

# BMJ Open Association between household context and emergency hospital use in older people: a retrospective cohort study on indicators for people living alone or living with somebody with frailty, developed from routine healthcare data in England

Therese Lloyd <sup>1</sup>, Elizabeth Crellin <sup>1</sup>, Richard James Brine,<sup>1</sup> Julia Y Shen,<sup>1,2</sup> Arne Timon Wolters<sup>1</sup>

**To cite:** Lloyd T, Crellin E, Brine RJ, *et al.* Association between household context and emergency hospital use in older people: a retrospective cohort study on indicators for people living alone or living with somebody with frailty, developed from routine healthcare data in England. *BMJ Open* 2022;**12**:e059371. doi:10.1136/bmjopen-2021-059371

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2021-059371>).

Received 30 November 2021  
Accepted 28 March 2022



© Author(s) (or their employer(s)) 2022. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

## Correspondence to

Therese Lloyd;  
[therese.lloyd@health.org.uk](mailto:therese.lloyd@health.org.uk)

## ABSTRACT

**Objectives** To derive two household context factors - living alone and living in a two-person household with a person who is frail - from routine administrative health data and to assess their association with emergency hospital use in people aged 65 or over.

**Design** Retrospective cohort study using national pseudonymised hospital data and pseudonymised address data derived from a minimised version of the Master Patient Index, a central database of all patient registrations in England.

**Setting** England-wide.

**Participants** 4 876 285 people aged 65 years or older registered at GP practices in England on 16 December 2018 who were living alone or in a household of up to six people, and with at least one hospital admission in the last 3 years.

**Outcomes** Rates of accident and emergency (A&E) attendance and inpatient emergency admissions over a 1-year follow-up period.

**Results** Older people living alone had higher rates of A&E attendances (adjusted rate ratio 1.09, 95% CI 1.09 to 1.10) and emergency admissions (1.14, 95% CI 1.14 to 1.15) than older people living in households of 2–6 people. Older people living with someone with frailty in a two-person household had higher rates of A&E attendance (adjusted rate ratio 1.09, 95% CI 1.08 to 1.10) and emergency admissions (1.10, 95% CI 1.09 to 1.11) than other older people living in a two-person household.

**Conclusions** We show that household context factors can be derived from linked routine administrative health data and that these are strongly associated with higher emergency hospital use in older people. Using household context factors can improve analyses, as well as support in the understanding of local population needs and in population health management.

## INTRODUCTION

The 'social (or wider) determinants of health'<sup>1</sup>—social context factors outside of the health and social care system that

## Strengths and limitations of this study

- Two household context factors, living alone and living with someone with frailty, were derived from pseudonymised routinely collected data; this created valuable additional patient-level information without the need to collect new data.
- National data from approximately 4.9 million people aged 65 or over were used to examine the association of the household context factors and emergency hospital use.
- The analysis adjusted for common demographic and clinical factors predictive of emergency hospital use.
- The study was restricted to individuals aged 65 or over who had a hospital admission in the previous 3 years, limiting the generalisability of our study.

affect a person's health, such as networks of family and friends, housing, education and employment opportunities—have long been recognised in the UK<sup>2,3</sup> and globally.

There is some evidence that a person's social context informs care: Stokes *et al* found that when identifying patients for multi-disciplinary teams (MDTs), medical practitioners felt that the patients' needs were often primarily related to socioeconomic or other social factors such as isolation, poor housing or living arrangements.<sup>4</sup> Some MDTs are aiming to address social, as well as health, needs.<sup>5</sup> Others are specifically targeting people with non-clinical needs, with the aim of addressing social needs which might otherwise lead to deteriorating health and escalating medical needs.<sup>6</sup>



However, unlike other risks observed by clinicians that are included in population health management tools,<sup>7</sup> social context is not routinely captured in National Health Service (NHS) or social care datasets, and where these are collected, they are often recorded in free text fields. Information on patients' circumstances is therefore not readily retrievable from electronic health records. This has implications not only for hospital staff but also analysts, commissioners or policy makers, who often rely on these data when analysing, planning or commissioning care.

The NHS in England holds a central database of all patients' registrations with general practitioner (GP) practices in England, which includes their address details. By assigning a Unique Property Reference Number (UPRN) to each address and pseudonymising the UPRN, it is possible to derive information on household composition while maintaining people's anonymity. This information can be used to create some important household context factors that may affect health and health outcomes, for example, living alone or living with someone with frailty.

Living alone is a risk factor for social isolation and may therefore be a marker of social isolation.<sup>8-9</sup> Social isolation reflects a lack of personal ties, social integration or sense of community<sup>10</sup> and has been found to be associated with both increased morbidity and mortality.<sup>8-11</sup> There are different groups of people at risk of social isolation, not least young people leaving home for the first time. However, older people may be at greater risk of social isolation as a result of loss of physical or mental ability, or deaths of close family and friends.<sup>11</sup> Living alone does not necessarily mean someone is socially isolated; approximately one-third of people aged 65 or over live on their own<sup>12</sup> but many may have friends or family living nearby. However, living alone has been found to be associated with higher emergency (unplanned) hospital use within one GP practice in South East London,<sup>13</sup> indicating that living alone still signals important social context at population level and warrants further investigation. Living alone may also have a detrimental effect on a person's mobility, nutrition and medication compliance.<sup>9-14</sup>

Living with someone with frailty may imply having informal care responsibilities. Informally caring for somebody else can have a detrimental effect on a person's own physical and mental health.<sup>15-17</sup> Informal carers may not only feel socially isolated,<sup>11</sup> but may also suffer from lack of sleep and neglect their own health and personal well-being,<sup>18-19</sup> or have difficulty accessing care.<sup>20</sup> A large England-wide survey of informal carers found they had worse health-related quality of life, with a disproportionate burden for already-marginalised groups.<sup>20</sup> According to the 2011 Census, 1.3 million (14%) people aged 65 or over living in households in England and Wales provided unpaid care in 2011, many of whom provided 50 hours or more unpaid care weekly.<sup>21</sup> There may now be over 2 million people aged 65 or older who are carers, with a significant proportion of carers aged 85 and over

caring for someone with multiple needs, often including dementia.<sup>22</sup>

In this paper, we demonstrate the value of deriving two household context factors from routinely collected address data: (1) living alone and (2) living with one other person who is frail. We explore the association between these factors and emergency hospital use in people aged 65 or over, as this population is at particular risk of both emergency hospital admission and isolation.

## METHODS

### Data sources and linkage

We accessed a minimised version of the Master Patient Index (MMPI), a health dataset based on English GP registration data. This dataset included individuals' gender, month and year of birth (and death where applicable), lower super output area (LSOA) and pseudonymised UPRNs. UPRNs are the official unique identifier of every spatial address in Great Britain<sup>23</sup> and were applied to each address location in the MMPI and pseudonymised by our data suppliers. We did not have access to actual patient addresses. Building on our previous work to identify care home residents from UPRNs,<sup>24</sup> we also accessed a flag to indicate if a property was a care home. The individual's LSOA was used to link to small area statistics provided by the Office for National Statistics on socioeconomic deprivation, rurality and geographical region.

### Study population and outcomes

Our study population consisted of all people aged 65 years or older registered at GP practices in England on 16 December 2018 who were living alone or in a household of up to six people. Household size was limited to six in order to exclude people living in establishments, as their care provision may differ from that of a single household. This restriction excluded less than 2% of households.<sup>12</sup> We excluded individuals without a valid pseudonymised UPRN or living in care homes at the study start date, and those living at properties containing seven or more people at any time in the year prior to the study start. People not admitted to hospital in the previous 3 years were also excluded, as hospital records were used to identify long-term conditions and ethnicities (online supplemental file 1).

Where both individuals in a two-person household were aged 65 or older, both were included in the study population and contributed to the analysis. If one household member was under 65, this member was not included in the study population but did contribute to defining the household context of their cohabitee.

Using a common pseudonymised NHS number, we linked the MMPI data to secondary uses service (SUS) hospital data from the previous 3 years. For any individual aged 65 or over with linked hospital records, we identified their long-term conditions, secondary care use and top-level ethnicity (based on the mode of ethnicities recorded).

The maximum follow-up period (study length) was 1 year unless censored because the person died, moved into a care home or their household composition changed.

We examined rates of accident and emergency (A&E) attendance and inpatient emergency admissions in the follow-up period.

### Household context factors

A person was defined as living alone if there was no other person with the same UPRN during the study period. For individuals living in two-person households we also linked the hospital records of their cohabitee, where these existed, to identify if the individual was living with someone recorded as frail. A person was identified as frail if they had any of the conditions or events in Soong et al's list of syndromes<sup>25 26</sup> coded in inpatient records in the previous 3 years. These include cognitive impairment, mobility problems and pressure ulcers, which may require care or support from the cohabitee.

### Statistical methods

We used multivariable regression to examine the association between emergency healthcare use (A&E attendances and emergency hospital admissions, respectively) and (1) living alone and (2) living with someone with frailty. We did this by comparing living alone to living in a household of 2–6 people and, separately, comparing living in a two-person household with a person with frailty to living in a two-person household where the cohabitee was not recorded as frail.

We ran both crude and adjusted analyses. Adjusted analyses included age, gender, ethnicity, geographical region (nine areas of England), socioeconomic deprivation (Index of Multiple Deprivation—IMD—quintiles), rural/urban classification, historic emergency hospital use in the last 12 months (including emergency admissions for chronic ambulatory care sensitive and acute urgent care sensitive conditions), and a range of long-term conditions recorded in the previous 3 years. These conditions included frailty indicators,<sup>25 26</sup> history of mental or serious mental ill health<sup>27</sup> and other conditions predictive of emergency hospital use<sup>28 29</sup> (see online supplemental file 2 for full list of covariates). We aimed to include as covariates as many variables as possible without overparametrising the model in order to remove any known confounding. We used a negative binomial model as the data was overdispersed. Rate ratios were produced to interpret the results.

### Subgroup analysis

We investigated whether the emergency hospital use of people living with someone with frailty differed depending on if they were male or female, as women in general provide more informal care than men.<sup>30</sup> We also investigated whether the emergency hospital use of people living alone differed according to their local deprivation quintile, as this may affect a person's access to informal or formal care (neither of which is observable

in our data). Differences in the rate ratios between population subgroups were examined by fitting a multivariable regression model including an interaction term between the household context factor and the population segment.

### Sensitivity analysis

In the main analyses, people were censored at the time their household composition changed. There is a risk that household change could be driven by deteriorating health, for example, if a person living alone had worsening illness and moved into a care home. This could underestimate a person's healthcare needs if they had continued living alone. Therefore, a sensitivity analysis examined only those whose household composition remained stable, that is, did not change over the year.

The main analyses adjusted for, among other covariates, emergency hospital use in the twelve months prior to the analysis period, as these variables may reflect the clinical severity of a patient's condition(s), which can be difficult to deduce from electronic health records. However, prior hospital use may also be affected by past household context factors (eg, living alone or living with somebody with frailty), potentially underestimating the effect of these household context variables. Therefore, we performed sensitivity analyses omitting prior hospital use covariates.

### Patient and public involvement

We sought input from a patient representative at the development stage, including on choice and relevance of household context factors. There was further engagement with this same and another representative on the interpretation of results and on an early draft of the paper.

## RESULTS

### Study populations

After applying the inclusion and exclusion criteria, there were 4 876 285 people aged over 65, registered with an English GP and living in England, with at least one hospital admission in the last 3 years and living in a household of up to six people (online supplemental file 1). The largest exclusion was due to no hospital admission in the previous 3 years (approximately 5m). Of the remaining individuals, 1 464 379 (30.03%) lived alone and 2 459 937 (50.45%) lived in a two-person household (table 1).

People living alone were more often female (66% vs 47%) and on average older (median age 79 vs 74) compared with people living in households of 2–6 people (table 1, online supplemental file 2). They also lived in more deprived areas; 19% lived in the most deprived quintile compared with 13% of individuals living in households of 2–6 people. Furthermore, more people living alone were frail (33% vs 21%, with on average 0.51 vs 0.30 frailty syndromes) and they had higher levels of multimorbidity (on average 2.30 vs 1.97 conditions) compared with people in households of 2–6 people. They

**Table 1** Baseline characteristics

	People 65+ years living in households up to six people*			People 65+ years living in households of two people*		
	All	Living alone	Not living alone	All	Living with someone with frailty	Cohabitee not recorded as frail
Total study population (65 years+)	4 876 285	1 464 379	3 411 906	2 459 937	255 312	2 204 625
Male	47.04%	34.02%	52.63%	52.44%	53.84%	52.28%
Age, median (IQR)	75 (70–81)	79 (72–85)	74 (69–79)	74 (70–80)	77 (71–83)	74 (70–80)
Ethnicity						
White	80.96%	83.06%	80.06%	82.85%	84.64%	82.64%
Mixed	0.23%	0.23%	0.23%	0.17%	0.16%	0.17%
Asian	2.55%	1.12%	3.16%	1.53%	1.38%	1.55%
Black	1.11%	1.11%	1.11%	0.66%	0.54%	0.67%
Other	0.62%	0.51%	0.67%	0.46%	0.40%	0.46%
Not stated/missing	14.52%	13.96%	14.76%	14.33%	12.88%	14.50%
Deprivation						
Quintile #5 (least deprived quintile)	23.37%	19.71%	24.94%	26.19%	24.52%	26.38%
Quintile #4	22.87%	20.89%	23.72%	24.45%	23.27%	24.59%
Quintile #3	21.29%	20.97%	21.43%	21.51%	21.22%	21.54%
Quintile #2	17.68%	19.63%	16.84%	16.08%	17.03%	15.96%
Quintile #1 (most deprived quintile)	14.80%	18.80%	13.08%	11.77%	13.95%	11.52%
Rural location	22.27%	19.08%	23.64%	25.04%	22.56%	25.32%
Diagnosis history (previous 3 years)						
No frailty syndromes, mean (SD)	0.36 (0.76)	0.51 (0.90)	0.30 (0.68)	0.29 (0.67)	0.40 (0.80)	0.28 (0.65)
No Elixhauser conditions, mean (SD)	2.07 (1.90)	2.30 (1.99)	1.97 (1.85)	1.95 (1.83)	2.22 (1.96)	1.92 (1.81)
Frailty (1+ frailty-related syndrome)	24.69%	32.72%	21.24%	21.05%	26.90%	20.37%
Multimorbidity (2+ Elixhauser conditions)	53.83%	58.93%	51.64%	51.15%	57.09%	50.46%
History of mental ill health	21.19%	26.18%	19.05%	18.30%	22.27%	17.84%
Rates of hospital usage (previous 12 months), mean (SD)						
A&E attendances	0.61 (1.27)	0.74 (1.50)	0.56 (1.16)	0.54 (1.14)	0.67 (1.30)	0.53 (1.11)
Emergency admissions	0.38 (0.88)	0.48 (1.01)	0.34 (0.81)	0.33 (0.80)	0.42 (0.93)	0.32 (0.79)

For more baseline characteristics, please see online supplemental file 2.

\*Study population consisted of all people aged 65 years or older, registered at GP practices in England on 16 December 2018 and living in England, with a valid pseudonymised UPRN, not living in a care home, with at least one hospital admission in the previous 3 years, and living in a household of either six people or fewer, or two people, respectively. A&E, accident and emergency; GP, general practitioner; UPRN, Unique Property Reference Number.

also had greater numbers of A&E attendance and emergency admissions in the twelve months prior to our study period (0.74 vs 0.56 and 0.48 vs 0.34, respectively) than people in households of 2–6 people.

Among people aged 65 or over living in two-person households, people living with someone with frailty had a median age of 77, compared with 74 for people living with a cohabitee who was not recorded as frail (table 1, online supplemental file 2). 54% (vs 52%) were male and 14% (vs 12%) lived in the most deprived quintile. People living with someone with frailty were on average themselves more likely to be frail (27% vs 20%), with on average 0.40 (vs 0.28) frailty syndromes, and had more long-term conditions (2.22 vs 1.92). They also had greater rates of A&E attendance and emergency admissions in the 12 months prior (0.67 vs 0.53 and 0.42 vs 0.32, respectively) compared with people living with a cohabitee who was not recorded as frail.

### Statistical analysis

People aged 65 or over living alone had on average 0.78 A&E attendances per person per year in the follow-up period, compared with 0.56 for people living in households of 2–6 people. They had on average 0.51 emergency admissions per person per year, compared with 0.33 for people living in households of 2–6 people (table 2). Without adjusting for baseline characteristics, people living alone had substantially higher rates of A&E attendance (unadjusted rate ratio 1.44, 95% CI 1.43 to 1.44) than people living in households of 2–6 people (table 3). They also had higher rates of emergency admissions (unadjusted rate ratio 1.60, 95% CI 1.60 to 1.61).

After adjusting for baseline characteristics, we found that people living alone still had statistically significantly higher rates of A&E attendances (adjusted rate ratio 1.09, 95% CI 1.09 to 1.10) and emergency admissions (1.14, 95% CI 1.14 to 1.15, table 3).

**Table 2** Crude rates of emergency hospital use (number of events per person per year)

Outcomes over the follow-up period	People 65+ years living in households up to six people				People 65+ years living in households of two people			
	Living alone		Not living alone		Living with someone with frailty		Cohabitee not recorded as frail	
	Events	Crude rate*	Events	Crude rate*	Events	Crude rate*	Events	Crude rate*
Total no people	1 464 379		3 411 906		255 312		2 204 625	
Person-years of follow-up	1 359 094		3 251 440		226 373		2 077 846	
A&E attendances	1 062 731	0.78	1 818 519	0.56	157 137	0.69	1 102 683	0.53
Emergency admissions	692 345	0.51	1 073 870	0.33	98 584	0.44	654 784	0.32

\*Number of events per person, per year.  
A&E, accident and emergency.

People living with someone with frailty had on average 0.69 A&E attendances per person per year, compared with 0.53 for people living in two-person households where the cohabitee was not recorded as frail. They had on average 0.44 emergency admissions per person per year, compared with 0.32 for people living in two-person households where the cohabitee was not recorded as frail (table 2). Without adjusting for baseline characteristics, people living with someone with frailty had substantially higher rates of A&E attendances (unadjusted rate ratio 1.33, 95% CI 1.32 to 1.34) and emergency admissions (unadjusted rate ratio 1.42, 95% CI 1.41 to 1.44) than the comparison population (table 3). After adjusting for baseline characteristics, people living with someone with frailty in a two-person household still had statistically significantly higher rates of both A&E attendance (adjusted rate ratio 1.09, 95% CI 1.08 to 1.10) and emergency admissions (1.10, 95% CI 1.09 to 1.11, table 3).

Adjusted models included as covariates gender, age, deprivation, ethnicity, geographical region, rural location, history of a range of diagnoses in previous 3 years and historic emergency hospital use in the last 12 months (covariates listed in online supplemental file 2).

### Subgroup analysis

#### Gender

There was no evidence that the adjusted rate ratio for A&E attendances or emergency admissions was statistically significantly different depending on if the person who was living with somebody with frailty was male or female (interaction test  $p=0.101$  and  $p=0.297$ , respectively, online supplemental file 3).

#### Level of deprivation

There was a statistically significant difference in the rate ratios of living alone for different levels of deprivation compared with the least deprived quintile (interaction tests  $p<0.02$ ) in all but the third quintile (ie, the middle group). While people living alone had higher rates of emergency hospital use than those not living alone in each of the five IMD quintiles, the rate ratio for the association between living alone and A&E attendances was lowest in the most deprived quintile (adjusted rate ratio 1.07, 95% CI 1.06 to 1.08) and highest in the least deprived quintile (adjusted rate ratio 1.11, 95% CI 1.10 to 1.11). Similarly, for emergency admissions, it varied between 1.10 (95% CI 1.09 to 1.11) in the most deprived quintile and 1.17 (95% CI 1.15 to 1.18) in the least deprived quintile.

**Table 3** Results of unadjusted and adjusted regression models

	Unadjusted model			Adjusted model		
	Rate ratio	95% CI	P value	Rate ratio	95% CI	P value
Living alone						
A&E attendances	1.44	1.43 to 1.44	<0.001	1.09	1.09 to 1.10	<0.001
Emergency admissions	1.60	1.60 to 1.61	<0.001	1.14	1.14 to 1.15	<0.001
Living with someone with frailty						
A&E attendances	1.33	1.32 to 1.34	<0.001	1.09	1.08 to 1.10	<0.001
Emergency admissions	1.42	1.41 to 1.44	<0.001	1.10	1.09 to 1.11	<0.001

A&E, accident and emergency.



(online supplemental file 3). In other words, the association between living alone and increased hospitalisation was stronger for less deprived groups.

### Sensitivity analysis

#### Stable household composition only

Limiting the study population to individuals whose household composition did not change over the year, the adjusted rate ratio for living alone compared with households of 2–6 people for A&E attendance was 1.06 (95% CI 1.06 to 1.07); for emergency admissions this was 1.10 (95% CI 1.09 to 1.10) (online supplemental file 4). For the analysis of living with someone with frailty, the adjusted rate ratio for A&E attendance was 1.08 (95% CI 1.07 to 1.09) and for emergency admissions 1.08 (95% CI 1.07 to 1.09).

#### Omitting covariates on prior emergency hospital use

Adjusting for baseline characteristics excluding prior emergency hospital use, the adjusted rate ratio for A&E attendance was 1.11 (95% CI 1.11 to 1.12) and for emergency admissions 1.16 (95% CI 1.15 to 1.16) for the living alone analysis (online supplemental file 4). For the analysis of living in a two-person household with someone with frailty, the adjusted rate ratio for A&E attendance was 1.11 (95% CI 1.10 to 1.12) and for emergency admissions 1.11 (95% CI 1.10 to 1.12).

## DISCUSSION

Our analysis showed that both living alone and living with somebody with frailty are strongly associated with higher emergency hospital use in the 1-year follow-up period. We found that differences in demographic characteristics and underlying health conditions explain most of this association; however, even after adjusting for baseline demographic and clinical characteristics, people living alone attend A&E 9% more often and are admitted to hospital in an emergency 14% more often than those living with others. Similarly, individuals living with someone who has frailty attend A&E 9% more often and are admitted to hospital as an emergency 10% more often than others in a two-person household.

It is important to note that although older people living alone may be at higher risk of social isolation, this is an imperfect proxy at best. For example, an individual residing alone may have a rich social network of family and friends and/or have access to formal or informal care; routine administrative data cannot capture these nuances. Similarly, individuals living in a two-person household with someone with frailty may have access to formal or informal support and care. Furthermore, this analysis does not provide insight into the mechanism by which these two household factors affect individuals' emergency healthcare needs.

Nevertheless, we have found a strong association between these two factors and emergency hospital use, even after correcting for other factors predictive of

hospital use. This indicates that these metrics are picking up on an additional healthcare need that is not explained by commonly known predictors, such as prior hospital use or frailty.

Ideally a person's support needs should be assessed individually and in person, especially for their clinical management. However, this analysis demonstrates how existing administrative data can be used to derive household context factors that can be used in the absence of such information being recorded. These household context factors could improve population risk algorithms, budget models or initial service eligibility criteria. For instance, these factors could be used to help identify populations for targeted anticipatory care initiatives such as MDTs that may be able to mitigate some social as well as medical risk factors to prevent later deteriorating health or hospitalisation.

Household context factors can also contribute to more robust research and evaluation by allowing for the adjustment of previously unobserved characteristics affecting healthcare outcomes, thereby decreasing the risk of bias in analyses.

This analysis found that, although higher levels of deprivation are associated with higher emergency hospital use, the interaction between level of deprivation and living alone was counterintuitive: individuals living alone in the most deprived areas had a lower increase in hospitalisation rates (compared with those not living alone in similar areas) than individuals living alone in the least deprived areas. It is not possible to determine from our analyses why this may be. It may be that there are differences in health-seeking behaviours, or different access to formal or informal care outside of the household, which in turn could lead to either more (if identifying need) or less (if addressing need) emergency hospital use. Qualitative research is needed to understand the mechanisms behind these results, and to provide context and nuance.

### Strengths and limitations

While prior studies on living alone or informal carers have used survey or local data, this analysis uses routinely collected national data from approximately 4.9m people aged 65 or over, thereby providing robust findings. Through accessing other routine data collections, the analysis could control for common demographic and clinical factors predictive of emergency hospital use, including many long-term conditions. However, the study population was restricted to people in England aged 65 and over, who were admitted to hospital in the 3 years prior to our analysis. Although this allowed for the derivation of pre-existing conditions from previous hospital records, our analysis is restricted to people that are older and sicker compared with the overall population, limiting the generalisability of our findings. Furthermore, the analysis was restricted to households of up to six people, in order to exclude communal establishments such as care home or prisons. Excluding households of seven or more people will likely disproportionately exclude people from

certain ethnic backgrounds, who more often have multigenerational households.<sup>31</sup>

Our findings are nonetheless broadly consistent with other studies that have previously found strong links between older people living alone and their emergency hospital use.<sup>13 32 33</sup> To our knowledge, there are no statistical studies on living with someone with frailty, although results are broadly consistent with the literature on informal carers. A study on multimorbidity within households found inconsistent results of cohabitants' multimorbidity status on emergency hospital use.<sup>16</sup>

The household context factors were derived from address information collected by general practices in England. For these to be accurate, address information needs to be up to date. Anecdotal evidence suggests that address information is typically well recorded, particularly for the older population, but this could not be validated.

Individuals' health conditions derived from hospital admission records may be under-reported<sup>34</sup> and, therefore, not fully adjusted for in analysis. In particular, frailty may be under-reported<sup>25</sup> or reported differently to general practice.<sup>35</sup> If some individuals who have a cohabitee with frailty were misclassified, the association with emergency hospital use was potentially underestimated. IMD quintiles are based on an individual's local neighbourhood and may not reflect an individual's economic circumstances. Ethnicity was derived from hospital records, the best available source for large-scale linkage. However, SUS has known limitations: minority ethnic groups are under-represented compared with national census, there is a substantial number of records with a code of 'not stated', 'not known' and 'other', and these are not uniformly distributed across ethnic groups.<sup>36</sup> SUS data do not include all mental health trust activity; therefore, emergency admissions for mental health issues may be under-reported.

The study only looks at hospital use over a 1-year period due to data constraints. Although this allows for an accurate reflection of the population, and accounts for seasonality, the impact of household context may have materialised either earlier or later than the study period, and so would ideally have been estimated from a long-term cohort.

### Future work

Other household context factors can be developed using the UPRNs derived from GP registration data, including recent bereavement, recent change to living alone, moving into a care home or multiple moves within a given period, which may be a proxy for unstable housing.

### CONCLUSION

This study shows 'proof of concept' that nationally collected and pseudonymised address data can be used to determine household context factors that provide important and useful information to understand patients' health and care needs, while maintaining patient confidentiality. In particular, living in a two-person household with someone with frailty is a

novel indicator, which has not previously been developed or analysed.

Both living alone and living with a person with frailty were shown to be strongly associated with higher emergency hospital use, underlining the importance of these household context factors in understanding individuals' health risk and the potential to harness these data for identifying individuals for targeted interventions like MDTs. Informal carers, who play a critical role in our health and social care system, are often overlooked; these analyses add to the evidence that it is crucial to provide support to this group, as well as to those living alone. Although other research, particularly on living alone, shows similar links, this is, to our knowledge, the first time that an analysis on routine data on a national scale has been used.

Although these metrics cannot replace a personal assessment of an individual's social context and support needs, our analyses demonstrate that these household context factors can be used not only to improve analyses, but also for planning, commissioning and population health management.

### Author affiliations

<sup>1</sup>Improvement Analytics Unit, The Health Foundation, London, UK

<sup>2</sup>Department of Health Services Research and Policy, London School of Hygiene and Tropical Medicine Faculty of Public Health and Policy, London, UK

**Acknowledgements** The authors thank Lynn Laidlaw for her input during the development stage and to her and Joanna C, both patient representatives, for their insights and comments on an early draft. We also thank Stefano Conti and Emma Vestesson for advice on the analysis, and Stephen O'Neill, Hardeep Aiden, Adam Tinson, Kathryn Marszalek and Mai Stafford for their comments on an earlier draft. This work uses data provided by patients and collected by the NHS as part of their care and support.

**Contributors** TL and RJB designed the study. RJB derived the household context indicators and created the analysis dataset. EC performed the analysis. TL, EC, RJB, JYS and ATW contributed to the interpretation of the work. TL, RJB and EC drafted the paper; all authors revised and contributed to the paper. All authors read and approved the final manuscript. ATW is the guarantor.

**Funding** JYS received PhD funding from UKRI/Economic and Social Research Council.

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

**Patient consent for publication** Not applicable.

**Ethics approval** This study requires no ethics board approval as the analysis uses pseudonymised data transferred by the National Commissioning Data Repository to the Improvement Analytics Unit, which is a data processor on behalf of NHS England and NHS Improvement.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** No data are available.

**Supplemental material** This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which

permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

#### ORCID iDs

Therese Lloyd <http://orcid.org/0000-0002-5915-6136>

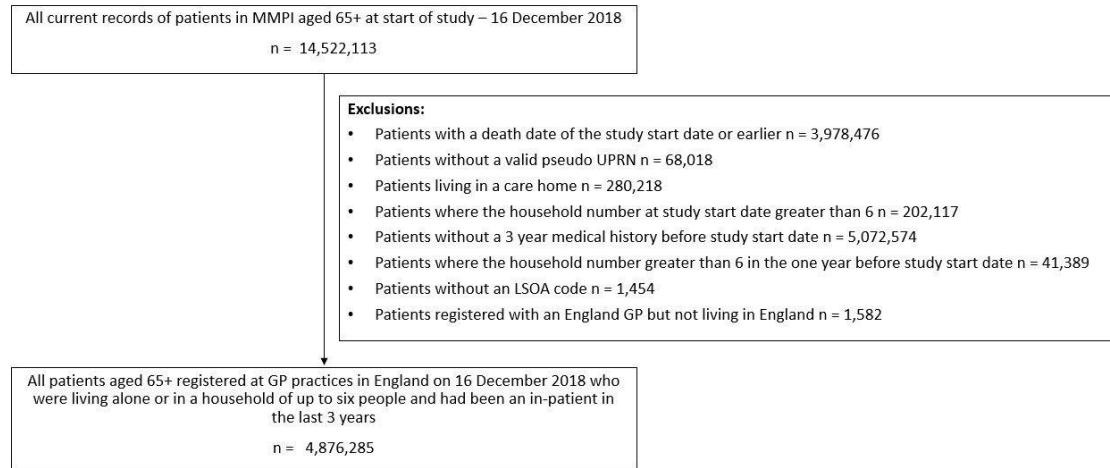
Elizabeth Crellin <http://orcid.org/0000-0001-8774-224X>

#### REFERENCES

- The Health Foundation. Social determinants of health. Available: <https://www.health.org.uk/topics/social-determinants-of-health> [Accessed 12 Oct 2021].
- Marmot M, Allen J, Goldblatt P. Fair society, healthy lives: strategic review of health inequalities in England post-201. London, 2010. Available: <http://www.instituteofhealthequity.org/resources-reports/fair-society-healthy-lives-the-marmot-review/fair-society-healthy-lives-full-report-pdf.pdf> [Accessed 21 Jun 2018].
- Marmot M, Wilkinson RG. *Social determinants of health*. 2nd edn. Oxford: Oxford University Press, 2005.
- Stokes J, Riste L, Cheraghi-Sohi S. Targeting the 'right' patients for integrated care: stakeholder perspectives from a qualitative study. *J Health Serv Res Policy* 2018;23:243–51.
- Stokes J, Panagioti M, Alam R, et al. Effectiveness of Case Management for 'At Risk' Patients in Primary Care: A Systematic Review and Meta-Analysis. *PLoS One* 2015;10:e0132340.
- Brown S. Qualitative evaluation of South Warwickshire place based teams 2021.
- Lewis G, Curry N, Bardsley M. Choosing a predictive risk model : a guide for commissioners in England 2011;20.
- Holt-Lunstad J, Smith TB, Baker M, et al. Loneliness and social isolation as risk factors for mortality: a meta-analytic review. *Perspect Psychol Sci* 2015;10:227–37.
- Bucholz EM, Rathore SS, Gosch K, et al. Effect of living alone on patient outcomes after hospitalization for acute myocardial infarction. *Am J Cardiol* 2011;108:943–8.
- Hawkey LC, Cacioppo JT. Loneliness matters: a theoretical and empirical review of consequences and mechanisms. *Ann Behav Med* 2010;40:218–27.
- Aiden H. Isolation and loneliness: an overview of the literature, 2016. Available: <https://www.redcross.org.uk/-/media/documents/about-us/research-publications/health-and-social-care/co-op-isolation-loneliness-overview.pdf>
- Sanders S. Families and households in the UK: 2019, 2019. Available: <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/datasets/familiesandhouseholdsfamiliesandhouseholds>
- Dreyer K, Steventon A, Fisher R. The association between living alone and health care utilisation in older adults : a retrospective cohort study of electronic health records from a London general practice 2018:15–17.
- Bucholz EM, Krumholz HM. Loneliness and living alone: what are we really measuring? *Arch Intern Med* 2012;172:997–1003.
- Bom J, Bakx P, Schut F, et al. The impact of informal caregiving for older adults on the health of various types of caregivers: a systematic review. *Gerontologist* 2019;59:e629–42.
- Stafford M, Deeny SR, Dreyer K, et al. Multiple long-term conditions within households and use of health and social care: a retrospective cohort study. *BJGP Open* 2021;5:1–14.
- Carers UK. State of caring 2018, 2018. Available: <https://www.carersuk.org/for-professionals/policy/policy-library/state-of-caring-2018-2>
- Vasileiou K, Barnett J, Barreto M, et al. Experiences of loneliness associated with being an informal caregiver: a qualitative investigation. *Front Psychol* 2017;8:1–11.
- Harding R, Epiphaniou E, Hamilton D, et al. What are the perceived needs and challenges of informal caregivers in home cancer palliative care? qualitative data to construct a feasible psycho-educational intervention. *Support Care Cancer* 2012;20:1975–82.
- Thomas GPA, Saunders CL, Roland MO, et al. Informal carers' health-related quality of life and patient experience in primary care: evidence from 195,364 carers in England responding to a national survey. *BMC Fam Pract* 2015;16:14–21.
- Office for National Statistics. What does the 2011 census tell us about older people, 2013. Available: <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/ageing/articles/whatdoesthe2011censustellusaboutolderpeople/2013-09-06> [Accessed 13 Oct 2021].
- Carers UK. Facts about carers 2019, 2019. Available: [https://www.carersuk.org/images/Facts\\_about\\_Carers\\_2019.pdf](https://www.carersuk.org/images/Facts_about_Carers_2019.pdf)
- OS Open UPRN. Ordnance survey. Available: <https://www.ordnancesurvey.co.uk/business-government/products/open-uprn> [Accessed 13 Oct 2021].
- Santos F, Conti S, Wolters A. A novel method for identifying care home residents in England: a validation study. *Int J Popul Data Sci* 2020;5:1666.
- Soong J, Poots AJ, Scott S. Developing and validating a risk prediction model for acute care based on frailty syndromes data source. : 2015.
- Soong J, Poots AJ, Scott S, et al. Quantifying the prevalence of frailty in English hospitals. *BMJ Open* 2015;5:e008456.
- Dorning H, Davies A, Blunt I. Quality Watch - Focus on : People with mental ill health and hospital use 2015.
- Elixhauser A, Steiner C, Harris DR, et al. Comorbidity measures for use with administrative data. *Med Care* 1998;36:8–27.
- Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005;43:1130–9.
- Department for Work and Pensions. Family resources survey 2018/2019, 2020. Available: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/791271/family-resources-survey-2017-18.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/791271/family-resources-survey-2017-18.pdf)
- Office for National Statistics. Households by age composition and ethnicity, UK 2018, 2020. Available: <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/adhocs/12005householdsbyagecompositionandethnicityuk2018> [Accessed 13 Oct 2021].
- Mu C, Kecmanovic M, Hall J. Does living alone confer a higher risk of hospitalisation? *Econ Rec* 2015;91:124–38.
- Hull SA, Jones IR, Moser K. Factors influencing the attendance rate at accident and emergency departments in East London: the contributions of practice organization, population characteristics and distance. *J Health Serv Res Policy* 1997;2:6–13.
- Lloyd T, Deeny SR, Steventon A. Weekend admissions may be associated with poorer recording of long-term comorbidities: a prospective study of emergency admissions using administrative data. *BMC Health Serv Res* 2018;18:1–12.
- Hollingshurst J, Housley G, Watkins A, et al. A comparison of two national frailty scoring systems. *Age Ageing* 2021;50:1208–14.
- Scobie S, Spencer J, Raleigh V. Ethnicity coding in English health service datasets, 2021. Available: <https://www.nuffieldtrust.org.uk/news-item/flawed-nhs-records-distort-our-view-of-ethnic-health-gaps-study-shows>



## Supplementary File 1. Inclusion and Exclusion Flow Chart. Created by the authors



Supplementary File 2. Baseline characteristics (full list). Created by the authors

	People 65+ years living in households up to 6 people <sup>a</sup>			People 65+ years living in households of 2 people <sup>a</sup>		
	All	Living Alone	Not living alone	All	Living with someone with frailty	Cohabitee not recorded as frail
Total study population (65 years+)	4,876,285	1,464,379	3,411,906	2,459,937	255,312	2,204,625
Male	47.04%	34.02%	52.63%	52.44%	53.84%	52.28%
Age, median [IQR]	75 [70, 81]	79 [72, 85]	74 [69, 79]	74 [70, 80]	77 [71, 83]	74 [70, 80]
Number living in household, mean (SD)	2.02 (0.99)					
Ethnicity						
White	80.96%	83.06%	80.06%	82.85%	84.64%	82.64%
Mixed	0.23%	0.23%	0.23%	0.17%	0.16%	0.17%
Asian	2.55%	1.12%	3.16%	1.53%	1.38%	1.55%
Black	1.11%	1.11%	1.11%	0.66%	0.54%	0.67%
Other	0.62%	0.51%	0.67%	0.46%	0.40%	0.46%
Not stated/missing	14.52%	13.96%	14.76%	14.33%	12.88%	14.50%
Deprivation						
Quintile #5 (least deprived quintile)	23.37%	19.71%	24.94%	26.19%	24.52%	26.38%
Quintile #4	22.87%	20.89%	23.72%	24.45%	23.27%	24.59%
Quintile #3	21.29%	20.97%	21.43%	21.51%	21.22%	21.54%
Quintile #2	17.68%	19.63%	16.84%	16.08%	17.03%	15.96%
Quintile #1 (most deprived quintile)	14.80%	18.80%	13.08%	11.77%	13.95%	11.52%
Rural location	22.27%	19.08%	23.64%	25.04%	22.56%	25.32%
Region						
East Midlands	8.94%	8.70%	9.04%	9.57%	9.18%	9.62%

East of England	11.69%	11.34%	11.84%	12.23%	11.61%	12.30%
London	10.07%	10.04%	10.09%	7.51%	7.93%	7.46%
North East	5.51%	6.02%	5.28%	5.61%	6.03%	5.57%
North West	14.10%	14.65%	13.86%	13.85%	15.13%	13.70%
South East	17.00%	16.57%	17.19%	17.36%	17.04%	17.40%
South West	11.89%	11.58%	12.02%	12.66%	12.11%	12.72%
West Midlands	10.62%	10.45%	10.69%	10.61%	10.64%	10.61%
Yorkshire and The Humber	10.19%	10.65%	9.99%	10.59%	10.33%	10.62%
Diagnosis history (previous three years)						
No. frailty syndromes, mean (SD) <sup>b</sup>	0.36 (0.76)	0.51 (0.90)	0.30 (0.68)	0.29 (0.67)	0.40 (0.80)	0.28 (0.65)
No. Elixhauser conditions, mean (SD) <sup>b</sup>	2.07 (1.90)	2.30 (1.99)	1.97 (1.85)	1.95 (1.83)	2.22 (1.96)	1.92 (1.81)
Frailty (1+ frailty related syndrome) <sup>b</sup>	24.69%	32.72%	21.24%	21.05%	26.90%	20.37%
Multimorbidity (2+ Elixhauser conditions) <sup>b</sup>	53.83%	58.93%	51.64%	51.15%	57.09%	50.46%
History of mental ill health	21.19%	26.18%	19.05%	18.30%	22.27%	17.84%
History of serious mental ill health	0.72%	1.18%	0.52%	0.48%	0.60%	0.47%
Elixhauser conditions (previous three years)						
Alcohol abuse	2.70%	3.29%	2.45%	2.36%	2.69%	2.32%
Blood loss anaemia	0.12%	0.15%	0.10%	0.10%	0.12%	0.10%
Deficiency anaemia	5.50%	6.65%	5.01%	4.84%	5.95%	4.71%
Cardiac arrhythmias	18.93%	21.61%	17.77%	18.14%	21.53%	17.75%
Coagulopathy	0.90%	0.92%	0.90%	0.89%	0.95%	0.88%
Depression	5.89%	7.71%	5.11%	4.97%	6.46%	4.80%
Diabetes, complicated	2.12%	2.20%	2.09%	1.90%	2.24%	1.86%
Diabetes, uncomplicated	15.85%	16.04%	15.76%	14.84%	16.76%	14.62%

Drug abuse	0.11%	0.18%	0.09%	0.07%	0.10%	0.07%
Fluid/electrolyte disorders	7.44%	9.82%	6.42%	6.22%	7.96%	6.01%
Hypertension, complicated	0.25%	0.26%	0.24%	0.23%	0.25%	0.22%
Hypertension, uncomplicated	52.18%	55.71%	50.66%	50.42%	54.70%	49.93%
Hypothyroidism	8.37%	10.17%	7.60%	7.64%	8.40%	7.56%
Liver disease	2.30%	2.39%	2.26%	2.17%	2.33%	2.15%
Lymphoma	0.97%	0.88%	1.01%	1.03%	1.04%	1.03%
Obesity	7.88%	7.19%	8.18%	7.92%	8.12%	7.90%
Other neurological disorders	4.26%	4.64%	4.10%	4.11%	4.88%	4.02%
Peptic ulcer disease excl. bleeding	1.54%	1.63%	1.50%	1.46%	1.63%	1.44%
Psychoses	0.42%	0.76%	0.27%	0.24%	0.32%	0.23%
Pulmonary circulation disorders	1.85%	2.20%	1.71%	1.69%	1.86%	1.67%
Peripheral vascular disease	4.96%	5.41%	4.76%	4.78%	5.74%	4.66%
Renal failure	9.99%	12.51%	8.91%	8.90%	11.31%	8.62%
Rheumatoid arthritis / collagen vascular diseases	5.57%	6.30%	5.26%	5.38%	5.94%	5.31%
Solid tumour without metastasis	7.30%	6.62%	7.59%	7.78%	7.89%	7.77%
Valvular disease	6.90%	8.05%	6.40%	6.46%	7.72%	6.32%
Weight loss	2.54%	2.99%	2.34%	2.27%	2.96%	2.20%
Congestive heart failure	7.15%	8.99%	6.36%	6.24%	8.04%	6.04%
Chronic pulmonary disease	19.67%	21.65%	18.82%	18.49%	20.95%	18.21%
Hemiplegia or paraplegia	1.18%	1.34%	1.11%	1.05%	1.28%	1.03%
Metastatic solid tumour / metastatic cancer	2.07%	1.89%	2.15%	2.17%	1.99%	2.19%
Frailty syndromes (previous three years)						
Anxiety or depression	8.51%	10.93%	7.46%	7.36%	9.14%	7.16%
Cognitive impairment	7.14%	9.95%	5.93%	5.80%	8.52%	5.49%

Functional dependence	1.32%	2.27%	0.91%	0.89%	1.57%	0.81%
Fall or significant fracture	11.80%	17.11%	9.52%	9.54%	12.65%	9.18%
Incontinence	1.78%	2.44%	1.50%	1.45%	2.00%	1.38%
Mobility problems	4.24%	6.31%	3.35%	3.25%	4.80%	3.07%
Pressure ulcers	1.36%	2.14%	1.03%	1.00%	1.47%	0.94%
Other conditions predictive of emergency admissions (previous three years)						
Miscellaneous cognitive dysfunction	6.35%	8.73%	5.33%	5.21%	6.97%	5.01%
Cerebral vascular disease	6.73%	8.33%	6.04%	5.97%	7.44%	5.80%
Dementia	3.09%	3.96%	2.72%	2.63%	4.05%	2.47%
Myocardial infarction	9.19%	9.59%	9.02%	8.91%	10.89%	8.68%
Any hospital usage (previous 12 months) <sup>b</sup>						
A&E attendance <sup>b</sup>	34.50%	39.42%	32.38%	31.73%	36.68%	31.15%
Emergency admission <sup>b</sup>	24.39%	29.48%	22.20%	21.81%	26.26%	21.29%
Chronic ACS emergency admission <sup>b</sup>	3.61%	4.48%	3.24%	3.14%	4.00%	3.04%
Acute ACS emergency admission <sup>b</sup>	6.07%	7.62%	5.40%	5.22%	6.92%	5.03%
Rates of hospital usage (previous 12 months), mean (SD)						
A&E attendances	0.61 (1.27)	0.74 (1.50)	0.56 (1.16)	0.54 (1.14)	0.67 (1.30)	0.53 (1.11)
Emergency admissions	0.38 (0.88)	0.48 (1.01)	0.34 (0.81)	0.33 (0.80)	0.42 (0.93)	0.32 (0.79)
Chronic ACS emergency admissions	0.05 (0.28)	0.06 (0.32)	0.04 (0.26)	0.04 (0.26)	0.05 (0.29)	0.04 (0.25)
Acute ACS emergency admissions	0.08 (0.36)	0.10 (0.42)	0.07 (0.33)	0.06 (0.32)	0.09 (0.38)	0.06 (0.31)

<sup>a</sup>Study population consisted of all people aged 65 years or older, registered at GP practices in England on 1 December 2018 and living in England, with a valid pseudonymized UPRN, not living in a care home, living in a household of 6 people or fewer, and with at least one hospital admission in the previous three years.

<sup>b</sup>Not adjusted for in the main analysis.

Supplementary File 3: Subgroup analyses: interaction results (a) living alone and deprivation and b) living with someone with frailty and gender. Created by the authors

	A&E attendance			Emergency admissions		
	Rate ratio	95%CI	P value for interaction term	Rate ratio	95%CI	P value for interaction term
<b>Living alone<sup>a</sup></b>						
Living alone, IMD quintile 5 (least deprived, reference group)	1.11	(1.10 to 1.11)		1.17	(1.15 to 1.18)	
Living alone, IMD quintile 4	1.09	(1.08 to 1.10)	0.012	1.14	(1.13 to 1.16)	0.009
Living alone, IMD quintile 3	1.11	(1.10 to 1.12)	0.548	1.17	(1.15 to 1.18)	0.993
Living alone, IMD quintile 2	1.09	(1.08 to 1.10)	0.005	1.14	(1.13 to 1.15)	0.001
Living alone, IMD quintile 1 (most deprived)	1.07	(1.06 to 1.08)	<0.001	1.10	(1.09 to 1.11)	<0.001
<b>Living with someone with frailty<sup>b</sup></b>						
Living with someone with frailty, female (reference group)	1.08	(1.07 to 1.10)		1.10	(1.09 to 1.12)	
Living with someone with frailty, male	1.10	(1.09 to 1.11)	0.101	1.09	(1.08 to 1.11)	0.297

<sup>a</sup>Adjusted for covariates listed in supplementary file 2, and interaction term for living alone and quintiles of deprivation.

<sup>b</sup>Adjusted for covariates listed in supplementary file 2, and interaction term for living with someone with frailty and gender.

Supplementary File 4. Sensitivity analyses: study population limited to individuals whose household composition did not change over the study period, and not adjusting for history of emergency hospital use. Created by the authors

	N	Rate ratio	95%CI	P value
<b>Living alone: study population limited to individuals whose household composition did not change over the study period<sup>a</sup></b>				
A&E attendances	4,601,533	1.06	(1.06 to 1.07)	<0.001
Emergency admissions	4,601,533	1.10	(1.09 to 1.10)	<0.001
<b>Living alone: not adjusting for history of emergency hospital use<sup>b</sup></b>				
A&E attendances	4,876,285	1.11	(1.11 to 1.12)	<0.001
Emergency admissions	4,876,285	1.16	(1.15 to 1.16)	<0.001
<b>Living with someone with frailty: study population limited to individuals whose household composition did not change over the study period<sup>a</sup></b>				
A&E attendances <sup>c</sup>	2,266,187	1.08	(1.07 to 1.09)	<0.001
Emergency admissions <sup>c</sup>	2,266,187	1.08	(1.07 to 1.09)	<0.001
<b>Living with someone with frailty: not adjusting for history of emergency hospital use<sup>b</sup></b>				
A&E attendances <sup>d</sup>	2,459,937	1.11	(1.10 to 1.12)	<0.001
Emergency admissions <sup>d</sup>	2,459,937	1.11	(1.10 to 1.12)	<0.001

<sup>a</sup>Adjusted for covariates listed in Supplementary File 2.

<sup>b</sup>Adjusted for covariates listed in Supplementary File 2 excluding emergency hospital use in the 12 months prior to analysis period.

<sup>c</sup>Note: A&E attendances: rate ratio 1.083 (95% CI 1.075 to 1.092). Emergency admissions: rate ratio 1.081 (95% CI 1.070 to 1.093).

<sup>d</sup>Note: A&E attendances: rate ratio 1.110 (95% CI 1.101 to 1.118). Emergency admissions: rate ratio 1.111 (95% CI 1.100 to 1.123).