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Factors associated with SARS-CoV-2 infection and outbreaks in long-term care facilities in England: a national cross-sectional survey

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Summary

Background Outbreaks of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection have occurred in long-term care facilities (LTCFs) worldwide, but the reasons why some facilities are particularly vulnerable to outbreaks are poorly understood. We aimed to identify factors associated with SARS-CoV-2 infection and outbreaks among staff and residents in LTCFs.

Methods We did a national cross-sectional survey of all LTCFs providing dementia care or care to adults aged 65 years or older in England between May 26 and June 19, 2020. The survey collected data from managers of eligible LTCFs on LTCF characteristics, staffing factors, the use of disease control measures, and the number of confirmed cases of infection among staff and residents in each LTCF. Survey responses were linked to individual-level SARS-CoV-2 RT-PCR test results obtained through the national testing programme in England between April 30 and June 13, 2020. The primary outcome was the weighted period prevalence of confirmed SARS-CoV-2 infections in residents and staff reported via the survey. Multivariable logistic regression models were fitted to identify factors associated with infection in staff and residents, an outbreak (defined as at least one case of SARS-CoV-2 infection in a resident or staff member), and a large outbreak (defined as LTCFs with more than a third of the total number of residents and staff combined testing positive, or with >20 residents and staff combined testing positive) using data from the survey and from the linked survey–test dataset.

Findings 9081 eligible LTCFs were identified, of which 5126 (56·4%) participated in the survey, providing data on 160,033 residents and 248,594 staff members. The weighted period prevalence of infection was 10·5% (95% CI 9·9–11·1) in residents and 3·8% (3·4–4·2) in staff members. 2724 (53·1%) LTCFs reported outbreaks, and 469 (9·1%) LTCFs reported large outbreaks. The odds of SARS-CoV-2 infection in residents (aOR 1·65 [1·56–1·74], p<0·0001) and staff (1·85 [1·72–1·98], p<0·0001), and of large outbreaks (2·33 [1·72–3·16], p<0·0001) were significantly higher in LTCFs in which staff often or always cared for both infected or uninfected residents compared with those that cohorted staff either infected or uninfected residents. Significantly increased odds of infection in residents (1·01 [1·01–1·01], p<0·0001) and staff (1·00 [1·00–1·01], p<0·0005), and of outbreaks (1·08 [1·05–1·10], p<0·0001) were associated with each one unit increase in the number of new admissions to the LTCF relative to baseline (March 1, 2020). The odds of infection in residents (1·19 [1·12–1·26], p<0·0001) and staff (1·19 [1·10–1·29], p<0·0001), and of large outbreaks (1·65 [1·07–2·54], p=0·024) were significantly higher in LTCFs that were for profit versus those that were not for profit. Frequent employment of agency nurses or carers was associated with a significantly increased odds of infection in residents (aOR 1·65 [1·56–1·74], p<0·0001) and staff (1·85 [1·72–1·98], p<0·0001), and of outbreaks (2·33 [1·72–3·16], p<0·0001) and large outbreaks (2·42 [1·67–3·51], p<0·0001) compared with no employment of agency nurses or carers. Compared with LTCFs that did not report difficulties in isolating residents, those that did did significantly higher odds of infection in residents (1·33 [1·28–1·38], p<0·0001) and staff (1·48 [1·41–1·56], p<0·0001), and of outbreaks (1·84 [1·48–2·30], p<0·0001) and large outbreaks (1·62 [1·24–2·11], p=0·0004).

Interpretation Half of LTCFs had no cases of SARS-CoV-2 infection in the first wave of the pandemic. Reduced transmission from staff is associated with adequate sick pay, minimal use of agency staff, an increased staff-to-bed ratio, and staff cohorting with either infected or uninfected residents. Increased transmission from residents is associated with an increased number of new admissions to the facility and poor compliance with isolation procedures.

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Introduction
The global burden of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is increasing, with many countries that successfully curtailed the first wave of the pandemic reporting new infections following the relaxation of lockdown measures.1

Long-term care facilities (LTCFs), which provide care to older adults and people with disabilities, have encountered among the highest rates of SARS-CoV-2 infection among both staff and residents, and account for 30–50% of all COVID-19-related deaths in countries including the USA,2 England,1 Scotland,3 France, Spain, and Sweden.4 Residents of LTCFs who become infected with SARS-CoV-2 are at an increased risk of severe outcomes compared with the general population because of their age and the high prevalence of comorbidity, but they are also highly exposed to infection through frequent close contact with other residents and staff in the care setting.5 Untreated infection, due to presymptomatic and asymptomatic infections, and low testing rates at the start of the pandemic, are likely to have played a key role in the rapid transmission of SARS-CoV-2 in LTCFs.6 In England, widespread one-off testing for SARS-CoV-2 using RT-PCR tests was not implemented for staff and residents in LTCFs until May 11, 2020. Before this date, SARS-CoV-2 testing was only available for residents or staff who were admitted to hospital or as part of outbreak investigations by Public Health England (PHE), which permitted a maximum of five tests per LTCF.7

In the UK, there are an estimated 400,000 residents living in approximately 11,000 LTCFs that provide care for older adults,8 but there is poor-quality demographic, infection prevention, or administrative data available for residents and staff in these facilities. Studies based on administrative data from Canada, the USA, and Europe have identified risk factors for SARS-CoV-2 infection.
and outbreaks in LTCFs, including lower staff-to-resident ratios, increased facility size, lower care quality ratings, a higher proportion of residents from minority ethnic groups, and LTCFs that are for profit rather than state-funded. However, as many of these studies are small and have relied on administrative data rather than surveys, they may have been unable to capture the wide range of potential factors that might influence infection risk.

To inform the SARS-CoV-2 pandemic response, we invited all managers of LTCFs in England to participate in a survey to collect information on the number of confirmed SARS-CoV-2 infections in staff and residents, staffing practices (eg, employment of temporary agency staff and sick pay policies), the use of disease control measures (eg, cleaning frequency, staff cohorting [ie, a staff member who cares for cohorts of either infected or uninfected residents and does not move between cohorts]), and isolation of residents), and the number of staff and residents at the facility. Responses were linked to results from the national SARS-CoV-2 testing programme. Our objective was to identify factors associated with SARS-CoV-2 infection and outbreaks in residents and staff. We also estimated the prevalence of laboratory-confirmed infections in residents and staff, and the proportion of LTCFs with outbreaks.

Methods

Study design and participants

We did a national cross-sectional survey of LTCFs providing dementia care or care to adults aged 65 years or older in England between May 26 and June 19, 2020. Eligible LTCFs were identified from a directory maintained by LaingBuisson. Survey responses were linked to individual-level SARS-CoV-2 RT-PCR test results obtained between April 30 and June 13, 2020, through the national testing programme, which aimed to test all residents and staff of LTCFs in England.

Ethical approval for the study was obtained from PHE’s Research Ethics and Governance Group (NR0210). Information sheets were sent to participants in advance. The telephone interviewer went through the consent form at the start of the survey and the completed consent form was then emailed to each care home manager after the interview.

Procedures

The survey collected data on LTCF characteristics, the use of disease control measures, and the number of confirmed cases of infection in staff and residents in each LTCF. Candidate risk factors for infection were identified from the published literature and from previous knowledge of disease control measures. Experts from the UK Office for National Statistics designed and piloted the survey using cognitive interview methods to test comprehension, accuracy, and question acceptability. In the weeks before the survey began, managers of eligible LTCFs were sent an invitation letter by PHE explaining that they would shortly receive a telephone call from Ipsos MORI. The letter outlined the purpose of the survey, listed the information that would be requested (so that it could be collated in advance of the interview), and explained that the survey should be completed by care home managers. Incentives for managers to participate in the survey were not provided. Subject to obtaining informed consent from managers, the finalised 30-min survey was delivered by telephone (appendix pp 2–8). Survey responses were recorded electronically and transferred securely to the National Health Service (NHS) COVID-19 data store reference library, which is powered by Palantir Foundry.

Data on LTCF characteristics included the degree of social deprivation, measured by the postcode-based Index of Multiple Deprivation (IMD), which is a summary measure of relative deprivation between small areas of England based on a weighted average of deprivation across seven domains: income, employment, education, health, crime, housing, and the living environment; region; size; the membership of a care home group; type of funding (for profit vs not for profit); the staff-to-bed ratio (total number of staff divided by the number of beds); and the Care Quality Commission’s (CQC) rating of the quality of leadership of the LTCF. In England, the CQC assesses the quality of an LTCF across five domains. We chose the leadership domain of the assessment (ie, the “well-led” question), in view of its relevance to the management of the pandemic.

Data on disease control measures included the use of barrier nursing (gloves, facemasks, and aprons); whether there were difficulties in isolating residents due to non-compliance (eg, because of dementia); the cohorting of staff with either infected or uninfected residents; cleaning frequency; sick pay for staff; employment of temporary agency staff; use of personal protective equipment; and how often staff worked at other locations. These factors were selected on the basis of theoretical assumptions about risk factors for transmission of SARS-CoV-2 and national guidance.

Managers were also asked to provide the number of new admissions to the LTCF and the number of weeks of closure to visitors since baseline (March 1, 2020). The survey also requested the number of confirmed cases of SARS-CoV-2 infection in staff (including cleaners, catering staff, and administrative staff) and residents, as well as the number of residents who had died since contracting COVID-19. In addition, individual-level data on age and sex, and whether they had symptoms on the date they had a nasopharyngeal swab taken, were available for care home staff and residents who underwent PCR testing via the national testing programme. This information could be linked to specific care homes using their CQC unique identification number.

A national community testing programme, which involved the testing of all staff and residents of LTCFs...
in England, was officially launched on May 11, 2020. PCR testing of clinical isolates from nasopharyngeal swabs was done by the National Bioresource Centre using an Applied Biosystems 7500 Fast RT-PCR system (Thermo Fisher Scientific, Waltham, MA, USA) with the Applied Biosystems TaqPath 1-Step Multiplex Master Mix (catalogue number A28523) and the TaqPath COVID-19-ASY-KIT 1000 (catalogue number A47817). Primer sequence details are not currently available.

For linkage of individual-level SARS-CoV-2 test results from the national testing programme to survey responses, an LTCF identifier was used to link individual test results to specific LTCFs, and to link test results with survey responses (figure 1, appendix p 9).

**Outcomes**

The primary outcome was the weighted period prevalence of confirmed SARS-CoV-2 infections in residents and staff reported via the survey. A survey-based outcome was preferred for the primary outcome because it was not possible to reliably attribute national programme test results to LTCFs using routine data before May, 2020. Additionally, the national testing programme measured infection at a point in time rather than over the course of the first wave of the pandemic. The three secondary outcomes were (1) the weighted point prevalence of SARS-CoV-2 in residents and staff between April 30 and June 13, 2020, measured using test results from the national programme test data; (2) the proportion of care homes with an outbreak (defined as one or more cases of infection); and (3) the proportion of LTCFs that had a large outbreak (defined as LTCFs with more than a third of the total number of residents and staff combined testing positive, or with >20 residents and staff combined testing positive).

**Statistical analysis**

Estimates of period prevalence of confirmed SARS-CoV-2 infections derived from the survey and point prevalence of confirmed infections derived from the national programme test data were weighted to provide nationally relevant estimates that take into account non-response by post-stratification, considering the LTCF size, IMD score, and the total number of LTCFs run by the provider. LTCFs were grouped into post-strata on the basis of combinations of the number of beds, IMD score, and the total number of LTCFs run by the provider. This resulted in 30 post-strata, which were collapsed into 21 post-strata to achieve a minimum of 50 responding LTCFs in each stratum, with each having a separate non-response weight adjustment contributing to the overall estimates (appendix p 9).

We investigated potential risk factors for ingress and spread of infection. We fitted multivariable logistic regression models to identify factors associated with infection in staff and residents, derived from the survey and from the linked survey—national testing
programme dataset. The outcomes of interest were binomial counts of infected residents and staff by LTCF (survey data) and the presence or absence of infection (linked dataset). A multilevel model was fitted in the linked dataset to estimate the individual-level and LTCF-level factors associated with infection, using random effects to account for clustering by LTCF. Using survey data, multivariable logistic regression models were also fitted to identify factors associated with outbreaks (ie, by comparing LTCFs with outbreaks with those that had no cases), and factors associated with large versus small outbreaks (ie, by comparing LTCFs in which a third of staff and residents combined were infected, or in which there were >20 cases of infection in staff and staff combined, with those that did not meet this definition, but had one or more cases).

All predefined risk factors and potential confounding factors were included in the models unless there was strong evidence of collinearity, assessed by variance inflation factors, or variables were uninformative (eg, staff training, as almost all managers reported staff training being trained). Risk factors with a variance inflation factor of more than 10 were excluded from the analysis. Weighting factors from the estimation of period prevalence were included in all models as adjustment factors to adjust for survey non-response.

Results were presented as proportions, adjusted odds ratios (aORs; adjusted for all other variables in the model) with 95% CIs, or both. All reported model p values were considered significant if p<0.008 (α=0.05), using the conservative Bonferroni adjustment for multiple hypothesis testing done for the six dependent variables (ie, odds of infection in residents [survey data], odds of infection in staff [survey data], odds of an outbreak [at least one case vs none; survey data], odds of a large outbreak vs an outbreak [survey data], odds of infection in residents [national programme testing data], and odds of infection in staff [national programme testing data]). A heatmap was used to visualise the strength of the association for each risk factor across all outcomes.

Sensitivity analyses were done to compare complete case data (primary analysis), with models fitted to imputed data. The proportion of variables with missing data is reported in the appendix (p 24).

All analyses were done with RStudio 3.5 in the secure NHS COVID-19 data store.

Role of the funding source
The funder had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results
We identified 9081 eligible LTCFs in England, 5126 (56–4%) of which participated in the survey between May 26 and June 19, 2020, providing data on 160033 residents and 248394 staff. Researchers from Ipsos MORI attempted to contact 8634 (95·1%) of 9081 eligible LTCFs at least once and 6164 (67·8%) of LTCFs were telephoned three or more times. Three LTCFs that participated in the survey but subsequently withdrew were excluded from analyses. Participating LTCFs were similar to those that did not participate in terms of the number of beds per LTCF, type of funding, region, and degree of deprivation, with survey weights varying from 1·5 to 2·2. The mean number of residents per LTCF was 32·2 (SD 17·3) and the mean number of staff was 48·5 (31·2), and most (4289 [83·7%] of 5126) LTCFs were for-profit (table 1). 2573 (50·2%) LTCFs were single institutions, and 1102 (21·5%) primarily provided dementia care. The uptake of disease control measures by each LTCF have been reported previously.27

A confirmed SARS-CoV-2 infection was reported in the survey for 19571 residents and 10630 staff, equivalent to a weighted period prevalence of 10·5% (95% CI 9·9–11·1) in residents and 3·8% (3·4–4·2) in staff. Of 5126 LTCFs, 2724 (53·1%) reported at least one case of SARS-CoV-2 during the survey period, and 469 (9·1%) reported a large outbreak. RT-PCR test results from the national testing programme were identified for 108289 residents and 248394 LTCFs between April 30 and June 13, 2020. Based on these data, the weighted prevalence of infection was 2·8% (2·4–3·1) in residents and 0·6% (0·5–0·8) in staff. 608 (95·9%) of 634 staff and 2657 (74·4%) of 3573 staff with a positive test were recorded as asymptomatic at the time of testing (appendix p 10).

For-profit status was associated with a significantly higher odds of infection in residents (aOR 1·19 [95% CI 1·12–1·26], p<0·0001) and staff (1·19 [1·10–1·29], p<0·0001) compared with LTCFs that were not for profit (table 2), with moderate evidence of an association with large outbreaks (1·65 [1·07–2·54], p=0·024; table 3). Compared with LTCFs with fewer than 25 beds, larger LTCFs (ie, those with >50 beds) were significantly more likely to have one or more cases of infection (2·76 [1·97–3·88], p<0·0001), but were not more likely to have large outbreaks (table 3), and the odds of infection in residents (0·87 [0·79–0·96], p=0·006) and staff (0·79 [0·70–0·90], p=0·0003) were significantly lower (table 2). There was substantial regional variation in the odds of infection and outbreaks in residents and staff (tables 2, 3). Residents in LTCFs with the highest degree of social deprivation (quintile [Q] 1) had significantly increased odds of infection compared with all other degrees of social deprivation (Q1 vs Q2–Q5, 1·08 [1·03–1·14], p=0·0012) (table 2), but the highest degree of social deprivation was not associated with significantly higher odds of outbreaks, or large outbreaks, compared with other degrees of social deprivation (table 3).

Compared with no employment of agency nurses or carers, frequent (ie, on most days or every day) employment of agency nurses or carers was associated with a significantly increased odds of infection in residents...
Articles

| Social deprivation | LTCFs (n=5126) |
|--------------------|----------------|
| Q1 (most deprived) | 871/5125 (17.0%) |
| Q2–Q5              | 4254/5125 (83.0%) |

| Provider type       | LTCFs (n=5126) |
|--------------------|----------------|
| For profit         | 4289 (83.7%)   |
| Not for profit     | 837 (16.3%)    |

| Number of beds     | LTCFs (n=5126) |
|--------------------|----------------|
| <25                | 1096 (21.4%)   |
| 25–50              | 2497 (48.7%)   |
| >50                | 1533 (29.9%)   |

| Number of residents| LTCFs (n=5126) |
|--------------------|----------------|
| 32–2               | 48 (13.1%)     |

| Number of staff    | LTCFs (n=5126) |
|--------------------|----------------|
| Number of nurses or carers | 33 (2.3%) |
| Number of cleaning, maintenance, or catering staff | 10 (7.1%) |
| Number of office or other staff | 4 (5.0%) |

| Region             | LTCFs (n=5126) |
|--------------------|----------------|
| East Midlands      | 488/5124 (9.5%) |
| East of England    | 556/5124 (10.9%) |
| London             | 282/5124 (5.5%) |
| North East         | 273/5124 (5.3%) |
| North West         | 715/5124 (14.0%) |
| South East         | 1006/5124 (19.6%) |
| South West         | 719/5124 (14.0%) |
| West Midlands      | 562/5124 (11.0%) |
| Yorkshire and the Humber | 523/5124 (10.2%) |

| Care Quality Commission rating of leadership at the LTCF |
|---------------------------------------------------------|
| Outstanding or good | 3724 (72.6%) |
| Requires improvement or is inadequate | 1323 (25.8%) |
| Not rated or inspected | 79 (1.5%) |

| Main type of care provided          | LTCFs (n=5126) |
|-------------------------------------|----------------|
| For residents with dementia         | 1102 (21.5%)   |
| For residents aged ≥65 years        | 4024 (78.5%)   |

Data are n/N (%), n (%), or mean (SD). LTCF=long-term care facility. Q=quintile.

Table 1: Baseline characteristics

(aOR 1.65 [95% CI 1.56–1.74], p<0.0001) and staff (1.85 [1.72–1.98], p<0.0001; table 2, figure 2), and an increased odds of outbreaks (2.33 [1.72–3.16], p<0.0001) and large outbreaks (2.42 [1.85–3.16], p<0.0001; appendix p 11) were significantly more likely to have outbreaks (2.60 [1.94–3.49], p<0.0001), but not large outbreaks.

Protective factors included statutory sick pay to staff, which significantly reduced the odds of infection in residents (aOR 0.80 [95% CI 0.75–0.86], p<0.0001) and staff (0.70 [0.65–0.77], p<0.0001) compared with no staff sick pay (table 2). Statutory sick pay also reduced the odds of large outbreaks compared with no payment, but this difference was not significant (0.59 [0.38–0.93], p=0.024; table 3). Each one unit increase in the staff-to-bed ratio was associated with a reduced odds of infection in residents (0.82 [0.78–0.87], p<0.0001) and staff (0.63 [0.59–0.68], p<0.0001; table 2).

Compared with the ability to isolate residents, being unable to isolate residents due to non-compliance (eg, due to dementia) was associated with an increased odds of infection in residents (aOR 1.33 [95% CI 1.28–1.38], p<0.0001) and staff (1.48 [1.41–1.56], p<0.0001), and an increased odds of outbreaks (1.84 [1.48–2.30], p<0.0001) and large outbreaks (1.62 [1.24–2.11], p<0.0004; figure 2). Compared with LTCFs that reported cleaning communal areas at least twice per day, those that reported cleaning these areas once per day had higher odds of infection in staff (1.10 [1.03–1.17], p=0.003), with some evidence of increased odds in residents (1.05 [1.00–1.11], p=0.039; table 2). Cleaning frequency in other areas, and frequency of personal protective equipment use did not affect the odds of infection or outbreaks in both staff or residents (tables 2, 3). Unexpectedly, the use of barrier nursing for both infected residents and all residents was associated with significantly higher odds of infection in both staff and residents and significantly higher odds of an outbreak compared with no barrier nursing (tables 2, 3), and there was moderate evidence that providing barrier nursing for all residents was associated with a higher odds of large outbreaks compared with no barrier nursing (1.44 [1.08–1.91], p=0.013; table 3). Each one unit increase in the number of new admissions to the LTCF relative to baseline was associated with increased odds of infection in residents (1.01 [1.00–1.02], p=0.024; table 3), and there was moderate evidence that observing barriers to infection using the linked dataset found an association between increasing age (per year) and the odds of infection in residents (aOR 1.01 [95% CI 1.01–1.04], p=0.0007; appendix p 11) but not in staff. Similar risk factors for infection were identified when the analysis was repeated using national programme test results as the outcome (appendix pp 11–13), and using multiple imputation to account for missing survey data in the sensitivity analysis (appendix pp 14–22).
Discussion
This cross-sectional study shows the widespread but variable impact of COVID-19 on LTCFs in England. Almost half of LTCFs did not report any cases of SARS-CoV-2 infection in the first wave of the pandemic, and remain vulnerable to current and future waves of infection, thus emphasizing the need for effective infection prevention and control strategies. Our findings

| Residents * | Adjusted OR (95% CI) | p value |
|-------------|----------------------|---------|
| Proportion with SARS-CoV-2 infection (%) |                      |         |
| Social deprivation                          |                      |         |
| Q2-Q5 (10·9%)                                | 1·00 (0·96–1·05)     | 0·0012  |
| Q1 (13·8%)                                   | 1·08 (1·03–1·14)     | NA      |
| Provider type                                 |                      |         |
| Not for profit                               | 1·00 (0·94–1·03)     | 0·48    |
| For profit                                   | 1·04 (0·99–1·09)     | 0·14    |
| Provider size                                 |                      |         |
| 1 LTCF                                       | 1 (ref) NA           | 2660/6766 (3·9%) | 0·19 |
| 2-9 LTCFs                                    | 0·98 (0·94–1·03)     | 0·48    |
| ≥10 LTCFs                                    | 1·04 (0·99–1·09)     | 0·14    |
| Main type of care provided                   | 1·00 (0·96–1·01)     | 0·67    |
| Region                                       | 1·00 (0·97–1·02)     | 0·47    |
| London                                       | 1·00 (0·96–1·01)     | 0·50    |
| East Midlands                                | 1·00 (0·96–1·01)     | 0·50    |
| East of England                              | 1·00 (0·96–1·01)     | 0·50    |
| North East                                   | 1·00 (0·96–1·01)     | 0·50    |
| North West                                   | 1·00 (0·96–1·01)     | 0·50    |
| South East                                   | 1·00 (0·96–1·01)     | 0·50    |
| South West                                   | 1·00 (0·96–1·01)     | 0·50    |
| West Midlands                                | 1·00 (0·96–1·01)     | 0·50    |
| Yorkshire and the Humber                     | 1·00 (0·96–1·01)     | 0·50    |
| Number of beds in LTCF                       |                      |         |
| <25                                          | 0·98 (0·96–1·01)     | 0·50    |
| 25-50                                        | 0·96 (0·96–1·01)     | 0·50    |
| >50                                          | 0·95 (0·96–1·01)     | 0·50    |
| Care Quality Commission rating of leadership at the LTCF | 1·00 (0·96–1·01) | 0·50 |
| Outstanding or good                          | 1·00 (0·96–1·01)     | 0·50    |
| Requires improvement or is inadequate         | 1·00 (0·96–1·01)     | 0·50    |
| Not rated or inspected                        | 1·00 (0·96–1·01)     | 0·50    |
| Main type of care provided                   | 1·00 (0·96–1·01)     | 0·50    |
| For residents aged <65 years                 | 1·00 (0·96–1·01)     | 0·50    |
| For residents with dementia                  | 1·00 (0·96–1·01)     | 0·50    |
| Staff sick pay                               | 1·00 (0·96–1·01)     | 0·50    |
| None                                         | 1·00 (0·96–1·01)     | 0·50    |
| Statutory                                    | 1·00 (0·96–1·01)     | 0·50    |
| Full or more than statutory                  | 1·00 (0·96–1·01)     | 0·50    |
| Employment of agency nurses or carers        | 1·00 (0·96–1·01)     | 0·50    |

(Table 2 continues on next page)
| Residents* |调整后OR（95% CI）| p值 | 工作人员 |调整后OR（95% CI）| p值 |
|---|---|---|---|---|---|
| SARS-CoV-2感染比例 | | | SARS-CoV-2感染比例 | | |
| (Continued from previous page) | | | | | |
| **Employment of other bank or agency staff** | | | | | |
| 无 | 9129/87490 (10.4%) | 1 (ref) | NA | 4798/124394 (3.9%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 1648/88392 (16.5%) | 1.28 (1.20-1.37) | <0.0001 | 802/135353 (5.9%) | 1.31 (1.20-1.42) | <0.0001 |
| 每周至少两次 | 1198/90993 (12.2%) | 1.08 (1.01-1.16) | 0.022 | 788/128865 (5.7%) | 1.34 (1.23-1.45) | <0.0001 |
| 每天或每天 | 1200/7685 (15.6%) | 1.08 (1.01-1.16) | 0.044 | 663/122019 (5.5%) | 1.04 (0.95-1.13) | 0.42 |
| **How often staff work at other sites** | | | | | |
| 无 | 11325/100485 (11.3%) | 1 (ref) | NA | 5983/143533 (4.2%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 1086/7647 (14.2%) | 1.12 (1.04-1.20) | 0.0024 | 591/12292 (4.8%) | 1.03 (0.94-1.13) | 0.53 |
| 每周至少两次 | 533/4656 (11.5%) | 0.97 (0.88-1.07) | 0.54 | 397/7311 (5.4%) | 1.26 (1.13-1.41) | <0.0001 |
| 每天或每天 | 47/372 (12.6%) | 1.27 (1.03-1.75) | 0.14 | 80/605 (11.5%) | 3.04 (2.38-3.88) | <0.0001 |
| **Cleaning frequency of communal areas** | | | | | |
| 无 | 472/985 (9.5%) | 0.85 (0.79-0.92) | <0.0001 | 325/100 (3.2%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 445/25950 (17.2%) | 1.30 (1.23-1.37) | <0.0001 | 247/13870 (16.4%) | 1.20 (1.13-1.29) | <0.0001 |
| 每天或每天 | 417/22083 (1.9%) | 0.31 (0.28-0.34) | <0.0001 | 169/28585 (0.6%) | 0.25 (0.21-0.30) | <0.0001 |
| **Cleaning frequency of communal touchpoints** | | | | | |
| 无 | 498/85396 (11.4%) | 1 (ref) | NA | 5035/119764 (4.2%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 319/25611 (12.0%) | 1.05 (1.00-1.11) | 0.039 | 1802/39301 (4.6%) | 1.10 (1.03-1.17) | 0.0027 |
| 其他 | 315/3253 (9.7%) | 0.7 (0.60-0.81) | <0.0001 | 214/4766 (4.5%) | 1.21 (1.02-1.45) | 0.030 |
| **Cleaning frequency of staff rooms** | | | | | |
| 无 | 11472/98778 (11.6%) | 1 (ref) | NA | 6180/144102 (4.3%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 930/9648 (9.6%) | 0.85 (0.79-0.92) | <0.0001 | 529/12907 (4.2%) | 0.99 (0.90-1.09) | 0.84 |
| 其他 | 533/4734 (12.5%) | 1.15 (1.03-1.28) | 0.017 | 332/6822 (4.9%) | 1.03 (0.90-1.19) | 0.66 |
| **Staff use of personal protective equipment** | | | | | |
| 无 | 6186/56322 (10.9%) | 1 (ref) | NA | 3522/81688 (4.3%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 5733/48225 (11.9%) | 1.02 (0.98-1.07) | 0.36 | 3012/69493 (4.3%) | 0.91 (0.86-0.96) | 0.0005 |
| 其他 | 1076/8403 (12.8%) | 1.24 (1.14-1.34) | <0.0001 | 512/12470 (4.1%) | 0.85 (0.77-0.95) | 0.0024 |
| **Barrier nursing for infected residents** | | | | | |
| 无 | 873/34565 (2.5%) | 1 (ref) | NA | 521/44708 (1.2%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 12127/78595 (15.4%) | 3.60 (3.34-3.88) | <0.0001 | 6530/119123 (5.5%) | 2.60 (2.36-2.86) | <0.0001 |
| **Barrier nursing for all residents** | | | | | |
| 无 | 4039/49269 (8.2%) | 1 (ref) | NA | 2129/69668 (3.1%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 8956/63891 (14.0%) | 1.42 (1.37-1.48) | <0.0001 | 4922/94143 (5.2%) | 1.39 (1.31-1.46) | <0.0001 |
| **Inability to isolate residents** | | | | | |
| 无 | 5993/69344 (8.6%) | 1 (ref) | NA | 2999/38839 (3.0%) | 1 (ref) | NA |
| 每隔一周两次或更多 | 7002/43816 (16.0%) | 1.33 (1.28-1.38) | <0.0001 | 4052/64992 (6.2%) | 1.48 (1.41-1.56) | <0.0001 |
### Table 2: Risk factors for SARS-CoV-2 infection in residents and staff of LTCFs based on survey data

|                           | Residents* | Adjusted OR (95% CI) | p value | Staff† | Adjusted OR (95% CI) | p value |
|---------------------------|------------|----------------------|---------|--------|----------------------|---------|
|                           | Proportion with SARS-CoV-2 infection (%) |                      |         | Proportion with SARS-CoV-2 infection (%) |                      |         |
| **Number of new admissions to the LTCF** |            |                      |         |        |                      |         |
| Baseline‡                  | NA         | 0 (ref)              | NA      | NA     | 0 (ref)              | NA      |
| Each one unit increase in admissions relative to baseline‡ | 12 995/113 160 (11.5%) | 1 01 (1.01-1.01) | <0.0001 | 7051/163 831 (4.3%) | 1 00 (1.00-1.01) | 0.0005 |
| **Number of weeks of closure to visitors** |            |                      |         |        |                      |         |
| Baseline‡                  | NA         | 1 (ref)              | NA      | NA     | 1 (ref)              | NA      |
| Each additional week relative to baseline‡ | 12 995/113 160 (11.5%) | 1 02 (1.00-1.04) | 0.012   | 7051/163 831 (4.3%) | 1 02 (1.0-1.03) | 0.14 |

Data are n/N (%), unless otherwise specified. ORs were adjusted for all other variables in the model. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. LTCF=long-term care facility. OR=odds ratio. Q=quintile. NA=not applicable. *The resident model includes 3311 LTCFs (R²=0.27). †The staff model includes 3138 LTCFs (R²=0.26). ‡Refers to the value at the start of the pandemic (March 1, 2020). §Caused by residents being unable to comply with control measures (eg, because they had dementia).
highlight the key role of staff, compliance with disease control measures, and new admissions to the LTCF in the transmission of infection, and are consistent with the long recognised drivers of infection in LTCFs, such as overcrowding, contact frequency, and staffing ratios.20–23 We identify specific strategies that could be deployed immediately to reduce the risk of COVID-19 in LTCFs, including provision of financial support to staff so they are incentivised to test and self-isolate when unwell, a reduction in the use of agency staff, an

| Proportion of LTCFs with a small outbreak of SARS-CoV-2 infection† | Adjusted OR (95% CI) | p value | Proportion of LTCFs with a large outbreak of SARS-CoV-2 infections‡ | Adjusted OR (95% CI) | p value |
|---|---|---|---|---|---|
| Care Quality Commission rating of leadership at the LTCF | | | | | |
| Outstanding or good | 1339/2292 (58·4%) | 1 (ref) | NA | 225/1339 (16·8%) | 1 (ref) | NA |
| Requires improvement or is inadequate | 515/793 (64·9%) | 1·17 (0·93–1·48) | 0·19 | 82/515 (15·9%) | 0·83 (0·61–1·11) | 0·21 |
| Not rated or inspected | 27/44 (61·4%) | 0·79 (0·34–1·82) | 0·58 | 3/27 (11·1%) | 0·87 (0·06–1·98) | 0·38 |
| Main type of care provided | | | | | |
| For residents aged ≥65 years | 1405/2406 (58·4%) | 1 (ref) | NA | 221/1405 (15·7%) | 1 (ref) | NA |
| For residents with dementia | 476/723 (65·8%) | 1·00 (0·79–1·28) | 0·94 | 89/476 (18·7%) | 0·99 (0·74–1·33) | 0·97 |
| Staff sick pay | | | | | |
| None | 134/224 (59·8%) | 1 (ref) | NA | 31/134 (23·1%) | 1 (ref) | NA |
| Statutory | 1415/2421 (58·4%) | 1·0 (0·68–1·45) | 0·99 | 232/1415 (16·4%) | 0·59 (0·38–0·93) | 0·024 |
| Full or more than statutory | 332/484 (68·6%) | 1·17 (0·74–1·86) | 0·50 | 47/332 (14·2%) | 0·55 (0·31–0·97) | 0·040 |
| Employment of agency nurses or carers | | | | | |
| None employed | 612/1372 (44·6%) | 1 (ref) | NA | 63/612 (10·3%) | 1 (ref) | NA |
| A few times per month | 428/620 (69·0%) | 1·61 (1·21–2·15) | 0·0013 | 6/428 (1·85) | 1·85 (1·23–2·77) | 0·0030 |
| A few times per week | 315/766 (65·8%) | 1·62 (1·23–2·13) | 0·0005 | 69/315 (16·1%) | 1·51 (1·02–2·24) | 0·038 |
| Most days or every day | 500/820 (61·5%) | 2·33 (1·72–3·16) | <0·0001 | 114/500 (22·8%) | 2·42 (1·67–3·31) | <0·0001 |
| Employment of other bank or agency staff | | | | | |
| None employed | 128/297 (43·4%) | 1 (ref) | NA | 121/128 (9·4%) | 1 (ref) | NA |
| A few times per month | 798/1417 (56·5%) | 1·70 (1·22–2·37) | <0·0001 | 172/798 (21·9%) | 1·90 (1·38–2·60) | <0·0001 |
| A few times per week | 641/1004 (63·9%) | 1·73 (1·28–2·33) | <0·0001 | 135/641 (20·9%) | 1·85 (1·34–2·55) | <0·0001 |
| Most days or every day | 542/841 (64·9%) | 2·32 (1·76–3·04) | <0·0001 | 107/542 (19·7%) | 2·42 (1·67–3·31) | <0·0001 |
| How often LTCF staff work at other sites | | | | | |
| Not at all | 1604/2775 (55·1%) | 1 (ref) | NA | 268/1604 (16·3%) | 1 (ref) | NA |
| A few times per month | 793/1405 (56·4%) | 1·06 (0·84–1·35) | 0·60 | 113/793 (14·1%) | 1·04 (0·74–1·47) | 0·83 |
| A few times per week | 637/1220 (51·9%) | 1·15 (0·94–1·41) | 0·25 | 92/637 (14·5%) | 1·00 (0·73–1·35) | 0·95 |
| Most days or every day | 927/1617 (57·5%) | 2·26 (1·79–2·86) | <0·0001 | 161/927 (17·9%) | 2·38 (1·63–3·46) | <0·0001 |
| Cohorting of staff with either infected or uninfected residents | | | | | |
| Often or always | 470/1389 (33·6%) | 1 (ref) | NA | 74/470 (21·2%) | 1 (ref) | NA |
| Rarely or sometimes | 726/2025 (35·9%) | 1·07 (0·84–1·35) | 0·59 | 110/726 (15·1%) | 0·99 (0·71–1·40) | 0·90 |
| Not at all | 586/1715 (34·2%) | 0·87 (0·67–1·11) | 0·42 | 89/586 (15·1%) | 0·98 (0·72–1·36) | 0·86 |
| NA | 138/707 (19·5%) | 0·37 (0·28–0·48) | <0·0001 | 10/138 (7·2%) | 0·52 (0·25–1·08) | 0·079 |
| Cleaning frequency of communal areas | | | | | |
| At least twice per day | 1384/2331 (59·4%) | 1 (ref) | NA | 225/1384 (16·3%) | 1 (ref) | NA |
| Once per day | 441/717 (61·5%) | 1·05 (0·80–1·37) | 0·73 | 78/441 (17·7%) | 1·10 (0·79–1·53) | 0·56 |
| Other | 56/81 (69·1%) | 0·87 (0·40–1·93) | 0·74 | 7/56 (12·5%) | 0·81 (0·30–2·17) | 0·67 |
| Cleaning frequency of communal touchpoints | | | | | |
| At least twice per day | 1643/2741 (59·9%) | 1 (ref) | NA | 277/1643 (16·9%) | 1 (ref) | NA |
| Once per day | 153/273 (56·0%) | 0·89 (0·64–1·13) | 0·56 | 20/153 (13·1%) | 0·74 (0·43–1·28) | 0·28 |
| Other | 85/315 (27·3%) | 2·25 (1·11–4·56) | 0·025 | 13/85 (15·3%) | 0·96 (0·45–2·06) | 0·92 |
| Cleaning frequency of staff rooms | | | | | |
| At least twice per day | 922/1573 (58·6%) | 1 (ref) | NA | 147/922 (15·9%) | 1 (ref) | NA |
| Once per day | 802/1275 (62·9%) | 0·98 (0·78–1·23) | 0·87 | 138/802 (17·2%) | 1·00 (0·75–1·35) | 0·95 |
| Other | 157/281 (55·9%) | 1·11 (0·76–1·62) | 0·60 | 25/157 (15·9%) | 0·98 (0·59–1·64) | 0·94 |

(Continued from previous page)
improvement in staff-to-bed ratios, and widespread adoption of disease control measures, such as staff cohorting and isolation. The likelihood of infection and outbreaks was reduced in LTCFs that often or always cohorted staff with either infected or uninfected residents compared with those that did not, consistent with a survey of 132 LTCFs in southwest France published in July, 2020.24 LTCFs that provided staff sick pay had significantly fewer cases of infection among both residents and staff compared with those that did not, and LTCFs that did not employ agency staff also had significantly fewer cases of infection compared with those that did. The odds of infection in staff were also higher in LTCFs in which staff frequently worked at other sites than in those in which staff did not work at other sites. This finding is consistent with another study done in England, which found that the odds of infection in care home staff was three times higher in those staff members who worked across multiple locations than those who worked at one site.25 Taken together, these results strongly suggest that staff play a key role in transmitting infection to each other and to residents, although it is difficult to discern a causal association between employment of agency staff and initiation of outbreaks without actual dates of employment and infection. The likelihood of infection in staff and residents was also associated with the number of new admissions to the LTCFs, highlighting the potential risks of importation of infection by new or returning residents. Almost half of LTCFs in this study did not report any cases of SARS-CoV-2 infection, and similar findings from regional studies in North America and Europe suggest that many staff and residents were still susceptible to

| Proportion of LTCFs with a small outbreak of SARS-CoV-2 infection* | Adjusted OR (95% CI) | p value | Proportion of LTCFs with a large outbreak of SARS-CoV-2 infections† | Adjusted OR (95% CI) | p value |
|---------------------------------------------------------------|----------------------|---------|---------------------------------------------------------------|----------------------|---------|
| All the time                                                  | 136/2137 (62.2%)     | 1 (ref) | NA                                                           | 228/1366 (16.7%)     | 1 (ref) | NA     |
| For delivering direct care to all residents                   | 191/375 (50.9%)      | 0.95 (0.71-1.30) | 0.80 | 29/191 (15.2%)     | 1.03 (0.66-1.61) | 0.90  |
| For delivering direct care to infected or shielding residents  | 25/47 (53.2%)        | 0.68 (0.34-1.36) | 0.28 | 2/25 (8.0%)       | 0.48 (0.11-2.15) | 0.34  |
| For any contact with all residents                             | 269/462 (58.2%)      | 0.85 (0.65-1.13) | 0.26 | 45/269 (16.7%)    | 0.90 (0.62-1.31) | 0.59  |
| For any contact with infected or shielding residents           | 30/48 (62.5%)        | 0.72 (0.35-1.52) | 0.39 | 6/30 (20.0%)      | 1.32 (0.50-3.42) | 0.58  |

| Barrier nursing for infected residents                         |                      |         | Barrier nursing for all residents                             |                      |         |
|---------------------------------------------------------------|----------------------|---------|---------------------------------------------------------------|----------------------|---------|
| No                                                            | 256/1083 (23.6%)     | 1 (ref) | NA                                                           | 25/256 (9.8%)       | 1 (ref) | NA     |
| Yes                                                           | 1625/2046 (79.4%)    | 5.33 (4.30-6.60) | <0.0001 | 285/1625 (17.5%) | 1.29 (0.79-2.09) | 0.31  |

| Inability to isolate residents¶                              |                      |         | Number of new admissions to the LTCF                         |                      |         |
|---------------------------------------------------------------|----------------------|---------|---------------------------------------------------------------|----------------------|---------|
| No                                                            | 1035/2052 (50.4%)    | 1 (ref) | NA                                                           | 128/1035 (12.4%)    | 1 (ref) | NA     |
| Yes                                                           | 846/1077 (78.6%)     | 1.84 (1.48-2.30) | <0.0001 | 182/846 (21.5%) | 1.62 (1.24-2.11) | 0.0004 |

| Number of weeks of closure to visitors                        |                      |         | Number of weeks of closure to visitors                        |                      |         |
|---------------------------------------------------------------|----------------------|---------|---------------------------------------------------------------|----------------------|---------|
| Baseline§                                                     | 1881/3129 (60.1%)    | 1 (ref) | NA                                                           | 310/1881 (16.5%)     | 1.00 (0.99-1.02) | 0.29  |
| Each additional week relative to baseline§                    | 1.08 (1.05-1.10)     | 0.0001 | 310/1881 (16.5%)     | 1.00 (0.99-1.02)     | 0.29  |

| Data are n/N (%), unless otherwise specified. ORs were adjusted for all other variables in the model. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. LTCF=long-term care facility. OR=odds ratio. Q=quintile. NA=not applicable. *The number of LTCFs with cases versus the number of LTCFs with no cases is based on 3129 LTCFs, of which 1881 (60.1%) had cases (R²=0.39). †A large outbreak was considered as an LTCF with more than a third of the total number of residents and staff combined testing positive, or with >20 residents and staff combined testing positive. If the large outbreak versus small outbreak model is based on 1881 LTCFs, of which 310 (16.5%) LTCFs were considered to have had a large outbreak (R²=0.09). ‡Refers to the value at the start of the pandemic (March 1, 2020). ¶Caused by residents being unable to comply with control measures (eg, because they had dementia).
56.4% partly reflects the fact that the survey was done rapidly (ie, within 5 weeks), because our aim was to generate rapid evidence to inform the pandemic response. As a result, 2470 (27.2%) of 9081 LTCFs were only telephoned once or twice, which might have reduced survey participation. LTCFs were also experiencing an intense workload at the time of the survey, which might have also influenced participation. Survey respondents and non-respondents were similar in terms of LTCF characteristics, such as size, membership of a care home group, postcode-based deprivation, and region. There was also substantial variation in the prevalence of SARS-CoV-2 infection between LTCFs, which provides some evidence that the number of infections did not strongly influence survey participation. However, we cannot exclude the possibility that other factors that were not captured by our sampling frame might have influenced the decision of managers to participate, thus introducing selection bias due to survey non-response. Managers of LTCFs were asked to report on behalf of their staff and residents, introducing the possibility of recall bias, and social desirability bias might have also affected survey responses. In addition, survey responses could potentially be biased by pressure on managers to report or not report details of LTCF operations. Finally, the survey lasted approximately 30 min, and although managers were given advance notice of the questions, interview fatigue might have reduced the quality of information that was obtained towards the end of the survey. Although we asked managers of LTCFs to report the number of residents who had died since contracting COVID-19, we did not include mortality as an outcome in our analysis because of concerns about the quality of this information and its interpretation. We did not include a definition for death in the questionnaire and, in the context of the limited testing capacity for COVID-19, it is difficult to reliably differentiate deaths caused by COVID-19 from deaths due to other causes.

Confidence in our results is increased by the evaluation of potential risk factors for SARS-CoV-2 infection among residents and staff, and risk factors for outbreaks and large outbreaks, that allowed us to investigate factors associated with both ingress and spread of infection, and by the fact that similar results were obtained in sensitivity analyses. The national scale of our study, and similarity of survey responders and non-responders in terms of LTCF characteristics and region, suggest that our findings could be generalisable to all LTCFs in England.

In conclusion, this study documented the substantial burden of SARS-CoV-2 across LTCFs in England during the first wave of the pandemic, and identified that staff and residents in half of LTCFs without outbreaks remain at a high risk of infection. Strategies that could be implemented immediately and might reduce the impact of COVID-19 in LTCFs include provision of financial support to LTCF staff to incentivise testing and infection after the first wave of the pandemic. Strategies that might prevent future infections include coordinated investment to recompense staff who are required to shield or self-isolate so that they do not take on multiple jobs, and investment to minimise reliance on agency staff and reduce the number of individuals who work across multiple locations. In June, 2020, the UK Government established the Infection Control Fund, which provides regions with financial support to cover the costs of implementing these measures. Given the likely importance of staff in transmission of infection, our finding that the prevalence of asymptomatic infection in this group is high emphasises the need for regular staff testing to facilitate early detection of infection and prevent outbreaks. Strategies are also required to improve the implementation of disease control measures, such as isolation. The association between new admissions and the increased odds of infection shows the importance of testing and isolating residents on admission to the LTCF.

Consistent with all cross-sectional studies, our findings could be subject to confounding and reverse causality, which are particularly problematic for measures that might be initiated in response to infection, such as barrier nursing or employment of agency staff. This is the most probable explanation for the unexpected association between use of barrier nursing and the risk of infections and outbreaks. Variability in access to testing capacity and earlier onset of the pandemic in London and the West Midlands compared with the rest of England are probable explanations for the regional differences in prevalence of infection observed in staff and residents in our study. The survey response rate of

| Structural factors | Infection outcome |
|--------------------|-------------------|
| Increased social deprivation | Infections in residents |
| For-profit status | Infections in staff |
| Larger LTCFs | Outbreak* |
| Staffing factors | Large outbreak† |

*Defined as LTCFs with more than a third of the total number of residents and staff combined testing positive, outbreaks, and large outbreaks. Red denotes strong evidence of an association with the specified risk factor, yellow denotes some evidence of an association, and green denotes no evidence of an association. Each column represents findings from each of the four risk factor analyses. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. LTCF=long-term care facility.†Defined as at least one case of SARS-CoV-2 per LTCF.

**Figure 2:** Heat map illustrating the main risk factors for SARS-CoV-2 infection and outbreaks in LTCFs.

The figure illustrates which risk factors are most strongly associated with SARS-CoV-2 infection in LTCF residents and staff, outbreaks, and large outbreaks. Red denotes strong evidence of an association with the specified risk factor, yellow denotes some evidence of an association, and green denotes no evidence of an association. Each column represents findings from each of the four risk factor analyses. SARS-CoV-2=severe acute respiratory syndrome coronavirus 2. LTCF=long-term care facility. *Defined as at least one case of SARS-CoV-2 per LTCF.†Defined as LTCFs with more than a third of the total number of residents and staff combined testing positive, or with more than 20 residents and staff combined testing positive.
self-isolation when sick, investment to reduce reliance on agency staff, and a focus on the implementation of disease control measures, such as staff cohorting and isolation of residents. The widespread and rapid adoption of these measures could support efforts to protect this susceptible sector of society from future waves of SARS-CoV-2 infection.

Declaration of interests
LS, AH, and SH designed the survey. OA and LW designed and piloted the questionnaire. OA, ST, DB, and LS designed the statistical analysis plan. DB, ST, and KS had full access to all the data in the study and statistically analysed the data. ST and DB accessed and verified the data. AD managed the project. GH extracted the dataset and did the data linkage under instructions from the research team. MK reviewed the literature. LS wrote the first draft of the manuscript. All authors revised and edited the manuscript. The corresponding author had final responsibility to submit for publication.

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Data sharing
Deidentified, LTCF-level data collected from the survey and the associated questionnaire will be deposited in the Office for National Statistics, Secure Research Service (SRS) at the time of publication in a peer reviewed journal, or shortly afterwards, for use by accredited researchers. The study protocol is also available on the University College London website. Accredited researchers can access the survey via the SRS following approval of a project proposal that explains the intended use of the dataset and the value of the project. Further details about applying to use the SRS are available from the Office for National Statistics website.

References
1. European Centre for Disease Prevention and Control. Resurgence of reported cases of COVID-19 in the EU/EEA, the UK and EU candidate and potential candidate countries. Stockholm: European Centre for Disease Prevention and Control, 2020.
2. Kaiser Family Foundation. State COVID-19 data and policy actions. 2021. https://www.kff.org/(state-covid-19-data-and-policy-actions/) (accessed Jan 28, 2021).
3. Office for National Statistics. Deaths involving COVID-19 in the care sector. England and Wales: deaths occurring up to 12 June 2020 and registered up to 20 June 2020 (provisional). 2020. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/deathsinvolvingcovid19inthehealthcaresectorenglandandwales/deathsoccurringupto12june2020andregisteredupto20june2020(provisional) (accessed Sept 16, 2020).
4. National Records of Scotland. Deaths involving coronavirus (COVID-19) in Scotland: week 29 (13 to 19 July 2020). 2020. https://www.nrscotland.gov.uk/files/statistics/covid19/covid-deaths-report-week-29.pdf (accessed Sept 16, 2020).
5. European Centre for Disease Prevention and Control. Surveillance of COVID-19 at long-term care facilities in the EU/EEA. Stockholm: European Centre for Disease Prevention and Control, 2020.
25 Ladhani SN, Chow JY, Janarthanan R, et al. Increased risk of SARS-CoV-2 infection in staff working across different care homes: enhanced CoVID-19 outbreak investigations in London care homes. J Infect 2020; 84: 621–24.

26 Fisman DN, Bogoch I, Lapointe-Shaw L, McCready J, Tuïte AR. Risk factors associated with mortality among residents with coronavirus disease 2019 (COVID-19) in long-term care facilities in Ontario, Canada. JAMA Netw Open 2020; 3: e2015957.

27 Burton J, Bayne G, Evans C, et al. Evolution and impact of COVID-19 outbreaks in care homes: population analysis in 189 care homes in one geographic region. Lancet Healthy Longev 2020; 1: E21–31.

28 Department of Health and Social Care. Coronavirus (COVID-19): care home support package. 2020. https://www.gov.uk/government/publications/coronavirus-covid-19-support-for-care-homes/coronavirus-covid-19-care-home-support-package (accessed Sept 16, 2020).

29 Goldberg SA, Lennerz J, Klempas M, et al. Presymptomatic transmission of SARS-CoV-2 amongst residents and staff at a skilled nursing facility: results of real-time PCR and serologic testing. Clin Infect Dis 2020; published online July 15. https://doi.org/10.1093/cid/ciaa991.