

# Impact of frailty in older people on health care demand: simulation modelling of population dynamics to inform service planning

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## Scientific summary

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# Scientific summary

## Background

As the population ages, prevalence of frailty and associated demand for health care in both primary and secondary care settings will rise. Identification and clinical management of frailty are a priority, but capacity and resources for delivery remain limited. There is an evidence gap in relation to the planning, commissioning and delivery of services for older people living with frailty and questions remain about the incidence and prevalence of different levels of frailty and the consequences for health outcomes, service use and costs.

## Objectives

The overarching aim of this study was to explore the incidence, prevalence, progression and impact of frailty within the ageing population. The specific study objectives were to: identify incidence and prevalence of frailty states in an ageing population; identify frailty trajectories and transitions in severity in the older population over time; explore drivers of progression of frailty, including clinical, socio-economic and demographic factors; examine the impact of frailty on service use, costs and pathways of care; explore the relationship between frailty status, socioeconomic factors, practice factors and service use and outcomes (mortality, unplanned admissions, residential care use); and predict trends in frailty, modelling of health and care demand and costs over time and in different service contexts. The final aim of these analyses was to inform the development of guidelines and tools to facilitate commissioning and service development, thus providing an evidence-based approach to planning primary and secondary care services for patients aged 50 and over with different levels of frailty.

## Study design and methods

This study used a retrospective observational study design with statistical modelling to inform simulation (system dynamics) modelling using routine healthcare data from primary and secondary care. Retrospective data were used to determine population prevalence, incidence and progression of frailty within an ageing cohort using the electronic Frailty Index (eFI) tool and data from the English Royal College of General Practitioners Research and Surveillance Centre (RCGP RSC) databank, with additional data from the Welsh Secure Anonymised Information Linkage (SAIL) Databank. Associated service use and costs were determined from linked routine data. Statistical analysis of the RCGP RSC data involved both descriptive summaries as well as multistate modelling to identify key socioeconomic variables (e.g. age, gender, deprivation, ethnicity) that are independently associated with frailty. A cost analysis of both primary and secondary care data was also conducted using generalised linear models to identify factors associated with costs and provide estimates of adjusted mean costs, by frailty and age categories. Five stakeholder engagement group (SEG) sessions were held at appropriate times throughout the study period to seek input from a broad range of health and care professionals and commissioners, members of the general public, patients and carers. These sessions focused on different aspects of the research as the project evolved, starting with the type of services available for people living with frailty and who would use them, to gaining feedback on ongoing analyses and ways of presenting the results, to informing and appraising the developing simulation model and suggesting scenarios that could be applied. Information from the statistical modelling as well as that gathered during patient and professional stakeholder events was used to inform the development of a system dynamics simulation model which could be used to examine the incidence, and progression of frailty in the 50 and over population. An initial model was developed and validated with the RCGP RSC data before further external validation against a comparable large data set from SAIL. The simulation was further adapted to

use Office for National Statistics (ONS) population estimates for England, thus allowing exploration of future population trends in frailty prevalence and health service impact over a 10-year period following 2017. As one of the benefits of simulation modelling is to consider 'what-if' scenarios, the baseline simulation model was used to explore future trends in frailty prevalence and the associated primary and secondary care demand if present trends continue. Further 'what-if' scenarios exploring the impact of reduced frailty incidence, slowed frailty progression and reduced unplanned hospitalisation were carried out.

## Study population

The primary data source for the study was the RCGP RSC, providing primary care data from England. The sample comprised an open cohort of the primary care population aged 50 and over (approx. 1.1 million people) during the year 2006, rising to 1,491,954 in 2017, with a total of 2.1 million people included overall and 15.5 million person-years of data. The data were linked to Hospital Episode Statistics (HES) secondary care data and ONS death registry data. A comparable data set from Wales, provided by SAIL, was used for external validation of the simulation model and included approximately 1.3 million people and 11 million person-years of data.

## Baseline measures

The eFI score was calculated for all adults aged 50 +, with scores recalculated at 12-month intervals for the study period. The population was stratified into Fit, Mild, Moderate and Severe frailty groups according to their eFI score [Fit: (0–0.12); Mild: (0.13–0.24); Moderate: (0.25–0.36); Severe: (> 0.36)]. Other variables included age, sex, Index of Multiple Deprivation (IMD) score, ethnicity, long-term condition diagnoses, urban/rural indicators, practice size.

## Outcomes

Frailty transitions, mortality, primary care [general practice surgery and home visits, telephone and electronic consultations, and individual medicines], secondary care [ambulance calls, emergency department (ED) attendances, critical care admissions, hospitalisations (unplanned and elective) and outpatient appointments] and care home residence. Costs were estimated for primary and secondary care and total care service use for the different frailty categories over 12 years. The influence of frailty on outcomes, service use and costs was explored using the RCGP RSC databank and via multistate and generalised linear models. These analyses along with information gathered during stakeholder events were used to inform the development of a prototype system dynamics simulation model (implemented in AnyLogic software) to explore the development and impact of frailty in the population and likely future scenarios over a 10-year time frame. The simulation model population projections were externally validated against retrospective data from the SAIL data set. The prototype simulation model was further adapted to use ONS population estimates for England, thus enabling population level projections of frailty in those aged 50 and over for a 10-year period following 2017. Baseline ('no service changes') projections of both the prevalence of frailty in the population and the associated primary, secondary and residential care use were examined over the period 2017–27. 'What-if' scenarios exploring the impact of reduced frailty incidence, slowed frailty progression and reduced unplanned hospitalisations were carried out.

## Findings

Frailty is already present in those aged 50–64, with approximately 10% of this age group having mild, moderate or severe frailty at baseline. The overall incidence of frailty in people aged 50 + was 47 cases per 1000 person-years at risk (PYAR). Mortality increased with age and frailty severity. The overall prevalence of frailty increased from 26.5% to 38.9% over the 12-year study period, with the greatest change in prevalence in the mild and moderate frailty categories. At least one transition between frailty categories was observed in 32.7% ( $n = 709,377$ ) of the cohort over a median follow-up of 7 years. The average age of transition from fit to mild was 69 years, fit/mild to moderate was 77 years and any category to severe was 81 years. In order of impact, older age, higher deprivation, female sex, Asian ethnicity and urban location are independent predictors of frailty onset and progression. For example, 4.8% of people aged 50–64 in the Fit category will experience a transition to a higher frailty state in a 12-month period, as compared to 21.4% in people aged 75–84. Trends in primary and secondary care service use were observed within frailty categories and age groups. Mean face-to-face appointments were generally similar within frailty categories across age groups, but with a notable decrease in appointments with older age in the severe category. Prescriptions increased with increasing age in both Fit and Mild frailty categories but decreased in moderate and severe categories. When stratified by age, mean annual outpatient appointments, ED attendances and hospital admissions (both elective and unplanned) were similar across age groups within the Fit and Mild categories, and decreased with increasing age in the moderate and severe categories. Individual annual total use of primary and secondary care services rise with frailty severity, but overall costs for people living with frailty are highest in the mild and moderate frailty groups due to their larger population numbers. An approximate doubling in costs was observed between fit and mild frailty categories, a trebling for moderate frailty, and quadrupling for severe frailty. Stakeholder engagement established that in addition to core primary and secondary care services, future work will need to consider additional community health care and social care services to provide a more complete overview of total care use and costs, while acknowledging that data on these services is more difficult to obtain. A focus on having the right services at the right time, for example preventative and well-being services for middle-aged adults to reduce onset of frailty, and supportive services for older adults to slow frailty progression and enable continued independence and hospital avoidance were discussed. The role of health inequalities and deprivation as demonstrated by the analyses was considered key to diversify service planning according to local needs. Simulation modelling has provided a useful means of capturing both the statistical modelling and cost analysis elements of the study along with the suggestions from both the patient and professional members involved in the stakeholder events. The development of the model with 16 connected subgroups and connected flows in and out of the groups has been an iterative approach and has benefited from the information contained in the two large data sets (RCGO RSC and SAIL) as well as ONS population estimates and projections. The system dynamics (SD) model has been extensively validated against summary descriptive data from the RCGP RSC cohort (with a 6.9% error) and externally against a similar data set from SAIL (9.3% error) before being scaled up (using ONS estimates for the number of people entering the 50 + population and those turning 65, 75 or 85 in a given year) to consider how frailty incidence and prevalence at a national population level could be represented over the period of the cohort study (2006–17) and 10 years into the future. The prototype simulation model is therefore able to consider the estimated frailty dynamics for England as well as the associated service use and costs in both baseline and ‘what-if’ scenarios. A baseline (no service changes) scenario experiment suggests what might happen if there is no change to current service provision and interventions caring for the population aged 50 and over (which is projected to increase from 20,045,766 to 21,755,097 between 2017 and 2027). Preliminary results suggest a projected increase in primary care service use and medication use with the cost for providing GP services and individual medicines in England rising by £3.1 billion for people with frailty. For secondary care, the rise in costs is estimated to be £2.7 billion for patients with frailty. The simulation predicted that the proportion of people with frailty will increase by another 7.1% between 2017 (41.5%) and 2027 (48.7%), and associated costs will rise by £5.8 billion over an 11-year period.

A scenario experiment exploring reducing frailty incidence by 5% indicates that almost 180,000 people remain fit each year rather than becoming frail (121,000 fewer mildly frail people, 27,500 fewer moderately frail and 12,800 fewer severely frail), which in turn could result in almost 300,000 fewer GP consultations (in the first year of the intervention) among the mildly frail and 14,000 fewer would be needed by those with moderate and severe frailty. In relation to secondary care services, there would be 114,000 fewer events among those that are mildly frail and an extra 57,000 among those that are fit. This would result in 5.3 million fewer secondary care service events in those with some degree of frailty over the projected 10-year period. Reducing frailty incidence could result in 26,418 fewer unplanned admissions and 47,506 fewer elective admissions. The cost savings from all these service use changes could amount to £266 million per annum by 2027.

A scenario experiment exploring a reduction in frailty progression indicates that almost 222,000 people remain mildly frail each year rather than becoming moderately or severely frail (68,200 fewer moderately frail and 110,000 fewer severely frail). The corresponding impact on primary care service use is projected to be 623,700 fewer GP consultations (face-to-face, telephone, home visits and e-consultations) per annum in 2027. In relation to secondary care services there could be 64,111 fewer Accident and Emergency (A&E) attendances, 1540 fewer admissions to critical care and 350,762 fewer outpatient appointments as well as 53,162 fewer unplanned admissions and 54,283 fewer elective admissions. The cost savings from all these service use changes could amount to £298.9 million per annum by 2027.

A scenario experiment considering reducing the number of unplanned hospital admissions among patients with frailty by 5% indicates 89,000 fewer hospital admissions. The cost saving from this service use change could amount to £153.8 million per annum by 2027.

Findings will be used to inform guidelines and recommendations for service providers and commissioners.

## Conclusions

This study provides new and robust evidence on incidence, prevalence and progression of frailty in an ageing population, in particular highlighting that frailty is already present in those aged 50–64 and that healthcare use and costs related to older people with frailty are substantial. The statistical modelling suggests that age, sex, deprivation, ethnicity and urban/rural location are all independently associated with frailty onset and progression and costs. The large increases in individual costs with more severe frailty need to be considered together with overall population prevalence of frailty categories, and the larger overall total costs of care for people with mild or moderate frailty need to be taken into account when deciding which services would be most cost-effective. The simulation model provides projections of frailty prevalence and associated service use and costs over 10 years. Frailty prevalence, service use and costs will continue to rise in the future due in part to the ageing population. Scenario analyses indicate that reduction of incidence and slowing of progression, particularly before the age of 65, has potential to reduce future service demand in both primary and secondary care settings. For example, in relation to primary care, reducing frailty incidence in all age groups could result in reduced GP consultations and home visits as well as fewer medicines used. In secondary care settings, there could also be reductions in ED attendances, hospital admissions and outpatient appointments. Reducing unplanned hospitalisations in older people with frailty would have a more modest impact on costs. The outputs and findings from each element of the study will be collated into a commissioning toolkit, comprising guidance on drivers of frailty-related demand and simulation model outputs that can be used for prediction of future demand and exploration of different service scenarios.

## Study registration

This study is registered as NCT04139278 [www.clinicaltrials.gov](http://www.clinicaltrials.gov).

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