EClinicalMedicine 26 (2020) 100533

Contents lists available at ScienceDirect

EClinicalMedicine

journal homepage: https://www.journals.elsevier.com/eclinicalmedicine

Research Paper

Investigation of SARS-CoV-2 outbreaks in six care homes in London, April 2020

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ARTICLE INFO

Article History:
Received 24 June 2020
Revised 11 August 2020
Accepted 13 August 2020
Available online 9 September 2020

Keywords:
Covid-19
Care homes
Case-fatality rate
Symptoms

ABSTRACT

Background: Care homes are experiencing large outbreaks of COVID-19 associated with high case-fatality rates. We conducted detailed investigations in six London care homes reporting suspected COVID-19 outbreaks during April 2020.

Methods: Residents and staff had nasal swabs for SARS CoV-2 testing using RT-PCR and were followed-up for 14 days. They were categorized as symptomatic, post-symptomatic or pre-symptomatic if they had symptoms at the time of testing, in the two weeks before or two weeks after testing, respectively, or asymptomatic throughout. Virus isolation and whole genome sequencing (WGS) was also performed.

Findings: Across the six care homes, 105/264 (39.8%) residents were SARS CoV-2 positive, including 28 (26.7%) symptomatic, 10 (9.5%) post-symptomatic, 21 (20.0%) pre-symptomatic and 46 (43.8%) who remained asymptomatic. Case-fatality at 14-day follow-up was highest among symptomatic SARS-CoV-2 positive residents (10/28, 35.7%) compared to asymptomatic (2/46, 4.3%), post-symptomatic (2/10, 20.0%) or pre-symptomatic (3/21,14.3%) residents. Among staff, 53/254 (20.9%) were SARS-CoV-2 positive and 26/53 (49.1%) remained asymptomatic. RT-PCR cycle-thresholds and live-virus recovery were similar between symptomatic/asymptomatic residents/staff. Higher RT-PCR cycle threshold values (lower virus load) samples were associated with exponentially decreasing ability to recover infectious virus ($P<0.001$). WGS identified multiple (up to 9) separate introductions of different SARS-CoV-2 strains into individual care homes.

Interpretation: A high prevalence of SARS-CoV-2 positivity was found in care homes residents and staff, half of whom were asymptomatic and potential reservoirs for on-going transmission. A third of symptomatic SARS-CoV-2 residents died within 14 days. Symptom-based screening alone is not sufficient for outbreak control.

Funding: None

Introduction

Amid the COVID-19 pandemic, community care facilities including nursing and residential homes have been termed "hubs" and "besieged castles" in North America and Europe, having experienced

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https://doi.org/10.1016/j.eclinm.2020.100533

Research in context

Evidence before this study

We searched PubMed with the terms "COVID-19 outbreak" or "SARS-CoV-2 outbreak" and "care home", "nursing home", "nursing facility" or "residential home" to identify publications relating to COVID-19 outbreaks since January 2020, focusing particularly on those where enhanced outbreak investigations were undertaken.

Large COVID-19 outbreaks associated with high cases fatality rates among residents have been reported worldwide. Outbreak investigation of single care homes identified high rates of asymptomatic and pre-symptomatic SARS-CoV-2detection by the time an outbreak is identified. Live virus has been isolated from asymptomatic residents and staff highlighting their potential for transmission within the care home setting. Whole genome sequence analysis identified the outbreak strains to be indistinguishable to those circulating in the local community.

Added value of this study

We found very high rates of SARS-CoV-2 positivity among residents (40%, range 26–79%) and staff (20%) in London care homes experiencing a COVID-19 outbreak, most of whom were asymptomatic at the time of testing. Case fatality at 14 days was high among symptomatic RT-PCR positive residents (36%) compared to asymptomatic SARS-COV-2 positive residents (4%). Individual genomic clusters involved multiple residents and at least one positive staff member within the same care home.

Implications of all the available evidence

Asymptomatic SARS-CoV-2 positive residents and staff are likely to be acting as potential reservoirs for local infection and transmission within care homes. Further studies are needed to assess whether infected residents and staff develop protective antibodies against SARS-CoV-2.

large outbreaks due to rapid transmission of SARS-CoV-2 [1–3]. Care homes have a unique, mixed population of multi-disciplinary staff and frail residents with multiple underlying comorbidities [4, 5]. Such residents are at high risk of severe complications and death due to respiratory viruses, such as influenza [6], and now COVID-19 [7–10].

In the UK, the first imported COVID-19 cases were confirmed in late January 2020 and autochthonous transmission confirmed in late February 2020. Case numbers increased rapidly from early March, with nationwide lockdown being announced on 23 March. London experienced faster transmission and higher rates of COVID-19 cases than any other region in the UK [11], with many care homes reporting large and sustained outbreaks, associated with high case-fatality rates (CFR) [8]. In England and Wales, there were 45,899 deaths among care home residents between March 02 and May 02 and 12,526 (27.3%) involved COVID-19 [12].

Beginning April 10, Public Health England (PHE) undertook an enhanced outbreak investigation in six London care homes experiencing COVID-19 outbreaks to increase understanding of disease transmission and inform urgent public health interventions. We assessed SARS-CoV-2 positivity in residents and staff at the care homes and followed them daily for two weeks. We evaluated differences in outcomes according to SARS-CoV-2 positivity, viral load and recovery of infectious virus according to timing and presence or absence of symptoms. We used whole genome sequence (WGS) analyses to inform about likely transmission routes infection.

Methods

We identified six care homes reporting a suspected outbreak (≥2 suspected cases) of COVID-19 to PHE during 10–13 April 2020. These were mainly nursing or mixed nursing/residential homes of different sizes, providing care for 43–100 residents with 14–130 staff. The care homes were in different stages of a COVID-19 outbreak. The earliest care home outbreak began on March 11 (CH1) and they had experienced 29 fatalities by the time of swabbing while the last home's outbreak began on April 07 with two fatalities among residents (Supplement Fig. 1). Initial contact with the care home involved conducting a risk assessment and immediate infection prevention

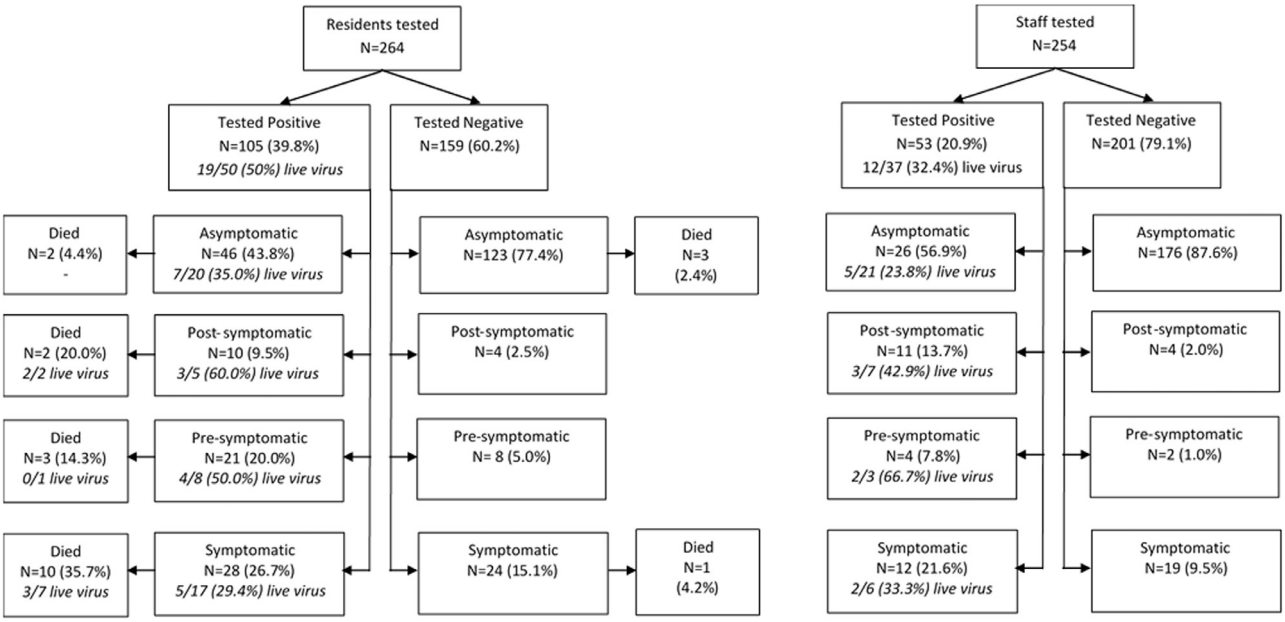

Fig. 1. SARS-CoV-2 positivity, symptoms, live virus isolation and deaths in residents and staff across six London care homes experiencing a COVID-19 outbreak during April 2020. In SARS-CoV-2 positive residents, live virus was isolated from 5/17 (29.4%) of symptomatic and 14/33 (42.4%) of asymptomatic residents at the time of testing ($P = 0.37$) and 14/40 (35.0%) survivors compared with 5/10 (50.0%) of fatal cases ($P = 0.38$).

and control advice was provided as per standard UK guidance. (Supplement Table 1).

We assessed SARS-CoV-2 positivity in the residents and staff (carers and those without caring duties), recorded their symptoms in the two weeks prior to sampling and followed them daily for new symptoms and outcomes for two weeks through daily phone-call and datasheet completion. Care home data were collected systematically covering resident demographics, facilities, staffing and infection control measures in place at the time of swabbing (Supplement Table 2). Staff working at the care home during the days of testing took nasal swabs for the residents and submitted their own samples by self-swabbing with appropriate instructions. Symptom status at the time of testing (symptomatic or asymptomatic) was recorded on the sample submission form.

Laboratory methods

Swabs from all six homes were couriered to the PHE reference laboratory on the day they were collected. Nucleic acid was extracted and analysed by a real-time reverse transcription (RT) PCR assay on an Applied Biosystems 7500 FAST system targeting a conserved region of the open reading frame (ORF1ab) gene of SARS-CoV-2, together with an internal control [13]. With RT-PCR, a positive reaction is detected by accumulation of a fluorescent signal. The cycle threshold (Ct) is defined as the number of amplification cycles required for the fluorescent signal to cross a pre-defined threshold (i.e. exceeds background level). Ct levels are inversely proportional to the amount of target nucleic acid in the sample so that lower Ct values reflect greater amount of target nucleic acid in the sample and hence higher viral loads. Detection of virus by RT PCR may not reflect the amount of infectious virus present. All SARS-CoV-2 positive samples with a Ct value of <35 were incubated on Vero E6 mammalian cells and virus detection was confirmed by cytopathic effect (CPE) up to 14 days post-inoculation. Whole genome sequencing (WGS) was performed on all RT-PCR positive samples [14]. Viral amplicons were sequenced using Illumina library preparation kits (Nextera) and sequenced on Illumina short-read sequencing machines. Raw sequence data was trimmed and aligned against a SARS-CoV-2 reference genome (NC_045512.2). A consensus sequence representing each genome base was derived from the reference alignment. Consensus sequences were assessed for quality, aligned using MAFFT (Multiple Alignment using Fast Fourier Transform, version 7.310), manually curated and maximum likelihood phylogenetic trees derived using IQtree (version 2.04).

Case definitions

A symptomatic individual was defined as typical COVID-19 symptoms (fever, persistent cough, sore throat, or shortness of breath; at that time, anosmia was not part of the case definition) in a staff member or resident and included additionally atypical (new confusion, reduced alertness, fatigue, lethargy, reduced mobility, diarrhea) COVID-19 symptoms in a resident at the time of swabbing. Post-symptomatic individuals had symptoms during the 14 days prior but were asymptomatic at the time of swabbing. Pre-symptomatic individuals developed symptoms in the 14 days after swabbing. Asymptomatic individuals did not exhibit any symptoms during the two weeks before or after swabbing.

Statistical analysis

Data are mainly descriptive. Data that did not follow a normal distribution were described as medians with interquartile ranges and compared using the Mann-Whitney U test. Categorical variables were described as proportions and compared using the chi-squared or Fisher's Exact test as appropriate. Logistic regression was used to assess independent risk factors for death among residents and included age in years, gender and RT-PCR positivity by symptom status at the time of swabbing.

Ethical approval

PHE has legal permission, provided by Regulation 3 of The Health Service (Control of Patient Information) Regulations 2002, to process patient confidential information for national surveillance of communicable diseases and as such, individual patient consent is not required.

Role of the funding source: This study did not receive any funding. The authors had sole responsibility for the study design, data collection, data analysis, data interpretation, and writing of the report. The authors are all employed by Public Health England, the study funder, which is a public body — an executive agency of the Department of Health. The first and last authors had full access to all the data in the study and final responsibility for the decision to submit for publication.

Results

Residents

The 518 individuals tested during the enhanced care home investigation included 264 residents and 254 staff members. Of the 264 residents, 105 (39.8%) were SARS-CoV-2 positive. Four residents were hospitalised and 21 (8.0%) died, including two of the hospitalised cases, within two weeks of testing. Their characteristics, symptom status and clinical outcomes are summarised in Table 1. Of the 105 SARS-CoV-2 positive residents, only 28 (26.7%) were symptomatic at the time of testing. Additional follow-up identified 10/105 (9.5%) residents as post-symptomatic, 21 (20.0%) pre-symptomatic and 46 (43.8%) who remained asymptomatic throughout the surveillance period (Fig. 1). The positive predictive value for SARS-CoV-2 in a resident who is symptomatic at the time of testing was 53.8% (28/52) and being symptomatic at any time within the follow-up period was 62.1% (59/95). The negative predictive value of being SARS-CoV-2 negative if asymptomatic at the time of testing was 63.7% (135/212), and being asymptomatic throughout the surveillance period was 77.4% (123/159). Of the 67 SARS-COV-2 positive residents who were asymptomatic before or at the time of testing, 21 (31.3%) developed symptoms in the following two weeks. Among the 159 residents who tested negative, 24 (15.1%) were symptomatic at testing, 4 (2.5%) reported symptoms consistent with COVID-19 in the previous two weeks and 8 (5.0%) developed symptoms after the test but were not re-tested for SARS-CoV2 (Table 2). There was no difference in age or sex between symptomatic and asymptomatic residents overall or by SARS-CoV-2 positivity status.

14-day case fatality rate

CFR within 14 days of testing was significantly higher in residents who were symptomatic at the time of testing compared with those who were asymptomatic, regardless of SARS-CoV-2 result (11/52 [21.2%] vs. 10/212 (4.7%); $P<0.001$) (Table 2, Fig. 1). Ten of the 28 (35.7%) SARS-CoV-2 positive residents who were symptomatic at the time of testing died within 14 days compared to 1/24 (4.2%) of symptomatic residents who tested negative ($P = 0.005$). Of the 212 residents who were asymptomatic at the time of testing, 77 (36.3%) tested positive for SARS-CoV-2 and the 14-day CFR was 9.1% (7/77) compared to a 14-day CFR of 2.2% (3/135) in those who tested SARS-CoV-2 negative ($P = 0.023$).

Among SARS-CoV-2 positive residents, 10/28 (35.7%) symptomatic residents died within 14 days compared to only 2/46 (4.3%) asymptomatic residents, 2/10 (20.0%) post-symptomatic and 3/21

Table 1
Investigation of symptomatic and asymptomatic residents and staff in six care homes experiencing different stages of a COVID-19 outbreak.

Care Home	Onset of first case	Died already at the time of swabbing	Date of nasal swab	Residents positive for SARS-CoV-2	SARS-COV-2 Positive Residents who were Symptomatic	SARS-CoV-2 Negative Residents who were Symptomatic	Self-isolating staff	Staff Positive for SARS-CoV-2	SARS-CoV-2 Positive Staff who were Symptomatic	SARS-CoV-2 Negative Staff who were Symptomatic
A (n = 94)	11 March	29 (5 in hospital)	14 April	18/33 (54.5%)	2/18 (11.1%)	1/15 (6.7%)	4/130	17/61 (27.9%)	4/17 (23.5%)	6/44 (13.6%)
B (n = 72)	20 March	9 (3 in hospital)	13 April	14/52 (26.9%)	4/14 (28.6%)	4/38 (10.5%)	7/85	0/20	-	0/20
E (n = 97)	23 March	4	15 April	12/57 (21.1%)	3/12 (25.0%)	0/45 -	15/70	6/40 (15.0%)	1/6 (16.7%)	0/34 -
F (n = 83)	28 March	11	14–17 April	11/27 (40.7%)	2/11 (18.2%)	0/16 -	7/65	10/56 (17.9%)	2/10 (20.0%)	5/46 (10.9%)
C (n = 98)	2 April	19	14 April	21/59 (35.6%)	9/21 (42.9%)	17/38 (44.7%)	19/110	2/39 (5.1%)	2/2 (100%)	3/37 (8.1%)
D (n = 74)	7 April	2	13 April	29/36 (80.6%)	8/29 (27.6%)	2/7 (28.6%)	5/14	18/38 (47.4%)	4/18 (22.2%)	5/20 (25.0%)
Total N = 518				105/264 (39.8%)	28/105 (26.7%)	24/159 (15.1%)		53/254 (20.8%)	12/53 (22.6%)	19/201 (9.5%)

(14.3%) pre-symptomatic residents (P = 0.005). Among SARS-CoV-2 negative residents, 4/159 (2.5%) (3 asymptomatic, 1 symptomatic) died (Fig. 1). After adjusting for age in years (aOR 1.0; 95%CI, 0.97–1.1; P = 0.49) and being female (aOR 1.7; 95%CI, 0.44–6.5; P = 0.45). in a multivariable logistic regression model, residents who were RT-PCR positive and symptomatic at the time of testing (aOR 21.8; 95% CI, 5.4–87.5; P<0.0001) and those who were RT-PCR positive but asymptomatic at the time of testing (aOR 4.3; 95% CI, 1.1–17.0; P = 0.04) but not residents who were symptomatic and SARS-CoV-2 RT-PCR negative (aOR 1.8; 95% CI, 0.18–18.5; P = 0.61) had a significantly higher odds of death within 14 days of testing compared to asymptomatic and SARS-CoV-2 RT-PCR negative.

Care home staff

In total, 254/474 (53.6%) staff were tested and 53 (20.9%) were SARS-CoV-2 positive but only 12 were symptomatic at the time of swabbing (Fig. 1). The positive predictive value of a symptomatic staff member being positive for SARS-CoV-2 was 38.7% (12/31) and the negative predictive value of being asymptomatic at the time of testing and negative for SARS-CoV-2 was 81.6% (182/223). Follow-up of the 53 SARS-CoV-2 positive staff members found 26 (49.1%) did not develop any symptoms in the two weeks before or after testing, whereas four (7.5%) were pre-symptomatic and 11 (20.8%) were post-symptomatic. Thus, of the 30 staff who had no historical or contemporaneous symptoms at the time of swabbing, only 4 (13.3%) went on to develop symptoms in the subsequent two weeks. There was no difference in age or sex between symptomatic and asymptomatic staff overall or by SARS-CoV-2 positivity status. All staff members survived their infection.

Cycle threshold and viral culture

There was no difference in Ct values for SARS-CoV-2 positive residents or staff who were post-symptomatic, symptomatic or pre-symptomatic at the time of swabbing compared to asymptomatic residents (Fig. 2a). In total, 87 samples with Ct values <35 were cultured and infectious virus was recovered from all of categories of symptomatic, post-symptomatic, pre-symptomatic and asymptomatic residents and staff. Based on symptom reporting alone (without repeat SARS-CoV-2 testing), live virus was isolated up to 13 days after and 12 days before symptom onset among residents and up to 6 days before and 7 days after symptom onset among staff (Supplement Table 3). Higher Ct values (lower virus load) samples are associated with decreasing ability to recover infectious virus from 100% (2/2) with Ct <20.00 to 17.0% (9/53) with Ct 30.00–34.99 (χ^2 for trend, P<0.001) (Fig. 2b), but showed no correlation with presence or absence of symptoms in staff or residents (Supplement Table 4). Virus recovery rates were similar in symptomatic and asymptomatic residents (5/17 [29.4%] vs. 14/33 [42.4%]; P = 0.37) and staff (2/6 [33.3%] vs. 10/31 [32.3%]; P = 0.96) at the time of testing, and were not different between fatal and non-fatal cases among residents (5/10 [50.0%] vs. 14/40 [35.0%]; P = 0.38).

WGS analysis

All 158 PCR positive samples underwent WGS analysis and 99 (68 residents, 31 staff) distributed across all the care homes yielded sequence sufficient for WGS analysis (Supplement Table 5). Phylogenetic analysis identified informal clusters, with evidence for multiple introductions of the virus into care home settings. All care home clusters of SARS-CoV-2 genomes included at least one staff member, apart from care home B with no PCR positive staff and high rates of staff self-isolation. Care home A exhibited three distinct sequence clusters and six singletons, potentially representing up to nine separate introductions. Genomic analysis did not identify any differences

Table 2
Characteristics of residents and staff in all six care homes.

	Symptom status				
	Asymptomatic	Post-symptomatic	Pre-symptomatic	Symptomatic	All
RESIDENTS					
SARS-CoV-2 Positive	*N* = 46	*N* = 10	*N* = 21	*N* = 28	*N* = 105
Female (%)	30 (65.2%)	10 (100%)	17 (81.0%)	25 (89.3%)	82 (78.1%)
Median age in years (IQR)	84 (78–90)	88 (85–91)	84 (80–91)	87 (80–91)	85 (78–90)
Median days symptom onset (IQR)	x	−5 (−6 to −3)	4 (2 to 11)	−7 (−10 to −4)	
Hospitalised	x	x	1 (4.8%)	2 (7.1%)	
Died	2 (4.4%)	2 (20.0%)	3 (14.3%)	10 (35.7%)	17 (16.2%)
SARS-COV-2 Negative	*n* = 123	*n* = 4	*n* = 8	*n* = 24	*n* = 159
Female (%)	84 (68.3%)	1 (25.0%)	6 (75.0%)	18 (75.0%	109 (68.6%)
Median age in years (IQR)	85 (78–90)	81 (74–87)	84 (80–88)	86 (80–89)	85 (80–91)
Median days symptom onset (IQR)	x	−7 (−8 to −5)	13 (12–13)	−8 (−13 to −6)	
Hospitalised	x	x	1 (12.5%)	x	
Died	3 (2.4%)	x	x	1 (4.2%)	4 (2.5%)
STAFF					
SARS-CoV-2 Positive	*N* = 26	*N* = 11	*N* = 4	*N* = 12	*N* = 53
Female (%)	16 (61.5%)	7 (63.6%)	3 (75.0%)	8 (66.7%)	34 (64.2%)
Median age in years (IQR)	50 (40–56)	54 (41–59)	38 (34–49)	40 (26–55)	47 (38–57)
Median symptom onset (IQR)	x	−7 (−9 to −4)	3 (2–5)	−5 (−9 to −3)	
SARS-CoV-2 Negative	*N* = 176	*N* = 4	*N* = 2	*N* = 19	*N* = 201
Female (%)	147 (83.5%)	2 (50.0%)	2 (100%)	16 (84.2%)	167 (83.1%)
Median age in years (IQR)	47 (39–56)	52 (26–77)	50 (35–65)	43 (29–57)	47 (35–56)
Median symptom onset (IQR)	x	N/A	9 days *	−6 (−16 to −5)	

* onset date not available for one resident; N/A, not available for two staff members.

between asymptomatic/symptomatic residents/staff. The ten sequences from residents who died were distributed across the lineages identified and were closely matched to sequences derived from non-fatal cases in the same care homes (Fig. 3).

Discussion

Investigation of six London care homes experiencing SARS Cov-2 outbreaks identified a high proportion of residents (39.8%) and staff (20.9%) who tested positive for SARS-CoV-2, of whom three-quarters were asymptomatic at the time of testing and half remained asymptomatic throughout the surveillance period, highlighting the silent nature of infection in this setting. The homes were at different stages of a SARS-CoV-2 outbreak with some already having experienced a high number of deaths. Among residents, SARS-CoV-2 positivity and being symptomatic were strong predictors of death. The large numbers of deaths that had already occurred prior to our investigations highlights the potential for prolonged COVID-19 outbreaks in institutional settings. RT-PCR Ct values and recovery of live viruses were similar among asymptomatic and symptomatic residents and staff despite the large age difference between the groups and also did not appear to alter the ratio between symptomatic and asymptomatic infections. We identified multiple introductions of the virus into individual care homes and individual care home clusters included at least one staff member. Genomic analysis did not identify any differences between asymptomatic/symptomatic residents/staff or between fatal and non-fatal cases.

Our findings provide further evidence for pre-symptomatic infection among residents in care homes experiencing a COVID-19 outbreak [10, 15, 16], but also identified a large cohort of residents and staff who remained asymptomatic throughout the surveillance period. A recent detailed longitudinal investigation of a COVID-19 outbreak in a single nursing facility in Seattle, Washington state, highlighted important common features and some key differences compared to our cohort [10]. The high rate of asymptomatic residents at the time of first (23/76, 30%) and second (24/49, 49%) swabbing a week later in the Seattle investigation is consistent with our findings of a high but variable prevalence of asymptomatic SARS-CoV-2 positive residents in care homes at different stages of a COVID-19 outbreak. The high 14-day case-fatality rate of 35.7% among symptomatic SARS-CoV-2 positive residents in our cohort was also consistent with the 26% reported in the Seattle care home.

However, while >85% of asymptomatic residents in the Seattle investigation went on to develop symptoms over the next seven days [10], in our cohort, half the residents remained asymptomatic during the surveillance period, possibly because of the maturity of the outbreaks in the London care homes at the time of testing, as evidenced by the number of deaths that had already occurred, although mild/non-specific symptoms might not have been identified by the care staff [17].

We did not observe any correlation in the RT-PCR CT values between symptomatic and asymptomatic residents or staff, nor any association with age, indicating that symptomatic and asymptomatic residents and staff of all ages had similar viral loads when infected with SARS-CoV-2. Like the Seattle investigation [10], and others [16, 18], we also found high rates of live virus isolation among symptomatic and asymptomatic residents and staff, highlighting the enormous potential for silent transmission of infection and the futility of symptom-based only surveillance in care homes and other similar settings [6]. We found that 20.0% of asymptomatic residents went on to develop symptoms at a median of four days after testing but, in our longer follow-up, some residents developed symptoms consistent with COVID-19 up to 13 days later, although repeat testing was not performed to confirm the diagnosis. Together with the Seattle investigation where live virus was isolated from specimens taken up to 6 days before and 9 days after the first symptoms [10], these findings provided the evidence for current recommendations to isolate test-positive residents for at least 14 days and test-positive staff for 7 days, although the latter has now been extended to 10 days in England.

Some SARS-COV-2-negative residents and staff in our cohort became symptomatic in the second week after testing which may indicate on-going transmission, but we did not undertake additional testing to confirm this. More regular screening with systematic testing of all residents and staff, irrespective of symptoms, and longer follow-up may have provided additional information on SARS-CoV-2 transmission and outcomes.

Genomic analysis of SARS-COV-2 strains identified separate introductions with distinct clusters that included at least one member of staff within each cluster, raising the question as to whether staff members might be the source of the infection, although it was not

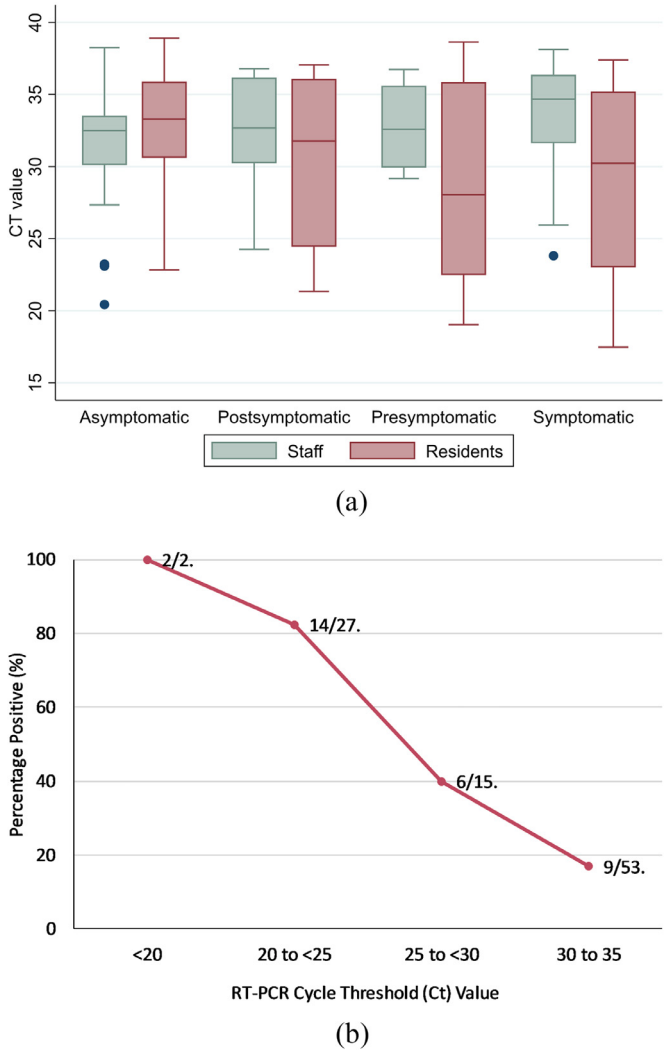

Fig. 2. a. Boxplot showing median Cycle Threshold (Ct) values with interquartile ranges (Boxes) along with minimum (Q1−1.5*IQR) and maximum (Q3+1.5*IQR) values (whiskers) and outlier values (blue circles) for asymptomatic, post-symptomatic, pre-symptomatic and symptomatic residents and staff. 2b. Live virus isolation by RT-PCR Cycle threshold (t) range in residents and staff of care homes. The data points include live virus isolation by number of strains tested.

possible to confirm the direction of infection with a single snapshot survey. In addition to staff, other potential sources included residents returning to care homes from hospitals at a time when they were not routinely tested for SARS-CoV-2 prior to discharge, new residents being admitted from the community or from other care homes, and visitors to the care homes [19].

The strengths of this investigation lie in the large number of residents and staff tested through a single national reference center across six different care homes each at different stages of a COVID-19 outbreak, with detailed virological analyses. Extensive and complete daily follow-up provided detailed understanding of symptom progression and identified a high prevalence of asymptomatic SARS-CoV-2 residents and staff who may serve as potential reservoirs of infection. This was the first systematic public health investigation of care home outbreaks in England and the findings, which were reported to decision makers in real time, played an important part in supporting national policy and support for care homes [20]. The six care homes were mainly nursing homes that were selected for enhanced investigations because they were experiencing large outbreaks within the same locality; they were not intended to be representative of the wider care home settings nationally. We collected minimal data on a large number of residents and staff to ensure complete ascertainment of symptoms and outcomes in order to understand infection and transmission of SARS-CoV-2 in care homes. We, therefore, did not collect detailed information on ethnicity, comorbidity or frailty status of the residents, which are also important determinants of outcomes [21–23]. We also did not use standard questionnaires to collect symptoms, allowing instead the staff to assess the residents who they knew well and report symptoms in free text. A limitation of the investigation was that we only tested the care homes once. Additional testing would have allowed more objective tracking of transmission and diagnosis in pre-symptomatic residents and staff, while testing for other viruses may have explained the development of new symptoms in SARS/CoV-2 positive and negative residents and staff. Moreover, SARS-CoV-2 testing detection could have been improved by testing multiple sites, such as the nose and throat [24], and repeated testing, but this was impractical in our cohort. We also only tested staff who were working at the care home at the time of the investigation and, therefore, may have missed testing those who were symptomatic and self-isolating at home.

Our results highlight the difficulties in controlling SARS-CoV-2 outbreaks in care homes and other institutional settings despite extensive infection control guidance and training [25, 26]. Infectious virus recovery in asymptomatic staff and residents emphasises their likely importance as silent reservoirs and transmitters of infection and explains the failure of infection control measures which have been largely based on identification of symptomatic individuals. When transmission is occurring in the community, enhanced infection prevention and control measures should be quickly implemented in care homes, along with rigorous and systematic testing for SARS-Cov-2 among staff and residents, with particular attention to infection control measures for visitors, new residents and movement of residents and staff from other facilities. Early and wide testing of residents and staff, along with immediate isolation of suspected cases, may help control the introduction and spread of SARsCoV-2 into care homes (Table 3). Point-of-care testing for SARS-CoV2 antigens/antibodies, if sufficiently sensitive and accurate, could potentially have a role in the near future.

Table 3
Potential strategies for prevention of COVID-19 in care home.

- Prevention is fundamental to controlling outbreaks in care homes by reducing introduction of SARS-CoV2, increasing infection prevention control (IPC) and early detection of COVID-19 cases in Care homes.
- Ensure early testing of unwell residents including those with atypical COVID-19 symptoms (drowsiness, reduced appetite, lethargy and fatigue)
- Limit close contact between residents along with immediate isolation of residents as soon as a single case is suspected
- Ensure residents are isolated for 14 days after a known high-risk exposure (e.g. admission to hospital), consider intermediate care and other local support to minimize risk of introduction into the home.
- Test Staff (any staff, not just carers) who are unwell with any symptoms, typical or atypical and ensure that they are negative for SARS-CoV-2 and asymptomatic (other viruses can cause similar illnesses) before they enter care home
- Exclude SARS-CoV-2 positive staff for 7 days from work, irrespective of whether symptomatic or asymptomatic at the time of testing (current guidelines in England now recommend 10 days exclusion)
- Avoid where possible, agency staff and ensure they get appropriate IPC training before they enter the care home
- Wider testing in the care home during the early detection of an outbreak: test all (including staff) those in contact with unwell resident including staff – this may be one part or one floor or the whole care home (residents and staff). The same principle applies for testing staff and residents who have been in contact with symptomatic staff
- Enhanced cleaning of high touch surfaces and hand hygiene before and after every resident contact
- Rigorous and systematic testing policy for staff and residents, with particular attention to infection control measures for visitors, new residents and movement of residents and staff from other facilities.

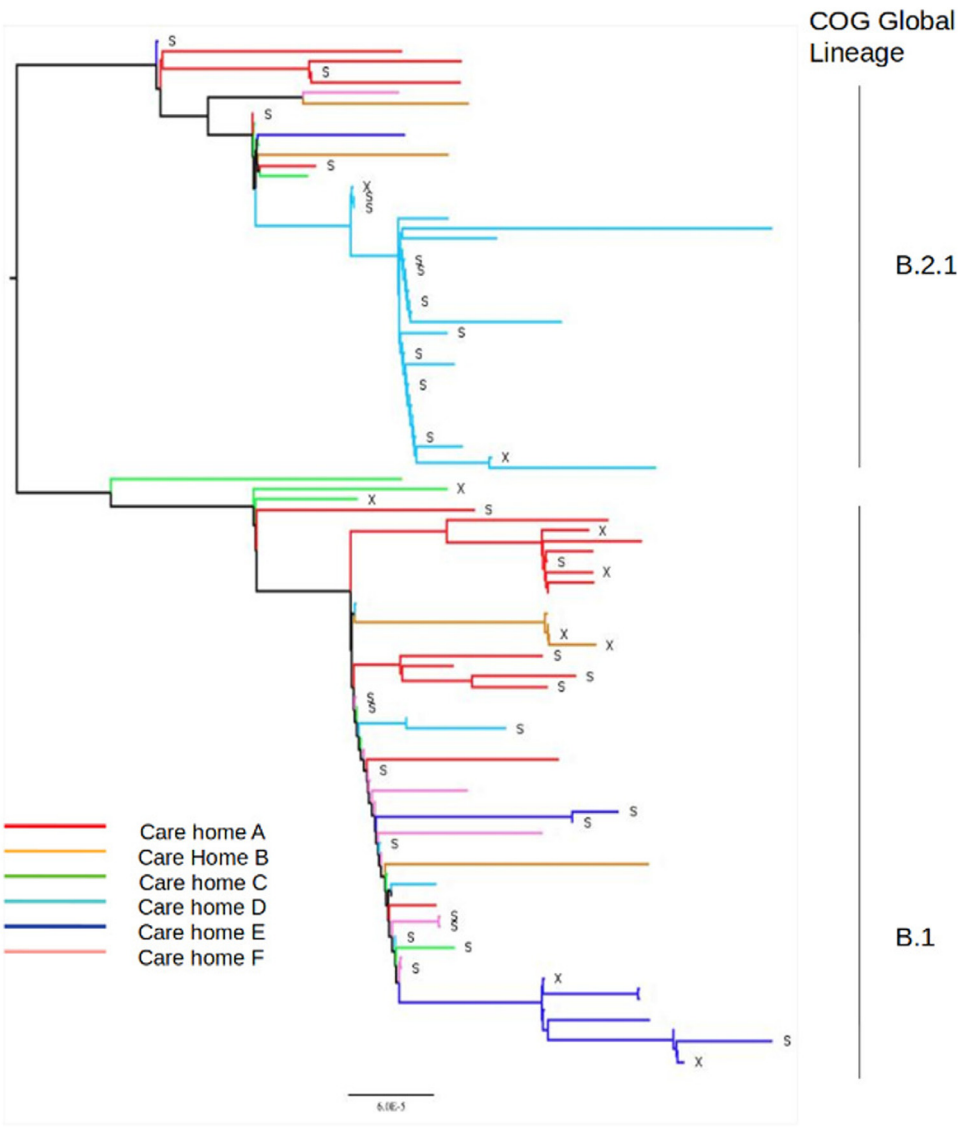

Fig. 3. Maximum Likelihood phylogeny of 99 SARS-CoV-2 genomes from individuals within six care homes. Coloured branches are used to indicate the care home, staff are annotated on the tree with (S), genomes from patients who died after testing positive for covid-19 are shown with (X). Unannotated tips in the phylogeny represent genomes from care home residents.

Care home residents are very vulnerable to COVID-19 and have a high case-fatality rate, particularly if symptomatic at the time of swabbing. With sustained community transmission, testing of all residents and staff irrespective of symptoms combined with measures to prevent virus introduction into care homes and robust infection prevention and control measures will be needed to control SARS-CoV-2 outbreaks in care homes. Further investigations to better understand transmission dynamics in care home, especially in relation to asymptomatic infection among residents and staff, are needed to develop a more tailored approach to SARS-CoV-2 outbreak control.

Declaration of Competing Interest

None

Acknowledgements

The authors are very grateful to the care home managers, their staff and the residents for their willingness to support the investigation, along with the staff in the immunization and countermeasures division, PHE Operations, the virus reference department, the London Coronavirus Response Cell and Field Services for their help and support with the investigation. The authors would also like to thank Dr Anna Jeffery Smith for her help with microbiological studies and analyses, as well as Natalie Groves and Ulf Schaefer for their help with the genomic analysis.

Data sharing statement

The investigation was conducted as Public Health England's duty to manage outbreaks in response the COVID-19 outbreak. There are no additional data for the Care Home Investigation in addition to what we have already reported.

Funding

Public Health England

Contributors

Study conception (SNL, JYC, EW-E), study oversight (JYC), oversight of laboratory work (MZ), protocol development (EF, RJ, MS-P,

KP, JF, E-CB, KD-C, AV, AB, ST, ZAC, FA, BP, EW-E, JYC, CB, MC, MZ), data collection (EF, RJ, MS-P,KP, JF, E-CB, KD-C, AV, AB, ST, ZAC, FA, BP, TM, EW-E, JYC), operational conduct (EF, RJ, MS-P,KP, JF, E-CB, KD-C, AV, AB, ST, ZAC, FA, BP, TM, NS, EW-E), manuscript preparation (EF, RJ, MS-P,KP, JF, E-CB, KD-C, AV, AB, ST, ZAC, FA, BP, KEB, MP, RG, NS, JE, EW-E, MS-C, MER, SH, CB, RM, MC, AL, MZ), virus isolation (MP,RG), PCR detection work (JE), laboratory genomics (AL), bioinformatics analyses (RM, MC), data analysis (KEB, MP, RG, NS, JE, MER, SH, RM, MZ).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.eclinm.2020.100533.

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