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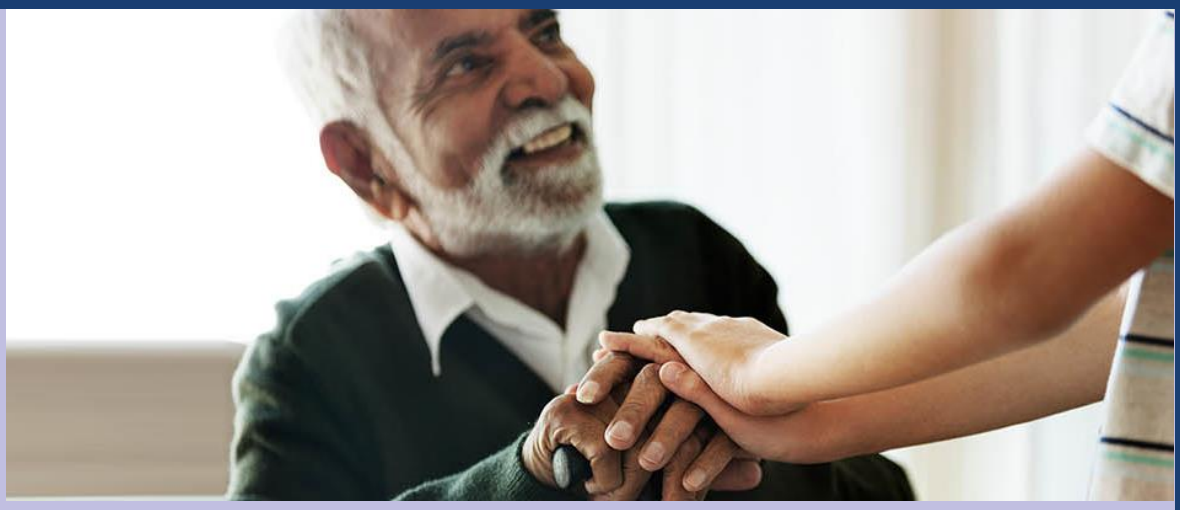

Using individual and neighbourhood profiles and trends to understand frailty with nationally representative population data

Part 4: The effect of mapped mismatch between levels of frailty and receipt of care on unplanned admission, admission due to falls, pressure ulcer, and fractures

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Background

Demands for care services for older people increases with population ageing (1). Government expenditure on formal adult social care reached £18.9 billion in 2020, with most recipients of services aged 65 years and older (2). That expenditure, however, covers only individuals deemed sufficiently in need and unable to cover their own care to receive the support they require. The 2014 Social Care Act requires adults who have assets over £23,250 (excluding the value of their main home) to pay the full cost of their care (3). Individuals who have assets less than £23,250 will contribute to the cost of their care from the local authority, depending on their income and savings. A substantial proportion of adult care in England is thus paid for privately or provided informally by carers, including spouses, other family members, friends or neighbours (4). Despite the government and private care expenditure and informal care, evidence indicates that around 1.5 million people aged 65+ in England have an unmet need for care (5).

Frailty, which describes how bodies gradually lose their in-built reserves with increasing age (6), is used as a framework for understanding health discrepancies among older adults and as a significant predictor of care receipt (7). Approximately 6.8% of people aged 60-64 in England have frailty, rising to around 40.8% of people over 90 (8). Almost all older people with frailty (93%) experience mobility problems, and over half of them have difficulties with washing, dressing or housework (9). Older people with frailty are thus more likely to be in need of social care services.

A study in England estimated that the mean annual formal social care costs for older adults living at home who were frail (£2,895) are nine times higher than for those who were not frail (£321) (10). This does not include informal costs, however, care home costs which will be much higher. Our prior work estimated that around 0.7 million and 1.6 million people aged 65+ in England were frail and prefrail, respectively, in 2018, but only 0.5 million adults in the same age group received government paid for care (11). We found also that 82% (124 from 151) of the local authorities in the study have a greater number of persons with frailty aged 65+ than care recipients within the same age range, suggesting, given that frail individuals are more likely to require care, that there may be a care deficit present in much of the country.

Frailty is associated with increased health care use, and hospital admissions represent a substantial proportion of the overall costs of the disease (12, 13). Frailty leads to an annual additional 1.0 million emergency admissions and 1.1 million elective admissions in England (14). Frail patients are also more likely to be attended by an ambulance for incidents which do not require conveyance to hospital (15). In addition, severely frail older people have seven times longer lengths of stay in hospital than non-frail older people, following emergency hospitalisation. The evidence on the effect of unmet need for care among frail older people and their future health care utilisation is limited. A study using data from 2,943 frail older people enrolled in the Program of All-inclusive Care for the Elderly (PACE) found that participants with unmet Activity of

Daily Living (ADL) needs have higher rates of admissions, and this association diminished when their needs were met (16). However, the types of admission were not specified in the study.

The aim of this analysis was to determine the impact of frailty and care received on the risk of unplanned admission to hospital for any cause and for conditions associated with frailty: falls (17, 18), pressure ulcers (19, 20), and fractures (21, 22).

Methods

Subjects and Setting

The analysis presented in the report uses data from a dataset that combines the English Longitudinal Study of Ageing (ELSA) (23) with the census of public hospital records in England, the Hospital Episode Statistics (HES) (24), and mortality data from the Office for National Statistics (25). ELSA is a panel survey of a representative sample of the household population aged 50 and older in England (23). Respondents are interviewed on a range of core topics, including demographic and economic characteristics, their health and wellbeing, and household structure. The baseline interviews of ELSA were conducted in 2002, with follow up surveys (or 'waves') undertaken at 2-year interval periods. To date, there have been nine waves of ELSA with the most recent in 2019. Our analysis used data from ELSA waves 6 to 8. All individuals included in the analysis had data linked to HES and Office for National Statistics (ONS) mortality (including those who dropped out of the study after the baseline survey). Both HES and ONS data was available until 31 January 2018. For the purposes of this report, we included ELSA participants aged 60 and older.

Measures

Frailty

Frailty was assessed using a frailty index derived from data collected as part of ELSA. The frailty index included 60 variables ('deficits') representing conditions that accumulate with age and are associated with adverse outcomes, including disability, mobility, sensory impairments, cognitive function, and chronic diseases. The full list of variables which were used to create the frailty index are shown in **Supplementary Table 1**. An individual's frailty index is calculated as the proportion of possible deficits which are present in an individual and ranges from 0 to 1. Frailty indices with at least 30-40 deficits can predict adverse outcomes accurately (26, 27). Frailty was measured at baseline (Wave 6). We categorised the frailty index into three groups: robust (frailty index ≤ 0.08), prefrail (frailty index >0.08-0.25) and frail (frailty index ≥ 0.25) (28).

Frequency of care and unmet need for care

Respondents in ELSA were asked to respond to questions about their care if they reported having at least one difficulty with mobility, an ADL or an Instrumental Activity of Daily Living (IADL) (29). Based on the frequency of care received, we categorised respondents into those in receipt of: [1] frequent care; [2] infrequent care; and [3] did not receive care. Participants who have received care were also asked whether their care meets their needs. We classified the respondents into having: [1] unmet care needs; [2] met care needs; and [3] did not receive care. The full description of each category is available in **Supplementary File 1**.

Outcome measures

1. Unplanned admissions:
   Hospitalisations were derived from the Hospital Episode Statistics data linked by NHS digital to ELSA participants' NHS number, date of birth, gender and postcode. An unplanned admission was defined as admission to hospital through: [1] accident and emergency; [2] general practitioner (GP) after request of immediate admission; [3] bed bureau (an administrative unit that ensures that patients needing urgent admission are directed to a hospital which will admit them (30)); [4] consultant clinic; [5] Mental Health Crisis Resolution team; and [6] other Accident and Emergency (A&E) (for instance, admitted from the Emergency Care Department of another provider where they had not been admitted (31)). The full list of the HES method of admission codes is shown in **Supplementary Table 2** (31).
2. Hospitalisation due to falls:
   For each respondent, a record of admission date, length of stay, primary diagnosis and secondary diagnoses of each hospitalisation is available (32). Diagnoses are coded according to the international classification of disease 10th version (ICD-10) (33). Falls correspond to the ICD-10 codes W00 to W19. The event "fall" was defined as the first hospitalisation where a diagnosis of fall was recorded since baseline (wave 6).
3. Hospitalisation due to pressure ulcer:
   Pressure ulcer corresponds to the ICD-10 codes L89. The event "pressure ulcer" was defined as the first hospitalisation where a diagnosis of pressure ulcer was recorded since baseline.
4. Hospitalisation due to fractures:
   Fractures correspond to the ICD-10 codes M, S and T (see **Supplementary Table 3**). The event "fracture" was defined as the first hospitalisation where a diagnosis of fracture was recorded since baseline.

Covariates

Age was included in the principal analysis as a continuous variable and in sensitivity analysis after categorisation into 5-year age groups (60-64; 65-69; 70-74; 75-79; 80-84; 85+). Gender (male / female), ethnicity (white / non-white) and marital status (married / not married) were categorised as indicated. Educational attainment was assessed as the highest educational level and categorised into lower than secondary school (reference), secondary school, and college or higher. Wealth was measured by the net total wealth of the respondent's benefit unit (defined as a single adult, or a married or cohabiting couple, and any dependent children (34)). Net total wealth comprised the sum of savings and investments after financial debt was subtracted. We split wealth into quintiles to investigate hierarchical effects of wealth.

Statistical analysis

To examine the effect of mismatch between levels of frailty and receipt of care on each hospitalisation category in this study, we employed competing-risk regression analysis using a version of the Fine and Gray analysis (35). This analysis allows a competing

risk – an event that might occur during the follow-up instead of the event of interest – to be considered in the model. Death is the potential competing risk in this study when examining hospital admissions. Mortality status was ascertained from linked register data, up to the end of January 2018. Frailty, frequency of care and need for care were defined at wave 6 (2012/2013) and the follow-up time up to 31 January 2018. We present the results as the subdistribution hazard ratios (SHRs) and 95% confidence intervals (95% CIs) (36). The subdistribution hazard function is defined as the instantaneous rate of occurrence of hospitalisation in older people who have not yet experienced it during the time of the study (36). The SHR is the ratio of these functions in the presence of two different values of a covariate (e.g., a person who is frail relative to a person who is not frail).

For unplanned admissions as the outcome, we performed the analysis separately for frequency of care and need for care. The first analysis included frailty status (robust as the reference, prefrail, and frail) and frequency of care (no care as the reference, infrequent and frequent care) while the second analysis included frailty status (robust as the reference, prefrail, and frail) and need for care (no care as the reference, met care needs, and unmet care needs). All analyses were adjusted for age, gender ethnicity, marital status, wealth and education.

We further performed the analysis by gender and categorised the care receipt into: (1) received care; and (2) did not receive care. The same categorisation was used for analysis for conditions associated with frailty: falls, pressure ulcers, and fractures.

We checked for the presence of an interaction between frailty status and frequency of care, as well as frailty status and need for care on the risk of hospitalisation. We further checked for the presence of an interaction between frailty status with frequency of care and need for care (**Supplementary File 1**).

Sensitivity analysis

We performed three types of sensitivity analyses. Firstly, we used age categorised into groups (60-64; 65-69; 70-74; 75-79; 80-84; 85+) instead of age as a continuous variable.

Secondly, we performed two analyses on different sets of short epochs of time. The first set of epochs of time are: [1] wave 6 as the baseline with 6 months follow-up; [2] wave 7 baseline with 6 months follow-up; and [3] wave 8 baseline; 6 months follow-up. The second set of epochs of time are: [1] wave 6 baseline with 12 months follow-up; [2] wave 7 baseline with 12 months follow-up; and [3] wave 8 baseline; 6 months follow-up. We performed two meta-analyses using those two sets of epochs of time. In those analyses, frailty status, frequency of care and need for care were defined at each wave 6, 7, and 8. The start date was defined as the interview date. Age was defined as the age at each wave, and we had two different follow-up lengths for each wave, except for wave 8: 6 and 12 months. We could not have the similar follow-up length in wave 8 as the data were only available until 31 January 2018 (6 months after Wave 8 enrolled).

Finally, we performed the analysis by putting a censor date between two interview dates if there were any changes in frailty status, frequency of care or need for care between two waves of ELSA. When a person's response changed between waves, we assumed the change occurred midway between the waves (censor date). The respondents were followed-up until the censor date, death or end of study if they did not change frailty status.

Results

Subject characteristics including frailty status

Descriptive characteristics of the study sample including the proportion of adults aged 60 years and older who were frail and prefrail are presented in **Table 1**. A total of 7,656 subjects, 3,535 men and 4,121 women were included in the analysis. Mean age was 71.1 years, and the majority (97.2%) were white. The majority (65.3%) were married. Almost half (48.8%) of the respondents graduated from college or higher. After application of sample weighting the proportion of subjects who were frail and prefrail was estimated as 17.7% and 40.6%, respectively.

The proportion of respondents with pre-frailty and frailty increased with age. Almost 10% of people aged 60-64 years were frail, increasing to 44.4% among those aged 85 and older. Compared to men, women were more likely to be frail (20.5% vs 14.5%) and also prefrail (43.9% vs 36.7%). Compared to those who did not complete high school, people who graduated from high school and college or higher were less likely to be both frail and prefrail. The proportion of respondents with frailty increased from 5.4% among the wealthiest quintile to 28.72% among the least wealthy quintile.

Characteristics for frequency of care

The proportion of respondents by frequency of care receipt, categorised by frailty status is illustrated in **Figure 1A**. Around a quarter of adults aged 60 years and older in England received care, of which approximately 60% received infrequent care, while the rest had frequent care. Frequency of care receipt is proportionally higher among frail and prefrail than robust older people. 6.4% and 47.6% of the prefrail and frail respondents, respectively, received frequent care. Around a fifth (20.9%) of respondents with prefrailty received infrequent care, while 36.0% of those with frailty had infrequent care.

Characteristics of respondents at baseline by frequency of care are shown in **Supplementary Table 4**. It shows that the proportions of individuals receiving either infrequent or frequent care were higher among those who were older, female, non-White, not married, those who had lower educational attainment and who were less wealthy.

Characteristics for the need for care

Around 18.8% of the respondents with prefrailty stated that they had met need of care, while 5.8% of them reported unmet need for care (**Figure 1B**). Half of the

respondents with frailty stated that they had met need, while almost one-third (31.3%) reported unmet need.

Characteristics of respondents at baseline categorised by need for care is shown in **Supplementary Table 5**. The proportions of individuals reporting unmet need for care were higher among those who were older, female, non-White, not married, had lower education attainment and were less wealthy.

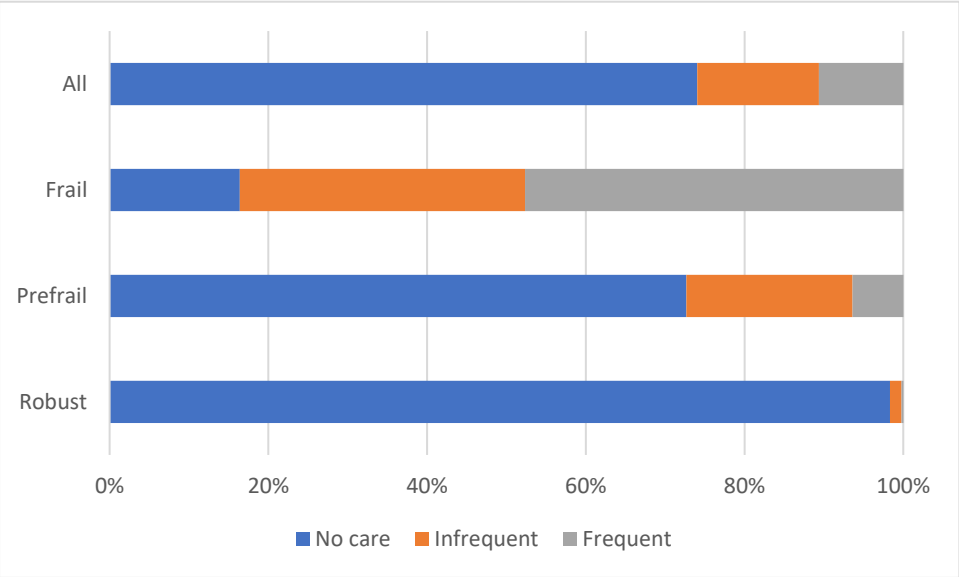
Table 1 Descriptive characteristics of the respondents in ELSA wave 6 (2012/2013). *Notes:* * unweighted; ** weighted

	Mean (SD) or frequency (%)*	Robust**	Prefrail**	Frail**
Frailty index	0.1 (0.1)			
Frailty status, n (%)				
Robust	3,357 (43.9)	2,910 (41.7)		
Prefrail	3,026 (39.5)		2,833 (40.6)	
Frail	1,268 (16.6)			1,239 (17.7)
Age, years	71.1 (8.2)	68.10 (6.5)	72.73 (8.4)	76.28 (9.6)
Age group				
60-64	1,949 (25.5)	1,048 (59.1)	557 (31.4)	168 (9.5)
65-69	1,867 (24.4)	847 (51.4)	602 (36.5)	199 (12.1)
70-74	1,347 (17.6)	500 (41.2)	540 (44.4)	175 (14.4)
75-79	1,205 (15.7)	319 (31.9)	484 (48.4)	197 (19.7)
80-84	698 (9.1)	147 (20.3)	353 (48.9)	222 (30.8)
85+	587 (7.7)	51 (8.2)	295 (47.4)	275 (44.4)
Gender, n (%)				
Men	3,535 (46.2)	1,574 (48.8)	1,182 (36.7)	468 (14.5)
Women	4,121 (53.8)	1,336 (35.6)	1,651 (43.9)	771 (20.5)
Ethnicity, n (%)				
White	7,442 (97.2)	2,819 (41.8)	2,758 (40.9)	1,169 (17.3)
Non-White	214 (2.8)	91 (38.6)	75 (31.9)	69 (29.5)
Married, n (%)				
No	2,653 (34.7)	696 (28.6)	1,065 (43.7)	677 (27.8)
Yes	5,001 (65.3)	2,213 (48.7)	1,767 (38.9)	562 (12.4)
Education attainment, n (%)				
Less than secondary school	2,507 (32.7)	706 (28.1)	1,108 (44.1)	699 (27.8)
Secondary school	1,414 (18.5)	570 (45.4)	528 (42.0)	159 (12.6)
College or higher	3,735 (48.8)	1,634 (50.9)	1,197 (37.3)	381 (11.9)
Wealth, n (%)				
5th quintile (most wealthy)	1,500 (20.0)	859 (61.6)	460 (33.0)	75 (5.4)
4th	1,500 (20.0)	686 (49.1)	608 (43.5)	103 (7.4)
3rd	1,499 (20.0)	614 (44.1)	604 (43.3)	177 (12.7)
2nd	1,504 (20.0)	498 (35.7)	617 (44.2)	281 (20.1)

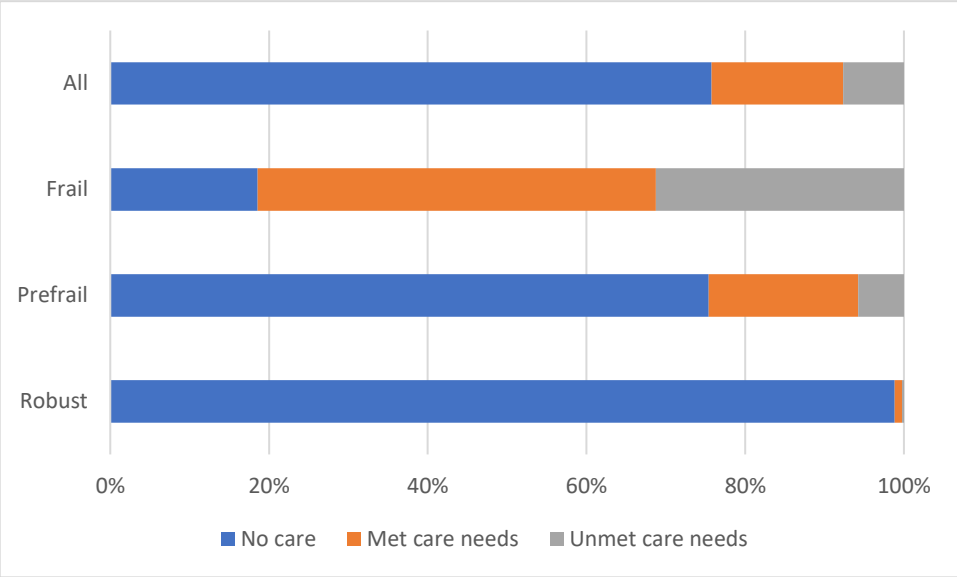
1st quintile (least wealthy)	1,495 (19.9)	334 (23.9)	661 (47.3)	401 (28.7)

Figure 1 The proportion of respondents by (A) frequency of care and (B) need for care in ELSA wave 6 (2012/2013). Respondents are categorised by frailty. Proportions are weighted using cross-sectional survey weight.

A. Frequency of care



B. Need for care



Frailty status, frequency of care and risk of unplanned hospital admission

During five years of follow-up, there were 2,663 unplanned admissions and 310 deaths (**Supplementary Table 6**). In an unadjusted competing risk model, compared to those who were robust, the subdistribution hazard ratios (SHRs) for unplanned hospital admission among people who were prefrail and frail were 1.80 (95%CI: 1.64; 1.97) and 2.74 (95%CI: 2.47; 3.03) respectively, see **Supplementary Table 7**. Compared to those who received no care, those who received infrequent and frequent care were more likely to have an unplanned hospital admission: SHR 1.70 (95%CI:1.55; 1.87) and 1.82 (95%CI:1.64; 2.02) respectively.

After adjustment for covariates, the SHRs for unplanned hospital admission among those who were prefrail and frail were attenuated (see **Table 2**). Compared to those who were robust, the adjusted SHR for unplanned admission for prefrailty was 1.76 (95%CI: 1.59; 1.95) and for frailty 2.46 (95%CI:2.13; 2.84). After adjustment for covariates including frailty status, compared to those not receiving care, the adjusted SHR for unplanned admission for infrequent care was 1.19 (95%CI:1.06; 1.33) and for frequent care 1.29 (95%CI:1.12; 1.48).

Taking account of death as a competing risk, the cumulative incidence of unplanned hospital admissions increased over time for all frailty categories; the slope was greater among those who were frail and prefrail than those who were robust (see **Figure 2**). The slope was also greater within frailty categories for those who were in receipt of care than those who were not. The cumulative incidence curve for frail people who had frequent care increased steeply with time, followed by frail people who had infrequent care.

Frailty status, need for care and risk of unplanned hospital admission

In an unadjusted competing risk model, compared to those who were not in receipt of care the SHRs for unplanned hospital admission among people who were in receipt of care and whose care needs were met was 1.82 (95%CI:1.64; 2.02) and those with an unmet need of care was 2.07 (95%CI:1.61; 2.67), see **Supplementary Table 7**.

After adjustment for covariates, including frailty status, the strength of the SHRs was attenuated. Compared to those not receiving care, the adjusted SHR for unplanned admission for those in receipt of care and whose care needs were met was 1.22 (95%CI: 1.09; 1.35) with a similar SHR for unmet need for care 1.21 (95%CI: 0.91; 1.61), though with the confidence interval embracing unity, see **Table 2**.

Taking account of death as a competing risk, cumulative incidence of unplanned hospital admissions was higher within frailty categories for those who were in receipt of care and whose care needs were met than those with an unmet need for care **(Figure 3)**.

For the first sensitivity analysis, we performed the analysis including the interaction between frailty with frequency of care and need for care. **Supplementary Figures 1 and 2** show that the analysis with the interaction between frailty with frequency of

care and need for care have similar values with those excluding the interaction, suggesting no interaction between frailty status and care receipt in their relationships with the risk of hospitalisation. The results of the sensitivity analyses using age group as the covariates (**Supplementary Table 8**), five different epoch of time (**Supplementary Figure 3**), and varying time of analysis (**Supplementary Table 9**) are similar to our principal results, suggesting the results are robust.

Table 2 Subdistribution hazard ratio (95% CI) for the association between frailty status, frequency of care, need for care and unplanned admissions.

	Frequency of care	**Need for care**
Frailty status, reference: robust		
Prefrail	1.76 (1.59; 1.95)	1.77 (1.60; 1.95)
Frail	2.46 (2.13; 2.84)	2.51 (2.18; 2.89)
Frequency of care receipt, reference: no care		
Received infrequent care	1.19 (1.06; 1.33)	
Received frequent care	1.29 (1.12; 1.48)	
Need for care, reference: no care		
Met care needs		1.22 (1.09; 1.35)
Unmet care needs		1.21 (0.91; 1.61)
Age (years)	1.05 (1.04; 1.05)	1.05 (1.04; 1.05)
Women (vs Men)	0.76 (0.70; 0.83)	0.76 (0.70; 0.83)
Non White (vs White)	1.24 (0.95; 1.61)	1.26 (0.97; 1.63)
Married	0.93 (0.85; 1.02)	0.93 (0.85; 1.02)
Wealth, reference: 1st quintile (least wealthy)		
2nd	0.89 (0.78; 0.99)	0.89 (0.79; 1.00)
3rd	0.78 (0.68; 0.88)	0.78 (0.69; 0.88)
4th	0.75 (0.66; 0.86)	0.75 (0.66; 0.86)
5th quintile (most wealthy)	0.66 (0.57; 0.76)	0.66 (0.57; 0.76)
Education, reference: less than high school		
High school	1.03 (0.92; 1.15)	1.03 (0.92; 1.15)
College or higher	0.98 (0.89; 1.07)	0.98 (0.89; 1.07)

Note: Unplanned admissions N=2,662, competing event deaths N=310. All models were adjusted for age, gender, marital status, wealth in quintiles and education attainment.

Figure 2 Estimates of the cumulative incidence of unplanned hospitalisation according to frailty status and frequency of care. Death was the competing risk.

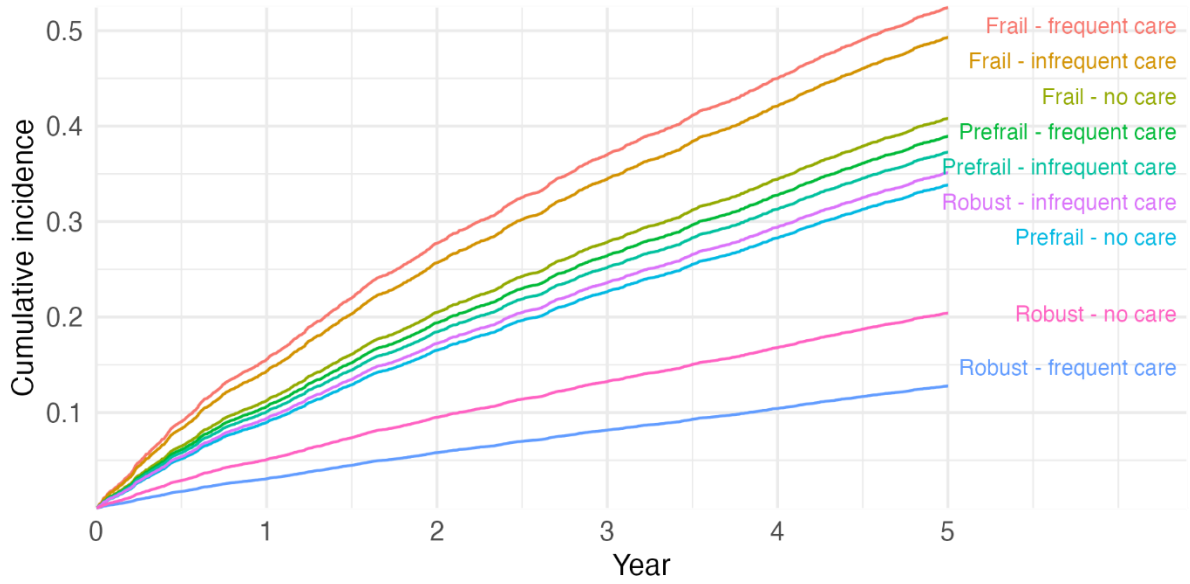
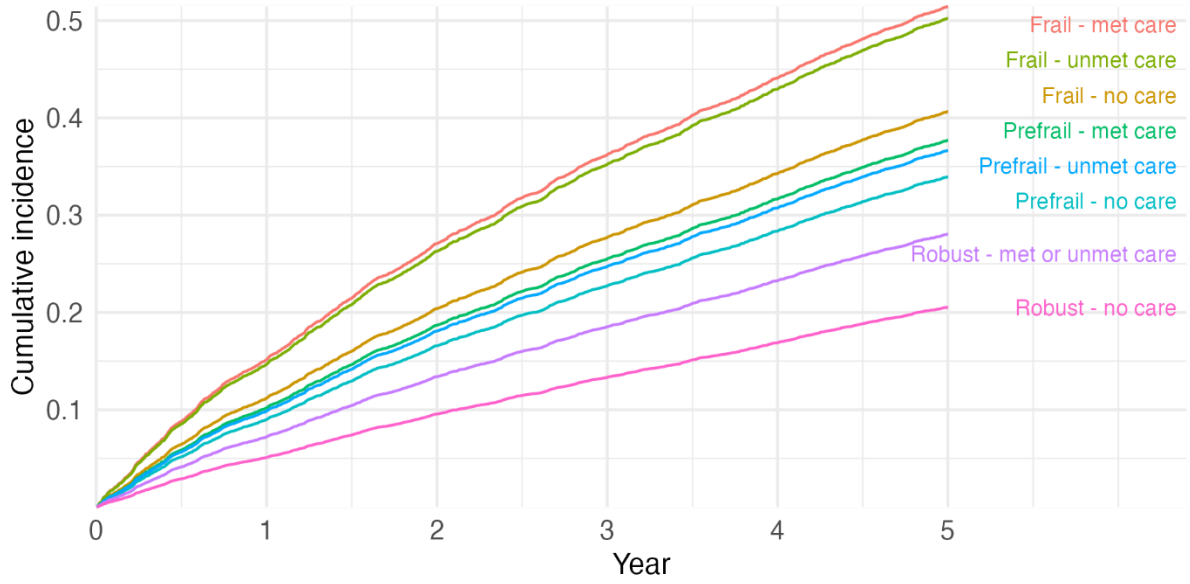


Figure 3 Estimates of the cumulative incidence curves of unplanned hospitalisation according to frailty status and need for care. Death was the competing risk.



Frailty, frequency for care and risk of unplanned admission: Influence of gender

Among men after adjustment for covariates including frailty status, compared to those who received no care, those who received care was associated with an increased risk of unplanned hospitalisation (SHRs 1.30; 95% CI 1.09, 1.54), see **Table 3**. This was true for women also (SHRs 1.31; 95% CI 1.14, 1.50). **Figure 4A** shows that among

men, those who were frail and received care had the steepest estimated cumulative incidence, followed by those who were frail and did not receive care. This order was similar for women, as being frail and receiving care had a steeper estimated cumulative incidence frail (**Figure 4B**).

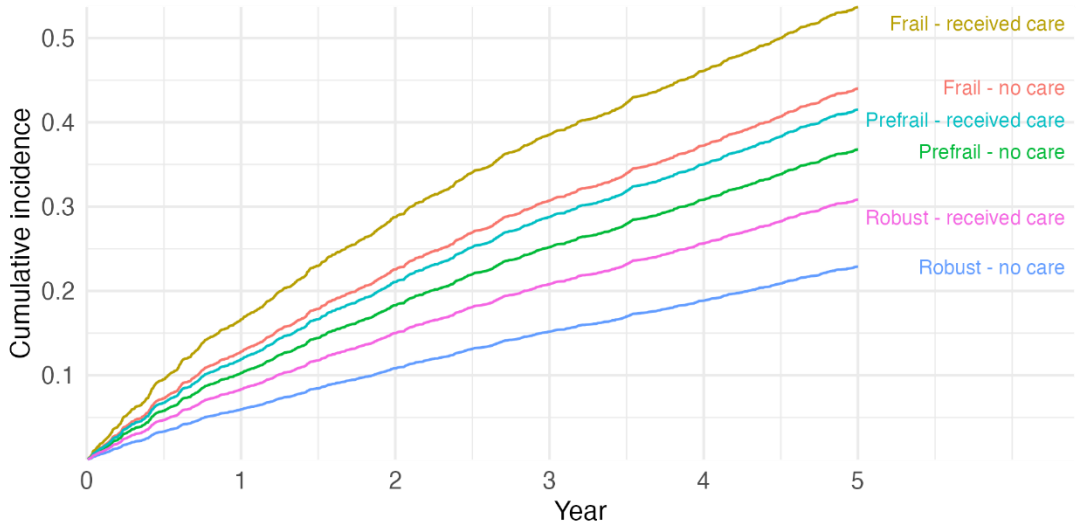
Table 3 Subdistribution hazard ratio (95% CI) for the association between frailty status and receive care with unplanned admissions by gender

	Male	**Female**
Frailty status, reference: robust		
Prefrail	1.73 (1.51; 1.98)	1.79 (1.54; 2.09)
Frail	2.39 (1.93; 2.94)	2.57 (2.12; 3.11)
Receive care, reference: no		
Yes	1.30 (1.09; 1.54)	1.31 (1.14; 1.50)

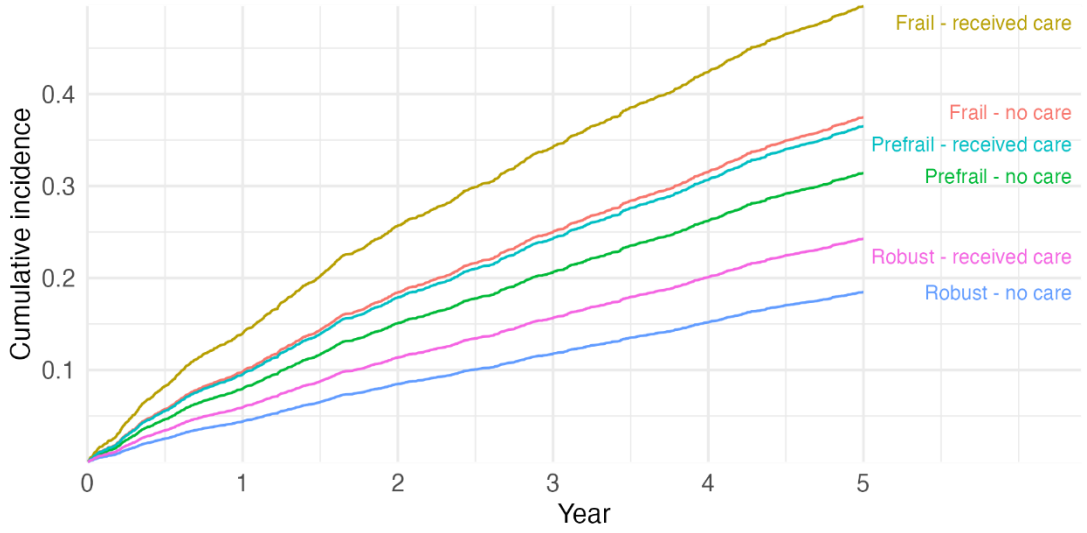
Note: Unplanned admissions N=2,662, competing event deaths N=310. [a]Adjusted for age group, gender, ethnicity, marital status, wealth and education.

Figure 4 Estimates of the cumulative incidence curves of risk of unplanned hospitalisation according to frailty status and receipt of care by gender. Death was the competing risk.

A. Male



B. **Female**



Frailty status, receipt of care and the risk of admissions due to falls, fractures and pressure ulcers

During five years of follow-up, there were 586, 159, and 432 admissions due to falls, pressure ulcers and fractures, respectively (**Supplementary Table 6**). **Table 4** report the SHR for the association between levels of frailty and receipt of care and the risk of hospitalisation due to a fall estimated using competing risk analysis. The adjusted SHRs for hospitalisation due to a fall among older adults who were prefrail and frail were 2.18 (95%CI: 1.68; 2.83) and 2.73 (95%CI: 1.95; 3.80) respectively, compared with those who were robust. Receiving care was associated with 1.30 (95% CI: 1.03; 1.63) higher risk of admissions due to falls.

The adjusted SHRs for hospitalisation due to a fracture among older adults who were prefrail and frail were 1.78 (95%CI: 1.35; 2.34) and 2.11 (95%CI: 1.45; 3.07) respectively, compared with those who were robust. Receiving care (SHR: 1.25; 95% CI: 0.95; 1.63) was not significantly associated with an increased risk of admissions due to fractures.

The adjusted SHRs for hospitalisation due to a pressure ulcer among older adults who were prefrail and frail were 3.66 (95%CI:1.79; 7.47) and 8.52 (95%CI:3.80; 19.12) respectively, compared with those who were robust. Receiving care was associated with 1.70 (95% CI:1.07; 2.69) times higher risk of admissions due to pressure ulcers.

Figure 5A shows that frail older people had the steepest estimated cumulative incidence curves for hospitalisation due to falls, followed by those who were prefrail and robust. Differently, prefrail older people with care had the steepest estimated cumulative incidence curve, followed by frail older people with no care (**Figure 5B**). Frail older people who received care had the steepest estimated cumulative incidence curves for hospitalisation due to pressure ulcers, followed by those who were frail and received no care (**Figure 5C**). The estimated cumulative incidence curves for hospitalisation due to falls, fractures and pressure ulcers for robust older people with and without care were the gentlest ones.

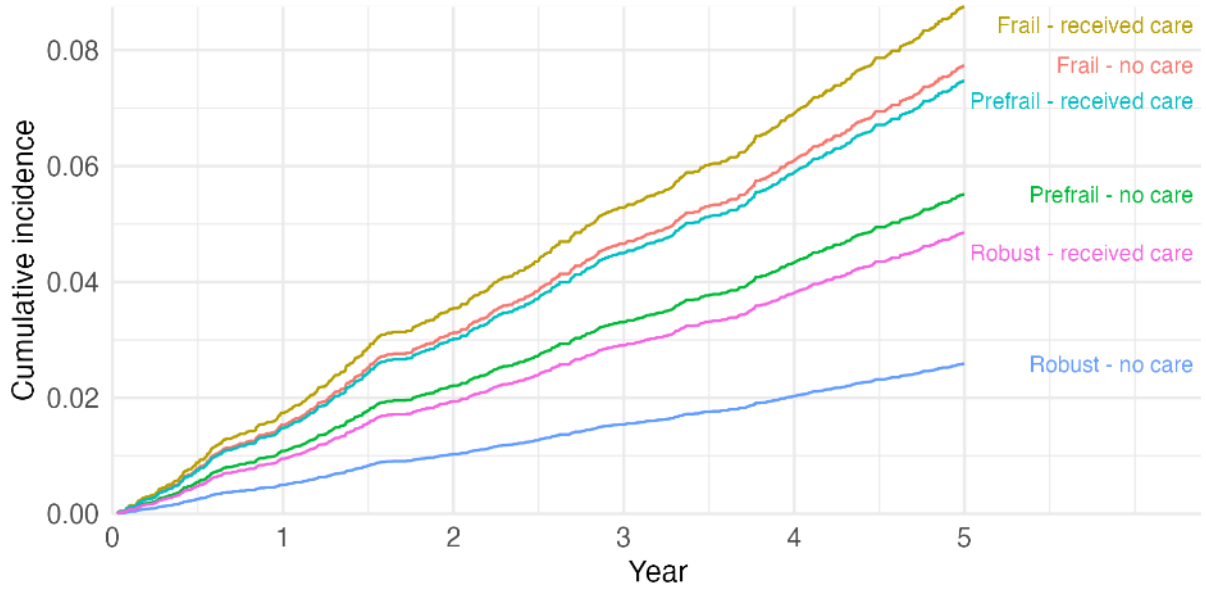
Table 4 Subdistribution hazard ratio (95% CI) for the association between frailty status and care receipt with hospitalisation due to falls, fractures, and pressure ulcers, England 2012-2018

	Hospitalisation due to falls[a]	**Hospitalisation due to fractures[a]**	**Hospitalisation due to pressure ulcers[a]**
Frailty status, reference: robust			
Prefrail	2.18 (1.68; 2.83)	1.78 (1.35; 2.34)	3.66 (1.79; 7.47)
Frail	2.73 (1.95; 3.80)	2.11 (1.45; 3.07)	8.52 (3.80; 19.12)
Received care, reference: No			
Yes	1.30 (1.03; 1.63)	1.25 (0.95; 1.63)	1.70 (1.07; 2.69)

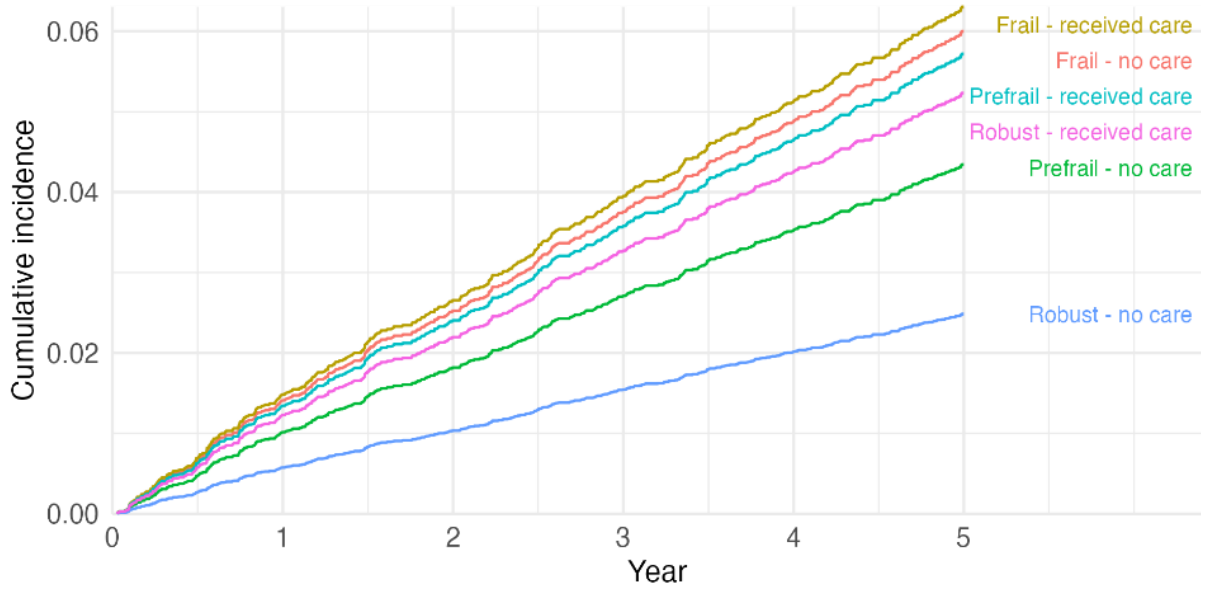
Note: [a]Adjusted for age, gender, ethnicity, marital status, wealth and education.

Figure 5 Estimates of the cumulative incidence curves of risk of hospitalisation due to falls, fractures, and pressure ulcers according to frailty status and receipt of care. Death was the competing risk.

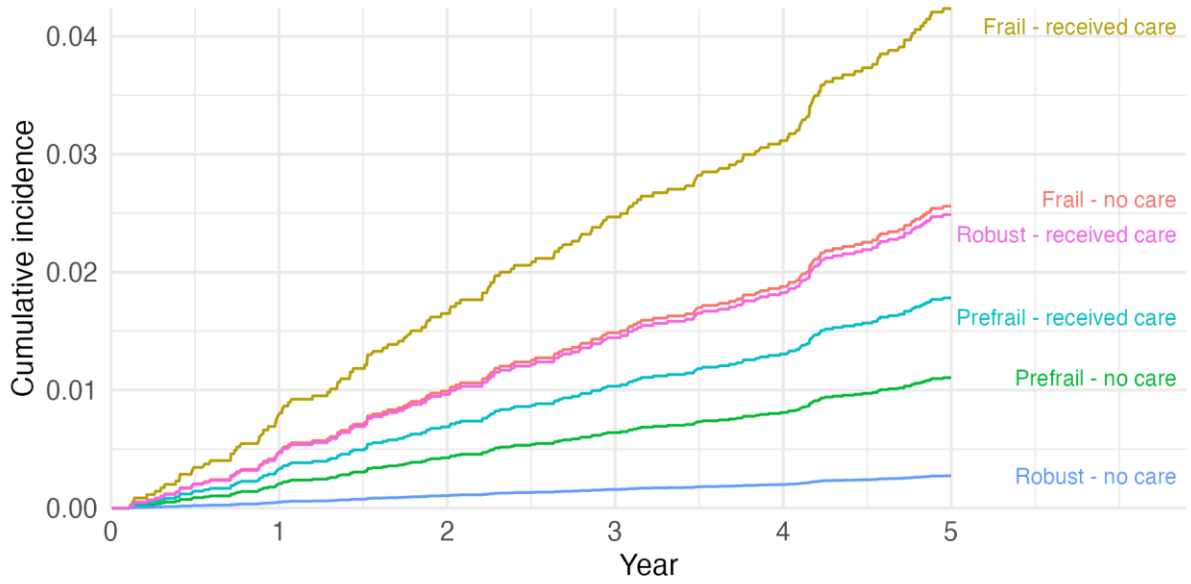
A. **Hospitalisation due to falls**



B. **Hospitalisation due to fractures**



C. Hospitalisation due to pressure ulcers



Discussion

Using a large population-based survey linked to national hospitalisation and mortality records, we found that 40.6% and 17.7% of adults aged 60+ in England were prefrail and frail, respectively. Both frailty and prefrailty were associated with a higher risk unplanned hospital admission, hospital admissions due to falls, fractures and also pressure ulcers. These findings corroborate previous studies which report an association between frailty and increase in both emergency and elective hospital admissions (14, 37-39). The impact of frailty on healthcare utilisation is substantial: the length of inpatient stay for severely frail patients was seven times longer than the non-frail patients (14).

Based on the categorisation of frequency of care used in this analysis, 15.2% and 10.4% adults aged 60+ in England received infrequent and frequent care, respectively, with the proportion reporting care receipt higher among prefrail and frail than robust individuals Figure 1). The data are consistent with previous findings (38-40). In a study based in primary care in Norwich, the average number of care plans was higher among severe frail older patients (2.97) than fit patients (2.22).

Our results indicate that compared to those receiving no care, receiving infrequent and frequent care were associated with higher risk of unplanned admission independent of frailty status. The risk of unplanned admissions was higher also among prefrail and frail older people who received infrequent and frequent care than those within the *same* frailty group who did not receive any care. In a cross-sectional study in the Netherlands, the greater the number of ADL limitations and the higher the frailty score of a person, the more they are to have both met and unmet care needs (41). In a separate analysis of data from ELSA the need for care among older people with intact memory/orientation was met more often while those with dementia or lower memory/orientation and few functional limitations reported higher unmet needs for care (42). The likely explanation is that those in receipt of care have poorer health than those who are not in receipt of care, and thus at higher risk of unplanned hospitalisation. It is thus important to provide identification of needs for care among older people and person-centred assessment to improve quality of life.

The recent National Institute for Health and Care Excellence (NICE) guidelines on multimorbidity highlight frailty as one of the target groups who required an individualised assessment and care plan, such as care planning and review, coordination of care, targeted enablement and support for self-management, and behaviour change approaches. Integrated care has emerged as an effective way to improve outcomes for older people with frailty (43). One of the examples is the Program of All-inclusive Care for the Elderly (PACE), a community-based long-term care, which included adult day healthcare and in-home support services and provided by an interdisciplinary team (16). Six weeks enrolment to PACE services reduced the number of admissions for older people who had been living with unmet ADL needs significantly; admission rates became similar to those who had their ADL needs met before PACE enrolment. A pilot study in Scotland found that anticipatory care planning for frail older adults can reduce unplanned admissions by 43% (44).

Tailoring care to address the specific need of frail older adults has the potential to reduce risk of unplanned hospitalisation.

In our analysis reporting an unmet need for care was associated with a small though non-significant risk of unplanned hospitalisation, with the magnitude of the risk similar to those whose care needs were reported as being met. Some caution though is needed in interpreting these data as our definition of care needs focused on the *adequacy* (met / unmet) of those who were already receiving care. There is a relative lack of data concerning the role of unmet need for care as a contextual factor when examining frailty and adverse health outcomes in older adults and for which further research is needed. Data from a Canadian study suggested that similar to our results that perceived unmet need for care among adults with chronic conditions was not associated with an increased risk of hospital admission (45), while two American studies did find an association (16, 46).

~~Only 7.2%~~In relation to the influence of gender our data suggest that after adjustment for covariates that receiving care (compared to receiving no care) was associated with higher risk of unplanned admissions among men and women and with magnitude of risk similar in men and women. In relation to admission type, receiving care was associated with higher risk of hospitalisation due to falls and pressure ulcers.

Strengths of our analysis include the nationally representative sample of non-institutionalised individuals which is generalisable to the English population. Furthermore, the survey used in this study was linked to national hospitalisation and mortality data which minimised loss at follow-up. Additionally, this study used a competing risk analysis strategy to consider mortality as a competing event rather than a survival analysis. Competing risk analysis accommodate the competing nature of multiple causes to the same event.

There are several limitations though which need to be considered in interpreting the findings. First, care receipt and need for care were measured only at baseline, with no data at follow up. It was not possible therefore to address how change in care receipt and care needs may have affected hospitalisation among older people. Second, questions about care were only asked when a respondent reported having difficulties in mobility, ADL or IADL in ELSA. Thus information on care receipt and the need for care excluded those who did not report any functional difficulties; it is possible that more people would have reported care receipt and care needs if the entire sample had been asked. In addition, perceived unmet needs were measured using only one question in ELSA, and which did not distinguish between different types of care need. A cross-sectional study among frail older adults in Netherlands examined different types of unmet needs for care, i.e., environmental (accommodation, household activities, food, and caring for another), physical needs (physical health, medication use, visual/hearing impairment, mobility/falls, and self-care), and psychosocial needs (memory, company, daytime activities, and information) (41). It found that the respondents reported the highest proportion of unmet care needs in the psychosocial domain. It is possible that different type of unmet needs may affect adverse health outcomes differently.

What are the potential implications of our findings. In our analysis frailty was associated with 2.5 increased risk of unplanned admission to hospital. As frailty is a potentially reversible health state (47) with early screening and intervention, good-quality and timely diagnosis of prefrailty and frailty in the community, and providing effective interventions at early stage, could be an effective strategy of reducing or delaying utilisation of secondary care services. Our data suggest that older people with frailty / prefrailty who are *already in receipt of care* are at significantly greater risk of unplanned hospitalisation and therefore a group who may potentially benefit from more detailed assessment and targeted or personalised community-based interventions with the aim of reducing their risk.

In conclusion older men and women who are in receipt of care are at increased risk of unplanned hospitalisation and other adverse outcomes. Those who are frail / prefrail are at greater risk, providing opportunities for targeted community-based interventions to reduce the impact on already overstretched secondary care services.

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Supplementary file

Supplementary File 1: Additional information on statistical analysis

Based on the frequency of care received, we categorised respondents into those in receipt of: 1] frequent care, if the respondents received help in the last month for using the toilet, getting in and out, eating, bathing/showering, walking across a room, dressing, and having meals on wheels; [2] infrequent care, if the respondents received help in the last month for grocery shopping, house or garden work, managing money, climbing at least one flight of stairs without resting, taking medication, walking 100 yards and if they had attended a day centre; and [3] did not receive care.

Participants who have received care were also asked whether their care meets their needs. We classified the respondents into having: [1] unmet care needs, if they answered that the care they had sometimes or hardly met their needs; and [2] met care needs, if they answered that the care they had met or usually met their needs; and [3] did not receive care.

We checked for the presence of an interaction between frailty status, frequency of care, and need for care by creating a second model for each analysis. In Model 2, we created nine main dependent variables combining frailty status and frequency of care: [1] robust and received no care [reference]; [2] robust and received infrequent care; [3] robust and received frequent care; [4] prefrail and received no care; [5] prefrail and received infrequent care; [6] prefrail and received frequent care; [7] frail and received no care; [8] frail and received infrequent care; and [9] frail and received frequent care. For analysis of the need for care, we created eight main dependent variables combining frailty status and need for care (there were no robust respondents reporting unmet need for care needs): [1] robust and received no care [reference]; [2] robust and received care; [3] prefrail and received no care; [4] prefrail and reported having met care needs; [5] prefrail and reported having unmet care needs; [6] frail and received no care; [7] frail and reported having met care needs; and [8] frail and reported having unmet care needs.

We looked for an interaction between frailty status, frequency of care, and need for care on the risk of hospitalisation by plotting the SHRs and 95% CIs using both models. In order to compare with Model 2, we calculated the SHRs of each category (i.e., robust and received no care as the reference; robust and received infrequent care; robust and received frequent care; prefrail and received no care; prefrail and received infrequent care; prefrail and received frequent care; frail and received no care; frail and received infrequent care; and frail and received frequent care) by adding the log of each frailty status, frequency of care, and need for care and then taking its exponential. An interaction effect was considered to exist if the two plots showed different values of the association of the categories and the risk of hospitalisation. **Supplementary Figures 1 and 2** show that the two plots have similar values, suggesting no interaction between frailty status and care receipt in their relationships with the risk of hospitalisation. The model without an interaction was thus preferable. Survey data was weighted using ELSA cross-sectional survey weight at wave 6 (29).

Supplementary Table 1: Deficit variables included in the ELSA Frailty Index

Description	Assigned values (1 indicates a deficit, 0 no deficit)				
1. Difficulty with walking 100 yards	No=0	Yes=1			
2. Difficulty sitting for about two hours	No=0	Yes=1			
3. Difficulty getting up from a chair after sitting for long periods	No=0	Yes=1			
4. Difficulty climbing several flights of stairs without resting	No=0	Yes=1			
5. Difficulty climbing one flight of stairs without resting	No=0	Yes=1			
6. Difficulty stooping, kneeling, or crouching	No=0	Yes=1			
7. Difficulty reaching or extending arms above shoulder level	No=0	Yes=1			
8. Difficulty pulling or pushing large objects like a living room chair	No=0	Yes=1			
9. Difficulty lifting or carrying weights over 10 pounds, like a heavy bag	No=0	Yes=1			
10. Difficulty picking up a 5p coin from a table	No=0	Yes=1			
11. Difficulty dressing, including putting on shoes and socks	No=0	Yes=1			
12. Difficulty walking across a room	No=0	Yes=1			
13. Difficulty bathing or showering	No=0	Yes=1			
14. Difficulty eating, such as cutting up your food	No=0	Yes=1			
15. Difficulty getting in or out of bed	No=0	Yes=1			
16. Difficulty using the toilet, including getting up or down	No=0	Yes=1			
17. Difficulty using a map to figure out how to get around in a strange place	No=0	Yes=1			
18. Difficulty preparing a hot meal	No=0	Yes=1			
19. Difficulty shopping for groceries	No=0	Yes=1			
20. Difficulty making telephone calls	No=0	Yes=1			
21. Difficulty taking medications	No=0	Yes=1			
22. Difficulty managing money, (e.g. paying bills and keeping track of expenses)	No=0	Yes=1			
23. Difficulty doing work around the house or garden	No=0	Yes=1			
24. Self-reported general health	Excellent=0	V.good-0.25	Good=0.5	Fair=0.75	Poor=1
25. Whether respondent has felt depressed much of the time during the past week	No=0	Yes=1			
26. Whether respondent felt everything they did during the past week was an effort	No=0	Yes=1			
27. Whether respondent felt their sleep was restless much of the time during the past week	No=0	Yes=1			
28. Whether respondent was happy much of the time during the past week	Yes=1	No=0			
29. Whether respondent felt lonely much of the time during the past week	No=0	Yes=1			
30. Whether the respondent enjoyed life much of the time during the past week	Yes=1	No=0			
31. Whether respondent felt sad much of the time during the past week	No=0	Yes=1			

32. Whether respondent could not get going much of the time during the past week	No=0	Yes=1					
33. High blood pressure or hypertension (self-reported)	No=0	Yes=1					
34. Angina (self-reported)	No=0	Yes=1					
35. Heart attack (including MI or coronary thrombosis) (self-reported)	No=0	Yes=1					
36. Congestive heart failure (self-reported)	No=0	Yes=1					
37. An abnormal heart rhythm (self-reported)	No=0	Yes=1					
38. Diabetes or high blood sugar (self-reported)	No=0	Yes=1					
39. A stroke (cerebral vascular disease) (self-reported)	No=0	Yes=1					
40. Chronic lung disease such as chronic bronchitis or emphysema (self-reported)	No=0	Yes=1					
41. Asthma (self-reported)	No=0	Yes=1					
42. Arthritis (including osteoarthritis , or rheumatism) (self-reported)	No=0	Yes=1					
43. Osteoporosis, sometimes called thin or brittle bones (self-reported)	No=0	Yes=1					
44. Cancer or a malignant tumor (excluding minor skin cancers) (self-reported)	No=0	Yes=1					
45. Parkinson's disease (self-reported)	No=0	Yes=1					
46. Any emotional, nervous or psychiatric problems (self-reported)	No=0	Yes=1					
47. Alzheimer's disease (self-reported)	No=0	Yes=1					
48. Dementia, organic brain syndrome, senility or any other serious memory impairment (self-reported)	No=0	Yes=1					
49. Self-reported eyesight (while using lenses, if appropriate)	Excellent=0	V.good=0.2	Good=0.4	Fair=0.6	Poor=0.8	Blind=1	
50. Self-reported hearing (while using hearing aid if appropriate)	Excellent=0	V.good=0.25	Good=0.5	Fair=0.75	Poor=1		
51. Whether respondent has fallen down at all /last year /last 2years	No=0	Yes=1					
52. Whether respondent has fractured hip ever /in last 2 years	No=0	Yes=1					
53. Whether respondent has had joint replacement ever	No=0	Yes=1					
54. Identify today’s date: day of month	Yes=0	No=1					
55. Identify today’s date: month	Yes=0	No=1					
56. Identify today’s date: year	Yes=0	No=1					
57. Identify the day of the week?	Yes=0	No=1					
58. Immediate word recall (sample organized into quartiles)	1st quintile=0	2nd=0.3	3rd=0.6	4th quintile=1			
59. Delayed word recall (sample organized into quintiles)	1st quintile=0	2nd=0.25	3rd=0.5	4th=0.75	5th quintile =1		
60. Have pain while performing the walking test	Yes=0	No=1					

Supplementary Table 2: Hospital Episode Statistics – Method of admission categories

Code	Method of admission
11	Waiting list
12	Booked
13	Planned
21	Accident and Emergency
22	GP-after request of immediate admission
23	Bed bureau
24	Consultant clinic
25	Mental Health Crisis Resolution team
28	Other: A&E
31	Admitted ante partum
32	Admitted post-partum
81	Transfer of any admitted patient from other hospital provider other than in an emergency
82	Baby birth
83	Baby born outside
99	Not known

Supplementary Table 3: ICD-10 codes for fractures

Code	Method of admission
M 484	Fatigue fracture of vertebra
M 495	Collapsed vertebra in diseases classified elsewhere
M 80	Osteoporosis with pathological fracture
M 843	Stress fracture, not elsewhere classified
M 844	Pathological fracture, not elsewhere classified
M 907	Fracture of bone in neoplastic disease
M 966	Fracture of bone following insertion of orthopaedic implant, joint prothesis or bone plate
S 02	Fracture of skull and facial bones
S 12	Fracture of neck
S 22	Fracture of rib(s), sternum and thoracic spine
S 32	Fracture of lumbar spine and pelvis
S 42	Fracture of shoulder and upper arm
S 52	Fracture of forearm
S 62	Fracture of wrist and hand level
S 72	Fracture of femur
S 82	Fracture of lower leg, including ankle
S 92	Fracture of upper limb, except ankle
T 02	Fractures involving multiple body regions
T 08	Fracture of spine, level unspecified
T 10	Fracture of upper limb, level unspecified
T 12	Fracture of lower limb, level unspecified
T 142	Fracture of unspecified body region

Supplementary Table 4: Descriptive characteristics of the respondents (n=6,984) by frequency of care in ELSA wave 6 (2012/2013).

	No care	Infrequent care	Frequent care
Age group			
60-64	1,540 (86.76)	145 (8.20)	89 (5.04)
65-69	1,372 (83.16)	159 (9.65)	118 (7.18)
70-74	962 (79.15)	142 (11.66)	112 (9.19)
75-79	707 (70.71)	181 (18.07)	112 (11.22)
80-84	407 (56.55)	190 (26.39)	123 (17.06)
85+	210 (33.80)	240 (38.72)	170 (27.48)
Gender, n (%)			
Men	2,617 (81.16)	306 (9.50)	301 (9.34)
Women	2,577 (68.55)	755 (20.09)	427 (11.36)
Ethnicity, n (%)			
White	5,039 (74.68)	1,018 (15.09)	690 (10.23)
Non-White	154 (65.46)	43 (18.39)	38 (16.15)
Married, n (%)			
No	1,517 (62.21)	629 (25.80)	292 (11.99)
Yes	3,675 (80.89)	423 (9.52)	436 (9.59)
Education attainment, n (%)			
Less than secondary school	1,598 (63.56)	532 (21.16)	384 (15.28)
Secondary school	995 (79.14)	165 (13.12)	97 (7.75)
College or higher	2,602 (80.97)	365 (11.36)	247 (7.68)
Wealth, n (%)			
1st quintile (least wealthy)	749 (62.53)	250 (20.85)	199 (16.62)
2nd	978 (63.73)	325 (21.17)	232 (15.10)
3rd	1,073 (75.77)	212 (15.01)	131 (9.22)
4th	1,173 (82.62)	155 (10.92)	92 (6.46)
5th quintile (most wealthy)	1,147 (86.13)	116 (8.70)	69 (5.17)

Supplementary Table 5: Descriptive characteristics of the respondents (N=6,984) by need for care in ELSA wave 6 (2012/2013).

	No care	Met care needs	Unmet care needs
Age group			
60-64	1,553 (87.51)	195 (11.02)	26 (1.47)
65-69	1,397 (84.69)	240 (14.53)	13 (0.78)
70-74	977 (80.35)	224 (18.40)	15 (1.25)
75-79	733 (73.32)	247 (24.74)	19 (1.94)
80-84	428 (59.33)	275 (38.18)	18 (2.49)
85+	228 (36.79)	360 (58.00)	32 (5.21)
Gender, n (%)			
Men	2,646 (82.06)	544 (16.87)	34 (1.07)
Women	2,666 (70.90)	1,005 (26.72)	89 (2.38)
Ethnicity, n (%)			
White	5,153 (76.36)	1,480 (21.93)	115 (1.71)
Non-White	159 (67.32)	68 (29.04)	9 (3.63)
Married, n (%)			
No	1,590 (81.88)	767 (31.45)	82 (3.36)
Yes	3,720 (65.19)	782 (17.20)	42 (0.92)
Education attainment, n (%)			
Less than secondary school	1,658 (65.97)	790 (31.43)	65 (2.60)
Secondary school	1,015 (80.79)	223 (17.72)	19 (1.50)
College or higher	2,638 (82.09)	536 (16.68)	39 (1.23)
Wealth, n (%)			
1st quintile (least wealthy)	780 (65.07)	378 (31.57)	40 (3.36)
2nd	1,011 (65.92)	479 (31.23)	44 (2.85)
3rd	1,098 (77.55)	297 (20.97)	21 (1.48)
4th	1,190 (83.84)	221 (15.55)	9 (0.61)
5th quintile (most wealthy)	1,157 (86.89)	165 (12.41)	9 (0.70)

Supplementary Table 6 The number of hospital admissions and death in each outcome. Presented are number (%)

Analysis outcomes	Number (%) of participants admitted to the hospital during the follow-up	Number (%) of participants died during the follow-up
Unplanned admissions	2663 (37.78)	310 (4.05)
Admissions due to fall	586 (7.65)	939 (12.26)
Admission due to pressure ulcer	159 (2.08)	1070 (13.98)
Admission due to fracture	432 (5.64)	1020 (13.32)

Supplementary Table 7: Unadjusted subdistribution hazard ratio (95% CI) for the association between frailty status, frequency of care, need for care and each of the covariates with unplanned admissions.

	Unadjusted SHRs (95% CIs)
Frailty status, reference: robust	
Prefrail	1.80 (1.64; 1.97)
Frail	2.74 (2.47; 3.03)
Frequency of care, reference: no care	
Received infrequent care	1.70 (1.55; 1.87)
Received frequent care	1.82 (1.64; 2.02)
Need for care, reference: no care	
Met care needs	1.80 (1.66; 1.95)
Unmet care needs	2.07 (1.61; 2.67)
Age (years)	1.06 (1.06; 1.07)
Women (vs Men)	0.98 (0.92; 1.06)
Non White (vs White)	1.08 (0.86; 1.36)
Married (vs Non married)	0.73 (0.68; 0.79)
Wealth, reference: 1st quintile (least wealthy)	
2nd	0.97 (0.87; 1.09)
3rd	0.77 (0.68; 0.87)
4th	0.71 (0.63; 0.80)
5th quintile (most wealthy)	0.56 (0.50; 0.64)
Education, reference: less than high school	
High school	0.81 (0.73; 0.90)
College or higher	0.73 (0.67; 0.79)

Note: Unplanned admissions N=2,662, competing event deaths N=310.

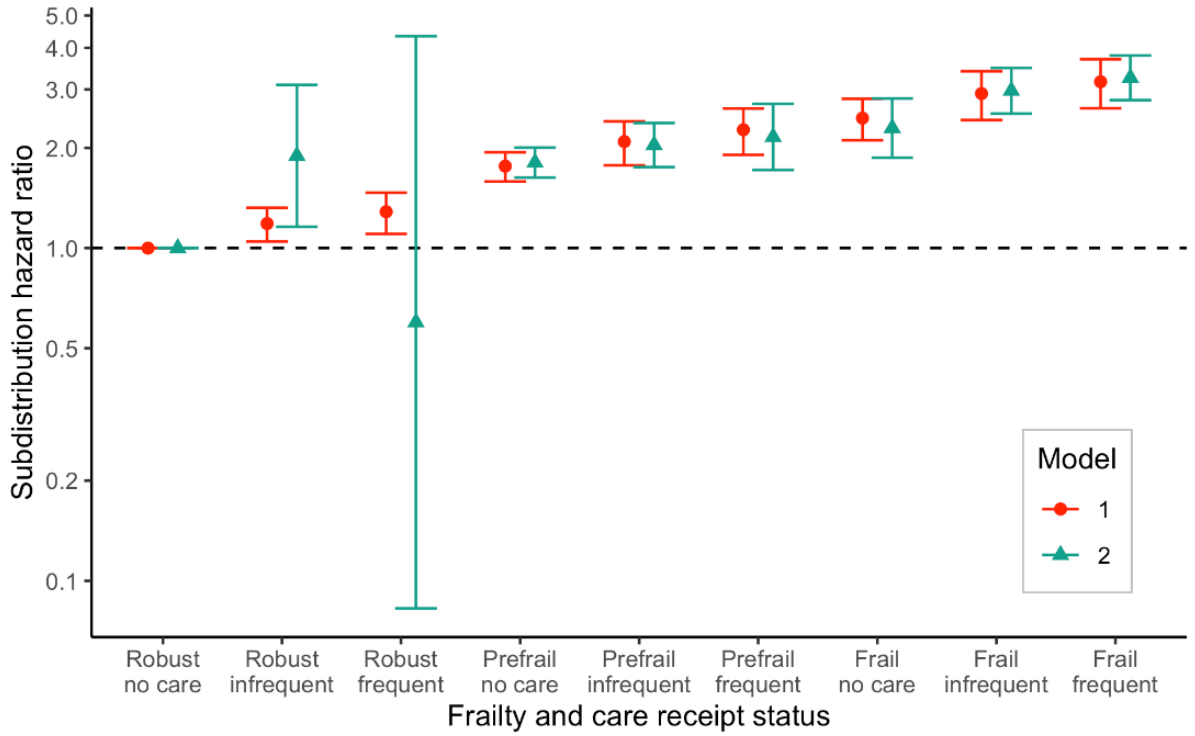
Supplementary Table 8: Subdistribution hazard ratio (95% CI) for the association between frailty status, frequency for care and need for care with unplanned admissions with age group as the determinant

	Frequency of care	Need for care
Frailty status, reference: robust		
Prefrail	1.75 (1.58; 1.93)	
Frail	2.48 (2.15; 2.85)	
Frequency of care, reference: no care		
Received infrequent care	1.20 (1.07; 1.35)	
Received frequent care	1.34 (1.17; 1.55)	
Need for care, reference: no care		
Met care needs		1.25 (1.13; 1.39)
Unmet care needs		1.26 (0.95; 1.66)
Age group, reference: 60-64		
65-69	1.16 (1.01; 1.33)	1.17 (1.02; 1.34)
70-74	1.75 (1.53; 2.01)	1.75 (1.53; 2.01)
75-79	2.23 (1.95; 2.55)	2.22 (1.94; 2.55)
80-84	2.58 (2.22; 3.00)	2.58 (2.22; 3.00)
85+	3.06 (2.60; 3.60)	3.05 (2.59; 3.59)
Women (vs Men)	0.76 (0.70; 0.83)	0.76 (0.70; 0.83)
Non White (vs White)	1.25 (0.96; 1.62)	1.26 (0.97; 1.63)
Married (vs Non Married)	0.90 (0.83; 0.99)	0.90 (0.83; 0.99)
Wealth, reference: 1st quintile (least wealthy)		
2nd	0.90 (0.79; 1.01)	0.90 (0.80; 1.01)
3rd	0.79 (0.69; 0.89)	0.78 (0.69; 0.89)
4th	0.77 (0.67; 0.88)	0.77 (0.67; 0.87)
5th quintile (most wealthy)	0.67 (0.59; 0.78)	0.68 (0.59; 0.78)
Education, reference: less than high school		
High school	1.04 (0.92; 1.16)	1.04 (0.92; 1.16)
College or higher	0.98 (0.90; 1.08)	0.98 (0.90; 1.08)

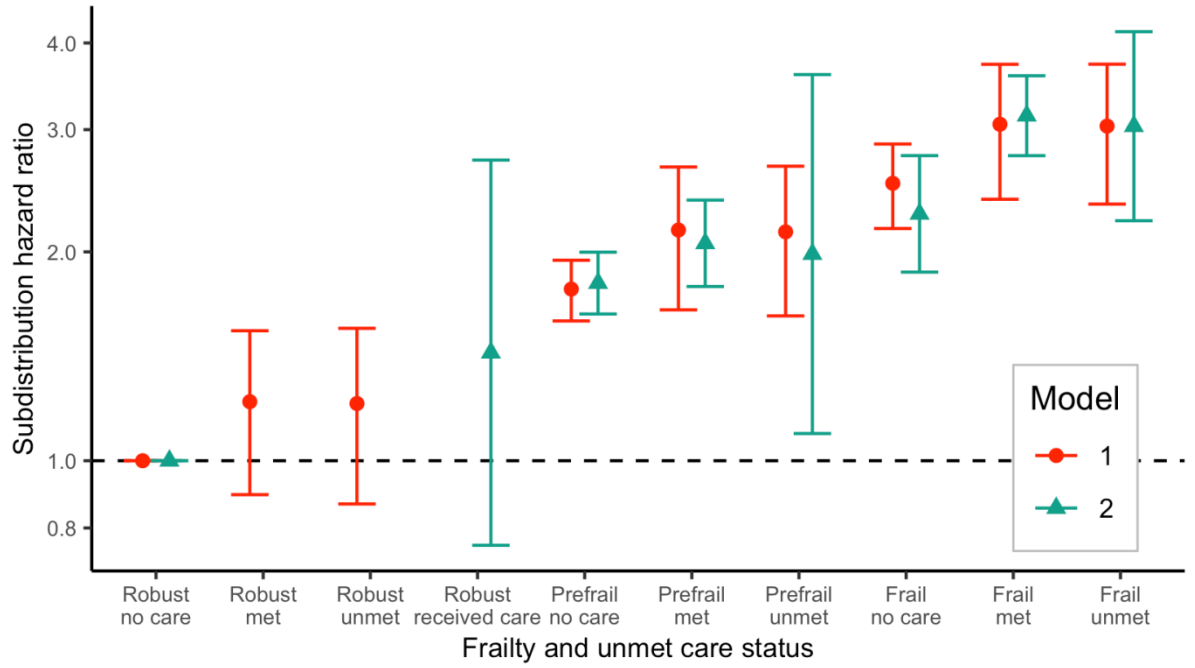
Supplementary Table 9: Subdistribution hazard ratio (95% CI) for the association between frailty status, frequency of care, and need for care with unplanned admissions with varying time analysis. Adjusted for age group, gender, ethnicity, marital status, wealth and education.

	Frequency of care	**Need for care**
Frailty status, reference: robust		
Prefrail	1.95 (1.73; 2.20)	
Frail	3.19 (2.72; 3.74)	
Frequency of care, reference: no care		
Received infrequent care	1.19 (1.04; 1.35)	
Received frequent care	1.41 (1.21; 1.64)	
Need for care, reference: no care		
Met care needs		1.27 (1.13; 1.43)
Unmet care needs		1.34 (1.01; 1.78)
Age	1.04 (1.04; 1.05)	1.04 (1.04; 1.05)
Women (vs Men)	0.76 (0.69; 0.83)	0.76 (0.69; 0.83)
Non White (vs White)	1.33 (0.99; 1.79)	1.34 (0.99; 1.81)
Married (vs Non Married)	0.90 (0.81; 0.99)	0.90 (0.81; 0.99)
Wealth, reference: 1st quintile (least wealthy)		
2nd	0.85 (0.74; 0.97)	0.85 (0.75; 0.97)
3rd	0.80 (0.70; 0.92)	0.80 (0.70; 0.92)
4th	0.77 (0.66; 0.89)	0.77 (0.66; 0.89)
5th quintile (most wealthy)	0.68 (0.58; 0.80)	0.68 (0.58; 0.80)
Education, reference: less than high school		
High school	1.04 (0.92; 1.18)	1.04 (0.92; 1.19)
College or higher	0.98 (0.89; 1.09)	0.98 (0.89; 1.09)

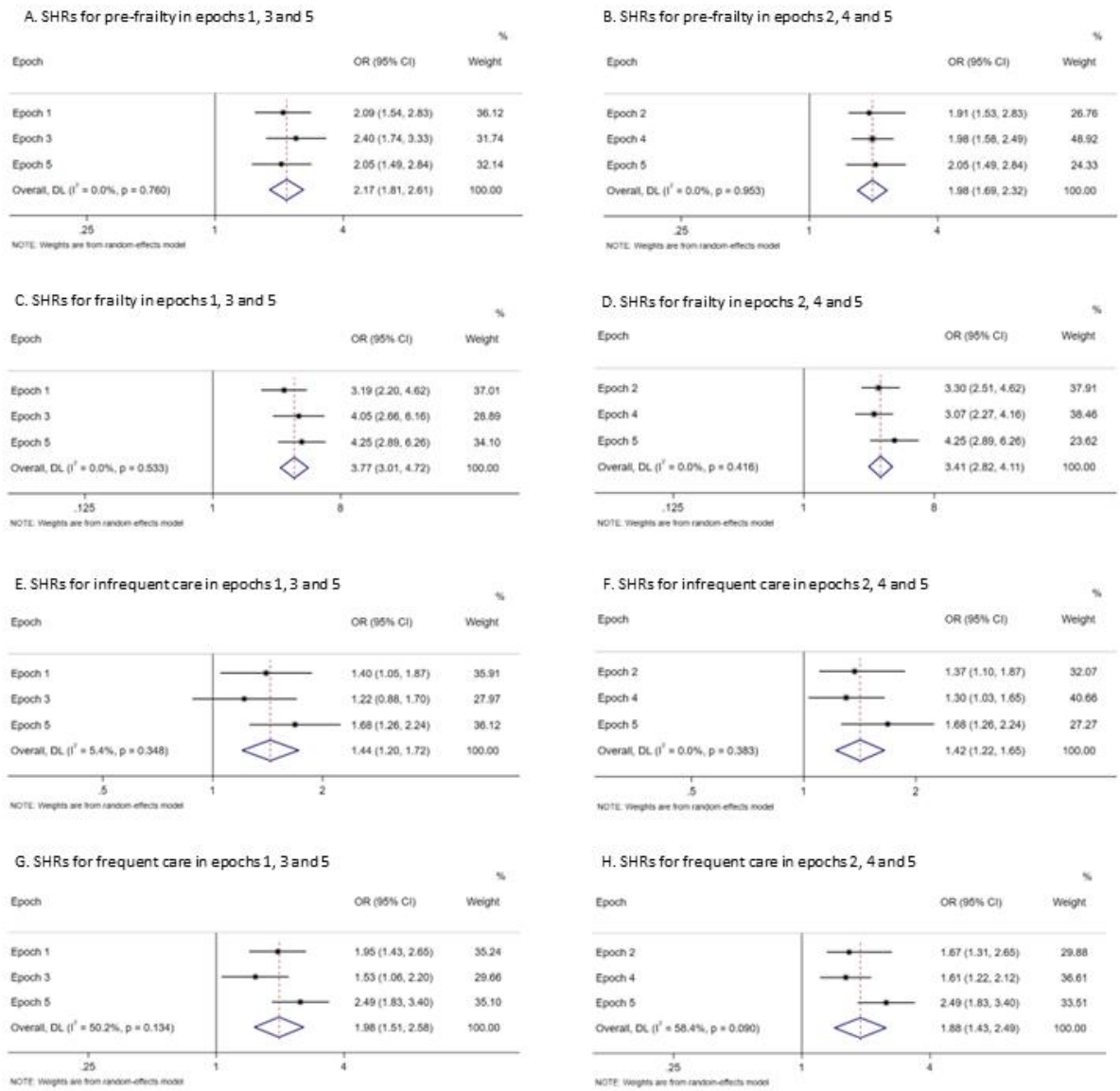
Supplementary Figure 1: Comparison between Model 1 and Model 2 in identifying the association between frailty status and frequency of care with unplanned admissions



Supplementary Figure 2: Comparison between Model 1 and Model 2 identifying the association between frailty status and need for care with unplanned admissions



Supplementary Figure 3: Subdistribution hazard ratio (95% CI) for the association between frailty status and frequency of care with unplanned admissions in as the determinant in each epoch of time (particular period of time)



Notes: Epochs: [1] wave 6 as the baseline with 6 months follow-up; [2] wave 6 baseline with 12 months follow-up; [3] wave 7 baseline with 6 months follow-up; [4] wave 7 baseline with 12 months follow-up; and [5] wave 8 baseline; 6 months follow-up.

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