

Risk assessment and implementation of risk reduction measures is not associated with increased transmission of SARS-CoV-2 compared with standard isolation at professional golf events

Patrick Gordon Robinson ^{1,2}, Andrew Murray,^{2,3} Matt Watson,² Graeme Close,^{2,4} Denis F Kinane^{5,6}

To cite: Robinson PG, Murray A, Watson M, *et al.* Risk assessment and implementation of risk reduction measures is not associated with increased transmission of SARS-CoV-2 compared with standard isolation at professional golf events. *BMJ Open Sport & Exercise Medicine* 2022;**8**:e001324. doi:10.1136/bmjsem-2022-001324

Accepted 29 March 2022



© Author(s) (or their employer(s)) 2022. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

¹Royal Infirmary of Edinburgh, Edinburgh Orthopaedics, Edinburgh, UK

²European Tour Performance Institute, Virginia Water, UK

³Physical Activity for Health Research Centre, University of Edinburgh, Edinburgh, UK

⁴Liverpool John Moores University, Liverpool, UK

⁵School of Dental Medicine, University of Bern, Bern, Switzerland

⁶Medical and Scientific Department, Cignost Diagnostics, Farnborough, UK

Correspondence to

Dr Andrew Murray;
docandrewmurray@gmail.com

ABSTRACT

Objectives The purpose of this prospective study was to report incidence and transmission of SARS-CoV-2, among professional golfers and essential support staff undergoing risk assessment and enhanced risk reduction measures when considered a close contact as opposed to standard isolation while competing on the DP World Tour during the 2021 season.

Methods This prospective cohort study included all players and essential support staff participating in 26 DP World Tour events from 18 April 2021 to 21 November 2021. High-risk contacts were isolated for 10 days. Moderate-risk contacts received education regarding enhanced medical surveillance, had daily rapid antigen testing for 5 days, with reverse transcriptase-polymerase chain reaction (RT-PCR) testing on day 5, mandated mask use and access to outside space for work purposes only. Low-risk contacts typically received rapid antigen testing every 48 hours and RT-PCR testing on day 5.

Results The total study cohort comprised 13 394 person-weeks of exposure. There were a total of 30 positive cases over the study period. Eleven contacts were stratified as 'high risk'. Two of these subsequently tested positive for SARS-CoV-2. There were 79 moderate-risk contact and 73 low-risk contacts. One moderate-risk contact subsequently tested positive for SARS-CoV-2 but did not transmit the virus. All other contacts, remained negative and asymptomatic to the end of the tournament week.

Conclusions A risk assessment and risk reduction-based approach to contact tracing was safe in this professional golf event setting when Alpha and Delta were the predominant variants. It enabled professional golfers and essential support staff to work.

INTRODUCTION

The COVID-19 pandemic has had a profound effect on the delivery of international sporting and cultural events. Golf is an outdoor sport where social distancing is always possible and it has been shown to be a relatively low-risk environment for viral transmission.^{1 2} At a

Key messages

What is already known on this topic

- ⇒ Research from professional golf in 2020 has shown no player to player transmission.
- ⇒ Studies from work settings have shown a risk assessed and lateral flow testing protocol to be a safe method of managing known contacts.

What this study adds

- ⇒ Risk assessment and implementation of risk reduction measures was not associated with increased transmission of SARS-CoV-2 compared with standard isolation.
- ⇒ Risk assessment and risk reduction measures can enable persons to work, and professional sports events to go ahead, where otherwise this may not have been possible.

How this study might affect research, practice or policy

- ⇒ This study adds to the evidence that risk assessment and risk reduction measures including regular testing may enable opportunities for persons to avoid standard isolation.

societal level, although initial risk mitigating measures centred around national lockdowns, restrictions were adapted to allow outdoor activities with an emphasis on social distancing, hand hygiene and the use of face coverings if in indoor facilities.²⁻⁴

Following guidance from the WHO^{5 6} and with collaboration between leading sports organisations and national governments, international sport was able to return, without negative impact on public health.⁷⁻⁹ Key non-pharmaceutical interventions were implemented at the DP World Tour events when competition resumed on 9 July 2020. These included mandatory online education for all players, social distancing both on and

off the golf course, enhanced hygiene measures, mask use when inside, and daily symptom and temperature checking. Reverse transcriptase polymerase chain reaction (RT-PCR) testing was conducted prior to events and on site using a mobile laboratory. With advances in scientific knowledge, and the mass deployment of vaccines, regulations and protocols changed regarding daily life, but also for sporting events. Knowledge has evolved that the virus is predominantly transmitted via droplet/airborne spread^{10 11} and less through surface fomites.^{12 13} Vaccines were shown to decrease transmission against both alpha and delta, which were the predominant variants during the period of study.¹⁴

During 2021, pilot studies took place to permit close contacts to work in essential sectors with regular testing.^{15 16} Some countries moved to a model where fully vaccinated individuals could avoid standard isolation, with or without regular testing based on the efficacy of vaccines against transmission, severe illness and death. The year 2021 also saw an increased role for Rapid Antigen Testing, as an adjunct to RT-PCR at major outdoor sporting events, and in other sectors and settings.^{17 18} Further studies have highlighted outdoor sports as a low-risk environment.^{19 20}

Recognising these changes, major sporting organisations worked with technical experts from the WHO and host national governments to put in place guidance for the management of close contacts in a sports setting, with the intention of providing consistency across borders for international sporting competition.^{21–24} A pilot study showed that a risk assessment and a risk reduction approach to contact tracing can be safe, and allowed persons to participate at a professional golf event, where otherwise they would have been required to isolate.²³ The purpose of this prospective study was to apply this protocol across an event season and additionally report incidence and transmission of SARS-CoV-2 among professional golfers and essential support staff.

METHODS

This prospective cohort study included all players and essential support staff participating in 26 DP World Tour events from 18 April 2021 to 21 November 2021. Essential support staff were caddies, television and scoring personnel and DP World Tour operational staff. These events took place in 13 countries on 3 different continents (Europe, Asia and North America) (table 1). Persons not holding annual accreditation for DP World Tour were not included. The US PGA, the US Open, the Olympic Golf Competition and the WGC FedEx competitions were not included as tournament and testing operations were run by other organisations for these events. Accredited persons were required to follow host country public health laws, while further guidelines were provided regarding:

- Maximising use of outdoor space.
- Avoiding discretionary contacts, and crowded areas, especially indoors.

Table 1 Participant questionnaire completed before attending venue each day

Question	Yes/no
1. Any new continuous cough?	
2. Any new shortness of breath?	
3. Any new fever (ie, feeling hot or cold to touch)?	
4. Any new loss of taste or smell?	
5. Any positive test for COVID-19 within the previous 14 days?	
6. Any contact with confirmed COVID-19 cases in the last 14 days?	
Questions designed by DP World Tour medical team using WHO and European public health recommendations	

- Wearing a 3 ply or medical mask in any shared indoor space.
- Observing excellent hand hygiene.²⁵
- Reporting any symptoms or contact to the COVID-19 support team or the medical doctors on site.

Each event duration was 7–8 days. A person episode was defined as attendance at the golf facility for the duration of the tournament.

Defining risk

When a case was identified, a full travel and contact history was taken, as well as a risk assessment of the initial contact. Persons considered high risk or direct contacts (as per the WHO guidelines)²⁶ were isolated. Where someone was considered a high-risk contact by WHO definition, but had completed a course of vaccination with a WHO approved vaccine course, they were considered a moderate-risk contact. Where all protocols had been followed, including the wearing of filtering face piece (2/3) masks on flights with high-efficiency particulate absorbing filtration, persons within two rows in any direction in an asymptomatic individual were considered moderate-risk contacts. Persons on the same aircraft but not within two rows in any direction were considered low-risk contacts.

For the majority of events, participants required a minimum of one negative RT-PCR test prior to travelling to each tournament or on arrival. High-risk contacts were isolated for 10 days.²⁷ If the host country permitted it, moderate-risk contacts received education regarding enhanced medical surveillance, had daily rapid antigen testing for 5 days, with RT-PCR day 5, mandated mask use and access to outside space for work purposes only. Low-risk contacts typically received rapid antigen testing every 48 hours and RT-PCR testing on day 5.

Testing was performed using a nasopharyngeal and oropharyngeal swab taken by a trained professional. For events from 1 October onwards, persons were permitted to self-swab if they had completed in-person and online training regarding the conduct of rapid antigen testing.

Each day, a symptom and contact history checklist (table 1) were performed prior to admission to the event. Pre-travel and pre-tournament testing, daily symptom and contact checks were tracked through an event accreditation and tracking application (RFID, London, UK). Abnormalities were followed up by the medical team.

Testing and processing

Testing was conducted by Cignpost Diagnostics (Farnborough, UK) on Co-Diagnostics (Salt Lake City, USA) platforms, or through established local laboratories. The CoDx reagent kits and thermocyclers were utilised and had the ability to detect virus with high sensitivity and specificity (>99%) and a limit of detection of 2.4 viral particles/μL. Typical turn around times and reporting were within 2–4 hours of swabbing. Each test assessed target genes up to a cycle threshold (Ct) of 40 cycles. Viral levels below Ct 40 were considered positive. Indeterminate samples were repeated, where necessary. Cignpost diagnostics or local laboratories also provided rapid antigen testing, using Abbott PanBio (Berkshire, UK),

Innova (California, USA) or SD Biosensor (Suwon, South Korea).¹⁸ Antibody testing was not conducted systematically on DP World Tour. Contact tracing was conducted in line with WHO and local public health guidelines/requirements, with each contact informed and appropriate action taken.²⁶

Local population COVID-19 rates

All local rates of COVID-19 were reported as new cases per day per 100 000. UK data were extracted from the Office for National Statistics.²⁸ Rates were presented as the number of cases on the date of commencement of the tournament. Non-UK data were extracted from the Our World in Data website in association with the University of Oxford.²⁹

RESULTS

There were a total of 26 events during the study period with 13 394 persons episodes involved. Players comprised 3707 (including reserves), caddies 3629, television personnel 2808, scoring personnel 1950 and DP World

Table 2 DP World Tour events following resumption of the 2021 season, with host nation COVID-19 incidence

Event	Location	Players (n=)	Date of event	National daily COVID-19 incidence per 100 000 of population
Gran Canaria Lopesan Open	Gran Canaria, Spain	151	22–25 Apr 2021	18.4
Tenerife Open	Tenerife, Spain	151	29–2 May 2021	17.7
Canary Islands Championship	Tenerife, Spain	131	6–09 May 2021	14.9
Betfred British Masters	Sutton Coldfield, England	156	12–15 May 2021	3.4
Made in Himmerland	Farso, Denmark	156	27–30 May 2021	16.8
Porsche European Open	Hamburg, Germany	153	5–07 Jun 2021	3.8
BMW International Open	Munich, Germany	156	24–27 Jun 2021	1
Dubai Duty Free Irish Open	Co. Kilkenny, Ireland	155	1–4 July 2021	7.7
Abrdn Scottish Open	North Berwick, Scotland	156	8–11 July 2021	40.8
The Open Championship	Kent, England	156	15–18 July 2021	54.4
Cazoo Open	City of Newport, Wales	133	22–25 July 2021	13.2
ISPS HANDA World Invitational	Co. Antrim, Northern Ireland	143	29–1 August 2021	41.9
Hero Open	Fife, Scotland	143	05–8 August 2021	38
Cazoo Classic	Kent, England	144	12–15 August 2021	40.7
D+D Real Czech Masters	Prague, Czech Republic	124	19–22 August 2021	1.8
Omega European Masters	Crans Montana, Switzerland	156	26–29 August 2021	29.2
DS Automobiles Italian Open	Rome, Italy	156	2–5 September 2021	10.8
BMW PGA Championship	Surrey, England	144	9–12 September 2021	56.4
Dutch Open	Cromvoirt, Netherlands	144	16–19 September 2021	12.7
Alfred Dunhill Links Championship	Fife, Scotland	168	30–03 October 2021	50.6
ACCIONA Open de Espana	Madrid, Spain	132	07–10 October 2021	3.7
Estrella Damm N.A. Andalucia Masters	Sotogrande, Spain	126	14–17 October 2021	3.3
Mallorca Golf Open	Balearic Islands, Spain	120	21–24 October 2021	4
Portugal Masters	Vilamoura, Portugal	108	4–7 November 2021	8.3
AVIV Dubai Championship	Dubai, UAE	114	11–14 November 2021	1
DP World Tour Championship	Dubai, UAE	53	18–21 November 2021	1

Table 3 Description of positive cases and contact risk by relevant events

	Cases (n=30)	Contact risk			Outcome of contacts
		High (n=11)	Moderate (n=79)	Low (n=73)	
Gran Canaria Lospean Open	2	2	23	48	All contacts negative
Betfred British Masters	2	0	0	0	All contacts negative
Made in Himmerland	2	1	3	0	All contacts negative
Dubai Duty Free Irish Open	2	0	4	4	All contacts negative
Abrdn Scottish Open	2	0	4	0	All contacts negative
The Open Championship	4	3	9	5	1 high risk tested positive
ISPS HANDA World Invitational	1	1	3	0	All contacts negative
Hero Open	2	1	2	0	1 high risk tested positive
D+D Real Czech Masters	1	0	2	0	All contacts negative
Omega European Masters	2	1	5	0	All contacts negative
BMW PGA Championship	3	1	6	4	1 moderate risk positive
Dutch Open	0	0	0	3	All contacts negative
Alfred Dunhill Links Championship	3	0	9	5	All contacts negative
Portugal Masters	2	0	6	0	All contacts negative
AVIV Dubai Championship	2	1	3	4	All contacts negative

Tour operational staff 1300. The mean number of travelling group was 516 persons per event (140 players, with 3 travelling reserves and 140 caddies, 108 TV, 75 scoring and 50 ESS. There were a total of 30 positive cases over the entire season.

Contacts

There were 163 persons who were declared a 'contact' and met the host national public health guidelines for contact tracing (table 2). Of these, 11 were stratified as 'high risk', due to sustained indoor contact (shared hotel room, shared prolonged contact at residential address, shared meal at 1 m for >1-hour indoors), without sufficient mitigation. Two (18%) of these subsequently tested positive for SARS-CoV-2. There were 79 moderate-risk contacts and 73 low-risk contacts. One moderate-risk contact (1%) subsequently tested positive for SARS-CoV-2 but did not transmit the virus. All other contacts remained negative.

High-risk exposure was typically shared indoor space (hotel room) or shared transport without completed vaccination course or wearing of personal protective equipment. Moderate-risk exposure was largely outdoor player-caddy encounters, outdoor interaction between event personnel, or shared outdoor meals at closer than 2 m, or high-risk exposure where a course of vaccination had been completed. Further contacts were established in off-site personnel including through contact tracing of airlines in collaboration with the host public health authority. It is estimated by the DP World Tour executives and medical team that the use of the risk assessment and risk reduction approach prevented the postponement or cancellation of three events during the 2021 season.

The number of players per event and local rates of COVID-19 at the time of the tournament can be seen in table 3. Local COVID-19 rates were reported on the date of the first day of the event. If this was not available, a weekly average was used. The mean number of daily cases per 100 000 of the population across 26 events was 12.3 (SD 15.6). The full vaccination rate (as per WHO definition) of the included participants in this study was <20% at the beginning of the study (18 April 2021) and increased, to >94% when polled on 1 November 2021.

Discussion and comparison to the literature

This study has shown the successful scaling up of previous pilot work regarding a risk assessed and risk reduction approach to contact testing at professional golf events. At an international, multievent scale this protocol was shown to be effective in minimising the transmission of SARS-CoV-2 and allowing a significant number of players, caddies and staff to safely participate in events despite being COVID-19 contacts and otherwise having to self-isolate and miss events.

Professional sport has been required to be dynamic in its health protocols and strategies due to the evolving nature of the COVID-19 pandemic.⁶ With variations in international SARS-CoV-2 rates and policy responses, elite sport has been required to liaise closely with public health organisations and government to abide by differences in legalisation and ensure the safety of participants and staff as well as the wider population.⁵ Using the risk assessment and risk reduction approach in this study, the DP World Tour avoided the unnecessary isolation of 151 participants. The ability for persons to participate in these events was beneficial for them and for the

events themselves. In addition, quarantine or isolation in foreign countries, distant to families and friends may have potential negative effects on mental and physical health. The DP World Tour chief medical officer and executives estimated that the protocol implemented in this study avoided the unnecessary postponement or cancellation of three events.

Comparison to literature

Initial modelling of testing schemes utilising daily lateral flow testing demonstrates an effective way of minimising viral transmission risk while maximising worker availability and isolation avoidance.³⁰ A pilot scheme undertaken by Public Health England enabled contacts of positive cases to undergo daily lateral flow testing instead of adhering to the previous national guidance of isolation.³¹ In addition, a follow-up study showed 52% of those who tested positive would be more likely to share details of those they had been in contact with, if they knew daily testing would be implemented as opposed to self-isolation.³² These protocols are supported by recent evidence showing the recalibrated absolute sensitivity of lateral flow testing to be much higher than previous thought with values greater than 80%³³ and this has been translated to a population level in Slovakia where rapid antigen screening was reported to have reduced COVID-19 incidence by 83%.³⁴ Population data in England have shown lateral flow testing to be useful for identifying infections among asymptomatic adults, particularly those with high viral loads who are more likely to transmit the disease.³⁵

In a randomised controlled trial of COVID-19 contacts at England secondary schools and colleges, the authors showed daily lateral flow testing to be non-inferior to self-isolation in regards to disease transmission, with similar rates of symptomatic infections in both groups.³⁶ It was reported that daily lateral flow testing, reduced COVID-19-related school absences by 39%. With evolving knowledge of the benefits of daily lateral flow testing, the Department of Health and Social Care currently recommends daily lateral flow testing and additional cautions for the general population of England if a fully vaccinated person has been in contact with a person who is positive for COVID-19.³⁷

The pilot study from the Gran Canaria Open 2021 demonstrated that a risk-assessed and risk reduction protocol was both feasible and effective in allowing a tournament to run safely while minimising the wider risk on a public health level to the host country.²³ This strategy was scalable to a full season on the DP World Tour. Enhanced measures of hygiene for those not legally required to isolate were also encouraged in this study. On the DP World Tour this included, minimising shared indoor space, making attractive outdoor space available, mandating masks when indoors, and daily symptom and contact checking at arrival to events. Although there have been encouraging findings in both the pilot study and this study, other research has found daily antigen testing

in collegiate athletes to be less effective, with false negative results leading to COVID-19 outbreaks.³⁸

Limitations

This study should be interpreted in light of its limitations. The reporting of contacts was primarily through self-reporting, which has typically been shown to be an underestimation of true contacts.³⁹ During the period of study, there was a significant change in the number of participants who were fully vaccinated. However, it would appear rates of COVID-19 across the course of the season were not particularly skewed to the beginning or the end of the season. The predominant variants in Europe, North America and Asia at the time of this study were Alpha and Delta. Therefore, the findings of this study are applicable to these variants. The Omicron variant has been shown to have different genotypic characteristics with potential vaccine evasion,⁴⁰ and therefore, a different approach may be appropriate.

CONCLUSION

A risk assessment and risk reduction approach to contact tracing as compared with standard isolation did not lead to increased transmission of SARS-CoV-2 in this cohort. Its implementation avoided unnecessary self-isolation for players and other participants and enabled events to proceed. This approach can be implemented effectively when medical, operational support and testing infrastructure are immediately available at events.

Twitter Andrew Murray @docandrewmurray

Acknowledgements Colleagues at the World Health Organisation, and various international governing bodies for sport (ATP, FIFA, F1, the IOC, PGA Tour, and World Rugby) were instrumental in shaping risk assessment and risk mitigation policies. We thank Dr. Volker Scheer for his contribution to the data collection.

Contributors PGR: wrote manuscript; AM (guarantor): study idea, data collection, wrote manuscript, final manuscript approval; GC: final manuscript approval; MW: final manuscript approval; DFK: data collection, final manuscript approval.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Ethical approval was granted by the local ethics committee of Liverpool John Moores University (21/SPS/025).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iD

Patrick Gordon Robinson <http://orcid.org/0000-0002-8117-2968>

REFERENCES

- 1 Robinson PG, Foster C, Murray A. Public health considerations regarding golf during the COVID-19 pandemic: a narrative review. *BMJ Open Sport Exerc Med* 2021;7:e001089.
- 2 All Parliamentary Group for Golf. *COVID-19 secure golf in the United Kingdom 2021: house of commons*, 2021.
- 3 Strain T, Sharp SJ, Spiers A, *et al*. Population level physical activity before and during the first national COVID-19 lockdown: a nationally representative repeat cross-sectional study of 5 years of active lives data in England. *Lancet Reg Health Eur* 2022;12:100265.
- 4 Department for Digital C, Media & Sport. Guidance on coronavirus (COVID-19) measures for grassroots sport participants, providers and facility operators, 2021. Gov.uk. Available: [https://www.gov.uk/government/publications/guidance-on-coronavirus-covid-19-measures-for-grassroots-sport-participants-providers-and-facility-operators#facilities](https://www.gov.uk/government/publications/guidance-on-coronavirus-covid-19-measures-for-grassroots-sport-participants-providers-and-facility-operators/guidance-on-coronavirus-covid-19-measures-for-grassroots-sport-participants-providers-and-facility-operators#facilities) [Accessed 1 Jan 2022].
- 5 World Health Organisation. Who mass gathering COVID-19 risk assessment tool – sports events, 2021. Available: <https://www.who.int/publications/i/item/10665-333187> [Accessed 14 Apr 2021].
- 6 World Health Organisation. Considerations for sports federations/ sports event organizers when planning mass gatherings in the context of COVID-19, 2020. Available: https://apps.who.int/iris/bitstream/handle/10665/331764/WHO-2019-nCoV-Mass_Gatherings_Sports-2020.1-eng.pdf
- 7 Robinson PG, Murray A, Close G, *et al*. Assessing the risk of SARS-CoV-2 transmission in international professional golf. *BMJ Open Sport Exerc Med* 2021;7:e001109.
- 8 Jones B, Phillips G, Kemp S. SARS-CoV-2 transmission during rugby League matches: do players become infected after participating with SARS-CoV-2 positive players? *Br J Sports Med* 2021;55:807–13.
- 9 Meyer T, Mack D, Donde K, *et al*. Successful return to professional men's football (soccer) competition after the COVID-19 shutdown: a cohort study in the German Bundesliga. *Br J Sports Med* 2021;55:62–6.
- 10 Greenhalgh T, Jimenez JL, Prather KA, *et al*. Ten scientific reasons in support of airborne transmission of SARS-CoV-2. *Lancet* 2021;397:1603–5.
- 11 World Health Organisation. COVID-19 strategy update, 2021. Available: <https://www.who.int/publications/m/item/covid-19-strategyupdate>
- 12 Mohamadi M, Babington-Ashaye A, Lefort A, *et al*. Risks of infection with SARS-CoV-2 due to contaminated surfaces: a scoping review. *Int J Environ Res Public Health* 2021;18. doi:10.3390/ijerph182111019. [Epub ahead of print: 20 Oct 2021].
- 13 Edwards T, Kay GA, Aljayyousi G. SARS-CoV-2 transmission risk from sports equipment (strike). *medRxiv* 2021;2021.7.
- 14 Bruxvoort KJ, Sy LS, Qian L, *et al*. Effectiveness of mRNA-1273 against delta, mu, and other emerging variants of SARS-CoV-2: test negative case-control study. *BMJ* 2021;375:e068848.
- 15 Perrault A, Charpignon M, Gruber J. Designing efficient contact tracing through Risk-Based Quarantining. *medRxiv* 2020;2020.11.16.20227389.
- 16 Public Health Ontario. Risk assessment approach for COVID-19 contact tracing, 2021. Available: <https://www.publichealthontario.ca/-/media/documents/ncov/main/2020/09/covid-19-contact-tracing-risk-assessment.pdf?la=en>
- 17 Mina MJ, Andersen KG. COVID-19 testing: one size does not fit all. *Science* 2021;371:126–7.
- 18 Larremore DB, Wilder B, Lester E, *et al*. Test sensitivity is secondary to frequency and turnaround time for COVID-19 screening. *Sci Adv* 2021;7. doi:10.1126/sciadv.abd5393. [Epub ahead of print: 01 01 2021].
- 19 Schumacher YO, Tabben M, Hassoun K, *et al*. Resuming professional football (soccer) during the COVID-19 pandemic in a country with high infection rates: a prospective cohort study. *Br J Sports Med* 2021;55:1092–8.
- 20 Schreiber S, Faude O, Gärtner B, *et al*. Risk of SARS-CoV-2 transmission from on-field player contacts in amateur, youth and professional football (soccer). *Br J Sports Med* 2022;56:158–164.
- 21 World Health Organisation. Mass gathering sporting risk assessment, 2021. Available: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/points-of-entry-and-mass-gatherings>
- 22 Murray AM, Pluim A, Calder BM, *et al*. Contact tracing for international elite sport during COVID-19. In: *BJSM*. In, 2021.
- 23 Robinson PG, Murray A, Sheer V, *et al*. Pilot evaluation of risk assessment and enhanced protocols regarding contacts at an international professional golf event. *BMJ Open Sport Exerc Med*. In Press 2021;7:e001127.
- 24 Robinson P, Murray A, Watson M. Risk assessment and implementation of risk reduction measures is not associated with increased transmission of SARS-CoV-2 compared to standard isolation at professional golf events. *Submitted BMJ Open SEM* 2021:2022-001324: PGA European Tour.
- 25 World Health Organisation. Hand Hygiene: Why, How & When? 2022. Available: https://www.who.int/gpsc/5may/Hand_Hygiene_Why_How_and_When_Brochure.pdf [Accessed 21/03/2022].
- 26 World Health Organisation. Contact tracing in the context of COVID-19, 2020. Available: <https://www.who.int/publications/i/item/contact-tracing-in-the-context-of-covid-19> [Accessed 21/05/21].
- 27 Public Health England. Stay at home: guidance for households with possible or confirmed coronavirus (COVID-19) infection, 2021. Gov. uk. Available: <https://www.gov.uk/government/publications/covid-19-stay-at-home-guidance/stay-at-home-guidance-for-households-with-possible-coronavirus-covid-19-infection> [Accessed 16/6/21].
- 28 Coronavirus. (COVID-19) infection survey, UK: office for national statistics. Available: <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases> [Accessed 16/03/2021].
- 29 Daily. New confirmed COVID-19 cases per million people: our world in data, 2020. Available: https://ourworldindata.org/explorers/coronavirus-data-explorer?yScale=log&zoomToSelection=true&minPopulationFilter=1000000&time=2020-02-22.latest&country=®ion=World&pickerMetric=total_deaths&pickerSort=desc&hideControls=true&Metric=Confirmed+cases&Interval=7-day+rolling+average&Align+outbreaks=true&Relative+to+Population=true [Accessed 16/03/21].
- 30 Quilty BJ, Clifford S, Hellewell J, *et al*. Quarantine and testing strategies in contact tracing for SARS-CoV-2: a modelling study. *Lancet Public Health* 2021;6:e175–83.
- 31 Love N, Ready D, Turner C. The acceptability of testing contacts of confirmed COVID-19 cases using serial, self-administered lateral flow devices as an alternative to self-isolation. *medRxiv* 2021:2021.03.23.21254168.
- 32 Martin AF, Denford S, Love N, *et al*. Engagement with daily testing instead of self-isolating in contacts of confirmed cases of SARS-CoV-2. *BMC Public Health* 2021;21:1067.
- 33 Petersen I, Crozier A, Buchan I, *et al*. Recalibrating SARS-CoV-2 antigen rapid lateral flow test relative sensitivity from validation studies to absolute sensitivity for indicating individuals shedding transmissible virus. *Clin Epidemiol* 2021;13:935–40.
- 34 Pavelka M, Van-Zandvoort K, Abbott S. The effectiveness of population-wide, rapid antigen test based screening in reducing SARS-CoV-2 infection prevalence in Slovakia. *medRxiv* 2020;2020.12.02.20240648.
- 35 García-Fiñana M, Hughes DM, Cheyne CP, *et al*. Performance of the Innova SARS-CoV-2 antigen rapid lateral flow test in the Liverpool asymptomatic testing pilot: population based cohort study. *BMJ* 2021;374:n1637.
- 36 Young BC, Eyre DW, Kendrick S, *et al*. Daily testing for contacts of individuals with SARS-CoV-2 infection and attendance and SARS-CoV-2 transmission in English secondary schools and colleges: an open-label, cluster-randomised trial. *Lancet* 2021;398:1217–29.
- 37 Department for Health and Social Care. Daily rapid testing for COVID-19 contacts launches this week, 2021. Gov.uk. Available: <https://www.gov.uk/government/news/daily-rapid-testing-for-covid-19-contacts-launches-this-week10/01/22>
- 38 Moreno GK, Braun KM, Pray IW, *et al*. SARS-CoV-2 transmission in intercollegiate athletics not fully mitigated with daily antigen testing. *medRxiv* 2021:2021.03.03.21252838.
- 39 Davis EL, Lucas TCD, Borlase A, *et al*. Contact tracing is an imperfect tool for controlling COVID-19 transmission and relies on population adherence. *Nat Commun* 2021;12:5412.
- 40 García-Beltrán WF, St Denis KJ, Hoelzemer A, *et al*. mRNA-Based COVID-19 vaccine boosters induce neutralizing immunity against SARS-CoV-2 omicron variant. *Cell* 2022;185:457–66.