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Effect on secondary care of providing enhanced support to residential and nursing home residents: a subgroup analysis of a retrospective matched cohort study

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ABSTRACT

Background Thirteen residential care homes and 10 nursing homes specialising in older people in Rushcliffe, England, participated in an improvement programme. The enhanced support provided included regular visits from named general practitioners and additional training for care home staff. We assessed and compared the effect on hospital use for residents in residential and nursing homes, respectively.

Methods Using linked care home and administrative hospital data, we examined people aged 65 years or over who moved to a participating care home between 2014 and 2016 (n=568). We selected matched control residents who had similar characteristics to the residents receiving enhanced support and moved to similar care homes not participating in the enhanced support (n=568). Differences in hospital use were assessed for residents of each type of care home using multivariable regression.

Results Residents of participating residential care homes showed lower rates of potentially avoidable emergency admissions (rate ratio 0.50, 95% CI 0.30 to 0.82), emergency admissions (rate ratio 0.60, 95% CI 0.42 to 0.86) and Accident & Emergency attendances (0.57, 95% CI 0.40 to 0.81) than matched controls. Hospital bed days, outpatient attendances and the proportion of deaths that occurred out of hospital were not statistically different. For nursing home residents, there were no significant differences for any outcome.

Conclusions The enhanced support was associated with lower emergency hospital use for older people living in residential care homes but not for people living in nursing homes. This might be because there was more potential to reduce emergency care for people in residential care homes. In nursing homes, improvement programmes may need to be more tailored to residents' needs or the context of providing care in that setting.

INTRODUCTION

As of 2016/17, approximately 420 000 people aged 65 years or over live in care homes across the UK.¹ Care homes offer accommodation and personal care (such as help with washing, dressing and taking

medicines) to residents 24 hours a day; if they also provide 24 hours' access to a qualified nurse they are known as nursing homes, otherwise they are residential care homes.² Older people living in care homes increasingly have complex health and care needs, including dementia, progressive frailty and need for end-of-life care.^{3–9} Caring for older care home residents is a key priority for the health and care system in England,^{10–12} as in many other countries, yet the quality of care received varies between care homes.^{13–18}

Following the National Health Service (NHS) Five Year Forward View in England,¹⁹ New Care Models vanguards were established, including six Enhanced Health in Care Homes (EHCH) pilots in 2015. The EHCH framework aimed to offer older people living in care homes better, joined-up health, care and rehabilitation services.²⁰ A key measure for success of the pilots was reduced emergency hospital use,^{3 20} since emergency admissions can be detrimental to older people's health and well-being,^{21 22} exposing them to stress and risk of infection,²³ as well as being costly to the NHS. Although emergency admissions are often necessary,²⁴ many emergency admissions may be avoidable and could have been managed outside of a hospital setting.^{21 25–28} Overall, aggregate figures of EHCH vanguards indicate that emergency admission rates from participating care homes remained broadly stable between 2014/2015 and 2017/2018, compared with higher rising rates for non-vanguard care homes over the same period.²⁹ There is likely to be substantial variation within this picture, and a need

to identify which elements of the interventions can reduce emergency admissions, for whom and in which contexts. This is particularly relevant as the NHS announced in January 2019 its 10-year Long Term Plan, which commits to improving NHS support to all care homes, including stronger links between care homes and primary care services and more support by a consistent team of health professionals. This includes rolling out the EHCH model²⁰ across all of England.¹²

There is little research into which interventions improve care and reduce hospital admissions from care homes; moreover, the available evidence is often of low quality.^{30–32} The evidence on reducing emergency admissions is mixed.^{3 29 30 33–47} However, our recent evaluation of an enhanced support package in Rushcliffe, which included regular visits from named general practitioners (GP) and additional training for care home staff, showed that older people moving to participating care homes had significantly lower rates of Accident & Emergency (A&E) attendances and emergency admissions than a matched control group.³⁵ Looking more broadly at the body of evidence on improving care in care homes, there is promising evidence emerging.³² For example, there are indications that training and support can lead to changes in staff priorities and practices.⁴⁸ There are several themes emerging, often in combination: multidisciplinary, partnership working and good working relationships between care home staff, GPs and other healthcare professionals^{3 15 31 32 40–42 44–47 49–54}; training for care home staff^{15 31 34 40 41 45 47 48 51 52 55–57}; the use of data for monitoring residents' outcomes^{43 47–49 53}; better preventative assessment and care management^{40 49 53}; advance care planning^{40 41 46 53 56}; end-of-life care planning^{31 32 41 49 53 57}; and medicines management.^{32 34 42 50}

Although residential and nursing homes may differ in both context (eg, nursing provision) and resident characteristics,^{58–60} there is, to our knowledge, no research into understanding how these differences may affect the outcomes of improvement programmes in care homes. The vast majority of studies either do not distinguish between residential and nursing homes or evaluate only one care home type. Furthermore, differences in interventions and study design make any patterns in study results between care home types difficult to discern.

There is, however, some evidence of variability between residential and nursing homes.¹⁶ For example, medication administration errors may be less likely among nursing homes.⁶¹ Residential care home residents may have higher ambulance call rates⁶² and higher emergency admission rates⁶³ than nursing home residents. There are indications that GPs visit nursing home more regularly than residential care homes^{43 64} and that nursing homes are more likely than residential care homes to have an aligned general practice and to pay a general practice to provide services,⁶⁵ even

though residential care home residents may also have needs requiring healthcare support.^{43 52}

The current study expands on the previous evaluation of the Principia enhanced support in Rushcliffe by examining the effect on hospital use in residential and nursing homes separately, and assessing whether the effect differed between care home types. Such information might inform both NHS England and healthcare teams looking to make improvements in care homes. Our analysis was specified a priori in the statistical analysis protocol written for the original evaluation⁶⁶ and is based on the same study period as that evaluation.

METHODS

The enhanced support intervention

The enhanced support was introduced in April 2014 for all care homes in Rushcliffe that care specifically for older residents, as well as two additional care homes in the nearby vicinity (14 residential and 10 nursing homes in total). It was developed by Principia, a local partnership of GPs, patients and community services, together with care home managers and the Rushcliffe Clinical Commissioning Group (CCG) lead. Principia became a Multidisciplinary Community Provider New Care Model vanguard in 2015.

Although the enhanced support was introduced before the EHCH vanguards, it shares elements of the EHCH model²⁰ and our earlier evaluation was quoted in the Long Term Plan as an example of a successful implementation of the model.¹² During the period of our study (17 August 2014 to 14 August 2016), the enhanced support consisted of four components.

1. Each care home was aligned with a general practice, which care home residents within the home were encouraged to register with, though this was not compulsory. Within each practice there was one named GP who visited the home on a regular (weekly or fortnightly) basis, meeting with those residents who were registered with the general practice as needed and proactively reviewing their medications and care plans. This ensured continuity of care for the residents and the development of personal relationships between the GP and both residents and staff. There was also a deputy GP who would step in if the regular named GP was absent. Needs were identified and discussed during the ward rounds. New residents were reviewed, including having comprehensive geriatric assessments. Principia estimated that approximately 90% of residents were registered with the aligned GP.
2. A programme of work engaging care home managers aimed to improve relationships between care providers working in different settings, promoting shared ownership and consistency of approach. This included a care home managers' network that met bimonthly and a monthly task group meeting between representatives of all members of the team.
3. The charitable organisation Age UK Nottingham and Nottinghamshire aimed to supply independent infor-

mation to residents and their families to inform their decision about whether to change to the aligned local general practice after moving to the care home and, more generally, provide a safe and trusted point of contact for residents. Age UK Nottingham and Nottinghamshire also facilitated the care home managers' network.

- Community nurses provided training to care home staff on an ad hoc basis, for example, following staff changes, changes to guidelines, requests from care managers or staff, or when community nurses or GPs identified a need. Training was provided on, for example, falls, heart failure, palliative care, wound care, catheter care, sepsis training and pressure sore management. Community nurses were not formally instructed in how to deliver this training but standardised slides were used for training purposes. They referred to or provided information on existing specialist community services; offered peer-to-peer support to nurses in nursing homes; and accompanied GPs on the regular resident review rounds in residential care homes. There were three teams of community nurses in Rushcliffe, each with responsibility for a group of care homes, thereby ensuring continuity of care for residents.

All four components were implemented in both residential and nursing homes, though with some differences. The training and support element (4) was delivered to all healthcare assistants in both nursing and residential care homes, but was optional for nurses in nursing homes. An important distinction was that community nurses typically attend nursing homes less frequently than residential care homes, since nursing homes employ their own nurses. Therefore, there were fewer opportunities for community nurses to recognise demand for training or share information and good practice in nursing homes than in residential care homes. However, a community nurse with a special interest in palliative care visited both residential and nursing homes regularly, providing end-of-life training, including pain management. Falls specialists delivered training to staff in both types of care home, including nurses, carers, administrative staff, ancillary staff and kitchen staff. Community nurses provided peer-to-peer nurse support in nursing homes only. In residential homes, the GP was accompanied on the ward rounds by a community nurse and either the care home manager or senior carer; in nursing homes, they were accompanied by an in-house nurse or the care home manager.

Study outcomes

The enhanced support aimed to improve residents' care, involvement in decisions about their care and quality of life. Consistent with the overall aims of the EHCH vanguards, there were specific objectives to reduce secondary care use, including A&E attendances and emergency admissions.

The primary outcome of interest for our study was potentially avoidable emergency admissions, identified

based on the primary diagnosis recorded in hospital administrative data. These were unplanned admissions for conditions that were potentially manageable, treatable or preventable outside of a hospital setting, or for conditions that could be caused by poor care or neglect.^{67 68} The list of conditions was developed by the Care Quality Commission (CQC) as part of their analysis on older people experiencing health and social care. Conditions included acute and chronic lower respiratory tract infections, decubitus ulcers (pressure sores), diabetes, food and drink issues, food and liquid pneumonitis, fractures and sprains, intestinal infections, pneumonia and urinary tract infections. For example, some fractures may be avoidable with appropriate risk assessment and falls prevention and urinary tract infections may be treatable within the community or care home. However, context is also a factor in determining whether a 'potentially avoidable' admission could in fact have been avoided. For example, if a residential care home resident had pneumonia, hospital admission may be the most effective way of eliminating the infection quickly, whereas the available nursing support in a nursing home may have been able to oversee treatment of the same condition within the nursing home. Admissions for these conditions cannot always be avoided. However, the enhanced support available in care homes could be expected to have greater impact on admissions for these conditions than others.

Other outcomes were emergency admissions (defined as any admission to hospital that was urgent and unexpected, that is, unplanned, and occurring either via A&E departments or directly via GPs or consultants in ambulatory clinics); A&E attendances (regardless of whether the person was subsequently admitted); number of hospital bed days (calculated as number of nights during which a resident was a hospital inpatient following emergency or elective admission); and attendances at outpatient departments (excluding instances where the patient did not attend a booked appointment). Furthermore, we analysed the proportion of deaths outside of hospital. This was a proxy for residents dying in their place of choice. Although we considered the number of elective admissions, results are not presented here due to the small number of events in the residential and nursing subgroups.

Hospital use was measured over the period during which individuals were resident in a care home, beginning from the month of moving into the home and ending in the month of moving out or death (or the end of our study period on 14 August 2016 if earlier). Outcomes were therefore measured over a maximum of 23 months, but over varying study durations for each resident depending on when they lived in the care home.

Data sources and linkage

We used pseudonymised administrative data from the Secondary Uses Service (SUS), a national database of all inpatient admissions, A&E attendances and outpatient appointments funded by the NHS in England. One challenge for our study was that SUS data do not accurately record whether an individual lives in a care home. We therefore identified residents of care homes from the National Health Applications and Infrastructure Services (NHAIS) database, which contains information on all registrations with general practices in England, including each patient's residential address and death information. From NHAIS, we received pseudonymised extracts for each month between August 2014 and August 2016 (with each extract created at 06:00 on the first Sunday after the 13th of each month). From these NHAIS extracts, we extracted a list of unique address fields for people aged 65 or over living at a care home postcode within the geographical areas of interest. These were isolated from any identifiable data and manually cross-referenced with the addresses of care homes registered with CQC, the health and social care service regulator in England, within a secure data environment. This information was then used by the Arden & Greater East Midlands Data Services for Commissioners Regional Office to create a pseudonymised database containing every care home stay that began between 17 August 2014 at 06:00 and 17 July 2016 at 06:00 and including the dates of the care home stay, date of death (where applicable) and some limited information about each care home, such as care home type and number of beds, derived from CQC data. The pseudonymised database of care home stays was then linked to the SUS data. In this way, we were able to identify care home residents more precisely than we could from SUS data alone.

Study populations

In order to create a 'pool' of potential control residents from which the matched controls could be drawn,⁶⁹ we selected six local authorities in England that were similar to Rushcliffe in terms of demographics, socioeconomic characteristics and age standardised emergency admission rates in the period prior to the introduction of the enhanced support.⁷⁰ The process was based on the method applied by the Office for National Statistics^{71 72} to determine comparable health areas in England. Any local authorities with area-wide interventions relating to care homes deemed untypical of usual care that we were aware of were excluded from the list, including EHCH vanguard sites.^{3 20} The final list of six comparison areas were Harborough, Blaby, Test Valley, South Cambridgeshire, Chelmsford and Brentwood.

Care homes were considered for inclusion in the study if they cared for adults over 65 years (according to care home criteria defined by CQC),⁷³ and either offered the enhanced support or were located in one

of the six comparison areas. However, one Principia care home was excluded as only around half of its residents received enhanced support under a Principia-led general practice, thus leaving 23 care homes for older people in the Principia group.

Residents were considered for inclusion in the study if they moved into one of the care homes between 17 August 2014 and 17 July 2016 when aged 65 or over. Residents who moved in earlier were excluded, as hospital activity is likely to differ depending on whether a person lives at home or in a care home and may also change depending on length of time spent in a care home. As NHAIS extracts before August 2014 were unavailable, it was not possible to determine move-in dates prior to that and therefore to match reliably on prior hospital use. As the enhanced support was introduced in April 2014, this allowed in effect for a 'bedding-in' period for the care homes of approximately 5 months. We excluded residents without a record of prior inpatient admission in the 2 years before moving to the care home, as prior hospital data were required to define certain baseline resident characteristics such as health conditions. People who were known to have previously lived in a care home (whether in Rushcliffe or in a comparison area) were also excluded.

The residential and nursing home subgroups were determined by information provided from the CQC database. Some care homes are 'dual registered', that is, provide care both with and without nursing but the CQC database lists these as 'nursing homes'; therefore, the nursing home population in this study will include some residents receiving only residential care. Online supplementary file 1 displays a flow diagram with details of inclusion/exclusion criteria.

Matching

Principia care home residents were matched to control residents moving to a care home in the comparison areas on a range of characteristics. These included both resident characteristics, such as age, gender, health conditions and prior hospital use; and care home characteristics, such as number of beds (tables 1 and 2). Health conditions included those linked to frailty, such as incontinence, mobility problems and pressure ulcers,^{74 75} and conditions predictive of emergency readmission, such as renal disease and metastatic cancer.⁷⁶ These baseline variables were chosen for their potential ability to predict future emergency hospital use and therefore, if they differed between care home residents in Rushcliffe and the comparison areas, could be confounders.

We performed the matching separately for residential and nursing homes, using Genetic Matching, a computer intensive search algorithm that can produce more closely balanced groups than traditional methods based on the propensity score.⁷⁷ Matching was done with replacement, that is, a control resident could be

Table 1 Baseline resident characteristics after matching (figures show per cent of residents unless otherwise stated)

	Residential care homes		Nursing homes	
	Principia	Matched controls	Principia	Matched controls
Total number of residents (residencies)	203	203	365	365
Total number of unique residents	203	166	365	263
Median age, years (IQR)	88.46 (83.72, 93.34)	89.04 (85.22, 92.33)	85.63 (80.80, 90.22)	86.72 (82.04, 90.13)
Male	28.6%	26.6%	42.7%	40.5%
White	86.7%	85.7%	89.9%	84.1%
Charlson index, based on health conditions recorded in 2 years prior to moving to the care home, mean (SD)	1.88 (1.53)	1.81 (1.57)	2.52 (1.95)	2.45 (1.87)
Number of conditions linked to frailty recorded in 2 years prior to moving to the care home, mean (SD)	2.03 (1.66)	1.89 (1.56)	2.19 (1.58)	2.03 (1.40)
Anxiety or depression	18.2%	15.8%	15.6%	20.5%
Cognitive impairment	50.2%	48.3%	58.1%	54.0%
Functional dependence*	25.1%	24.1%	23.8%	15.9%
Fall or significant fracture	53.2%	49.3%	52.1%	46.8%
Incontinence	11.3%	8.4%	15.1%	9.3%
Mobility problems	22.7%	22.2%	26.8%	27.9%
Pressure ulcers	7.9%	6.9%	8.8%	16.4%
Other health conditions recorded in the 2 years prior to moving to the care home that were considered predictive of hospital readmission				
Metastatic cancer with solid tumour	Freq <10	Freq <10	7.7%	6.0%
Other malignant cancer	9.4%	9.4%	19.5%	15.1%
Chronic pulmonary disease	13.3%	9.4%	20.0%	17.5%
Congestive heart failure	15.8%	10.3%	16.2%	23.8%
Dementia	52.2%	49.8%	53.4%	49.9%
Diabetes with chronic complications	Freq <10	Freq <10	2.7%	2.7%
Hemiplegia or paraplegia	Freq <10	Freq <10	4.1%	4.7%
Moderate or severe liver disease	Freq <10	Freq <10	Freq <10	Freq <10
Other liver disease	Freq <10	Freq <10	2.7%	Freq <10
Peripheral vascular disease	Freq <10	Freq <10	7.9%	7.9%
Renal disease	Freq <10	Freq <10	Freq <10	Freq <10
Hospital use prior to moving to the care home, mean (SD)				
Potentially avoidable emergency admissions in prior year	0.45 (0.68)	0.41 (0.66)	0.51 (1.03)	0.57 (0.93)
Potentially avoidable emergency admissions in year before prior year	0.12 (0.41)	0.11 (0.41)	0.16 (0.53)	0.17 (0.49)
Emergency admissions in prior year	1.61 (1.39)	1.49 (1.08)	1.76 (1.56)	1.78 (1.51)
Emergency admissions in year before prior year	0.59 (1.06)	0.49 (0.92)	0.66 (1.22)	0.69 (1.05)
A&E attendances in prior year	1.65 (1.63)	1.70 (1.35)	1.68 (1.52)	1.76 (1.68)
Hospital bed days in prior year	24.29 (27.32)	24.70 (27.38)	45.78 (46.63)	43.99 (43.37)
Elective admissions in prior year	0.24 (0.50)	0.17 (0.43)	0.43 (1.19)	0.37 (1.17)
Outpatient attendances in prior year	3.45 (4.04)	2.60 (4.17)	4.51 (7.18)	3.78 (5.84)

All percentages are based on number of residents (residencies). Percentages are suppressed where there was an underlying frequency of less than 10. See online supplementary file 3 for an assessment of the balance between Principia and the matched control groups.

*Functional dependence indicates a change in discharge destination from hospital to an institution providing more social and functional support than at hospital admission.

A&E, Accident & Emergency.

matched to more than one Principia resident.⁷⁸ The similarity of the Principia and matched control groups was judged separately for residential and nursing homes using the standardised mean difference, defined as the difference in means between the Principia and control group as a proportion of the SD in the Principia group.⁷⁸ If the standardised mean difference for

a baseline variable is within the $\pm 10\%$ threshold, then we considered that variable to be balanced.⁷⁹

Statistical approach

We assessed the difference in hospital use between Principia and matched control residents for each care home type by fitting multivariable regression models. We did

Table 2 Baseline care home characteristics after matching (figures show per cent of care homes unless otherwise specified)

	Residential care homes		Nursing homes	
	Principia	Matched controls	Principia	Matched controls
Number of residents (residencies)	203	203	365	365
Number of care homes	13	47	10	27
Number of beds per care home, mean (SD)	38.25 (20.03)	38.89 (17.54)	52.05 (16.81)	54.51 (25.49)
Care home registered as caring for older people only	100.0%	100.0%	78.4%	78.4%
Rural setting	56.2%	52.7%	55.3%	39.5%
Index of Multiple Deprivation (IMD) quintile				
1 (most deprived)	N/A	0%–5%	N/A	0%–5%
2	N/A	0%–5%	N/A	0%–5%
3	25%–30%	15%–20%	N/A	0%–5%
4	0%–5%	25%–30%	55%–60%	55%–60%
5 (least deprived)	65%–70%	50%–55%	40%–45%	40%–45%
Care home location (local authority)				
Principia*	100.0%	0.0%	100.0%	0.0%
Harborough	N/A	18.7%	N/A	3.0%
Blaby	N/A	15.3%	N/A	7.4%
Test Valley	N/A	8.4%	N/A	37.3%
South Cambridgeshire	N/A	22.2%	N/A	27.1%
Chelmsford	N/A	19.2%	N/A	13.2%
Brentwood	N/A	16.3%	N/A	12.1%

All percentages are based on number of residents (residencies). For IMD quintiles, ranges are provided to ensure that the percentages are not disclosive. See online supplementary file 3 for an assessment of the balance between Principia and the matched control groups.

*Includes Rushcliffe and one care home in a neighbouring area receiving Principia enhanced support.
N/A, not applicable.

this, rather than fitting a model with an interaction term to data from both residential and nursing homes, as we were interested in understanding the effect of enhanced support within each care home type's context and patient population. However, we also assessed whether there was any difference in the rate ratios between care home types by fitting a multivariable regression model to data from both residential and nursing homes, and including an interaction term between the intervention assignment and the care home type.

For each outcome, several models were explored to determine which most appropriately fitted the data. Reviewed modelling options included different model specifications (eg, Poisson, Negative Binomial) and

different sets of covariates, taking into account data sparsity (see online supplementary file 2 for details of final models). All baseline characteristics presented in tables 1 and 2 were potential covariates. Where a similarly good fit was observed for different models of a given outcome, we typically opted for the model that adjusted for the largest covariate set not leading to overparametrisation.

Sensitivity analyses

We also calculated crude rates of hospital activity in residential and nursing homes across England for the period 18 January 2015 to 15 January 2017. The same inclusion/exclusion criteria were applied as detailed above, that is, new residents aged 65 or over moving to care homes caring for older people during the study period and who had an inpatient admission in the 2 years prior to moving in. Although rates in the matched control subgroups were not expected to be representative of the country as the comparison areas were chosen to be similar to Rushcliffe, by calculating crude rates of emergency hospital use for residents aged 65 or over moving to care homes across England we aimed to frame our results within the national context. National care home residents were identified using similar methods as detailed above, with the exception of using automated address cleaning software provided by Experian.⁸⁰ This software assigns a standardised address format to each address that can be used to match addresses electronically; this was necessary given the size of the national data.

RESULTS

Study populations

After applying the inclusion and exclusion criteria, 203 residents moving to 13 Principia residential care homes and 365 residents moving to 10 Principia nursing homes were included in the study: see flow diagram, online supplementary file 1. As expected, given that residential care homes do not provide in-house nursing care, Principia residential care residents had on average fewer health conditions than Principia nursing residents (eg, cancer and chronic pulmonary disease), and a lower Charlson score (1.88 vs 2.52) (table 1). They also had lower levels of hospital use prior to moving to the care home and fewer died during the study period (27% vs 41%, table 3). Principia residential care residents had, however, similar levels of frailty to their nursing home counterparts, as measured by items such as the number of hospital admissions relating to falls/significant fractures prior to moving to the care home. Residential care homes were in general smaller than nursing homes (mean 38 vs 52 beds). None of the Principia care homes were located in the most deprived areas of England, as measured by the Index of Multiple Deprivation (table 2).

Following matching, in the residential subgroup, matched control residents were similar to Principia residents across most resident and care home characteristics, although the Principia residents had a consistent

Table 3 Crude rates of secondary use (number of events per person per year)

Outcomes over the follow-up period	Residential care homes				Nursing homes			
	Principia		Matched controls		Principia		Matched controls	
	Events	Crude rate*	Events	Crude rate*	Events	Crude rate*	Events	Crude rate*
Total number of residencies	203		203		365		365	
Total number of unique residents	203		166		365		263	
Person-years of follow-up	145.3		139.3		182.1		189.6	
Potentially avoidable emergency admissions	29	0.20	56	0.40	44	0.24	38	0.20
Emergency admissions	86	0.59	129	0.93	124	0.68	100	0.53
A&E attendances	119	0.82	185	1.33	124	0.68	131	0.69
Hospital bed days†	5.5 (15.6)	0.035 (0.115)	5.9 (12.4)	0.039 (0.107)	3.5 (8.9)	0.031 (0.094)	3.5 (10.1)	0.034 (0.120)
Outpatient attendances	303	2.09	204	1.46	350	1.92	394	2.08
Deaths out of hospital (% of all deaths)	40	74.1%	38	69.1%	127	84.1%	138	88.5%
Deaths (% of all records)	54	26.6%	55	27.1%	151	41.4%	156	42.7%

*Number of events per person per year.

†Hospital bed days are presented as mean (SD) of the absolute number of bed days (in 'events' column) and of hospital bed days as a proportion of the length of stay in the care home (in the 'crude rate' column).

A&E, Accident & Emergency.

pattern of slightly higher prevalence of health conditions and hospital use in the period before moving to the care home. In nursing homes, the two groups were somewhat less well balanced, especially on residents' conditions linked to frailty, but there was no pattern to the imbalance (tables 1 and 2, online supplementary file 3). There were no significant differences in mortality rates between the Principia and the matched control subgroups (online supplementary file 4).

Comparisons of hospital use

In residential care homes, Principia residents were followed up for an average of 22 months and matched control residents for 21 months. In nursing homes, Principia residents were followed for 15 months and matched control residents for 16 months.

In residential care homes, Principia residents had lower crude rates of potentially avoidable emergency admissions than matched control residents (0.20 vs 0.40 per person per year) (table 3). The adjusted rate ratio associated with receiving the enhanced support was 0.50 (95% CI 0.30 to 0.82), equivalent to on average 0.20 less of these admissions per person per year among the Principia residents (95% CI -0.28 to -0.07) (table 4, online supplementary file 4). The Principia residential care home residents also had lower rates of emergency admissions than matched controls (0.59 vs 0.93 per person per year, adjusted rate ratio 0.60, 95% CI 0.42 to 0.86), equivalent to 0.37 less emergency admissions per person per year (95% CI -0.54 to -0.13). They also had lower A&E attendances (0.82 vs 1.33 per person per year, adjusted rate ratio 0.57, 95% CI 0.40 to 0.81), equivalent to 0.57 less A&E attendances per person per year (95% CI -0.80 to -0.25).

In nursing homes, there was no statistical difference in rates of emergency hospital use between the

Principia and matched control residents (tables 3 and 4, online supplementary file 4).

Across all three measures of emergency hospital use, there were differences in the adjusted rate ratios between residential and nursing homes, with the rate ratios being statistically significantly lower for residential care homes (table 4, online supplementary file 4).

There was no evidence of a difference between Principia and matched control residents in either residential or nursing homes on total hospital bed days, outpatient attendances or deaths outside hospital. There was also no evidence of a difference in rate ratios between the two care home types for any of these measures (tables 3 and 4, online supplementary file 4).

Sensitivity analyses

In the above analysis, we noticed that matched control residents of residential care homes had higher emergency hospital use than matched control residents of nursing homes, despite having lower levels of sickness (tables 1 and 3). For example, crude rates of emergency admissions in the matched control group were 0.93 per person per year in the residential care homes versus 0.53 in nursing homes. We therefore explored whether a similar pattern existed across similar care home residents in England and found that it does (table 5).

DISCUSSION

In residential care homes, Principia residents experienced fewer potentially avoidable emergency admissions, emergency admissions and A&E attendances than matched control residents. In nursing homes, the results were inconclusive as to whether Principia residents experienced more or fewer emergency hospital activity than the matched control group. The difference in results between residential and nursing

Table 4 Results of adjusted regression models

Outcomes over the follow-up period	Relative difference		Absolute difference		P value	Interaction test P value*
	Point estimate	95% CI	Point estimate	95% CI		
Residential care homes						
Potentially avoidable admissions	0.50	(0.30 to 0.82)	-0.20	(-0.28 to -0.07)	0.007	0.020
Emergency admissions	0.60	(0.42 to 0.86)	-0.37	(-0.54 to -0.13)	0.004	0.005
A&E attendances	0.57	(0.40 to 0.81)	-0.57	(-0.80 to -0.25)	0.001	0.008
Hospital bed days†	0.81	(0.43 to 1.53)	-0.007	(-0.022 to 0.021)	0.467	Count: 0.858 Zero: 0.135
Outpatient attendances	1.28	(0.88 to 1.86)	0.41	(-0.18 to 1.26)	0.169	0.266
Deaths outside hospital	1.25	(0.54 to 2.92)	17.3%	(-31.8% to 132.7%)	0.608	0.558
Nursing homes						
Potentially avoidable admissions	1.17	(0.76 to 1.81)	0.03	(-0.05 to 0.16)	0.484	
Emergency admissions	1.15	(0.85 to 1.56)	0.08	(-0.08 to 0.30)	0.352	
A&E attendances	1.04	(0.78 to 1.38)	0.03	(-0.15 to 0.26)	0.806	
Hospital bed days	1.07	(0.64 to 1.80)	0.002	(-0.012 to 0.027)	0.790	
Outpatient attendances	0.97	(0.71 to 1.32)	-0.06	(-0.60 to 0.67)	0.840	
Deaths outside hospital	1.00	(0.40 to 2.49)	0.00	(-53.1% to 131.9%)	0.992	

All relative differences are rate ratios, apart from deaths outside hospital and deaths, which are ORs. See online supplementary file 2 for a list of covariates each outcome was adjusted for and for model fit statistics. Absolute differences are calculated by first calculating the relative difference, then multiplying the relative difference with the crude rate in the matched control group, and then comparing the resulting rate to the crude rate.

*Interaction test of residential versus nursing homes.

†The absolute difference in hospital bed days shows the difference in the proportion of hospital bed days out of the period residents were followed up in the study. The interaction model estimating hospital bed days is a Hurdle model and produces separate effect estimates on whether a resident is hospitalised or not ('Zero' part) and on the number of hospital bed days following hospitalisation ('Count' part).

A&E, Accident & Emergency.

homes was statistically significant. Before considering what these findings might imply for the impact of the enhanced support, it is necessary to acknowledge the strengths and limitations of the study.

Strengths and limitations of this study

A well-known issue with observational studies is that, in the absence of randomisation, there may be differences between the groups that could confound estimates of treatment effectiveness. Here, we compared

Table 5 National crude rates of emergency hospital use for care home residents aged 65 or over across England

	Residential care homes	Nursing homes
Total number of residents in England*	66 236	81 491
Person-years of follow-up	45 639	48 758
Crude rates (number per person per year) for outcomes		
Potentially avoidable emergency admissions	0.39	0.36
Emergency admissions	1.04	0.87
A&E attendances	1.44	1.10

*Residents aged 65 or over moving to care homes caring for older people during the period mid-January 2015 to mid-January 2017 in England. The same inclusion/exclusion criteria were applied as in the main analysis.

A&E, Accident & Emergency.

the hospital use of Principia care home residents with the hospital use of a retrospectively matched control group, formed of residents moving to care homes in six other local authorities in England. These areas were chosen for having similar demographic and socio-economic characteristics to Rushcliffe, as well as similar per capita rates of emergency admissions. The matching algorithm ensured that the matched control residents had broadly similar characteristics as Principia residents at the point of moving to the care home (including age, gender, health conditions and prior hospital use) and also moved to care homes with similar characteristics. The analysis allowed for further risk adjustment to be made at the multivariable regression stage. Notwithstanding this, there may be unobserved differences that may have affected the estimated rate ratios. For example, the groups might differ in social isolation, or the areas might differ in terms of their healthcare provision. Coding practices within administrative hospital records can also vary between hospitals.⁸¹ We somewhat reduced the risk of unobserved confounding by selecting matched controls from six (rather than one) different comparison areas. Furthermore, it is reassuring that the outcomes in residential and nursing homes are different, as unobserved differences in hospital practices or coding would be expected to confound outcomes in both care home types. We were also reassured that there were no

significant differences in mortality rates between the Principia and the matched control subgroups; as it was not expected that the Principia enhanced support would have a substantial effect on mortality, this lends further reassurance that the compared resident groups were similar.

One observation is that the matched control residents in the nursing subgroups experienced much less emergency hospital use than the national average (tables 3 and 5). Although there is no reason to expect these rates to be the same, this result could mean that nursing homes in the control group were offering particularly good care, making it more difficult to detect a significant improvement in Principia nursing homes. To investigate this possibility, we performed a sensitivity analysis removing one comparison area at a time. This indicated that no single comparison area was driving the results (results not shown).

Both the evaluation of the enhanced support and the national analysis were based on the subset of residents who moved to a care home during the study period and had a history of prior hospital use. Their rates of hospital use may differ from those of the overall care home population.

A strength of our study is that we linked administrative hospital records to CQC data and information derived from patient registration data. This resulted in a database containing the hospital histories of every care home resident in the selected areas, without the problems of non-response that can be encountered in study designs that use survey data. However, we could only identify people as living in a care home when their addresses were updated on their GP record. This happens routinely when individuals move to care homes on a permanent basis, but we are likely to have excluded residents who moved to the care home temporarily. Also, as NHAIS extracts were only available from August 2014 onwards, we could not compare the rates of hospital admission between Principia and control care homes before the intervention was introduced. Furthermore, we did not examine other aspects of quality of care, such as quality of life, resident experience or medicine management.

The list of conditions for which emergency admissions are potentially avoidable was developed by the CQC.^{67 68} As the focus of the CQC analysis was on older people experiencing health and social care, the list was not specific to care home residents. However, from a list of commonly defined ambulatory care sensitive conditions from the literature, CQC selected those that affected older patients particularly from care home postcodes, then added additional conditions that were considered to indicate potential poor care within the community or care home (eg, fractures and pressure sores).⁶⁸ Furthermore, the list captures some of the most common preventable causes of harm in care homes.⁴⁸ Further research is needed to validate the appropriateness of these conditions as a marker of

avoidable admissions for the care home population. In the meantime, the data presented can only be taken as an illustration of the range of health conditions for which care home residents are admitted to hospital, some of which are potentially avoidable.

For the sensitivity analysis of national rates of emergency hospital use, commercial software was used to automate the address cleaning before electronically matching addresses. Our validation work showed that this method, although correctly identifying care home residents, underestimated the number of care home residents compared with manual matching. There is, however, no reason why this would have biased the results.

Subgroup analyses such as the ones presented in this paper can sometimes produce false positives. However, using published criteria to evaluate the credibility of subgroup analyses,⁸² the subgroup difference here is considered very plausible. In particular, the subgroup analysis by care home type was specified a priori and was the only subgroup specified; care home type was determined at baseline; the comparison was made within, rather than between, studies; the interaction test was highly significant, suggesting a low likelihood that chance alone explained the apparent difference between residential and nursing homes; and the effect was consistent across several closely related outcomes relating to emergency hospital use.

Given the strengths and limitations described above, one plausible explanation for the difference in emergency hospital use in residential care homes is that the enhanced support reduced hospital use in residential care homes, although we could not altogether rule out confounding. The effect of enhanced support appears to be different between residential and nursing homes.

Mechanisms and interpretation

Assuming that the difference in rate ratios in emergency care between residential and nursing homes is due to a difference in impact of the enhanced support, there could be a number of contributing factors.

First, the intervention might have been applied differently in residential and nursing homes. For example, there were some differences in how the community nurse support and training operated, with residential care home staff receiving more training than nursing home staff. The training, which is not part of 'usual care' in care homes, might also have led to more regular contact between care home staff and community nurses in residential care homes, improving the quality of the relationships and helping to establish community nurses as a useful point of contact when care home staff are concerned about a resident's health, rather than relying on emergency services.^{21 52}

Second, residents of residential care homes might have been more amenable ('impactable')⁸³ to the additional support than residents of nursing homes since, while frail, they had in general fewer health conditions

than nursing home residents. Nursing home residents, in contrast, had higher rates of health conditions such as cancer and chronic pulmonary disease and were more often nearing their end of life. Given nursing home residents' clinical history and the shorter average time spent in the home, there may be more limited scope to reduce their hospital use.

A third possibility is that the enhanced support was more effective in residential care homes than in nursing homes even if applied in the same way. Residential care homes do not have 24 hours' access to nursing expertise as in nursing homes, and so may have benefited more from the additional support from GPs and community nurses.^{21 34}

A fourth possibility is that what qualifies as 'usual care' may differ between residential and nursing homes. In general, it is common for a care home to have residents registered with several different general practices and for the GP 'on call', rather than a regular named GP, to visit a resident if required.⁸⁴ However, it may be that nursing homes are on the whole benefitting from more regular GP contact than residential care homes.^{43 64 65 84} This may be particularly true in the matched control nursing homes, which had on average lower rates of emergency hospital use than nursing homes nationally (tables 3 and 5). This could be limiting the difference between 'usual care' and the enhanced support in nursing homes and thereby affect our ability to detect a difference in Principia care homes. Furthermore, nursing home residents in general have more well-defined and preterminal conditions⁸⁵ and are therefore more likely to have predicted medical pathways and more established end-of-life planning, even in the absence of the enhanced support. Staff may therefore feel more able to make decisions on whether or not to admit nursing home residents to hospital.

These last two hypotheses are supported by our observation that nationally, residential care home residents have higher rates of A&E attendances and emergency admission than nursing home residents, suggesting that there could be more potential to reduce emergency admissions among residents in those homes than in nursing homes. It may be that residential care home residents also often have complex healthcare needs^{43 52} and that in the absence of clinical knowledge, health problems may not be detected and addressed as early as they could be or managed as well,⁵² or that staff do not feel confident to make decisions regarding their residents' health, therefore relying more on emergency services.^{21 34 52} As such, the impact of additional GP and community nurse support, advice and training may be larger in residential care homes, increasing the staff's ability to proactively manage health risks and reducing their reliance on emergency services.

Several studies have pointed towards the importance of care home and NHS staff working together as partners^{32 48} to codesign and implement concerted approaches to healthcare¹⁵ and of acknowledging

care home staff's knowledge and skills.⁴⁵ Nursing home staff include nurses with clinical expertise, who may feel more responsible for their residents' clinical needs than other care home staff. In nursing homes, improvement programmes may therefore require more engagement and emphasis on coproduction in order to build good working relationships and codevelop the elements of the intervention.

It is not possible to determine which of these—or other—intervention-specific or contextual factors contributed to the observed differences in emergency hospital use. A qualitative evaluation could shed light on the likelihood of and interplay between the above outlined factors.

Comparison with other studies

To our knowledge no previous studies have compared the impact of enhanced support interventions between residential and nursing homes in the way that we have. A recent evaluation of an EHCH vanguard programme implemented in Sutton CCG indicated that the enhanced care provided may have affected residents of nursing and residential care homes differently; however, this was not formally investigated.³³ More evaluations of the type we propose are needed to increase the evidence base on how improvement programmes are affected by the differing contextual factors in residential and nursing homes. Furthermore, complementing qualitative evaluations would help identify enablers and barriers to implementation, as well as the 'active ingredients' of such programmes, thereby helping improve the replicability and scalability of successful interventions.

Compared with other patient groups, there is little robust quantitative research into care in care homes. One reason for this is that there is no readily available database identifying care home residents in administrative data such as hospital records. Encouragingly, two other research teams have recently investigated or developed methods for identifying care home residents from patient addresses.^{86 87} However, it is important that these data are routinely and consistently collected and easily accessible to both research teams and care providers, if we are to understand residents' healthcare needs, produce robust evaluations and ultimately improve care for this vulnerable patient group.

CONCLUSIONS

This study shows that people moving to residential care homes participating in the enhanced support experienced significantly fewer potentially avoidable emergency admissions, emergency admissions and A&E attendances than a matched control group. However, there was no evidence that people moving to participating nursing homes experienced lower hospital use. The impact of the enhanced support appears to differ between the two types of care homes.

It may be that improvement programmes such as the enhanced support have more potential to reduce emergency hospital use among residents in residential than nursing homes. Indeed, we observed in this study that nationally, residential care home residents tend to use more emergency hospital services than nursing home residents, even though we would expect them to be less sick, given that residential care homes do not provide in-house nursing support. There may be scope to reduce emergency admissions among nursing home residents but improvement programmes may need to be more tailored to the needs of nursing home residents and the context of providing care in that setting.

Given the ongoing policy changes in the English NHS and their emphasis on improving care in care homes,^{10–12} this study may inform decisions about what interventions should be implemented and/or how they should be targeted, thereby helping to support implementation of care home interventions in the future.

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REFERENCES

1. LaingBuisson. Care of older people: UK market report; 2017.
2. NHS. Care homes. Available: <https://www.nhs.uk/conditions/social-care-and-support-guide/care-services-equipment-and-care-homes/care-homes/> [Accessed 1 Oct 2018].
3. Baylis A, Perks-Baker S. Enhanced health in care homes Learning from experiences so far. The King's Fund 2017. Available: https://www.kingsfund.org.uk/sites/default/files/2017-11/Enhanced_health_care_homes_Kings_Fund_December_2017.pdf
4. Alzheimer's Society. Fix dementia care: NHS and care homes. 2016. Available: https://www.alzheimers.org.uk/sites/default/files/migrate/downloads/fix_dementia_care_nhs_and_care_homes_report.pdf
5. British Geriatrics Society. Fit for frailty Part 1. 2014. Available: https://www.bgs.org.uk/sites/default/files/content/resources/files/2018-05-23/fff_full.pdf
6. Bowman C, Meyer J. Formative care: defining the purpose and clinical practice of care for the frail. *J R Soc Med* 2014;107:95–8.
7. National End of Life Care Intelligence Network (NEoLCIN). The role of care homes in end of life care: Briefing 2 - Place and cause of death for permanent and temporary residents of care homes. 2017. Available: <http://www.endoflifecare-intelligence.org.uk/resources/publications/carehomes> [Accessed 1 Oct 2018].
8. Prince M, Knapp M, Guerchet M, *et al*. Dementia UK update (second edition). Alzheimer's Society 2014. Available: https://www.alzheimers.org.uk/sites/default/files/migrate/downloads/dementia_uk_update.pdf [Accessed 1 Oct 2018].
9. Boyd M, Broad JB, Kerse N, *et al*. Twenty-year trends in dependency in residential aged care in Auckland, New Zealand: a descriptive study. *J Am Med Dir Assoc* 2011;12:535–40.
10. NHS. Next steps on the five year forward view. 2017. Available: <https://www.england.nhs.uk/wp-content/uploads/2017/03/NEXT-STEPS-ON-THE-NHS-FIVE-YEAR-FORWARD-VIEW.pdf> [Accessed 1 Oct 2018].
11. NHS England, NHS Improvement, Care Quality Commission, *et al*. Delivering the Forward View : NHS planning guidance 2016/17 - 2020/21. 2016. Available: <https://www.england.nhs.uk/wp-content/uploads/2015/12/planning-guid-16-17-20-21.pdf> [Accessed 1 Oct 2018].
12. NHS. The NHS long term plan. Available: <https://www.longtermplan.nhs.uk/> [Accessed 11 Jan 2019].
13. Healthwatch. What's it like to live in a care home? Findings from the Healthwatch network. 2017. Available: https://www.healthwatch.co.uk/sites/healthwatch.co.uk/files/20171117_-_whats_it_like_to_live_in_a_care_home.pdf [Accessed 2 Aug 2018].
14. Care Quality Commission. The state of health care and adult social care in England 2016/17. 2017. Available: https://www.cqc.org.uk/sites/default/files/20171123_stateofcare1617_report.pdf [Accessed 15 Oct 2018].
15. Goodman C, Davies SL, Gordon AL, *et al*. Optimal NHS service delivery to care homes: a realist evaluation of the features and mechanisms that support effective working for the continuing care of older people in residential settings. *Health Serv Deliv Res* 2017;5:1–204.
16. Care Quality Commission. Time to listen in care homes. dignity and nutrition inspection programme 2012. 2013. Available: http://www.cqc.org.uk/sites/default/files/documents/time_to_listen_-_care_homes_main_report_tag.pdf [Accessed 15 Oct 2018].
17. Bowman CE, Elford J, Dovey J, *et al*. Acute hospital admissions from nursing homes: some may be avoidable. *Postgrad Med J* 2001;77:40–2.
18. Goodman C, Gordon AL, Martin F, *et al*. Effective health care for older people resident in care homes: the optimal study protocol for realist review. *Syst Rev* 2014;3:1–7.
19. NHS. Five year forward view. 2014. Available: <http://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf>
20. NHS. New care models: the framework for enhanced health in care homes. 2016. Available: <https://www.england.nhs.uk/wp-content/uploads/2016/09/ehch-framework-v2.pdf>

21. Care Quality Commission. Beyond barriers: how older people move between health and social care in England. 2018. Available: <https://www.cqc.org.uk/publications/themed-work/beyond-barriers-how-older-people-move-between-health-care-england>
22. NHS Improvement. Guide to reducing long Hospital stays. 2018. Available: https://improvement.nhs.uk/documents/2898/Guide_to_reducing_long_hospital_stays_FINAL_v2.pdf [Accessed 1 Aug 2018].
23. Krumholz HM. Post-hospital syndrome--an acquired, transient condition of generalized risk. *N Engl J Med* 2013;368:100–2.
24. Smith P, Sherlaw-Johnson C, Ariti C, *et al.* Focus on : Hospital admissions from care homes. Quality Watch 2015. Available: https://www.health.org.uk/sites/health/files/QualityWatch_FocusOnHospitalAdmissionsFromCareHomes.pdf [Accessed 1 Oct 2018].
25. Harrison JK, McKay IK, Grant P, *et al.* Appropriateness of unscheduled hospital admissions from care homes. *Clin Med* 2016;16:103–8.
26. Hanger HC, Fletcher V, Sidwell A. Acute medical admissions of older people from residential care facilities: are they appropriate? *N Z Med J* 2011;23–32.
27. Ouslander JG, Maslow K. Geriatrics and the triple aim: defining preventable hospitalizations in the long-term care population. *J Am Geriatr Soc* 2012;60:2313–8.
28. Ouslander JG, Berenson RA. Reducing unnecessary hospitalizations of nursing home residents. *N Engl J Med* 2011;365:1165–7.
29. National Audit Office. Developing new care models through NHS vanguards. National audit office 2018. Available: <https://www.nao.org.uk/report/developing-new-care-models-through-nhs-vanguards/> [Accessed 1 Aug 2018].
30. Graverholt B, Forsetlund L, Jamtvedt G. Reducing hospital admissions from nursing homes: a systematic review. *BMC Health Serv Res* 2014;14.
31. Centre for Reviews and Dissemination. Interventions to reduce unplanned admissions from care home settings. 2014. Available: https://www.york.ac.uk/media/crd/Ev_Briefing_unplanned_admissions_from_care_homes.pdf [Accessed 1 Nov 2018].
32. Burns E, Nair S. New horizons in care home medicine. *Age Ageing* 2014;43:2–7.
33. Conti S, Gori C, Caunt M, *et al.* The impact of providing enhanced support for Sutton homes of care residents findings from the improvement analytics unit. The Health Foundation 2018. Available: <https://www.health.org.uk/publications/the-impact-of-providing-enhanced-support-for-sutton-homes-of-care-residents> [Accessed 1 Oct 2018].
34. Sherlaw-Johnson C, Crump H, Curry N, *et al.* Transforming health care in nursing homes: an evaluation of a dedicated primary care service in outer East London. Nuffield trust 2018. Available: <https://www.nuffieldtrust.org.uk/research/transforming-health-care-in-nursing-homes-an-evaluation-of-a-dedicated-primary-care-service-in-outer-east-london> [Accessed 30 Jul 2018].
35. Lloyd T, Wolters A, Steventon A. The impact of providing enhanced support for care home residents in Rushcliffe. 2017. Available: <http://www.health.org.uk/sites/health/files/IAURushcliffe.pdf>
36. Maniatopoulos G, Hunter D, Erskine J, *et al.* North East Vanguards Programme : Final Evaluation Report May 2017. 2017. Available: <https://www.necs.nhs.uk/wp-content/uploads/2018/03/NEVE-Final-Report-September-2017.pdf>
37. Connolly MJ, Boyd M, Broad JB, *et al.* The aged residential care healthcare Utilization Study (ARCHUS): a multidisciplinary, cluster randomized controlled trial designed to reduce acute avoidable hospitalizations from long-term care facilities. *J Am Med Dir Assoc* 2015;16:49–55.
38. Kuo YF, Raji MA, Goodwin JS. Association between proportion of provider clinical effort in nursing homes and potentially avoidable hospitalizations and medical costs of nursing home residents. *J Am Geriatr Soc* 2013;61:1750–7.
39. Marshall M, de Silva D, Cruickshank L, *et al.* What we know about designing an effective improvement intervention (but too often fail to put into practice). *BMJ Qual Saf* 2017;26:578–82.
40. Hullick C, Conway J, Higgins I, *et al.* Emergency department transfers and hospital admissions from residential aged care facilities: a controlled pre-post design study. *BMC Geriatr* 2016;16:1–10.
41. Ouslander JG, Lamb G, Tappen R, *et al.* Interventions to reduce hospitalizations from nursing homes: evaluation of the interact II collaborative quality improvement project. *J Am Geriatr Soc* 2011;59:745–53.
42. Winstanley L, Brennan W. Advanced practice and support in prescribing and medicine management for care homes. *J Care Serv Manag* 2007;1:233–44.
43. Evans G, Bch BM. Factors influencing emergency hospital admissions from nursing and residential homes: positive results from a practice-based audit. *J Eval Clin Pract* 2011;17:1045–9.
44. National Institute for Health Research. NIHR Dissemination Centre. Advancing care - Research with care homethemed review. 2017. Available: <https://www.dc.nihr.ac.uk/themed-reviews/care-home-research.htm>
45. Davies SL, Goodman C, Bunn F, *et al.* A systematic review of integrated working between care homes and health care services. *BMC Health Serv Res* 2011;11.
46. Hutchinson AF, Parikh S, Tacey M, *et al.* A longitudinal cohort study evaluating the impact of a geriatrician-led residential care outreach service on acute healthcare utilisation. *Age Ageing* 2015;44:365–70.
47. Connolly MJ, Broad JB, Boyd M, *et al.* The 'Big Five'. Hypothesis generation: a multidisciplinary intervention package reduces disease-specific hospitalisations from long-term care: a post hoc analysis of the ARCHUS cluster-randomised controlled trial. *Age Ageing* 2016;45:415–20.
48. Marshall M, Pfeifer N, de Silva D, *et al.* An evaluation of a safety improvement intervention in care homes in England: a participatory qualitative study. *J R Soc Med* 2018;111:414–21.
49. Malhotra G, Somerville M. Reducing unscheduled emergency hospital admissions from care settings - a learning and development perspective. 2014. Available: https://bucks.collections.crest.ac.uk/17368/1/17368_Reducing_unscheduled_emergency_hospital_admissions_final_report_April_2014.pdf
50. Banerjee A, James R, McGregor M, *et al.* Nursing home physicians discuss caring for elderly residents: an exploratory study. *Can J Aging* 2018;37:133–44.
51. Evans S, Means R, Powell J, *et al.* Making care homes part of the community? An evaluation of the Gloucestershire partnerships for older people project. *Qual Ageing Older Adults* 2013;14:66–74.
52. Wild D, Nelson SJ, Szczepura A. Providing nursing support within residential care homes. *Joseph Rowntree Foundation* Published Online First: 2008. Available: <http://eprints.uwe.ac.uk/12744> [Accessed 1 Dec 2018].
53. Ouslander JG, Bonner A, Herndon L, *et al.* The interventions to reduce acute care transfers (INTERACT) quality

- improvement program: an overview for medical directors and primary care clinicians in long term care. *J Am Med Dir Assoc* 2014;15:162–70.
54. Frey R, Boyd M, Robinson J, *et al*. The supportive hospice and aged residential exchange (SHARe) programme in New Zealand. *Nurse Educ Pract* 2017;25:80–8.
 55. Brownhill KM. Training in care homes to reduce avoidable harm. 2013. Available: https://www.nursingtimes.net/Journals/2013/10/25/p/t/r/Training-in-care-homes-to-reduce-avoidable-harm_301013.pdf [Accessed 1 Dec 2018].
 56. Garden G, Green S, Pieniak S, *et al*. The Bromhead care Home service: the impact of A service for care home residents with dementia on hospital admission and dying in preferred place of care. *Clin Med* 2016;16:114–8.
 57. Hockley J, Watson J, Oxenham D, *et al*. The integrated implementation of two end-of-life care tools in nursing care homes in the UK : an in-depth evaluation 2010;24:828–38.
 58. Bowman C, Whistler J, Ellerby M. A national census of care home residents. *Age Ageing* 2004;33:561–6.
 59. Challis D, Mozley CG, Sutcliffe C, *et al*. Dependency in older people recently admitted to care homes. *Age Ageing* 2000;29:255–60.
 60. Forder J, Fernandez JL. *Length of stay in care homes. Report commissioned by Bupa Care Services, PSSRU Discussion Paper 2769*. Canterbury: PSSRU Published Online First, 2011.
 61. Barber ND, Allred DP, Raynor DK, *et al*. Care homes' use of medicines study: prevalence, causes and potential harm of medication errors in care homes for older people. *Qual Saf Health Care* 2009;18:341–6.
 62. Hancock J, Matthews J, Ukoumunne OC, *et al*. Variation in ambulance call rates for care homes in Torbay, UK. *Health Soc Care Community* 2017;25:932–7.
 63. Smith P, Sherlaw-Johnson C, Ariti C, *et al*. Quality Watch Focus on : Hospital admissions from care homes, 2015. Available: https://www.health.org.uk/sites/default/files/QualityWatch_FocusOnHospitalAdmissionsFromCareHomes_appendices.pdf
 64. Rothera I, Jones R, Harwood R, *et al*. General practitioner contacts with older residents I N nursing and residential homes 2009;4788.
 65. Glendinning C, Jacobs S, Alborz A, *et al*. A survey of access to medical services in nursing and residential homes in England. *Br J Gen Pract* 2002;52:545–8.
 66. Lloyd T, Steventon A. Statistical Analysis Protocol for an evaluation of providing enhanced support for care home residents in Rushcliffe. *The Health Foundation* Published Online First: 2016. Available: <https://www.health.org.uk/publications/the-impact-of-providing-enhanced-support-for-care-home-residents-in-rushcliffe> [Accessed 20 Jan 2019].
 67. Care Quality Commission. The state of health care and adult social care in England in 2012/13. 2013. Available: https://www.cqc.org.uk/sites/default/files/documents/cqc_soc_report_2013_lores2.pdf [Accessed 1 Sep 2016].
 68. Care Quality Commission. The state of health care and adult social care in England in 2012/13. Technical Annex 1: avoidable admissions. 2013. Available: https://www.cqc.org.uk/sites/default/files/documents/state_of_care_annex1.pdf [Accessed 1 Oct 2018].
 69. Steventon A, Grieve R, Sekhon JS. A comparison of alternative strategies for choosing control populations in observational studies. *Health Serv Outcomes Res Methodol* 2015;15:157–81.
 70. Lloyd T, Wolters A, Steventon A. Technical appendix : The impact of providing enhanced support for care home residents in Rushcliffe. The Health Foundation 2017. Available: <https://www.health.org.uk/sites/health/files/IAURushcliffeTA.pdf>
 71. Office for National Statistics. Methods for national statistics 2001 area classification for health areas. 2001. Available: <https://webarchive.nationalarchives.gov.uk/20160128205413/http://www.ons.gov.uk/ons/guide-method/geography/products/area-classifications/ns-area-classifications/ns-2001-area-classifications/methodology-and-variables/health-areas/index.html> [Accessed 1 Nov 2018].
 72. Office for National Statistics. Methodology note for the 2011 area classification for local authorities. 2015. Available: <https://www.ons.gov.uk/methodology/geography/geographicalproducts/areaclassifications/2011areaclassifications/methodologyandvariables> [Accessed 1 Nov 2018].
 73. Care Quality Commission. Care quality Commission website. Available: <http://www.cqc.org.uk> [Accessed 18 Sep 2017].
 74. Soong J, Poots AJ, Scott S, *et al*. Quantifying the prevalence of frailty in English hospitals. *BMJ Open* 2015;5:e008456.
 75. Soong J, Poots AJ, Scott S, *et al*. Developing and validating a risk prediction model for acute care based on frailty syndromes. *BMJ Open* 2015;5:e008457.
 76. Billings J, Blunt I, Steventon A, *et al*. Development of a predictive model to identify inpatients at risk of re-admission within 30 days of discharge (PARR-30). *BMJ Open* 2012;2:e001667.
 77. Diamond A, Sekhon JS. Genetic matching for estimating causal effects: a general multivariate matching method for achieving balance in observational studies. *Rev Econ Stat* 2013;95:932–45.
 78. Stuart EA. Matching methods for causal inference: a review and a look forward. *Stat Sci* 2010;25:1–21.
 79. Normand ST, Landrum MB, Guadagnoli E, *et al*. Validating recommendations for coronary angiography following acute myocardial infarction in the elderly: a matched analysis using propensity scores. *J Clin Epidemiol* 2001;54:387–98.
 80. Experian. Experian JukeBox. Available: <https://www.digitalmarketplace.service.gov.uk/g-cloud/services/115957991094393> [Accessed 12 Nov 2018].
 81. Bottle A, Aylin P. Comorbidity scores for administrative data benefited from adaptation to local coding and diagnostic practices. *J Clin Epidemiol* 2011;64:1426–33.
 82. Sun X, Briel M, Walter SD, *et al*. Is a subgroup effect believable? updating criteria to evaluate the credibility of subgroup analyses. *BMJ* 2010;340:c117.
 83. Lewis GH. "Impactability models": identifying the subgroup of high-risk patients most amenable to hospital-avoidance programs. *Milbank Q* 2010;88:240–55.
 84. Donald IP, Gladman J, Conroy S, *et al*. Care home medicine in the UK--in from the cold. *Age Ageing* 2008;37:618–20.
 85. Waldrop DP, Kusmaul N. The living-dying interval in nursing home-based end-of-life care: family caregivers' experiences. *J Gerontol Soc Work* 2011;54:768–87.
 86. Housley G, Lewis S, Usman A, *et al*. Accurate identification of hospital admissions from care homes; development and validation of an automated algorithm. *Age Ageing* 2018;47:387–91.
 87. Burton JK, Marwick CA, Galloway J, *et al*. Identifying care-home residents in routine healthcare datasets: a diagnostic test accuracy study of five methods. *Age Ageing* 2019;48:114–21.