (16.4)
Self-described as gender queer	1 (0.6)	0 (0.0)	1 (0.8)
Not specified	0 (0.0)	0 (0.0)	0 (0.0)
State of residency			
Queensland	155 (98.1)	28 (93.3)	127 (99.2)
New South Wales	3 (1.9)	2 (6.7)	1 (0.8)
Victoria	0 (0.0)	0 (0.0)	0 (0.0)
Northern Territory	0 (0.0)	0 (0.0)	0 (0.0)
South Australia	0 (0.0)	0 (0.0)	0 (0.0)
Not specified	0 (0.0)	0 (0.0)	0 (0.0)

Continued

Table 1 Continued

	All participants	Primary site	Secondary site
	M (SD)/n (%)	M (SD)/n (%)	M (SD)/n (%)
Neighbourhood SES	6.66 (2.47)	7.03 (2.01)	6.57 (2.56)
Time 3	N=163	N=29	N=134
Age	17.31 (0.47)	17.38 (0.49)	17.32 (0.47)
Gender			
Female	112 (80.0)	20 (69.0)	110 (82.1)
Male	27 (19.3)	9 (31.0)	23 (17.2)
Self-described as gender queer	1 (0.7)	0 (0.0)	1 (0.8)
Not specified	0 (0.0)	0 (0.0)	0 (0.0)
State of residency			
Queensland	160 (98.2)	28 (96.6)	132 (98.5)
New South Wales	2 (1.2)	1 (3.5)	1 (0.8)
Victoria	0 (0.0)	0 (0.0)	0 (0.0)
Northern Territory	1 (0.6)	0 (0.0)	1 (0.8)
South Australia	0 (0.0)	0 (0.0)	0 (0.0)
Not specified	0 (0.0)	0 (0.0)	0 (0.0)
Neighbourhood SES	6.75 (2.49)	6.97 (2.28)	6.71 (2.55)
Time 4	N=140	N=24	N=116
Age	17.33 (0.47)	17.42 (0.50)	17.29 (0.46)
Gender			
Female	130 (79.8)	17 (70.8)	95 (81.9)
Male	32 (19.6)	7 (29.2)	20 (17.2)
Self-described as gender queer	1 (0.6)	0 (0.0)	1 (0.9)
Not specified	0 (0.0)	0 (0.0)	0 (0.0)
State of residency			
Queensland	138 (98.6)	23 (95.8)	115 (99.1)
New South Wales	1 (0.7)	1 (4.2)	0 (0.0)
Victoria	0 (0.0)	0 (0.0)	0 (0.0)
Northern Territory	1 (0.7)	0 (0.0)	1 (0.9)
South Australia	0 (0.0)	0 (0.0)	0 (0.0)
Not specified	0 (0.0)	0 (0.0)	0 (0.0)
Neighbourhood SES	6.69 (2.55)	6.67 (2.33)	6.69 (2.61)

SES, socioeconomic status.

data were excluded from T0, 6 from T1, 3 from T2 and 3 from T3, additional to the final sample described above. Figure 1 presents a detailed breakdown of participant recruitment, retention and attrition at each timepoint for primary site and secondary site attendees. Means, SD and correlations between key participant characteristics and outcomes across timepoints are presented in online supplemental table 1. The data and analysis code are available on the Open Science Framework.[24]

ICCs confirmed that a multilevel analytical approach was appropriate, with differences between participants accounting for 48% of the variance in physical distancing from friends, 51% of the variance in physical distancing from strangers and 59% of the variance in protective behaviour. Time, site and the time ×site interaction was systematically added to the model for each outcome as fixed effects.

Physical distancing from friends

Analyses revealed a significant effect of time, $\chi^2(4)=15.73$, p=0.003. Planned contrasts were conducted to compare physical distancing from friends at T0 to each subsequent timepoint. The distance participants anticipated they would maintain from their friends was consistently and substantially less than half the Australian Government recommendation of 1.5 m (M=0.34 m, SD=0.03 metres)

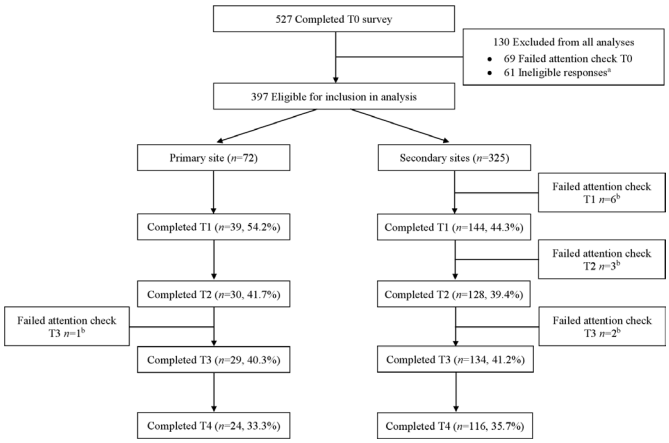

Figure 1 Flow diagram of participant recruitment, retention and attrition over the course of the research study. [a]Ineligible responses included invalid email or mobile number, non-Australian postcode, self-reported age was younger than 16 years or older than 19 years. [b]Data from participants who failed the attention check at a specific timepoint were excluded from analyses for that timepoint only. Note that, although there was attrition over time, reducing statistical power, the analysis method used all available data such that participants who completed some but not all timepoints were included in the analyses.

and declined over time. Compared with T0, distance was significantly lower at T2 ($t(777)=-2.85$, p=0.017), T3 ($t(777)=-3.10$, p=0.008), and T4 ($t(774)=-2.75$, p=0.023). An effect of site was also found, β=−0.30, $\chi^2(1)=7.02$, p=0.008, such that, averaging across time, the secondary site group anticipated maintaining significantly less distance from their friends, relative to the primary site group. The time ×site linear interaction was significant, $t(756)=3.80$, p=0.001 (figure 2). Planned contrasts revealed that the distance the primary site group anticipated they would maintain from their friends declined over time. Among the primary site group, compared with T0, distance was significantly lower at T3 (t(758)=−3.39, p=0.003) and T4 ($t(756)=-3.68$, p=0.001). In contrast, for the secondary site group, there were no significant changes over time in anticipated physical distancing from friends (ps≥0.118).

Physical distancing from strangers

Results revealed a significant effect of time, $\chi^2(4)=26.93$, p<0.001. The distance participants anticipated they would maintain from strangers declined over time. Compared with T0, distance was significantly lower at T1 (t(762)=−2.81, p=0.019), T2 (t(764)=−3.57, p=0.002), T3 (t(764)=−3.65, p=0.001) and T4 (t(760)=−4.34, p<0.001). Despite this decrease; however, at all timepoints, participants anticipated they would comply with Australian Government physical distancing guidelines (ie, maintain a minimum of 1.5 m from strangers; M=1.67 m, SD=0.38 m; see figure 2). There was no significant effect of site, β=0.04, $\chi^2(1)=0.11$, p=0.742, or time ×site interaction, $\chi^2(4)=6.96$, p=0.138.

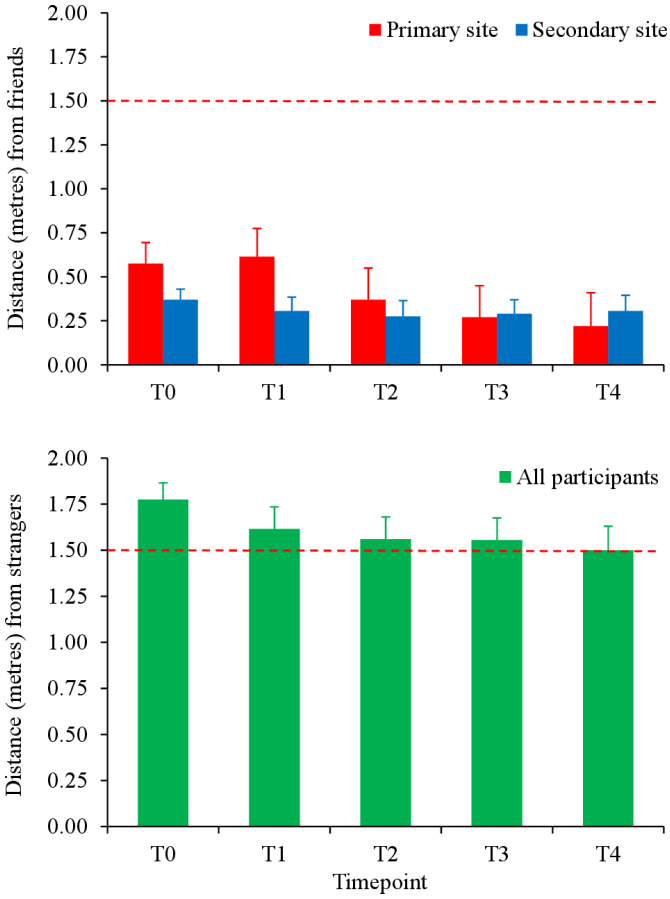

Figure 2 Change in anticipated physical distancing from friends over time among primary and secondary site attendees (top); and change in anticipated physical distancing from strangers over time among all participants (bottom). The red dotted line indicates Australian physical distancing guidelines (ie, minimum 1.5 m).

Protective behaviours

There was a significant effect of time, $\chi^2(4)=221.23$, p<0.001 (figure 3). Compared with baseline, anticipated protective behaviour was significantly lower at T1 (t(727)=−9.79, p<0.001), T2 (t(727)=−11.24, p<0.001), T3 (t(727)=−13.30, p<0.001) and T4 (t(723)=−10.46, p<0.001). There was no effect of site, β=−0.004, $\chi^2(1)=0.001$, p=0.974, or time ×site interaction, $\chi^2(4)=2.84$, p=0.586.

DISCUSSION

This study examined—for the first time—COVID-safe behaviour before, during and after a mass gathering during the COVID-19 pandemic. Overwhelmingly, participants anticipated they would fail to comply with public health recommendations by maintaining less than half the recommended 1.5 m distance from their friends, providing empirical evidence that mass gathering attendees are likely to violate COVID-19 safety protocols, which can pose a threat to public health. For those who celebrated at the primary mass gathering site, distancing from friends also declined during the event and beyond,

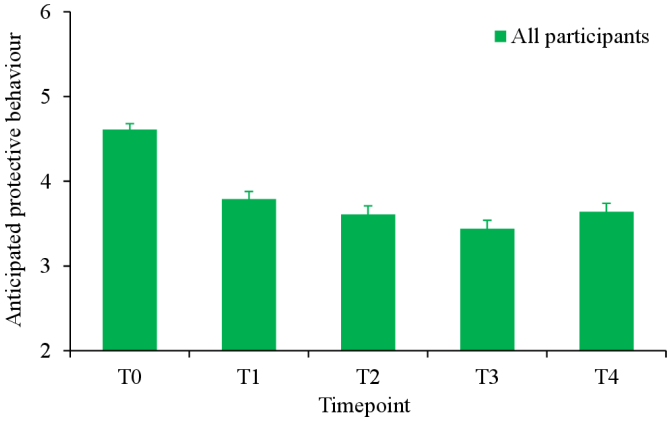

Figure 3 Change in additional anticipated protective behaviour over time among all participants. Values on the y-axis correspond to the seven-point Likert scale used to assess agreement with statements regarding anticipated engagement in protective behaviour (1=strongly disagree, 7=strongly agree). Higher scores indicate greater anticipated engagement in protective behaviour.

reaching its lowest point (a mere 22 cm) 3 weeks postevent. Among young people celebrating at secondary sites, on the other hand, distancing from friends remained relatively stable over time. Somewhat promisingly, all participants consistently anticipated that they would maintain at least the recommended minimum 1.5 m distance from strangers. However, we observed declines in physical distancing from strangers and in additional protective behaviours during the mass gathering among young people celebrating at both primary and secondary sites. Concerningly, these declines in anticipated COVID-safe behaviour also persisted up to 3 weeks later.

Our findings have a range of important implications and extend previous research in several ways. First, they suggest that participating in a mass gathering event can negatively impact COVID-safe behaviour, and that this effect is likely to endure after the event has finished. This is consistent with existing evidence that mass gatherings can have a lasting *positive* impact on attendees' health,[3 25] suggesting that both the positive and negative behavioural and psychological impacts of mass gatherings can carry forward into other aspects of people's lives. Declines in physical distancing over time are also consistent with previous research in non-mass gathering contexts.[26] This has implications for the way we appraise, model and respond to the risks associated with mass gatherings during the COVID-19 pandemic. For example, to accurately estimate the public health risks of these events, it may be necessary to consider not only *direct* virus transmission during the event but also the downstream increase in transmission that may subsequently occur in the community, due to attendees demonstrating a sustained reduction in COVID-safe behaviour.

Second, our findings align with evidence that the behavioural risks people take vary according to who they are with.[10 13] We found that participants reported substantially less physical distancing from their friends than from strangers (an average difference of 1.33 m). This is particularly concerning because COVID-19 transmission is more likely to occur from a friend or family member than from a stranger.[27] This highlights an urgent need for public health messaging, both at mass gatherings and more widely, that explicitly emphasises the risk posed by close contact with known others.[28]

Third, few differences in COVID-safe behaviour were observed between young people celebrating at a primary mass gathering site and those celebrating at secondary sites. This highlights the need to consider the broader public health risks that mass gatherings pose beyond the site of formal events. For events that people engage with or celebrate widely, the elevated risk of transmission may not be confined to those that attend organised mass gathering sites. For example, sporting events often trigger gatherings in bars, other public spaces and people's homes—gatherings that, while smaller, may also be high risk. The one variable on which we observed a difference between primary and secondary site attendees was distancing from friends. This was greater for primary site attendees at baseline and T1, but declined over time to a lower level in the primary site group than the secondary site group by the final timepoint. Although these findings should be interpreted with caution (particularly given the relatively small sample size of the primary site group), they may reflect the impact of the strong public health messaging that largely targeted primary site attendees prior to the event—an impact that seemingly did not persist for the full event.

Strengths, limitations and future research

Confidence in our findings comes from the study's high ecological validity (due to the in situ data collection) and longitudinal design (which enabled us to examine changes in COVID-safe behaviour over time). However, some limitations should be noted. Social media was used to recruit participants, which may have caused selection bias. This study also focused on anticipated rather than actual behaviour using self-report measures that had not been prevalidated and may have been prone to social desirability bias. While the potential for bias could not be eliminated, several steps were taken to minimise it, including the inclusion of attention checks at all timepoints, provision of incentives to reduce attrition, and refraining from disclosing the hypotheses to participants until after the study was completed.

It should also be noted that the current study took place before COVID-19 vaccines were available in Australia. While COVID-19 safety at mass gatherings remains critical to public health risk mitigation—particularly in the face of new variants—vaccine availability may influence COVID-safe behaviour at these events. Future research assessing people's actual COVID-safe behaviours at mass gatherings (eg, observational analyses of mask wearing), in combination with epidemiological analyses of event-related disease spread and data on vaccine uptake, would

be valuable. In addition, research is urgently needed to examine whether it is possible to improve COVID-safety through interventions that consider the nuance of peoples' social relationships (eg, that emphasise maintaining physical distance specifically from friends and non-household family). Recent research provides useful insights into behaviour change strategies that may be most effective in these interventions[23 28] (see Drury *et al*[6] for a recent review and recommendations). It is for future research to empirically test the efficacy of such strategies in the context of mass gatherings.

CONCLUSION

As mass gatherings return around the world, it is critical for governments and event organisers to understand the public health risks that these events pose, particularly regarding COVID-19 transmission. The findings from this study indicate that people's compliance with public health recommendations may diminish during mass gatherings, with enduring consequences for their risk behaviour in the weeks following such events. The results also demonstrate that it matters with whom people engage in COVID-safe behaviours, because mass gathering attendees are much less likely to physically distance appropriately from their friends than from strangers. Sustained public health messaging before, during and following mass gathering events should explicitly emphasise the risks posed by close contact with known others and the importance of COVID-safe behaviours in mitigating these risks. More generally, public health messaging and interventions must consider contextual factors and the lasting impacts of mass gatherings on COVID-safe behaviour if they are to be effective in modelling, managing and mitigating risks of infection at these events.

Acknowledgements The authors thank the Safer Schoolies Initiative Unit of the Queensland Government Department of Environment and Science for their support of this project.

Contributors TC was responsible for obtaining research funding. All authors were involved in the study design. JAR and TC were involved in the data collection and management. JAR was responsible for the data analysis and generation of figures. All authors were involved in the interpretation of results. JAR and MS were involved in drafting the manuscript and all authors were involved in revising the manuscript. JAR is the guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Funding This project was supported by the Queensland Government Department of Environment and Science, Safer Schoolies Initiative Unit.

Competing interests All authors had financial support from Queensland Government Department of Environment and Science Safer Schoolies Initiative Unit for the submitted work.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This project received ethical approval from the Australian National University Human Research Ethics Committee (protocol number 2018/558) and the University of Queensland Human Research Ethics Committee (protocol number 16-PSYCH-MCP-32-AH). In accordance with the approved ethics protocol, all participants provided informed consent prior to taking part in this study. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. De-identified individual participant data and analysis code that underlie the results reported in this manuscript are available on the Open Science Framework: https://osf.io/er247/.

ORCID iDs
Joanne A Rathbone http://orcid.org/0000-0003-3910-2648
Mark Stevens http://orcid.org/0000-0002-7908-3624
Tegan Cruwys http://orcid.org/0000-0001-5296-3480
Laura J Ferris http://orcid.org/0000-0002-2127-1825

REFERENCES

1 Memish ZA, Stephens GM, Steffen R, *et al*. Emergence of medicine for mass gatherings: lessons from the hajj. *Lancet Infect Dis* 2012;12:56–65.
2 Hopkins N, Reicher S. Mass Gatherings, health, and Well-Being: from risk mitigation to health promotion. *Soc Issues Policy Rev* 2021;15:114–45.
3 Tewari S, Khan S, Hopkins N, *et al*. Participation in mass gatherings can benefit well-being: longitudinal and control data from a North Indian Hindu pilgrimage event. *PLoS One* 2012;7:e47291.
4 Cruwys T, Saeri AK, Radke HRM, *et al*. Risk and protective factors for mental health at a youth mass gathering. *Eur Child Adolesc Psychiatry* 2019;28:211–22.
5 World Health Organization. Holding gatherings during the COVID-19 pandemic: who policy brief, 2021. Available: https://www.who.int/publications/i/item/holding-gatherings-during-the-covid-19-pandemic-who-policy-brief-2-august-2021 [Accessed 08 Sep 2021].
6 Drury J, Rogers MB, Marteau TM, *et al*. Re-opening live events and large venues after Covid-19 'lockdown': Behavioural risks and their mitigations. *Saf Sci* 2021;139:105243.
7 The Union of European Football Associations. COVID-19 guidance for your Euro 2020 match [Internet], 2021. Available: https://www.uefa.com/uefaeuro-2020/event-guide/london/stadium/ [Accessed 08 Sep 2021].
8 Euronews. EURO 2020 final: Lack of attention to COVID-19 "devastating", says WHO chief. Euronews [Internet], 2021. Available: https://www.euronews.com/2021/07/12/euro-2020-final-lack-of-attention-to-covid-19-devastating-says-who-chief [Accessed 08 Sep 2021].
9 Smith JAE, Hopkins S, Turner C, *et al*. Public health impact of mass sporting and cultural events in a rising COVID-19 prevalence in England. *Epidemiol Infect* 2022;150:e42.
10 Cruwys T, Stevens M, Donaldson JL, *et al*. Perceived COVID-19 risk is attenuated by ingroup trust: evidence from three empirical studies. *BMC Public Health* 2021;21:1–11.
11 Firing K, Laberg JC. Personal characteristics and social identity as predictors of risk taking among military officers: an empirical study. *Int J Manag* 2012;29:86–98.
12 Loersch C, Bartholow BD. The color of safety: ingroup associated colors make beer safer. *J Exp Soc Psychol* 2011;47:190–4.
13 Cruwys T, Greenaway KH, Ferris LJ, *et al*. When trust goes wrong: a social identity model of risk taking. *J Pers Soc Psychol* 2021;120:57–83.

14 Morton TA, Power SA. Coming together after standing apart: what predicts felt safety in the post-coronavirus crowd? *Soc Sci Med* 2022;293:114649–9.
15 O'Brien J, Barry D, Babekuhl D. State and territory breakdowns of new daily confirmed COVID-19 cases in Australia [Internet], 2021. Available: https://www.covid19data.com.au [Accessed 30 Sep 2021].
16 Hartley A, Jacques O, Young B. Thousands of Queensland schoolies descend on the Gold and Sunshine Coasts to celebrate end of a turbulent year [Internet], 2020. Available: https://www.abc.net.au/news/2020-11-21/queensland-schoolies-head-to-gold-and-sunshine-coasts/12904570 [Accessed 30 Sep 2021].
17 Forbes T, Dyer N. Gold Coast police won't be redeployed to Sunshine Coast as schoolies migrate north to celebrate [Internet], 2020. Available: https://www.abc.net.au/news/2020-11-09/police-to-remain-at-gold-coast-despite-schoolies-in-noosa/12863150 [Accessed 30 Sep 2021].
18 Australian Bureau of Statistics. Census of population and housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016 [Internet], 2018. Available: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/2033.0.55.001Main+Features12016?OpenDocument [Accessed 29 Mar 2022].
19 Lenth RV, Buerkner P, Herve M. *Estimated marginal means, AKA least-squares means*, 2021.
20 Bates D, Mächler M, Bolker B, *et al*. Fitting Linear Mixed-Effects Models Using lme4. *J Stat Softw* 2015;67:1–48.
21 Finch WH, Bolin JE, Kelley K. *Multilevel modeling using R*. Second edition. CRC Press, 2019.
22 Cheung MW-L. Implementing restricted maximum likelihood estimation in structural equation models. *Struct Equ Modeling* 2013;20:157–67.
23 Stevens M, Cruwys T, Rathbone JA, *et al*. Predicting substance use at a youth mass gathering event: the role of norms and the importance of their source. *J Stud Alcohol Drugs* 2021;82:320–9.
24 Rathbone JA, Stevens M, Cruwys T. Data from: Covid-safe behaviour before, during, and after a youth mass gathering event: a longitudinal cohort study. *Open Science Framework* 2022 https://osf.io/er247/
25 Khan SS, Hopkins N, Reicher S, *et al*. Shared identity predicts enhanced health at a mass gathering. *Group Processes & Intergroup Relations* 2015;18:504–22.
26 Ayre J, Cvejic E, McCaffery K, *et al*. Contextualising COVID-19 prevention behaviour over time in Australia: patterns and long-term predictors from April to July 2020 in an online social media sample. *PLoS One* 2021;16:e0253930.
27 Keeling M. The implications of network structure for epidemic dynamics. *Theor Popul Biol* 2005;67:1–8.
28 Cruwys T, Stevens M, Greenaway KH. A social identity perspective on COVID-19: health risk is affected by shared group membership. *Br J Soc Psychol* 2020;59:584–93.