Management of a large outbreak of COVID-19 at a British Army Training Centre: lessons for the future

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Abstract

Introduction

The COVID-19 pandemic has posed major challenges for infection control within training establishments, both civilian and military. Here we present a narrative review of an outbreak that occurred at the Royal Military Academy Sandhurst (RMAS) in January – March 2021 in the context of the circulating highly transmissible SARS-CoV-2 variant B.1.1.7, first identified in Kent, UK.

Methods

Testing for SARS-CoV-2 was performed using a combination of reverse transcriptase PCR (RT-PCR) and Lateral Flow Devices (LFDs). Testing and isolation procedures were conducted in line with a pre-established symptom stratification system. Genomic sequencing was performed for a small number of isolates.

Results

By the end of the outbreak 185 cases (153 Officer Cadets, 32 permanent staff) had contracted confirmed COVID-19. This represented 15% of the total RMAS population. This resulted in 0 deaths and 0 hospitalisations, but due to necessary isolation procedures did represent an estimated 12,959 person days of lost training. Of those samples sequenced, all were found to be the Alpha lineage B.1.1.7.

Conclusions

We discuss the key lessons learnt from the after-action review by the Incident Management Team. These include the importance of multidisciplinary working, the utility of sync matrices to monitor outbreaks in real time, issues around Officer Cadets reporting symptoms, timing of high-risk training activities, infrastructure and use of LFDs. COVID-19 represents a vital learning opportunity to minimise impact on future training, but also for future pandemics, which may produce considerably higher morbidity and mortality in military populations.

(Abstract 241 words)

Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic has posed major challenges for those managing institutional outbreaks, both within the civilian and military context.[1] In the United Kingdom (UK), cases began to emerge in January 2020, peaking in mid-April, then declining to low levels in the summer months.[2] In September 2020, cases began to rise again in a second wave of cases/deaths that surpassed the first. Cases peaked in the first week of January 2021 before declining. This second wave saw the emergence of a new highly transmissible variant (the Alpha lineage B.1.1.7) first

identified in South East England in September 2020.[3] The outbreak described occurred during this second UK wave.

Infection control in military training facilities poses similar challenges to other large institutions with captive populations (e.g. care homes, prisons). However, they differ in that, like other educational establishments (e.g. schools, universities), a balance needs to be struck between optimising infection control and facilitating education/training. An inability to train military personnel has substantial downstream effects on defence and national security. We present this outbreak, and the lessons drawn from it for the interest of the wider infection control community. They are particularly relevant to those responsible for training establishments that cannot rely on virtual learning alone.

Methods

Setting

Royal Military Academy Sandhurst (RMAS) is responsible for initial officer training within the British Army. It is based on a ~44-acre site in the town of Sandhurst, Berkshire in South East England. It hosts residential commissioning courses with an annual intake of ~1000 Officer Cadets. Predominantly Officer Cadets are UK citizens, but there is also a cohort of international cadets. At the time of the outbreak, RMAS was hosting 111 international cadets, representing 44 countries. The mean age of the cadets is 24 with a 10:1 M:F ratio. It hosts a cadre of instructing staff who are resident on-site.

The largest cohort of Officer Cadets attend the 44-week regular commissioning course which is taught in three separate terms (designated Juniors, Intermediates and Seniors). At any one time there are cadets from all three terms on site.

Officer Cadets are divided into Platoons comprising roughly 30 personnel. Three Platoons are organised into a Company. Junior Companies lived in Old College and the Intermediate/Senior Companies in New College and Victory Building. Old College is a Greek Revival style building and New College is a large Edwardian building. Both have large sash windows and good ventilation. Victory Building is a 1960s style building with small windows and relatively poor ventilation. The Academy established an isolation facility for potential positive cases. This was a purpose built accommodation block with each room providing ensuite facilities, the only such area on the campus.

In general, Companies and Platoons live and train in isolation, being brought together only for large outdoor exercises.

Laboratory testing

Testing for SARS-CoV-2 was performed using either reverse-transcriptase (RT) PCR or Lateral Flow Devices (LFDs). PCR testing was performed on combined nasal and throat swabs using the Hologic Panther Fusion platform, with sampling performed by trained medical staff. PCR was performed for all Officer Cadets/staff members presenting with symptoms. Innova LFDs were used for the initial day 0 and day 7 screening (described below) and during the enhanced case finding phase of the outbreak (i.e. testing of asymptomatic individuals). They were self-performed under observation by trained RMAS staff in accordance with the manufacturer SOP. Towards the end of the outbreak, PCR was conducted in the Defence Covid Laboratory using in house E gene and Taqpath Thermofisher assay.

Whole genome sequencing

Whole genome sequencing of SARS-CoV-2 samples was performed by the COVID-19 Genomics UK Consortium (COG-UK) at the University of Portsmouth sequencing site. Sequencing was performed using the ARTIC nCOV-2019 sequencing protocol V3 (LoCost), using primers from Integrated DNA Technologies (Iowa, USA).[4, 5] Samples were sequenced on a GridION X5 system (Oxford Nanopore Technologies, UK) along with a synthetic positive control (Twist Biosciences, USA) and a nuclease-free water negative control. Analysis of the resulting data was performed using the ARTIC fieldbioinformatics toolkit V1.2.1 (https://github.com/artic-network/artic-ncov2019). Lineage assignment for resulting consensus sequences was conducted using Pangolin (https://github.com/cov-lineages/pangolin) with PANGOLearn version 2021-04-21.[6] Resulting consensus sequence fasta files and mapped read BAM files were deposited in the European Nucleotide Archive (ENA), and high-quality (>90% coverage) consensus genome files were deposited in the Global Influenza Surveillance and Response System (GISAID) database. Accession numbers are available in Supplementary Table 1.

Infection control precautions

Prior to the outbreak, training was performed in Platoon households to minimise interaction. Infrastructure limited the ability to house Platoons in separate compounds. In general Platoons shared communal ablutions, apart from in the dedicated isolation facility, as described above. Face masks were required to be worn indoors.

Ethics statement

All data was acquired as part of the routine outbreak management. This report does not fulfil the definition of research, therefore does not require formal ethical approval. This work also forms part of the COG-UK surveillance study, which was granted ethical approval by the PHE Research Ethics and Governance Group (REGG) on 8th April 2020 (PHE R&D ref: NR0195).

Funding

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Results

Narrative of the outbreak

The course of the outbreak is summarised in Figure 1 and Table 1. What follows is a narrative description of the outbreak, its investigation and management.

Officer Cadets returned to RMAS in the first week of January 2021. This coincided with the eventual peak of the second UK wave. They entered an initial 14 day period of controlled monitoring where 2m social distancing measures was rigorously enforced. LFD testing was performed on day 0 (arrival)

and day 7. Officer Cadets were not permitted to leave the site apart for medical emergencies and exercises. Some had travelled abroad during the holidays prior to their return to RMAS, but were subject to national requirements for travel and quarantine.

Day 0 and 7 testing each returned a single positive case, with both isolated. On day 11, three symptomatic staff members were tested, found to be positive and isolated. Over the following days three further symptomatic staff cases were identified.

No other positive cases were identified. On day 14 controlled monitoring was lifted and, where necessary for training, Officer Cadets were permitted to break 2m social distancing within their Platoon households. Social distancing remained between the different Platoons.

On day 18 a symptomatic Officer Cadet in Juniors Platoon 1 presented and was tested. Platoon 1 began isolation on day 21, when a positive result for that Officer Cadet was received. The following day two individuals from Platoon 2 presented with symptoms, were found to be positive and isolated along with the rest of the platoon. Over the following days, two additional symptomatic Officer Cadets from Platoon 1 and five from Platoon 2 were found to be positive.

Between day 15 and 19, Intermediates took part in a 5 day outdoor exercise. On days 20 and 21 a scheduled Academy Weekend took place, which involved all the Officer Cadets in both Intermediates and Seniors term. During this weekend, no training activity was scheduled and Officer Cadets were allowed to spend their time as they wished, within the confines of their accommodation. The following day (day 22) the first symptomatic positive case was identified in Seniors Platoon 6. On day 23 another large Group Activity for a subset of Officer Cadets in both Intermediates and Seniors took place and a second positive symptomatic case, this time in Intermediates, was identified. Over the following days a large number of symptomatic Officer Cadets began coming forward for testing and case numbers rapidly rose (see Figure 1).

At this point, RMAS command staff isolated all Officer Cadets in their rooms and physical training was stopped. An Incident Management Team (IMT) was convened on day 29. The IMT included HQ staff from Army Recruiting and Initial Training Command, RMAS staff (both medical and non-medical), Defence Public Health and Defence Microbiology. Enhanced case finding by testing asymptomatic individuals at 3 daily intervals began. LFDs were utilised due to the large numbers involved. Platoons had to complete 14 days isolation and return 3 rounds of negative LFDs, before being released from isolation. This was on the basis that previous work has suggested that frequent LFD testing may outperform less frequent PCR testing with regards to identifying cases.[7]

On day 32, Juniors Platoon 1 (i.e. the first platoon with a positive case) completed its isolation period. Three days later another student in that Platoon presented with symptoms and was found to be positive, resulting in a second period of isolation. On investigation it transpired that a student in Platoon 1 had had unauthorised contact with a visitor to campus and this likely represented reintroduction of the virus. Enhanced case finding identified two additional cases in Juniors Platoon 3 and one in Platoon 2. Overall, the IMT judged that the Juniors outbreak was separate from the much larger outbreak in Intermediates/Seniors. This is likely because they lived in an entirely separate building (Old College), did not have any contact with the other terms and did not participate in the Academy Weekend or Group Activity. Of note, all cases in Juniors were concentrated in a single Company, likely reflecting their shared accommodation.

By the end of the outbreak there had been 138 confirmed cases in Intermediates/Seniors, representing 75% (138/185) of the outbreak case numbers. Of these, 58% (80/138) were identified by asymptomatic LFD testing and 42% (58/138) by symptomatic PCR testing. Given that the first

symptomatic case presented a single day after the Academy Weekend, we have concluded that SARS-CoV-2 must have been circulating prior. It is likely that both the Academy Weekend and the Group Activity represented amplification events given how rapidly subsequent cases emerged.

Intermediates Company 3 (Platoons 7, 8 and 9) were outliers, continuing to return positive cases well beyond the others. This company was housed in Victory College, separate from the rest of the Officer Cadets. Members of the IMT conducted a site visit and it became evident that Platoons 7 and 8 shared ablutions and laundering facilities on the 1st floor of the building. The pattern of positive cases was striking with cases clustering around shared facilities, rather than along the length of the corridor (see Supplementary Figure 1). Platoon 9 had far fewer cases, which was likely explained by them being on the ground floor and having effectively double the facilities per person.

Overall, 185 individuals tested positive for SARS-CoV-2 by either PCR or LFD, with 0 hospitalisations and 0 deaths. This is a reflection of the relatively young and fit population. By calculating the number of days each platoon was in isolation and multiplying this by the number of members in each platoon we estimate that 12,959 person days of lost training (i.e. 35 person years) were generated by this outbreak. Whilst some of this was mitigated with knowledge/theory lessons being taught virtually while Platoons were in isolation, the lost training time and implications are stark.

Genomics

As the majority of tests were performed using the Panther Fusion PCR platform or LFDs, most samples were not available for genomic sequencing. The initial 10 symptomatic cases were re-swabbed and sent for whole genome sequencing. The percentage of the genome covered at high depth in the resulting consensus sequence for each sample and the resulting lineage identified is shown in Supplementary Table 1. Five samples showed nearly 100% genome coverage, with lower coverage samples indicative of lower viral load. Nine samples (90%) were identified as the Alpha variant B.1.1.7 with high probability. The tenth sample had <50% coverage, meaning that no lineage could be assigned. However, all mutations identified for this sample were consistent with B.1.1.7.

Conclusions

Multi-Disciplinary Working

The IMT that oversaw the management of the outbreak contained a multi-disciplinary team, including members from a broad range of backgrounds. There was support from Behavioural Psychologists who interviewed many of the staff and students following the outbreak, gaining invaluable insights. This multi-disciplinary working and shared decision making was key to the successful control of the outbreak and we encourage others to work similarly in future.

Monitoring the outbreak – use of sync matrices

During the outbreak, the IMT utilised a sync matrix to track progress. A simplified and redacted version is available as Supplementary Figure 2. This was an invaluable tool. In a complex environment, with individuals localised in units and then in turn different localities, having a single key point of reference for the IMT was vital, particularly as the IMT was convened virtually. It was also extremely useful during the after-action phase. We would advocate for the use of similar tools in future.

Issues with reporting of symptoms

Despite Officer Cadets being encouraged to report any symptoms, we have concerns from our investigation that this did not happen universally. That lost training time through isolation potentially delayed graduation, almost certainly was a factor. Amongst the Juniors and Staff groups 80% and 94% of cases respectively were identified in symptomatic individuals, presenting for testing. This is in contrast to only 42% in Intermediates/Seniors. Given the low rates of true asymptomatic infection this suggests that Officer Cadets in these later phases of the course may have been downplaying symptoms and failing to report them.[8] We also feel that the Public Health England (PHE) symptom definition is insufficiently sensitive in our population.

This is a difficult issue to tackle. While it may be tempting to allow progress, despite lost training time, this may not always be appropriate if key assessments have been missed etc. We would suggest that institutions seek to reinforce a culture of openness and dissuade stigma.

Timing of high-risk events

From the investigation of this outbreak, we identified two high-risk events (the Academy Weekend and Group Activity) where transmission was likely amplified, fuelling the rapid rise in cases. Based on the transmission dynamics, the timing of these two events was unfortunate. Given the average incubation period of COVID-19 is ~5-6 days, with peak infectiousness ~day 3-4,[9] holding events where there is a risk of transmission around 3-4 days apart will dramatically increase the risk of a rapid rise in cases.

We would suggest that high-risk events should be scheduled at least 5-6 days apart. This is particularly important with circulation of variants with high transmissibility such as the Alpha variant B.1.1.7 and the Delta variant B.1.617.2. By lengthening the time period between events, this risk should be minimised by allowing individuals time to develop symptoms and take appropriate action before attending a second high-risk event at peak infectivity. A similar approach should be taken in future with other infectious agents where pre-symptomatic transmission occurs.

Infrastructure

The physical environment is a key consideration to the infection control practitioner. RMAS has many in-built advantages in controlling disease spread, when compared with many institutions. Firstly, Officer Cadets have individual rooms, so isolation is feasible when required. This is in contrast to other training establishments, where sometimes ~30 individuals sleep and work in the same large room. Additionally, it is a campus composed of several discrete buildings that can be selectively isolated, as opposed to a single large compound.

This outbreak proves that, even in this favourable environment, COVID-19 has the potential to spread rapidly. The case of Intermediates Platoons 7 and 8 illustrates that shared ablutions represent a risk when it comes to spreading infection, making control difficult. Additionally, these Platoons were housed in less well-ventilated accommodation (i.e. Victory College), which may have played a role. When designing training establishments in the future, the experience of COVID-19 should be kept in mind by considering smaller units of well-ventilated rooms with individual ablutions.

Lateral flow devices

LFDs were utilised to test asymptomatic individuals, identifying 46% (85/185) of the total case number. LFDs have been used in various settings for asymptomatic screening.[10] Their performance

varies between assays and manufacturers, but they offer a potentially cheap and convenient alternative to gold standard PCR testing. In our cohort, 8 individuals tested negative on LFD, only to then present with symptoms and test positive by PCR in the subsequent 48 hours, suggesting the LFD results were false negatives. We would encourage the use of LFDs in contexts such as this i.e. an outbreak setting with high incidence and limited PCR capacity. We caution against their use as a screening tool as they can offer false reassurance. For example, we would advise against their use to screen the crew of a ship prior to embarkation, due to the high risk of false negatives and the consequences of missed cases.

Closing remarks

COVID-19 poses a challenge for infection control in large institutions. Its transmission via airborne aerosols and droplet contact make indoor areas with poor ventilation hazardous.[11] Its often mild presentation make it difficult for infectious individuals to realise that they pose a risk, particularly the case in young, fit individuals. The transmission dynamics of SARS-CoV-2 compound this, whereby individuals are at their most infectious 1-2 days prior to the development of symptoms.[9]

In young healthy populations the risk of serious illness and death from COVID-19 is low, but lost training time can be substantial and has major implications for defence and national security. Low mortality amongst the young may well not be the case in future pandemics. It is sobering to note that the average age-specific mortality for H1N1 Spanish Flu was 28 years old, almost exactly the average age of our population.[12] It is key that lessons learned from COVID-19 are retained and translated into action. From our investigation of this outbreak, we draw several lessons that will inform our practice in future and hope will be of use to others.

(Main text 2998 words)

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Key messages:

- Multidisciplinary working with a broad range of stakeholders is key to successful outbreak management
- Utilising a shared, live sync-matrix to track cases is invaluable
- There will inevitably be situations where the needs of infection control and training conflict
- Taking account of transmission dynamics of SARS-CoV-2 when planning training activity can help reduce its spread
- Physical infrastructure is crucial when controlling outbreaks. Training establishments in future should be designed with this in mind

Figure 1 Graph demonstrating cumulative rise in cases over the course of the outbreak. The majority of cases were in Intermediates/Seniors Officer Cadets. Smaller, probably unrelated outbreaks occurred in the Juniors and Staff groups

Table 1 Characteristics of positive cases

Supplementary Table 1 Details and accession numbers for sequenced isolates

Supplementary Figure 1 Schematic map of the 1st floor of Victory College showing distribution of positive cases in Intermediates, Platoons 6 and 7. Cases appeared to cluster around shared facilities rather than along the length of the corridor.

Supplementary Figure 2 Redacted sync matrix utilised by IMT during the described outbreak.

Figure 1

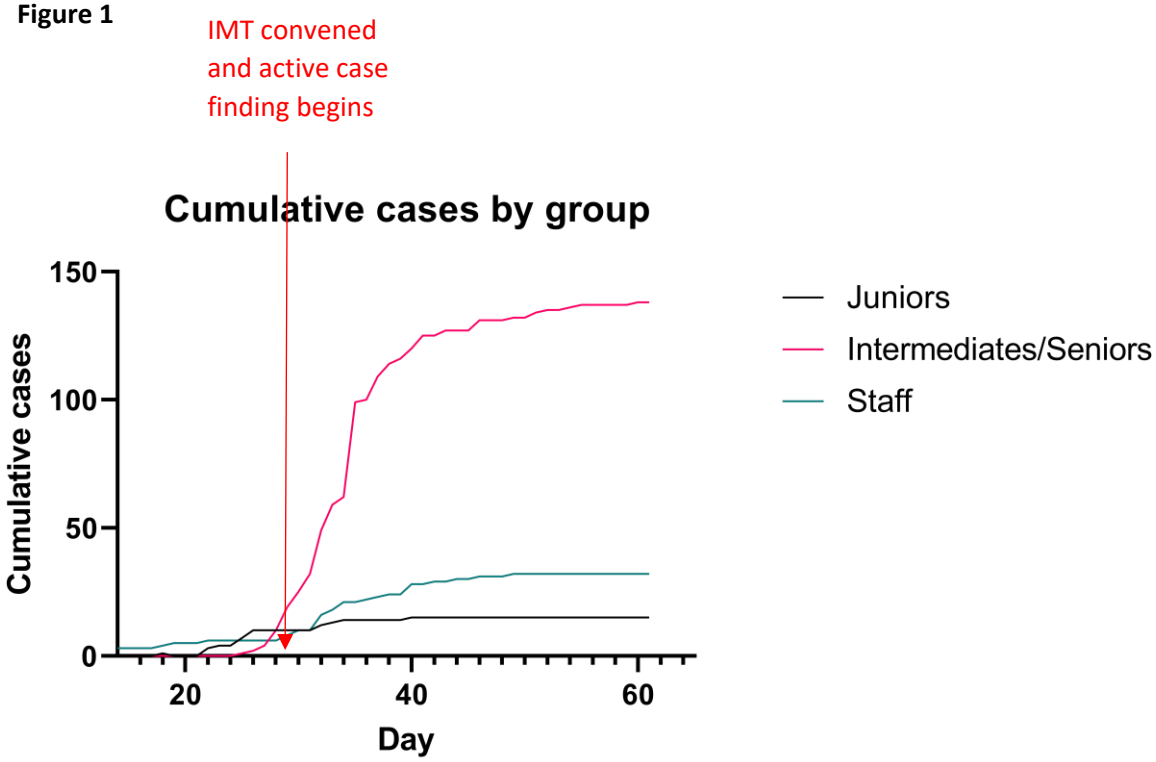


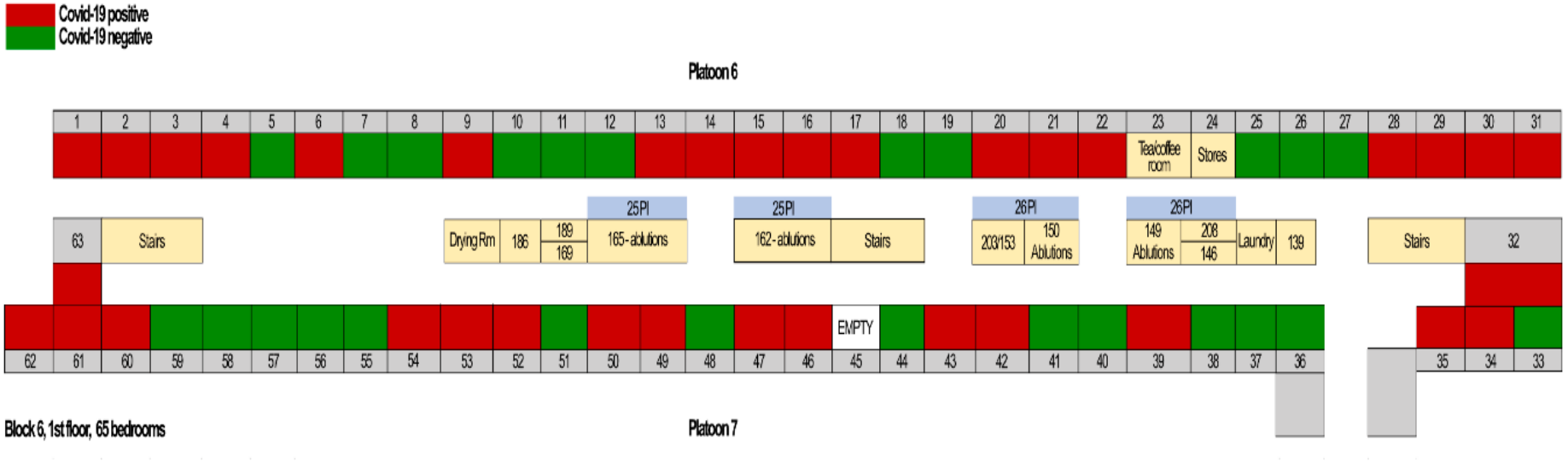
Table 1

	Population	Total positive cases (% group)	PCR positive (% of positives)	LFD positive (% of positives)
Juniors	258	15 (6)	12 (80)	3 (20)
Intermediates/Seniors	454	138 (30)	58 (42)	80 (58)
Staff	483	32 (7)	30 (94)	2 (6)
Total	1195	185 (15)	100 (54)	85 (46)

Supplementary Table 1

Central sample ID	Coverage	Pangolin Lineage	pangolin_note	ena_sample.accession	ena_run.accession	gisaid.accession	gisaid.secondary_accession
PORT-2DB0A2	99.6	B.1.1.7	17/17 B.1.1.7 SNPs	ERS5758563	ERR5302569	EPI_ISL_1000283	hCoV-19/England/PORT-2DB0A2/2021
PORT-2DB0B1	57.7	B.1.1.7	14/17 B.1.1.7 SNPs	ERS6057533	ERR5509490	NA	NA
PORT-2DB0C0	99.6	B.1.1.7	17/17 B.1.1.7 SNPs	ERS5757827	ERR5301737	EPI_ISL_1000284	hCoV-19/England/PORT-2DB0C0/2021
PORT-2DB0DF	47.8	None	N_content:0.52	NA	NA	NA	NA
PORT-2DB0EE	99.6	B.1.1.7	17/17 B.1.1.7 SNPs	ERS5753526	ERR5297266	EPI_ISL_1000285	hCoV-19/England/PORT-2DB0EE/2021
PORT-2DB0FD	80.4	B.1.1.7	16/17 B.1.1.7 SNPs	ERS6062087	ERR5514209	NA	NA
PORT-2DB109	82.3	B.1.1.7	16/17 B.1.1.7 SNPs	ERS6055761	ERR5507649	NA	NA
PORT-2DB118	83.9	B.1.1.7	16/17 B.1.1.7 SNPs	ERS6049792	ERR5501458	NA	NA
PORT-2DB127	99.6	B.1.1.7	17/17 B.1.1.7 SNPs	ERS5756800	ERR5300669	EPI_ISL_1000286	hCoV-19/England/PORT-2DB127/2021
PORT-2DB136	99.6	B.1.1.7	17/17 B.1.1.7 SNPs	ERS5758505	ERR5302496	EPI_ISL_1000287	hCoV-19/England/PORT-2DB136/2021

Supplementary figure 1



Supplementary figure 2