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COVID-19 testing in outbreak-free care homes: what are the public health benefits?

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SUMMARY

Background: COVID-19 care home outbreaks represent a significant proportion of COVID-19 morbidity and mortality in the UK. National testing initially focused on symptomatic care home residents, before extending to asymptomatic cohorts.

Aim: The aim was to describe the epidemiology and transmission of COVID-19 in outbreak free care homes.

Methods: A two-point prevalence survey of COVID-19, in 34 Liverpool care homes, was performed in April and May 2020. Changes in prevalence were analysed. Associations between care home characteristics, reported infection, prevention and control interventions, and COVID-19 status were described and analysed.

Findings: No resident developed COVID-19 symptoms during the study. There was no significant difference between: the number of care homes containing at least one test positive resident between the first (17.6%, 95% confidence interval (CI) 6.8–34.5) and second round (14.7%, 95% CI 5.0–31.1) of testing ($p > 0.99$); and the number of residents testing positive between the first (2.1%, 95% CI 1.2–3.4) and second round (1.0%, 95% CI 0.5–2.1) of testing ($P = 0.11$). Care homes providing nursing care (risk ratio (RR) 7.99, 95% CI 1.1–57.3) and employing agency staff (RR 8.4, 95% CI 1.2–60.8) were more likely to contain test positive residents. Closing residents shared space was not associated with residents testing positive (RR 2.63, 95% CI 0.4–18.5).

Conclusions: Asymptomatic COVID-19 care homes showed no evidence of disease transmission or development of outbreaks; suggesting that current infection prevention and control measures are effective in preventing transmission. Repeat testing at two to three weeks had limited or no public health benefits over regular daily monitoring of staff and

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residents for symptoms. These results should inform policies calling for regular testing of asymptomatic residents.

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Introduction

Outbreaks of COVID-19 in care homes represent a significant proportion of total COVID-19 mortality in the United Kingdom (UK). At the time of this study 28.3% of all UK COVID-19 deaths were among care home residents [1,2]. Care home residents are more vulnerable to severe infection with COVID-19, as they are more likely to be older (immunosenescence), and with comorbidities that predispose to severe disease [3,4]. Institutional settings such as care homes are high-risk sites for outbreaks of infectious disease, as can be observed during seasonal influenza [5]. Interventions to protect care home residents in the UK have focused on preventing the introduction of the virus into homes and stopping further spread if residents become symptomatic or test positive for COVID-19 [6]. However, once a home has multiple symptomatic residents, it can be hard to suppress an outbreak, and many care homes in the UK have seen large outbreaks with significant mortality [7].

Testing of care home residents in England was initially focused on care homes with outbreaks of COVID-19 and symptomatic individuals, predicated on their meeting an agreed case definition [6,8,9]. Two features of COVID-19 make such policies problematic: while this case definition for older people is wider than that for the rest of the population, COVID-19 can often present atypically in this cohort, and presentations may fall outside case definitions [10,11]. Additionally, it has been shown that respiratory secretion viral load may be high at symptom onset [12,13]. As the COVID-19 pandemic has progressed, there has been increased recognition of the importance of asymptomatic transmission, including transmission by individuals in the incubation phase of the disease [14–16]. Small-scale studies have reported a burden of asymptomatic, or pre-symptomatic COVID-19 infection in care homes [17,18]. As such, testing strategies that only capture residents with symptoms may miss crucial opportunity to prevent transmission for asymptomatic individuals, and an important window for intervention in preventing spread from those who may display symptoms at a later date.

While testing of care home residents in England has been extended to include those without symptoms, the epidemiology of COVID-19 in care homes without current declared outbreaks is poorly understood. Likewise, it is not clear how testing policies focusing on care homes without outbreaks can be best designed to support health protection interventions [15].

This study was conducted in the Liverpool City Council area, between 28th April and 15th May 2020. There were 2779 newly laboratory-confirmed cases of COVID-19 in England on the first day of the study, and the rate of infection was declining from a peak in early April [19]. At the start of the study (24th April 2020), 56 of 90 (62%) care homes in Liverpool previously had COVID-19 outbreaks. There are no studies in the literature detailing the epidemiology of COVID-19 in multiple, outbreak-free care homes across two time points. One study details

two serial point-prevalence surveys in one ‘skilled nursing facility’ containing 89 residents, following the identification of one initial case [17]. A large UK-based survey across a large number of care homes ($N = 5,126$) found 3.9% of residents tested positive, dropping to 3.3% among asymptomatic residents [20].

This study sought to describe the epidemiology of COVID-19 in 34 care homes with no recorded case or outbreak across two points in time and explore key factors associated with the presence of COVID-19 in care homes.

Methods

All care homes with no reported confirmed or suspected cases of COVID-19 in the Liverpool City Council area were invited to take part in the study. Prior to the testing, all care homes in the city had received extensive advice and support regarding infection prevention and control (IPC) from local health and care partners. Residents were consented for swabbing, with best-interest assessments undertaken by a medical practitioner for those who were unable to provide consent. Care home staff carried out naso- or oropharyngeal swabbing following training via teleconference. Where residents tested positive, care homes were provided with a package of IPC advice and support in line with best-practice guidance and available evidence-based practice.

Information about resident demographics and care home characteristics were collected. Resident demographics were limited to age and sex; care home characteristics included details on type of care provided, client group, whether residents had single or shared rooms, whether care homes used agency staff. Information on the adoption of IPC practices since the start of the COVID-19 pandemic in the UK was collected, including whether homes had enhanced cleaning protocols, whether they were closed to visitors, and whether there was restricted use of shared space. In addition, all care homes were asked daily and at study conclusion whether any resident had developed COVID-19 symptoms, been hospitalized for COVID-19 or died from COVID-19.

Samples were analysed at Public Health England approved Public Health England (PHE) and National Health Service (NHS) laboratories, using real-time polymerase chain reaction (PCR) testing with high specificity and sensitivity [21]. Descriptive statistical analysis included calculation of prevalence of SARS-CoV-2 infection overall and by home. The crude prevalence of residents testing positive for each round was compared using a chi-squared test (χ^2 test). The mean prevalence within home was compared using a Wilcoxon signed-ranks test. The crude prevalence of care homes containing at least one test positive resident for each round was compared using a χ^2 test.

Where the prevalence of positive residents was high enough, a Poisson regression model was created to explore the above variables whilst accounting for care home differences. Where the prevalence was too low to allow appropriate stratification, univariable analysis was undertaken in the form of χ^2

tests or Fisher's exact test dependent on the numbers within the contingency tables. Differences in mean age between sexes, the number of staff and residents in negative and positive homes, and the ratio of staff to residents were compared using an independent *t*-test.

All statistical analyses were carried out using R language (version 3.2.0) [22], and results were deemed significant where $P < 0.05$. No ethical approval was required as these data were collected as part outbreak prevention and management, and public health surveillance under the Health Protection Legislation (England) Guidance 2010 [23].

Results

Resident demographics and care home characteristics

Complete age and sex information was available for 714 (99.6%) of the residents (Table I). The population was predominately female ($N = 433$, 60.4%). The mean age of residents was 74 years (median 80, range: 19–106). The mean age of males was 68 years (median 72, range: 19–99), and for females was 78 years (median 83, range: 20–106). An independent *t*-test showed that the male residents were significantly younger than female residents ($P < 0.0001$).

Participating care homes had a mixed range of client groups. Twelve care homes provided care solely for elderly residents; five care homes catered for residents with learning disabilities; four care homes had wide accepting criteria with resultant mixed client groups; four care homes catered for residents with acute brain injuries (ABI); three care homes catered for elderly mentally infirm (EMI) residents; three for dementia residents, and three for residents with predominant mental health diagnoses.

SARS-CoV-2 prevalence

All care homes that were invited ($N = 34$) agreed to take part. Across the two rounds of testing 818 residents were tested, with a total of 1554 swabs collected and tested (Figure 1). The two rounds of testing were carried out at intervals of 16 or 17 days (variation for operational reasons). The care homes had a combined capacity of 856 residents, information on occupancy rates was not available.

Of the 717 residents with test results available for both rounds of testing, 3.1% (95% confidence interval (CI) 1.9–4.6, $N = 22$) tested positive. In the first round of testing, 768 residents were tested; no samples were discarded due to sampling issues; and 16 residents in six different care homes tested positive (Figures 1 and 2). The overall crude prevalence of residents testing positive was 2.1% (95% CI 1.2–3.4%) (Table II). The mean within-care-home prevalence of residents was 1.7% (95% CI 0.2–3.3), ranging from 0 to 18.9%. The crude prevalence of care homes containing at least one test positive resident was 17.6% (95% CI 6.8–34.5).

In the second round, 736 (95.8%) of the residents tested in the first round were tested. An additional 50 new residents were swabbed increasing the total tested in the second round to 786 residents. Of these, 22 (2.9%) of the samples were discarded due to sampling issues (Figures 1 and 2). Thirty-two residents who were tested in the first round were not tested in the second round, for a variety of reasons, including resident(s) not being available at the time of testing. In the second round, eight residents across five care homes tested positive. The crude prevalence of residents testing positive was 1.0% (95% CI 0.5–2.1%). The mean within care home prevalence of residents was 0.8% (95% CI 0.0–1.6), ranging from 0 to 11.1%. The crude prevalence of care homes containing at least one test positive resident was 14.7% (95% CI 5.0–31.1%). In total there were 23 positive tests across the two rounds. Twenty-two different individuals tested positive, one resident tested positive in both rounds of testing. None of the residents, across all care homes, showed any clinical signs of COVID-19 throughout the study period.

There was no significant difference between crude prevalence of residents testing positive between the first and second round of testing ($P = 0.11$) (Table III). Due to the within-home prevalence data having a non-normal distribution, a Wilcoxon signed-ranks test was performed. The output indicated that there was no statistical difference between the within home prevalence in the first round of testing and the second round of testing ($W = 26$, $P = 0.29$). There was also no significant difference between the crude prevalence of care homes containing at least one test positive resident between the two testing dates ($P > 0.99$). Where homes did have positive cases, the numbers of cases were small (Figure 3), as such the study did not show evidence for a large amount of within-home transmission.

Table I

Risk of asymptomatic care home residents testing positive for COVID-19, stratified by sex and age

Age group	Male		Female		Test method	Risk ratio (95% CI)	P
	Positives	Negatives	Positives	Negatives			
≤40	1	21	0	18	NA	NA	NA
41–50	1	19	0	6	NA	NA	NA
51–60	1	40	1	35	Fisher's exact	0.88 (0.06–13.53)	>0.99
61–70	4	50	1	35	Fisher's exact	2.67 (0.31–22.9)	0.66
71–80	3	65	2	80	Fisher's exact	1.81 (0.31–10.51)	0.82
81–90	4	61	2	179	Fisher's exact	5.57 (1.05–29.69)	0.09
91+	1	10	1	73	Fisher's exact	6.73 (0.45–99.93)	0.49
≤70	7	130	2	94	Fisher's exact	2.52 (0.55–18.06)	0.20
>70	8	136	5	332	Chi squared	3.89 (1.24–13.29)	0.01
Total	15	266	7	426	Chi squared	3.30 (1.36–8.00)	0.007

CI, confidence interval.

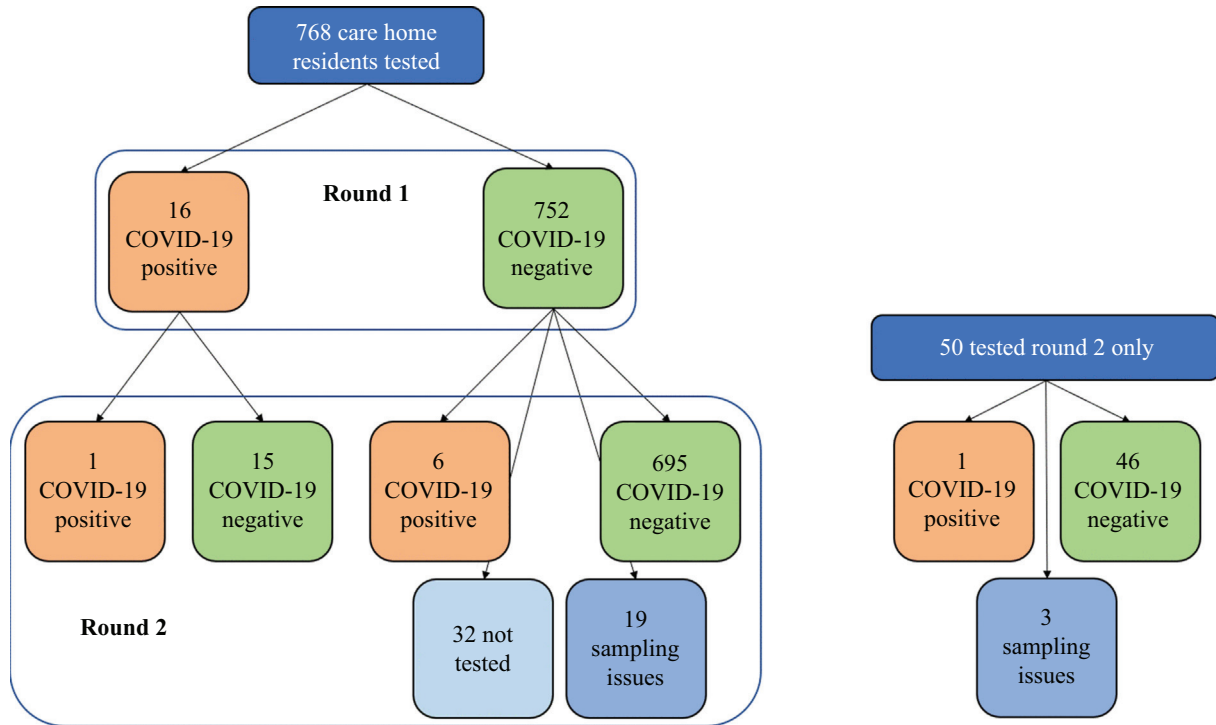


Figure 1. Flow diagram detailing resident test results through both rounds of swabbing.

Associations with resident demographics and care home characteristics

Males were 3.3 times more likely to test COVID-19 positive than females (risk ratio (RR): 3.30, 95% CI 1.36–8.00, $P=0.007$). On stratification of sex data by age, there was no age-band where there was a significant difference of test positivity between sexes (Table I).

Overall, 76.5% (95% CI 58.8–89.3%, $N = 26$) of care homes remained free of COVID-19 throughout the study period. Due to the low prevalence and sparsity of the data, stratification could not appropriately be performed and only univariable analysis

could be performed. Of the 34 homes, 52.9% ($N = 18$) were purely residential in nature, the remainder offered nursing support. Homes offering nursing support were 7.88 times more likely to have residents test positive than residential home (RR: 7.88, 95% CI 1.08–57.27, $P=0.02$) (Table III).

There was no association between single- or multiple-occupancy rooms and COVID-19 test positive status ($P>0.99$). Care homes using agency staff were associated with a nine times higher risk of having a COVID-19 test positive resident (RR: 8.40, 95% CI 1.16–60.84, $P=0.018$). Ninety-one percent (90.91%, $N = 30$) of care homes were performing enhanced cleaning routines. All care homes had closed to visitors prior to the study. There was no association between whether homes restricted residents’ use of shared space and COVID-19 test positive status. There was no statistical difference ($P=0.22$, $N = 34$) in the mean number of residents in negative (mean = 23.08, standard deviation (SD) = 11.74) or positive (mean = 28.88, SD = 10.76) homes. Positive care homes had a significantly ($P=0.01$, $N = 34$) higher number of staff (mean = 49.63, SD = 23.11) compared with negative homes (mean = 30.48, SD = 16.11). There was no significant difference ($P=0.91$, $N = 34$) between the mean staff-resident ratio of negative (mean = 1.93, SD = 1.70) and positive care homes (mean = 1.86, SD = 1.23).

Discussion

This is the largest study to date reporting on the point prevalence at more than one time point of SARS-CoV-2 infection in COVID-19 outbreak-free care homes. Smaller-scale studies [17], and unpublished internal surveillance reports had suggested that there might be a significant burden of undetected disease in UK care homes, however this study

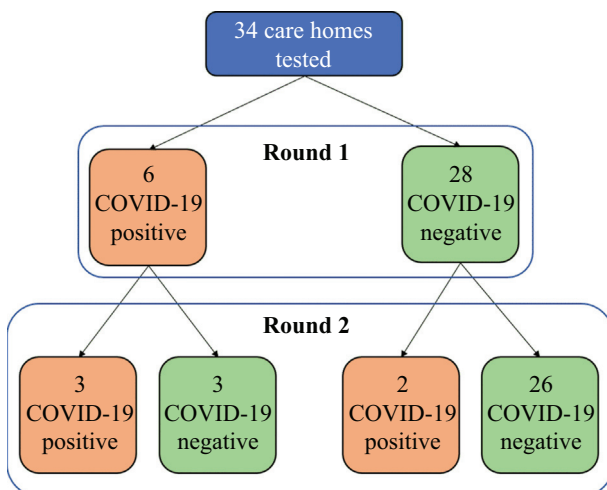


Figure 2. Flow diagram detailing care home test results through both rounds of swabbing.

Table II

The crude prevalence of COVID-19 in care homes with no reported cases or outbreaks

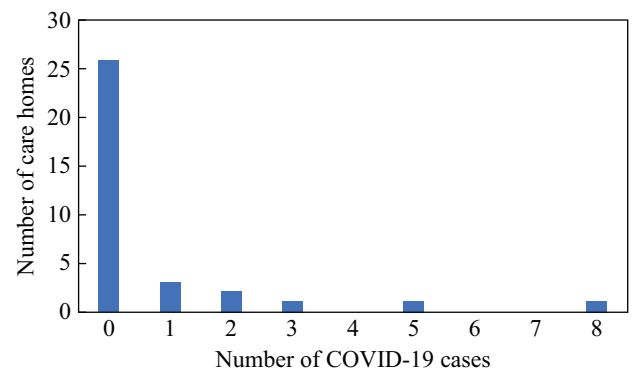
	Round of testing	No. reporting	No. negative	No. positive	COVID-19 prevalence (95% CI)	P
Care homes	1	34	28	6	17.6% (6.8–34.5%)	>0.99
	2	34	29	5	14.7% (5.0–31.1%)	
Residents	1	768	752	16	2.1% (1.2–3.4%)	0.11
	2	764	756	8	1.0% (0.5–2.1%)	

CI, confidence interval.

shows that the prevalence was low at this stage of the pandemic. This finding has been echoed by the UK Vivaldi study, although this does not specifically report on care homes with no reported outbreaks [20]. Additionally, all residents that tested positive during the study remained asymptomatic for a period of 21 days for those testing positive in round one and 14 days in round two (the study did not follow up on symptoms beyond this period); testing asymptomatic residents did not detect any pre-symptomatic individuals, only 'truly asymptomatic' individuals. This suggests that while COVID-19 prevalence is low, there are likely small numbers of asymptomatic cases in outbreak-free care homes, posing a threat as potential foci of outbreaks. These residents will not be detected by testing policies predicated on symptom status.

The lack of significant difference between the prevalence of COVID-19 within homes and between the gross percentage of residents testing positive between the first and second round, and the high proportion of care homes remaining COVID-19 free suggest that implementing robust IPC measures can be effective at preventing the introduction of the virus in to care homes, and asymptomatic individuals are less likely to cause further transmission and outbreaks.

Whilst the infection prevalence was low, the source of the 16 infections that were detected is unclear, given the extent of measures in place at that time. Univariable analysis showed that some care home factors were associated with the likelihood of residents testing positive for COVID-19. Care homes that provided nursing care were more likely to contain test positive residents (RR 7.88, 95% CI 1.08–57.27). This finding, in line with findings from other studies looking into seasonal

**Figure 3.** The number of test-positive asymptomatic COVID-19 cases per care home.

influenza and pneumonia in care homes [24,25], and this could be due to the higher level of dependency of nursing home residents [4], necessitating closer contact from those providing care which in turn facilitates transmission. Care homes employing agency staff were similarly at a greater risk of having residents test positive (RR 8.40, 95% CI 1.16–60.84). The link between the use of agency staff and poorer care outcomes in care homes has been reported previously [26,27], and this echoes the findings of the Vivaldi study [20]. It may be that staff working across multiple settings act as vectors, facilitating spread between facilities. Furthermore, agency staff may not have time to fully familiarise themselves with IPC procedures in care homes that are new to them, or that agency staff

Table III

Univariable analysis of key characteristics of COVID-19 asymptomatic care homes

Characteristics	Test method	Risk ratio (95% CI)	P
Care home type (N = 34)			
Residential	Ref	NA	NA
Nursing	Fisher's Exact	7.88 (1.08–57.27)	0.024
Were agency staff employed? (N = 33)			
No	Ref	NA	NA
Yes	Fisher's Exact	8.40 (1.16–60.84)	0.018
Was the use of shared space restricted? (N = 33)			
No	Ref	NA	NA
Yes	Fisher's Exact	2.63 (0.37–18.45)	0.55
Room Type (N = 34)			
Mixed (single and multiple occupancy)	Ref	NA	NA
Single	Fishers Exact	1.07 (0.17–6.59)	>0.99
Was enhanced cleaning performed? (N = 33)	Not calculable. 90.9% (N = 30) care homes did enhanced cleaning		
Was the home closed to visitors? (N = 33)	All care homes were closed to visitors		

CI, confidence interval.

are a manifestation of a wider problem in a care home that is also impacting on the implementation of IPC and increasing the risk of infection. While this study is not able to answer these questions, agencies supporting care homes during the pandemic may wish to look at homes utilising agency staff and consider what additional support may be required. This study found no association between care home staff to resident ratios and the risk of resident COVID-19 infection, or the size of care home (by resident numbers). However, the mean number of staff was significantly higher in those care homes with positive test results compared with care homes with negative test results. This is more likely related to the higher number of staff entering the facilities.

All care homes were closed to visitors and implemented enhanced cleaning regimes prior to the study; as such this paper is unable to comment on the effectiveness of these measures. However, our study did find that there was no association between whether a care home had restricted the use of shared space by residents and the chances of a home containing test-positive residents. The wellbeing of residents must be an important consideration when recommending IPC interventions. It has been suggested that social distancing and visitor restrictions have had a significant impact on the mental health of those in care homes [28], and the closure of shared space may further impact on the mental, social and physical wellbeing of residents. As such, this policy should be carefully considered in future guidance.

The finding that male residents were significantly more likely to have asymptomatic infection than female residents is of interest. There is a clear association reported between male sex, severity of disease and mortality. These results support an association between male sex and susceptibility to infection.

The two swabbing rounds were conducted at an interval of 16–17 days. There was no significant difference between either the prevalence of COVID-19 within homes or the percentage of homes containing positive residents. This provides useful information for those considering regular mass testing of care home residents as part of COVID-19 management strategies. Where community prevalence is low and numbers of outbreaks in care homes are steady, repeat testing at intervals of less than 3–4 weeks is unlikely to add value to daily monitoring of symptoms, and the resource-intensive nature of testing and impact on frail and elderly residents should be considered. In this study, test results were reported within 24–48 h by local laboratories, thus it is likely that behaviour changes as a result of first swab results were able to impact on transmission. Where testing regimes are experiencing significant reporting delays, this reduces the merit of mass swabbing exercises.

The low number of swabs rejected by the laboratory due to sampling quality (1.4%) demonstrate that swabbing undertaken by trained care home staff (via video-conference supplemented with a video of self-swabbing) was of good quality.

Limitations

The low prevalence of positive residents meant that analysis adjusting for each of the variables and within care home associations, could not be performed. Therefore, it was not possible to truly quantify the level of risk posed by each of the variables independently. The low prevalence meant that some

variables could not be examined, and those variables that were statistically significant, had very wide confidence intervals. These associations should be seen as more general trends, rather than definitive levels of relative risk, and are worthy of further exploration. The study was not powered to detect whether any excess mortality occurred in the participating care homes.

Where care homes were asked to detail the interventions implemented prior to the commencement of the study, this was not externally verified, thus it is possible that there may be an element of social desirability bias in their responses (i.e. reporting the implementation of desired IPC measures, when there have been none/limited implementation of the desired IPC measures). Further study into the effects of individual IPC measures would help to develop a better understanding of how best to protect care home residents.

In conclusion, the low prevalence of SARS-CoV-2 infection in homes in the first round of testing, in the context of community transmission with a large number of care home outbreaks in the study area, demonstrates that effective IPC measures can successfully prevent the introduction of SARS-CoV-2 into care homes. The results from the second round of testing further reinforce the continued success of these IPC measures, i.e. care homes where SARS-CoV-2-positive residents were identified in the first round of testing did not lead to further transmission or development of outbreaks of COVID-19.

Male residents and nursing homes were identified as more likely to have infections than female residents and residential homes. The use of agency staff was associated with an eight-fold increased risk and this needs to be considered in future support to care homes. Closing shared spaces was not associated with an increased risk of infection.

This study has implications for those considering developing policies for the regular swabbing of asymptomatic care home residents and when considering the tailoring of IPC interventions to care homes during the ongoing pandemic. While transmission of COVID-19 is currently low in the UK, these considerations will be particularly important for informing care home policy if a second rise in infection occurs in order to aid the prevention of the high COVID-19 mortality seen in care homes during the first peak of infection.

Author contributions

R.G. drafted the paper and contributed to the design and implementation of the study. S.G. helped draft the paper and contributed to the design and implementation of the study. J.S.P.T. undertook the analysis, contributed to the design and implementation of the study and commented on the paper. C.T. and E.C. and W.S. contributed to the design and implementation of the study and commented on the manuscript. A.C., K.L. and R.B. contributed to the implementation of the study. M.A., J.M., A.F., R.V. and M.B.J.B. contributed to the design and implementation of the study. IH and NW commented on the manuscript. All authors approved the final version of the manuscript.

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Conflict of interest statement

The authors have no conflicts of interest to declare.

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