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Prospective Surveillance of Respiratory Infections in British Antarctic Survey Bases During the COVID-19 Pandemic

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Background. The British Antarctic bases offer a semiclosed environment for assessing the transmission and persistence of seasonal respiratory viruses.

Methods. Weekly swabbing was performed for respiratory pathogen surveillance (including SARS-CoV-2), at 2 British Antarctic Survey bases, during 2020: King Edward Point (KEP, 30 June to 29 September, 9 participants, 124 swabs) and Rothera (9 May to 6 June, 27 participants, 127 swabs). Symptom questionnaires were collected for any newly symptomatic cases that presented during this weekly swabbing period.

Results. At KEP, swabs tested positive for non–SARS-CoV-2 seasonal coronavirus (2), adenovirus (1), parainfluenza 3 (1), and respiratory syncytial virus B (1). At Rothera, swabs tested positive for non–SARS-CoV-2 seasonal coronavirus (3), adenovirus (2), parainfluenza 4 (1), and human metapneumovirus (1). All bacterial agents identified were considered to be colonizers and not pathogenic.

Conclusions. At KEP, the timeline indicated that the parainfluenza 3 and adenovirus infections could have been linked to some of the symptomatic cases that presented. For the other viruses, the only other possible sources were the visiting ship crew members. At Rothera, the single symptomatic case presented too early for this to be linked to the subsequent viral detections, and the only other possible source could have been a single nonparticipating staff member.

Keywords. Antarctic; SARS-CoV-2; imported; infection; personnel; respiratory virus; surveillance; symptomatic; transmission.

The Antarctic has been fortunate in managing to remain free of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the viral cause of coronavirus disease 2019 (COVID-19), until December 2020, when the first cases of COVID-19 were reported from this remotest continent [1, 2]. Previous studies in Antarctic research bases have documented infections with rhinoviruses [3], adenoviruses [4], and possibly other respiratory viruses that were never identified at the time [5] in base personnel. A study where human volunteers at one of the British Antarctic bases (Stonington Island) were artificially inoculated with rhinovirus type 2, exhibited more severe disease compared to similarly inoculated volunteers in Salisbury, England [6]. This suggested that people living in extreme conditions, particularly after a period of isolation, may be more susceptible to more severe disease when exposed to such seasonal respiratory viruses [7, 8].

Although these older studies lacked viral sequence analysis capabilities to more definitively link cases epidemiologically, traditional epidemiological techniques strongly suggested that the viruses did indeed transmit, albeit slower than expected, between base personnel. Since then, the application of molecular diagnostic and viral sequencing methods to outbreak investigations have played a substantial role in furthering our understanding of how respiratory viruses are transmitted, particularly influenza [8] and SARS-CoV-2 [9, 10].

The British Antarctic Survey (BAS) bases offer a unique environment to enhance our understanding of these seasonal respiratory viruses further [11], as all personnel and their movements on these bases are carefully controlled and tracked routinely for health and safety purposes. Additional restrictions on these Antarctic bases, including the screening and monitoring of base personnel, were introduced during the COVID-19 pandemic in early 2020 by the Council of Managers of National Antarctic Programs [12], to prevent the introduction and spread of SARS-CoV-2 in Antarctic personnel. This was important as if any infected personnel became severely ill, urgent medical evacuation would be required to transfer them to overseas intensive care facilities, which would be subject to the unpredictable Antarctic weather conditions [1].

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This present study is an extension of a more recent pilot study at the Rothera base [13], which found evidence of seasonal coronaviruses amongst 2 out of 40 participating personnel from the BAS's Rothera base, during a 1-month period (March 2017). Although there were 5 symptomatic cases identified in this study, only 2 cases had an identifiable respiratory virus cause. Similar to the previous studies [3, 4], this showed a limited extent of infection with these respiratory viruses in Antarctic base personnel.

In this larger follow-up study, we performed surveillance at 2 BAS bases (King Edward Point [KEP] and Rothera), and screened for both respiratory viruses (including SARS-CoV-2) and bacteria. These 2 bases are over 2000 km apart and had no contact with each other during the study period.

METHODS

Ethics

Ethics approval for the study at both sites (KEP and Rothera) was granted by the BAS Animal Welfare and Ethics Review Body. All participants gave their informed consent to participate in this study.

British Antarctic Survey Bases

The study focuses on respiratory virus transmission amongst isolated BAS personnel. Three of the 5 BAS research stations are operational year round, with staff completely cut off from the outside world for weeks to months, depending on the site. We selected 2 stations that are operational year round as study sites: KEP (latitude, −54.28325; longitude, −36.493735) on the subantarctic island of South Georgia, and Rothera (latitude, −67.56842; longitude, −68.12579) on the Antarctic peninsula.

These selected semiclosed communities offer a unique opportunity to investigate viral surveillance and transmission within a living and working cohort with minimal exposure to external parties. Life on these Antarctic stations is routinely monitored as part of operational safety requirements, including any external contact.

Study Design

The aim of the study was to explore respiratory pathogen dynamics in a closed population of BAS personnel, across 2 sites, using a prospective observational cohort. This involved both regular and sporadic acute sampling for respiratory pathogens (both viruses and bacteria) study combining viral swabs and questionnaires amongst a semi-isolated population cohort. It was conducted during deployment by the medical officers to KEP (K. H. G., sample identification MC) and the Rothera (J. C. B., sample identification RC) research stations.

Recruitment

Overwintering personnel at the KEP (during July–September 2020) and Rothera (during May–June 2020) BAS Research Stations were recruited. Volunteers at both stations were talked through participant information on a one-to-one basis, with the opportunity to ask questions. Discussion of symptomatic participant contact questionnaires took place, to ensure participants were familiar with which symptoms to report.

Study Period

At KEP, the start date was chosen as the first available date after the station winter resupply visit by the Fisheries Protection Vessel (FPV), which transported the sampling swabs to the station. Weekly nasopharyngeal swabs were taken starting on 30 June 2020 and continuing for 3 months until 29 September 2020, covering the period of most extreme isolation on the station. At the start of the study period, the KEP BAS station personnel had a winter cohort of 9 (plus 2 South Georgia and the South Sandwich Islands Government Officers living separately to BAS staff) and had been isolated for 46 days since 15 May 2020. There was no interaction with the FPV crew who did not disembark at this initial resupply. For the purposes of the KEP study cohort, n = 9.

At Rothera, the study period was during May to June 2020, covering a similar time period to the previous work by Everett et al 2019 [13]. A total of 28 participants were recruited, with 1 subsequent voluntary withdrawal before testing began, leaving 27 participants. One participant required medical evacuation for an unrelated issue (a hand injury requiring surgery) after the first testing point but their partial results are included (RC6339). The start date for the study was selected as the first day that work schedules would allow for all overwintering personnel to be present on station following departure of the summer staff and delivery of sampling materials. Regular sampling began on 9 May and ended on 6 June 2020, with symptomatic sampling extended until 15 December with the arrival of incoming summer staff.

Respiratory Sampling and Storage

At KEP, baseline nasopharyngeal swabs were taken, starting on 30 June until 29 September 2020, every 7 days from consenting participants. Similarly, at Rothera, nasopharyngeal swabs were taken, starting 9 May 2020 until 6 June 2020, once per week during a 24-hour sampling period to give the greatest chance of sampling all participants. Not all participants were available at every sampling period due to off-site work commitments.

At both bases, nasopharyngeal swabbing was conducted by the station doctor (K. H. G. at KEP, J. C. B. at Rothera). Swabs were collected using virus transport medium (Virocult; Medical Wire and Equipment), and labelled with the participants' anonymized number and date. The swabs were packaged and stored in a delegated −80°C freezer.

Samples remained on each station, stored at −80°C, until the summer station uplift (1 February 2021 for KEP and 19 February 2021 for Rothera), when they were transferred to the United Kingdom (Harwich). Samples were kept in a −80°C freezer throughout sea transport. Upon arrival in the UK, the swabs were transported to Leicester Royal Infirmary virology laboratory for viral testing.

At both bases, in addition to regular weekly swabbing to monitor for the presence and spread of asymptomatic disease, participants with any symptomatic respiratory illness were requested to present to the doctor for further samples. All symptomatic participants were asked to fill out a symptomatic patient questionnaire (Supplementary Material). The questionnaire was designed to extract more details about their symptoms, as well as their contacts and related activities to inform possible transmission scenarios.

Laboratory Respiratory Pathogen Testing (Leicester, UK)

Samples were tested for SARS-CoV-2, as well as common seasonal viruses: influenza A, influenza B, parainfluenza viruses (PIVs, types 1–4), respiratory syncytial virus (RSV) A and B, adenoviruses (AdVs), rhinoviruses, enteroviruses, parechoviruses, bocavirus, human metapneumovirus (hMPV), and seasonal coronaviruses (CoVs, all 4 species 229E, OC43, NL63, HKU1, but we were unable to distinguish between them in this updated version of the kit) using an AusDiagnostics kit (catalog No. 20602). The respiratory virus target sensitivities and limits of detection for this kit were similar to that reported previously, as the same kit was still in use [13] (Supplementary Material).

Additional testing for respiratory bacterial pathogens was also performed on the same samples, using the AusDiagnostics (catalog No. 20631) bacterial pneumonia panel (*Mycoplasma pneumoniae, Chlamydophila pneumoniae, Chlamydophila psittaci, Legionella pneumophila, Legionella longbeachae, Haemophilus influenza, Haemophilus parainfluenzae, Haemophilus haemolyticus, Streptococcus pneumoniae, Staphylococcus aureus, Bordetella pertussis, Coxiella burnetti, Mycobacterium tuberculosis complex, Aspergillus fumigatus, Pneumocystis jirovecii*, and *Cryptococcus neoformans)*.

Two hundred and fifty-one nasopharyngeal swabs in ∑-VIROCULT (Sigma) viral transport media arrived in Leicester (10 April 2021) and were stored at −80°C prior to testing at the Virology laboratory at the Leicester Royal Infirmary.

Each sample had a 200 µL aliquot mixed with 200 µL buffer AL (QIAGEN) before heating at 87°C for 10 minutes. All samples were extracted on the QIAsymphony using the QIAsymphony DSP Virus/Pathogen kit (QIAGEN). Sample eluates were tested using multiplex-tandem polymerase chain reaction (MT-PCR) on the AusDiagnostics High-plex instrument using the Respiratory Pathogen 16-well (catalog No. 20602) and Pneumonia 16-plex (catalog No. 20631) PCR assays following manufacturer's instructions. Limits of detection for each of the viral targets on this assay were provided by the manufacturer and are shown in the Supplementary Material. All positive samples were retested and eluates and residual samples were stored at −80°C; with all results tabulated using Microsoft Excel version 2016. Additional melting point analysis was performed by the AusDiagnostics team to distinguish between any same-species viruses that were detected to ascertain if they were linked or distinct transmission events.

RESULTS

Eventually, there were 9 participants from KEP (with a total of 124 swabs) and 27 participants from Rothera (total, 127 swabs) who agreed to take part in the study. The timeline of the sampling and test results for both KEP and Rothera are shown in the Supplementary Material 1 and 2. Table 1 and Table 2 show the positive respiratory pathogen results.

All the bacteria identified in these samples from both bases (KEP and Rothera) (*S. aureus, S. pneumoniae, H. influenzae, A. fumigatus, P. jirovecii*) were considered to be colonizers, as none of the participant questionnaires completed indicated any more serious symptoms or signs of bacterial pneumonia, requiring antibiotic therapy.

The mix of respiratory viruses identified in both bases were consistent with seasonal viruses that are known to persist throughout the year, albeit at low levels in some cases. However, the earliest positive samples in each base (21 July 2020 for KEP; 16 May 2020 for Rothera) were taken from individuals who were at least 1 week postentry. This is longer than the typical incubation and shedding period for RSV, seasonal CoVs, PIVs, and hMPV (approximately 1–3 days incubation,

Table 1. King Edward Point Base Positive Results (Out of a Total of 124 Samples, 9 Participants)

Participant No.	Sample ID	Collection Date	AusDx Respiratory Virus Result	AusDx Pneumonia Panel Results
MC409	493783	21 Jul 2020	Parainfluenza 3	*Staphylococcus aureus, Haemophilus influenzae*
MC220	493731	4 Aug 2020	Seasonal coronavirus[a]	*Aspergillus fumigatus*
MC321	493735	4 Aug 2020	Respiratory syncytial virus B	*Aspergillus fumigatus*
MC337	493816	18 Aug 2020	Seasonal coronavirus[a]	*Staphylococcus aureus*
MC220	493826	2 Sep 2020	Adenovirus	*Aspergillus fumigatus, Haemophilus influenzae*

Sampling period was 30 June to 29 September 2020.

[a]Further melt curve analysis indicated than the seasonal coronaviruses were distinct from each other.

Table 2. Rothera Base Positive Results (Out of a Total of 127 Samples, 27 Participants)

Participant No.	Sample ID	Collection Date	AusDx Respiratory Virus Result	AusDx Pneumonia Panel Results
RC4506	493896	16 May 2020	Adenovirus[a]	*Staphylococcus aureus*
RC9223	493940	23 May 2020	Seasonal coronavirus[b]	*Staphylococcus aureus*
RC0325	493863	30 May 2020	Human metapneumovirus	*Streptococcus pneumoniae, Staphylococcus aureus*
RC1082	493865	30 May 2020	Parainfluenza 4	*Haemophilus influenzae*
RC0627	493866	30 May 2020	Adenovirus[a]	*Streptococcus pneumoniae, Haemophilus influenzae*
RC0760	493868	30 May 2020	Seasonal coronavirus[b]	*Staphylococcus aureus*
RC5694	493877	30 May 2020	Seasonal coronavirus[b]	*Pneumocystis jirovecii, Staphylococcus aureus*

Sampling period was 9 May to 6 June 2020.

[a]Melt curve analysis indicated that the 2 adenoviruses were distinct.

[b]Melt curve analysis indicated that the seasonal coronavirus collected 23 May 2020 was distinct from the other 2 seasonal coronaviruses. The latter 2 seasonal coronaviruses (identified in samples collected on the same date) may have been acquired from the same source.

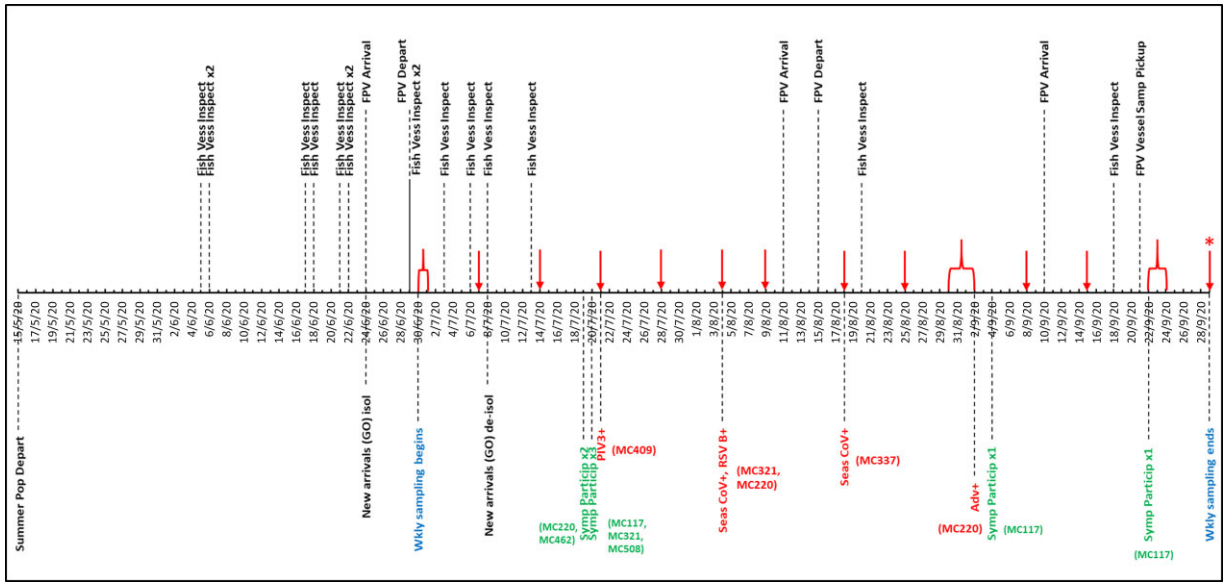

Figure 1. King Edward Point base timeline of events. Note the central dateline. The vertical arrows or brackets represent roughly weekly sampling time points, with symptomatic cases and PCR-confirmed viral infections as indicated. In some weeks, the sampling dates (brackets) were more spread out due to participants' convenience. *Two late samples (both PCR negative) were collected on 6 October 2020 (MC220, MC462) as part of this last weekly batch of samples. Abbreviations: AdV+, adenovirus positive; Fish Vess Inspect, fisheries vessel inspection; FPV, Fisheries Protection Vessel; GO, government officer; isol, isolated; MC, King Edward Point participating base personnel; PCR, polymerase chain reaction; PIV3+, parainfluenza 3 positive; RSV B+, respiratory syncytial virus B positive; Seas CoV+, seasonal coronavirus positive; Summer Pop Depart, summer population of base personnel departure; Symp, symptomatic; Wkly, weekly.

followed by 5–7 days virus shedding), but within the usual incubation period for AdVs (5–10 days). As the previous weekly sampling showed no positive results, this then raises the question of how these viruses entered the base and infected these participants. The timelines of activities for the 2 bases are shown in Figure 1 (KEP) and Figure 2 (Rothera).

For KEP (Table 1 and Table 3, and Figure 1), the first positive sample (PIV3, 21 July 2020, MC409) may have been acquired from infected base personnel, who may have been infected with this virus—possibly from visiting FPV crew members—but whose viral load was below the limit of detection (450–925 RNA copies/mL virus transport medium) for the diagnostic assay (Supplementary Material) at the point of swabbing. There were no other external visits or contact events within 7 days of this sample date. However, for the seasonal CoVs and RSV B viruses detected on 4 August 2020 (MC220, MC321), the FPV crew could not have been the source for these viruses, as by this time the station had been completely isolated from external contact for 22 days.

The seasonal coronavirus detected on 18 August 2020 (MC337) could have again been from FPV crew members who had arrived on 11 August and moored at KEP until 15 August 2020. The FPV crew did disembark during the daytime to perform maintenance and cargo tasks, although an outdoors-only

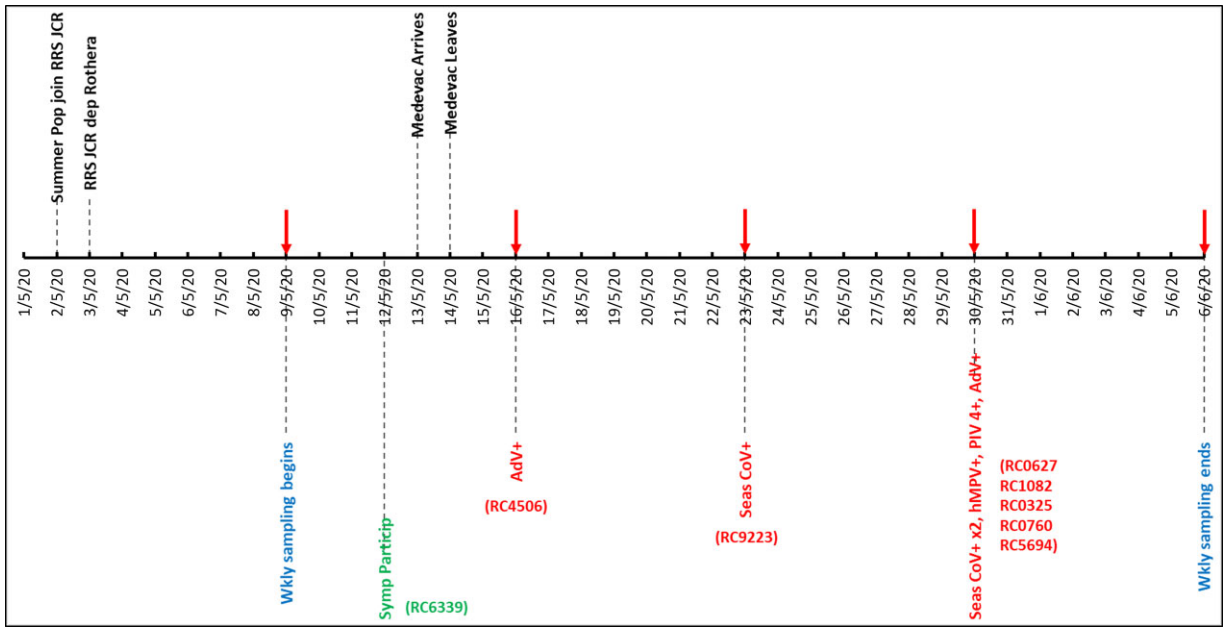

Figure 2. Rothera base timeline of events. Note the central dateline. The vertical arrows represent sampling time points, with symptomatic cases and PCR-confirmed viral infections as indicated. Abbreviations: AdV+, adenovirus positive; hMPV+, human metapneumovirus positive; PCR, polymerase chain reaction; PIV4+, parainfluenza 4 positive; RC, Rothera participating base personnel; RRS JCR, Royal Research Ship James Clark Ross; Seas CoV+, seasonal coronavirus positive; Summer Pop Depart, summer population of base personnel; Symp, symptomatic; Wkly, weekly.

policy was in place with 2-meter distancing. This is the most likely source as at this point, aside from the FPV mooring, the station had been completely isolated from outside contact for 36 days. Further melting point analysis indicated that the 2 seasonal CoVs (from MC220, 4 August 2020; and MC337, 18 August 2020) were distinct and not related (Table 1).

The AdV infection detected on 2 September was from the same participant (MC220) who had regular exposure to sewage as part of his job. Adenoviruses have a longer incubation period (5–10 days) and can be shed for longer (1–3 weeks) in stool. However, no other study participant had had adenovirus infection diagnosed prior to this, from whom the virus could have been shed into the sewage system—although again, we cannot rule out one of the FPV crew being the source for this virus.

From this KEP data, there were 5 laboratory-confirmed viral infections out of 9 participants over a study period of 92 days (30 June to 29 September, inclusive). This gives an infection rate of 0.55 infections per person over 92 days (approximately 13 weeks), or 4.3 infections per 100 persons per week.

For Rothera, all the identified respiratory virus infections (Table 2 and Table 4, and Figure 2) were detected in the samples taken on 16 (AdV, RC4506), 23 (seasonal CoV, RC9223), and 30 (hMPV, PIV4, AdV, seasonal CoV from RC0325, RC1082, RC0627, RC0760, RC5694, respectively) May 2020.

Apart from the Medevac crew for the AdV (RC4506, 16 May), there were no external events that could have acted as a source for these viruses. Participant RC9223 could have acted as a source of seasonal CoV for participants RC0760 and RC5694. However, melting point analysis indicated that the seasonal CoV from RC9223 was different from those from RC0760 and RC5694, which were more closely related. Similarly, melting point analysis also indicated that the 2 AdVs (RC4506 and RC0627) were distinct from each other. The sources of the other viruses (hMPV, PIV4) could only have been nonstudy personnel (just one person, a base technician; Table 4) in the Rothera base, unless there were low levels of infection in some of the study participants that failed to be detected during the weekly sampling but were still sufficient to transmit infection to others.

From this Rothera data, there were 6 laboratory-confirmed viral infections out of 27 participants, over a study period of 29 days (9 May to 6 June, inclusive). This gives an infection rate of 0.22 infections per person over 29 days (approximately 7 weeks), or 3.2 infections per 100 persons per week—which is very similar to the infection rate at KEP.

DISCUSSION

The findings in this study have demonstrated several features that have been reported in other previous Antarctic studies, although previous studies have not been conducted during an ongoing global pandemic with a novel zoonotic virus (SARS-CoV-2). Fortunately, there were no cases of COVID-19 (the disease caused by SARS-CoV-2) detected in

Table 3. Risk Assessment of Possible Sources of Respiratory Viruses, With Justifications, Amongst Participating and Nonparticipating Personnel at King Edward Point Base

Possible Source	Relevant Dates	Possibly Infecting	Relevant Dates	Reasons
FPV crew	3, 6, 8, 13 Jul 2020	MC409 (PIV3)	21 Jul 2020	Unlikely to have been a source due to FPV crew not disembarking during this visit. Resupplies were offloaded via crane without human contact. These were disinfected prior to being transferred to Biosecurity for 3 d quarantine before being used for restock.
		2 symptomatic cases (MC220, MC462)	19 Jul 2020	
		3 symptomatic cases (MC117, MC321, MC508)	20 Jul 2020	
		1 symptomatic case (MC117)	22 Sep 2020	Possible outdoor socializing on the ice between base staff and FPV crew members, without strict 2-m social distancing at all times.
Government Officers	8 Jul 2020	MC409 (PIV3)	21 Jul 2020	Very unlikely to have been a source due to strict separation and PPE use and no outdoors socializing on the ice.
		2 symptomatic cases (MC220, MC462)	19 Jul 2020	
		3 symptomatic cases (MC117, MC321, MC508)	20 Jul 2020	
MC117, MC508	23, 25 Aug 2020	MC220 (AdV)	2 Sep 2020	MC117 and MC508 were on a field trip, and missed their regular sampling. They then rejoined their base crew without completing their missed sampling or questionnaires.
		Symptomatic case (MC117, symptoms may have persisted)	4 Sep 2020	
Nonparticipating base staff	Not applicable	Not applicable	Not applicable	There were no nonparticipating base staff.

Abbreviations: FPV, Fisheries Protection Vessel; PPE, personal protective equipment.

Table 4. Risk Assessment of Possible Sources of Respiratory Viruses, With Justifications, Amongst Participating and Nonparticipating Personnel at Rothera Base

Possible Source	Relevant Dates	Possibly Infecting	Relevant Dates	Reasons
Medevac crew	13, 14 May 2020	…	16 May 2020	Unlikely as Medevac crew had no contact with base personnel without PPE, stayed in separate buildings and only met base personnel outdoors with strict 2 m social distancing
Symptomatic case (RC6339)	12 May 2020	RC4506 (AdV)	16 May 2020	RC6339 was swabbed but then left the base on the Medevac
Nonparticipating base staff	Whole study period	Not applicable	Not applicable	This single nonparticipant (a base technician) interacted as normal with the rest of the base personnel, without any restrictions

these 2 KEP and Rothera study cohorts. Both of these participating cohorts had arrived at their bases (during December 2019–January 2020) before the onset of the pandemic and wider dissemination of SARS-CoV-2, and later thereafter during the study period visiting staff (Government Officers and FPV crew members) observed strict pandemic precautions.

Several findings from this study are of interest. Firstly, all the identified symptomatic cases were mild. Unlike the findings of Holmes et al [6], who found more severe disease in an isolated BAS population who were *artificially* infected with rhinovirus type 2, there were no cases of severe disease at these 2 study sites (KEP and Rothera).

Secondly, whilst there were several symptomatic cases there was very limited identifiable transmission of any particular virus throughout the base personnel in either the KEP or Rothera sites. Seasonal coronavirus was detected in 2 and 3 participants at KEP and Rothera, respectively, but no additional cases were detected indicating ongoing propagation of these viruses through the other personnel on these bases.

One limitation of the diagnostic assay used was that it did not distinguish between the 4 different species of seasonal CoVs (OC43, 229E, NL63, HKU1), although the melting point analysis (including for the AdVs) indicated that some of these viruses were distinct from the others. The other viruses detected in each base were only detected in unique individuals: PIV3, RSV B, and AdV at KEP; hMPV and PIV4 at Rothera. The infection rate at each base was approximately 3–4 infections per 100 people per week—or 0.22–0.55 infections per person.

These KEP and Rothera 2020 respiratory virus infection rates are very similar to those previously reported over 40 years ago

by Warshauer et al [3], at the US McMurdo Station Antarctic base with base cohorts of 200 men, of 0.43–0.45 infections per person, during 36 days from 31 August to 5 October 1976, mainly due to rhinoviruses, and by Shult et al [4] of 1.5 infections per 100 persons per week, over 33 days during 2 September to 4 October 1977, mainly due to adenovirus 21.

From our previous study [13], the infection rate was 2 laboratory-confirmed infections out of 40 participants over 4 weeks (28 days, during March–April 2017), giving an even lower equivalent rate of 0.05 infections per person, or 1.25 infections per 100 participants per week. Thus, it appears that naturally occurring seasonal respiratory virus infections transmit relatively slowly and inefficiently amongst isolated Antarctic base personnel, despite the closed, crowded living conditions.

Thirdly, and perhaps the most intriguing feature of this and our previous study [13] is that the source of these respiratory viruses remains unknown. Tables 3 and 4 identify and assess possible sources for some of these viral infections on each base. The incubation for most of these viruses is too short to account for the appearance of these viruses 1 week or more into the closed base isolation period—without there being an intermediate, yet unknown source or sources for these viruses, somewhere on the base. This may be from nonparticipating base personnel or visitors, who would include, for example, the FPV crew with whom some of the BAS personnel did socialize outdoors, where the 2-m social distancing rule may not have always been observed.

As many of these seasonal respiratory viruses do cause asymptomatic infections [14, 15]; this certainly adds to the plausibility of this explanation, although we do not know how long such viruses will be shed in such cases. This also suggests a breakdown in the otherwise strict base infection control procedures during this period. Unfortunately, we were not able (and will probably never be able) to test such visiting FPV crew members, so will therefore always miss potential sources of these seasonal viruses.

Also, despite the requirement for participants to attend for swabbing and completion of a questionnaire as soon as they developed new symptoms, it became apparent that some of the participants were attending for swabbing after symptoms had been present for several days. The participants were professional scientists in their own right, working on their own projects, so to some extent this was not unexpected. This also led to some participants presenting late for their weekly swabs at KEP base (Supplementary Material 2). However, as there was no formal isolation or quarantine facility or requirement within the bases, any infections would have been soon detected in others if there were any significant outbreaks, on the routine weekly swabbing. We did not see any evidence of sustained outbreaks with any respiratory virus in either base.

The timelines for KEP (Figure 1) and Rothera (Figure 2) show examples of *symptomatic* participants in whom no virus was detected, and *asymptomatic* participants in whom viruses were detected. Again, there is an earlier example of this, where Allen et al [5] reported an outbreak of common cold-like illness that eventually affected 10 out of 12 men on the BAS Adelaide Island base. Despite exhaustive diagnostic testing using viral and bacterial culture methods, viral serology (complement fixation and hemagglutination inhibition), electron microscopy—and even serial human volunteer inoculation experiments—none of these investigations provided convincing evidence of any particular viral or bacterial agent. Although possible that samples may have deteriorated during storage, handling, and transport (ie, accounting for some false-negative test results), this was unavoidable as samples generally cannot be processed on site in these remote bases [16].

Thus, despite best efforts, seasonal respiratory viruses can be introduced into Antarctic bases by incoming or visiting personnel, together with facilitating human behaviors. However, it appears that isolation and extreme weather conditions do not necessarily confer a higher risk of rapid spread nor more clinically severe disease.

Supplementary Data

Supplementary materials are available at *The Journal of Infectious Diseases* online (http://jid.oxfordjournals.org/). Supplementary materials consist of data provided by the author that are published to benefit the reader. The posted materials are not copyedited. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

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Notes

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Author contributions. J. W. T., M. D., S. H., and T. E. conceived and developed the study concept and protocols. M. D., S. H., T. E., and M. W. developed it further from the British Antarctic Survey side and prepared and submitted the ethics approval. K. G. and J. B. conducted and managed the study on site at the bases, including the sampling, packaging, and transport of the samples back to the UK. P. W. B., N. W., J. S., M. O., and G. O. performed the sample testing in Leicester, which was coordinated and supervised by J. W. T., C. M., and C. W. H. The first draft was written by K. G., J. B., and J. W. T. with additional input from S. S. F. K., M. D., M. W., and S. H. All authors critically reviewed the final version of the manuscript and approved its submission.

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