

Mass testing after a single suspected or confirmed case of COVID-19 in London care homes, April-May 2020: implications for policy and practice

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Abstract:

Introduction: Previous investigations have identified high rates of SARS-CoV-2 infection among residents and staff in care homes reporting an outbreak of COVID-19. We investigated care homes reporting a single suspected or confirmed case to assess whether early mass testing might reduce risk of transmission during the peak of the pandemic in London.

Methods: Between 18-27 April 2020, residents and staff in care homes reporting a single case of COVID-19 to Public Health England had a nasal swab to test for SARS-CoV-2 infection by RT-PCR and subsequent whole genome sequencing. Residents and staff in two care homes were re-tested eight days later.

Results: Four care homes were investigated. SARS-CoV-2 positivity was 20% (65/333) overall, ranging between 3-59%. Among residents, positivity ranged between 3-76% compared to 3-40% in staff. Half of the SARS-CoV-2 positive residents (23/46, 50%) and 63% of staff (12/19) reported symptoms within 14 days before or after testing. Repeat testing 8 days later in two care homes with the highest infection rates identified only two new cases. Genomic analysis demonstrated a small number of introductions of the virus into care homes, and distinct clusters within three of the care homes.

Conclusions: We found extensive but variable rates of SARS-CoV-2 infection among residents and staff in care homes reporting a single case of COVID-19. While routine whole home testing has now been adopted into practice, care homes must remain vigilant and should be encouraged to report a single suspected case, which should trigger appropriate outbreak control measures.

Keywords: SARS-CoV-2, COVID-19, care home, long-term care facility, mass testing, older people.

Key points:

- Mass testing showed extensive but variable rates of SARS-CoV-2 infection in care homes reporting a single case.
- Rapid reinforcement of infection prevention and control measures can mitigate further transmission of SARS-CoV-2 in care homes.
- A single suspected or confirmed case of SARS-CoV-2 in a care home should trigger mass testing regardless of symptoms.
- Genomic analysis suggests silent transmission of SARS-CoV-2 in care homes following a small number of introductions of the virus.
- Almost half of SARS-CoV-2 positive care home residents and staff did not develop symptoms during the surveillance period.

Introduction

Outbreaks of SARS-CoV-2 in care homes have devastating consequences for residents [1-4]. Age, multimorbidity, disability, cognitive impairment and frailty make care home residents at higher risk of becoming infected with and dying from COVID-19 [5-7]. Non-specific and atypical presentations of COVID-19, especially in older adults with dementia and neurological conditions, can hinder early identification of cases [4,5,8-10], leading to delays in isolation of positive cases and reinforcement of stringent infection prevention and control (IPC) measures, and potentially allowing for rapid and extensive spread of SARS-CoV-2 within the care homes.

In the UK, imported cases of SARS-CoV-2 were first detected in late January 2020 followed by sustained community circulation from early March, with London being one of the earliest and most affected cities [11]. Between 02 March and 01 May 2020, the UK Office for

National Statistics (ONS) reported 45,899 deaths of care home residents, of which 27% involved COVID-19 [12]. With approximately 400,000 older people living in UK care homes [13], 5,167 out of 15,514 (33%) nursing and residential homes in England had declared an outbreak by 01 May 2020, including 539 homes in London [14].

Early in the first wave of the pandemic, little was known about the risk of infection and transmission of SARS-CoV-2 in care homes. Following the large number of outbreaks in care homes reported to Public Health England (PHE), enhanced outbreak investigations were initiated. In the first phase of the investigations conducted during 10-13 April 2020, we found that by the time an outbreak – defined as at least two suspected cases within 14 days – was reported in a care home, almost half the residents and a fifth of staff had already been infected with SARS-CoV-2, most of whom were asymptomatic at the time of testing [15]. We therefore hypothesised that mass testing of residents and staff after a single case of SARS-CoV-2 in a care home might allow early identification and isolation of infected individuals and, together with rapid reinforcement of IPC measures, could potentially prevent further spread of the virus within the care home. Phase two of the London care home investigations, therefore, aimed to assess incidence, symptom status and transmission of SARS-CoV-2 through mass testing of staff and residents in care homes reporting a single suspected or confirmed case, with repeat testing one week later.

Methods

Recruitment

At the start of the COVID-19 pandemic in England, care homes were asked to report suspected or confirmed outbreaks (defined as 2 or more cases) to Public Health England (PHE) for further management. A suspected case was defined as any individual who developed COVID-19 symptoms (fever or cough as per national guidance at the time). Between 18 to 27 April 2020, we prospectively recruited all London care homes with a minimum of 30 residents reporting a single case of suspected or confirmed SARS-CoV-2 infection in a resident or staff member to PHE for further management. We contacted the care home managers to confirm that they did only have a single suspected or confirmed case since the start of the pandemic and were willing to undertake serial testing for their residents and staff. Care home managers provided consent for participation in the surveillance.

Infection prevention and control advice

Upon reporting, care homes received expert advice and support, including testing for SARS-CoV-2 infection and recommendations on appropriate IPC measures to minimise transmission in line with national guidance [16]. Once enrolled, care homes were contacted regularly by phone by a member of the PHE investigation team, who provided IPC advice, shared relevant guidance, answered queries and supported managers in the appropriate implementation of all IPC measures (Supplement Table S1).

Testing

Two rounds of mass testing were undertaken in the recruited care homes. Nasal swabs were taken from all residents and staff working in the care homes at the time of the first round of testing (day 0). The residents and staff were re-tested on day 8 to detect any further transmission of the virus within the care home. In two of the care homes, due to practical considerations, it was not possible to re-test residents on day 8 so only staff were re-tested. Staff members who tested positive for SARS-CoV-2 were re-swabbed every week until a negative result was obtained. Following verbal consent from the resident or next-of-kin as appropriate, nasal swabs for residents were taken by trained care staff who received detailed sampling instructions. Staff members (including agency and night staff) were given written information about the investigation and gave their implicit consent to participate by providing self-sampled nasal swabs. Swabs were couriered to the PHE reference laboratory on the day of collection. Nucleic acid was extracted and analyzed 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 [17].

Assessment of symptom status and follow-up

Individuals were classified as symptomatic if they reported typical (fever $>37.8^{\circ}\text{C}$ or new continuous cough) or atypical (new confusion, reduced alertness, fatigue, lethargy, reduced mobility, diarrhoea) COVID-19 symptoms or other non-specific symptoms. Symptom status was collected for staff and residents at the time of testing and in the two weeks prior to testing. Daily telephone follow-up was undertaken for 14 days from the date of first sampling using a standard data collection proforma to collect details on symptoms, hospitalisation and death. Care home level data, including administration, facilities, staffing, and IPC measures in place were collected using a standardised data collection tool.

Whole genome sequencing (WGS)

WGS was performed on all RT-PCR positive samples. 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)

Ethics approval

This investigation was undertaken as part of PHE's role to monitor and manage outbreaks of communicable disease. 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.

Results

Descriptive analysis of care homes

Four care homes were recruited for this investigation. Care home D was a mixed residential and nursing home and the other three were residential homes (Table 1). IPC measures in all care homes included enhanced cleaning, closing to visitors, isolating residents in single rooms where possible, and restricting use of shared spaces, although these were implemented at different times. Care homes A and D were closed to visitors, restricted shared spaces and isolated residents by the end of March 2020. In contrast, care homes B and C did not implement isolation and restriction of shared spaces until after mid-April.

Table 1: Summary description of the care homes layout, number of residents and staff, type of staff working in each care home, and infection control measures at the time of the survey; London, 2020

Care Home	Type	Layout	Communal areas	Room types	Resident capacity	Number of residents*	Number of permanent staff	Type of staff	Infection Control	Hospital admission in 4 weeks prior to 1st case
A	Residential	3 floors 4 units	Each unit has a communal lounge and dining area	All single occupancy en-suite rooms	46	43	34	Do not employ agency staff, but staff also worked elsewhere	23/03/20: Enhanced cleaning and isolating in single rooms were possible 01/04/20: Closed	No

								e. Now asking staff to choose between jobs	to admissions and visitors 14/05/20: Difficulty accessing PPE (especially fluid repellent masks)	
B	Residential	3 floors	3 communal lounges	All single occupancy rooms, only 9 en-suite	39	35	28	Do not employ agency staff. One employee works in an adult learning unit too	15/03/20: Closed to visitors (except End of life care) 23/03/20: Enhanced cleaning and closed to admissions 24/04/20: Isolating in single rooms and restricted shared space	Last day visit to hospital on 16/03/20
C	Residential	3 floors	Unknown	2 double rooms, the rest single rooms. All en-suite	34	32	30	Employed agency staff for the first time following COVID-19. One staff member worked in another home but stopped when suspicion of cases started	23/03/20: Closed to admissions and visitors 24/04/20: Enhanced cleaning, isolation in single rooms, cohorting and restriction of shared space	No
D	Residential and Nursing	3 units: 2 nursing 1 residential	Unknown	All single occupancy en-suite rooms	58	51	106	Do not employ agency staff now. Bank nursing staff work elsewhere but have not returned to the home since lockdown began	16/03/20: Closed to visitors (except End of Life care) 23/03/20: Enhanced cleaning, isolation in single rooms, restricted shared space and closed to admissions 24/04/20: Started cohorting	One resident returned on 21/04/20 and isolated

* Number of residents present at the care home at the time of the survey may differ from the number of residents tested during the study. This may be due to residents not consenting to testing, residents having died or hospitalised, and new residents being admitted.

First round of sampling (Day 0)

Testing took place within two days of a care home reporting a single suspected or confirmed case of SARS-CoV-2. Overall SARS-CoV-2 positivity was 20%, with higher positivity rates in care homes B (31%) and C (59%) compared to care homes A (11%) and D (3%) (Table 2).

Among residents, SARS-CoV-2 positivity ranged between 3-76% compared to 3-40% in staff, with a similar trend of lower positivity rates in care homes A and D. Half of the SARS-CoV-2 positive residents (23/46) and 63% (12/19) of staff reported having symptoms. Of these positive and symptomatic cases, when questioned individually, 13/23 residents and 7/12 staff reported varying symptoms in the 14 days prior to the test; and 10/23 residents and 5/12 staff reported symptoms in the 14 days after the test (Table 2).

Among 268 SARS-CoV-2 negative staff and residents, 10 (4%) reported having symptoms in the 14 days before or after testing, including 4 residents and 6 staff members (Table 3).

Table 2: Number of residents and staff by care home that tested positive for SARS-CoV-2 in the first round of sampling and whether they reported symptoms in the 14 days prior and the 14 days after testing.

Care home	Total SARS-CoV-2 positive (%)	Residents					Staff				
		No. tested	No. SARS-CoV-2 positive (%)	No. SARS-CoV-2 positive and symptomatic			No. tested	No. SARS-CoV-2 positive (%)	No. SARS-CoV-2 positive and symptomatic		
				Symptoms in 14 days before	Symptoms within 14 days	Total symptomatic (%)			Symptoms in 14 days before	Symptoms within 14 days	Total symptomatic (%)
A (n=24)	9 (11%)	42	7 (17%)	2	0	2 (29%)	39	2 (5%)	0	1	1 (50%)
B (n=65)	20 (21%)	35	15 (42%)	6	2	8 (53%)	30	5 (17%)	4	0	4 (80%)
C (n=54)	32 (50%)	29	22 (76%)	3	8	11 (50%)	25	10 (40%)	2	4	6 (60%)
D (n=13)	4 (3%)	59	2 (3%)	2	0	2 (100%)	74	2 (3%)	1	0	1 (50%)
Total (n=33)	65 (20%)	165	46 (28%)	23 (50%)			168	19 (11%)	12 (63%)		

Table 3. Characteristics of residents and staff by clinical status, testing results and outcome.

Residents	Symptomatic		Asymptomatic		All	
SARS-CoV-2 Positive	23		23		46	
Female	17	74%	19	83%	36	78%
Median age in years (IQR)	88 (82-94)		83 (76-92)		86.5 (81-93)	
Hospitalised	4	17%	0	0%	4	9%
Died	6	26%	0	0%	6	13%

SARS-CoV-2 Negative	4		115		119	
Female (%)	2	50%	92	80%	94	79%
Median age in years (IQR)	80 (78-81)		87 (82-91)		87 (81-91)	
Hospitalised	0	0%	0	0%	0	0%
Died	1	25%	0	0%	1	1%
Staff	Symptomatic		Asymptomatic		All	
SARS-CoV-2 Positive	12		7		19	
Female (%)	12	100%	5	71%	17	89%
Median age in years (IQR)	57 (44-62)		51 (32-52)		51 (40-60)	
Hospitalised	0	0%	0	0%	0	0%
Died	0	0%	0	0%	0	0%
SARS-CoV-2 Negative	6		143		149	
Female (%)	5	83%	114	80%	119	80%
Median age in years (IQR)	58 (50-65)		49 (41-57)		50 (41-58)	
Hospitalised	0	0%	0	0%	0	0%
Died	0	0%	0	0%	0	0%

Second round of sampling (Day 8)

SARS-CoV-2 positivity among residents and staff decreased between the first and second rounds of sampling (Table 4). There were only two cases (one resident and one staff in different care homes) who initially tested negative on day 0 but subsequently tested positive on day 8 (Table 4). Of the 19 staff members who tested positive initially, two remained positive at day 8 but both tested negative one week later.

Table 4: Results of the mass swabbing by period of testing, in residents and staff by care home; London, 2020

Care home		First period of testing			Second period of testing			Number of new positive cases in second period of testing 8 days later
		Tested*	Positive	%	Tested*	Positive	%	
A	Residents	42	7	17%	41	3	7%	1
	Staff	39	2	5%	39	0		0
B	Residents	35	15	43%	Not tested			0
	Staff	30	5	17%	17	1	6%	0
C	Residents	29	22	76%	Not tested			0
	Staff	25	10	40%	25	2	8%	1
D	Residents	59	2	3%	59	0	0	0
	Staff	74	2	3%	74	0	0	0

* Note that not all the staff and residents tested in both periods are necessarily the same people.

Outcomes

There were four hospitalisations during the surveillance period, all in symptomatic residents (4 of 23 symptomatic SARS-CoV-2 positive residents, 17%) of care home C (Table 3).

Seven residents died; all were symptomatic and six were SARS-CoV-2 positive (6 of 23 symptomatic SARS-CoV-2 positive residents, 26%). Four deaths occurred in care home C and the other care homes reported one death each.

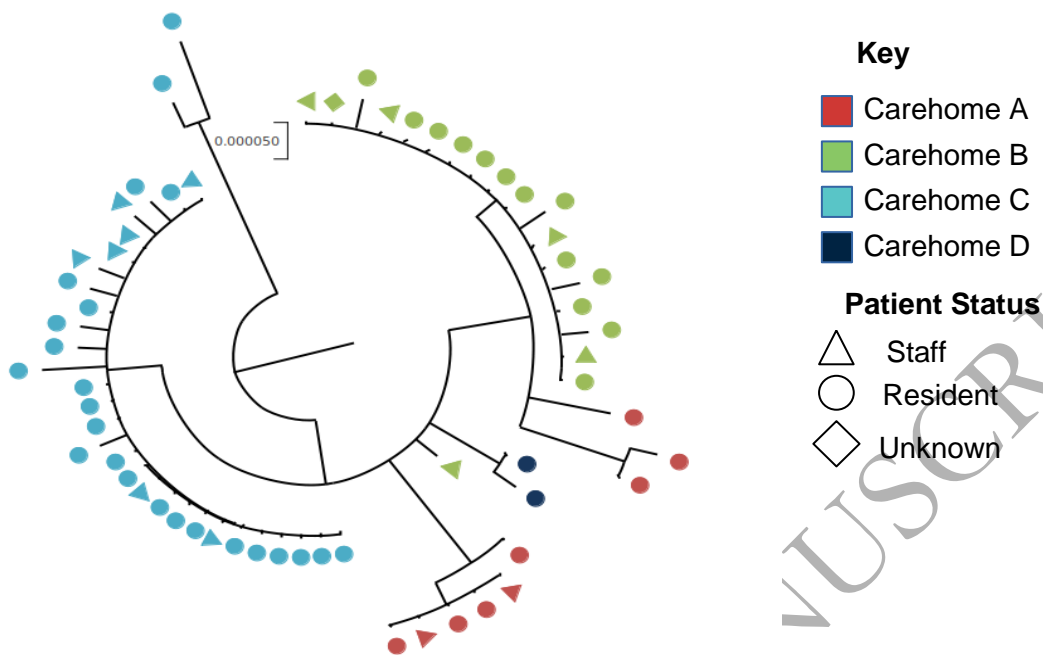
Whole Genome Sequencing Analysis

In total, 65 positive PCR samples from four care homes were submitted for WGS analysis. Four samples did not yield a genome sequence of sufficient quality (>80% coverage at > 10 fold depth).

Phylogenetic analysis of 61 SARS-CoV-2 genomes (Figure 1) identified care home specific clusters in three of the four care homes which indicated likely transmission within the care home setting. The majority of genomes from samples in care homes A, B and C formed clusters of highly similar sequences that were largely identical with a maximum of 2 single-nucleotide polymorphisms (SNPs) different (care home: A – 6 of 9 genomes, B - 18 of 19 genomes, C - 29 of 31 genomes). These large clusters contained genomes derived from both staff and residents. In all three care homes there were additional sequences external to the main genomic clusters, that likely represented additional introductions of SARS-CoV-2 into the care home. There were only two genomes identified from care home D, these were only 1 SNP different from each other. Overall, phylogenetic analysis of this set of genomes did not indicate that there was transmission between the four care homes in this study, at that time.

Figure 1. Maximum-likelihood phylogeny of 61 SARS-CoV-2 genomes. Samples were taken from individuals in four care homes (represented by differing colours). Care home staff and residents are shown using different shaped markers. Markers located along a circular line indicates highly similar sequences, forming a cluster. Branch length indicates increasing number of SNPs difference between genomes.¹

¹ Example: Sequences from care home A (red markers) are located in two distinct parts of the tree image. There is a cluster of six sequences where five sequences are identical, and one sequence is one SNP different from those five. The other three care home A sequences are located in a different part of the phylogeny separated by long branches from the initial cluster of six sequences. The length of the branches indicates that these two groups are more than 10 SNPs apart and therefore it is most likely that they represent separate introductions into the care home. It is unclear but quite possible that the group of three care



Discussion

This investigation found that by the time care homes reported their first case of suspected or confirmed SARS-CoV-2 infection during the peak of the pandemic in London, UK, all four investigated care homes had additional staff and residents who tested positive for SARS-CoV-2 infection, almost half of whom did not report any symptoms in the 14 days before or after the test. Infection rates were highly variable, ranging from 3-76% in residents and 3-40% in staff. Genomic analysis showed clusters in three of the four care homes indicating that the virus was already spreading silently within the care home when the first suspected case was identified. A second round of mass testing eight days later found very few additional cases suggesting that reinforcement of IPC measures may have mitigated further transmission.

There are now many published reports of care home outbreaks across the globe, demonstrating high rates of SARS-CoV-2 infection and transmission, resulting in high rates of hospitalisation and death, mainly among the older frail residents [4,6,10,18-24]. This

home A sequences represents two introductions into the care home setting, based on the SNP distance (branch length) between them.

information, however, was not available during the early pandemic. In the first phase of our care home investigations, we found high rates of SARS-CoV-2 infection among residents and staff in six London care homes reporting a possible outbreak with two or more confirmed or suspected cases of COVID-19 [15]. In that investigation, too, a high case fatality rate was observed among symptomatic SARS-CoV-2 positive residents, demonstrating the vulnerability of this group. Subsequent serological testing in the same London care homes found nearly all SARS-CoV-2 positive and two-thirds of SARS-CoV-2 negative staff and surviving residents had SARS-CoV-2 antibodies, highlighting the true extent of virus spread within these care homes [25].

In order to try and identify outbreaks earlier, we immediately initiated phase two of the investigation to identify care homes reporting a single suspected or confirmed case of SARS-CoV-2. We hypothesised that this would allow early identification and isolation of infected individuals, which along with reinforcement of strict IPC measures, would prevent further transmission of the virus and protect the residents and staff. We found evidence for moderate transmission when mass screening was undertaken following a single case, although there was wide variation in the levels of infection detected among residents and staff across the four care homes under investigation. These differences are may be due to the care homes being at different stages of their outbreak at the time of initial testing. In care home C, for example, the outbreak continued to evolve, resulting in several hospitalisations and deaths in the two weeks after the initial swabbing. Other potential factors may be differences in resident profile, staff occupational risk factors such as working across different care homes [26], or compliance with recommended IPC measures. Of note, care homes B and C, which had higher SARS-CoV-2 infection rates, began isolating residents and restricting the use of shared spaces in late April when directly advised by PHE. This was almost a month later than in care homes A and D, which were more proactive. The difference in control measures in the care homes could explain the findings of genomic analysis which identified significant clusters in care homes B and C, and suggests that following SARS-CoV-2 introduction into the care home, the virus was likely to have spread more extensively in these care homes with less stringent IPC measures in place. Very few staff members reported working across different care homes, although it is possible they may not have volunteered this information to the care home managers.

The identification of additional cases through mass testing in the first round emphasises the importance of maintaining high vigilance in such high-risk settings, given the variable clinical manifestations of SARS-CoV-2 especially in older residents with multiple comorbidities [8-10]. In particular, we found that although these care homes had reported only one suspected or confirmed case, upon further enquiry, a large proportion of residents and staff who tested

PCR positive reported having varying symptoms in the 14 days before the test. The reason for this is unclear, but it suggests that often COVID-19 infection may not be considered as a possibility when the presentations are mild or non-specific in both residents and staff, which further delays testing and means that staff may continue to work even if they have symptoms. Our findings also highlight the challenges posed by asymptomatic cases, which have been shown to play an important part in SARS-CoV-2 transmission, especially in institutional settings in care homes [4,6,15]. Our investigation found high rates of asymptomatic infection among both residents and staff, which varied by care home from 25% to 67%. The standard practice at the time was for care homes and other institutional settings to report outbreaks with at least 2 suspected or confirmed cases to PHE, which would initiate additional testing of symptomatic individuals only along with reinforcement of IPC measures. However, a high proportion of asymptomatic cases highlight the limitations of symptom-based surveillance and signals the need for mass testing of all staff and residents to identify and rapidly isolate infected residents and staff.

We conducted repeat testing one week after the initial sampling which identified very few additional SARS-CoV-2 infections, unlike our experience with the other London care home outbreaks, which lasted for many weeks and were associated with large numbers of hospitalisations or deaths [15]. It is likely that early reporting to PHE and the resultant early mass testing increased awareness and vigilance in the care homes and led to rapid identification and isolation of infected asymptomatic residents and staff who may otherwise have been missed. Moreover, the investigation team maintained daily contact with the care homes throughout the surveillance period to reinforce stringent IPC practices and provide outbreak management support.

In keeping with emerging reports of widespread asymptomatic SARS-CoV-2 infections in countries experiencing with high rates of SARS-CoV-2 [4,6,19-22], the findings of our first phase of investigations led to national recommendations for mass testing in care homes experiencing an outbreak. The phase two investigation reported here, however, provided additional unique information on the risk of infection and transmission in care homes reporting a single suspected or confirmed case, which had not been reported elsewhere. This additional insight informed and supported public health authorities to update the UK care home testing strategy in May 2020 and provide whole home testing for all residents and staff as soon as they identified a single symptomatic case. As testing capacity increased, the UK government announced routine whole-home testing to be implemented weekly for all care home staff, and monthly for residents regardless of symptoms, in addition to mass testing in response to a suspected case or outbreak [27].

There are some limitations to this investigation. Due to practical considerations, residents in care homes B and C were not tested during the second period of sampling. It is therefore not possible to determine with certainty that transmission was controlled after the initial testing although no additional cases or outbreaks were reported in these two care homes.

Additionally, testing was voluntary and not all the residents and staff were tested on both occasions, although the numbers that were not tested at both time points was low. It was also not possible to independently assess the level and rigour of IPC measures implemented by care homes and, therefore, it cannot be stated with certainty that these measures were directly responsible for limiting transmission and controlling the spread of infection. Symptom status for staff was self-reported, while resident symptoms were reported by their care staff, and both may be subject to potential recall or recording bias. A further limitation is that due to practical considerations, data on other contributing factors such as comorbidities and frailty were not routinely collected.

An important strength of this study, however, is the high uptake of testing among residents and staff across four care homes. The findings of this study highlight the limited value of symptom-based screening and further underscores the need for timely mass testing to confirm the extent of SARS-CoV-2 infections in care homes and other similar institutional settings.

Our findings indicate that, during periods of continuous community SARS-CoV-2 transmission, care homes are extremely vulnerable to large outbreaks. While routine whole home testing has now been adopted into practice across the country, with further roll out of rapid tests using lateral flow devices for staff, care homes must remain vigilant and should be encouraged to report a single case of suspected or confirmed SARS-CoV-2 in a resident, staff or visitor to public health authorities. This should trigger appropriate outbreak control measures, with rapid mass testing, isolation of infected individuals and reinforcement of robust IPC measures.

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