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SHORT REPORT

External validation of the electronic Frailty Index using the population of Wales within the Secure Anonymised Information Linkage Databank

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Abstract

Background: frailty has major implications for health and social care services internationally. The development, validation and national implementation of the electronic Frailty Index (eFI) using routine primary care data has enabled change in the care of older people living with frailty in England.
Aims: to externally validate the eFI in Wales and assess new frailty-related outcomes.
Study design and setting: retrospective cohort study using the Secure Anonymised Information Linkage (SAIL) Databank, comprising 469,000 people aged 65–95, registered with a SAIL contributing general practice on 1 January 2010.
Methods: four categories (fit; mild; moderate and severe) of frailty were constructed using recognised cut points from the eFI. We calculated adjusted hazard ratios (HRs) from Cox regression models for validation of existing outcomes: 1-, 3- and 5-year mortality, hospitalisation, and care home admission for validation. We also analysed, as novel outcomes, 1-year mortality following hospitalisation and frailty transition times.
Results: HR trends for the validation outcomes in SAIL followed the original results from ResearchOne and THIN databases. Relative to the fit category, adjusted HRs in SAIL (95% CI) for 1-year mortality following hospitalisation were 1.05 (95% CI 1.03-1.08) for mild frailty, 1.24 (95% CI 1.21-1.28) for moderate frailty and 1.51 (95% CI 1.45-1.57) for severe frailty. The median time (lower and upper quartile) between frailty categories was 2,165 days (lower and upper quartiles: 1,510 and 2,831) from fit to mild, 1,155 days (lower and upper quartiles: 756 and 1,610) from mild to moderate and 898 days (lower and upper quartiles: 584 and 1,275) from moderate to severe.
Conclusions: further validation of the eFI showed robust predictive validity and utility for new outcomes.

Keywords: *frailty, primary care, electronic frailty index, electronic health record, cumulative deficit, older people*

Key points

- Hazard ratios for adverse outcomes increase as frailty increases.
- Frailty has major implications for health and social care services internationally.
- External validation of the electronic Frailty Index.

Introduction

Background

Healthy ageing, prevention and management of frailty are key challenges for policy makers, planners, commissioners and providers seeking to ensure sustainability of health and social care services internationally [1, 2]. The recent conceptualisation of frailty as a long-term condition is enabling development of novel approaches to these challenges [3].

An important component of long-term condition management is identifying subgroups of a population at increased risk of adverse outcomes [4, 5]. The development, validation and national implementation of an electronic Frailty Index (eFI) using electronic health records (EHRs) showed the predictive ability for frailty-related adverse outcomes such as mortality, hospitalisation and nursing home admission [6] and has enabled new care models for people living with frailty [7]. This has led to change in National Health Service (NHS) policy in England, including the requirement to identify and manage people living with moderate and severe frailty [8].

Aims

The aim of this work was to externally validate the eFI by comparing existing results to those created using Welsh data. We also extended the work to the outcomes of 1-year mortality following hospital admission and frailty transition times.

Methods

Study design

We used longitudinal anonymised EHRs from the SAIL Databank [9–11] to conduct a retrospective cohort study. We used primary care general practice data collected from 1 January 2000 to 31 December 2009 to define our cohort. We used primary care, hospital admissions, mortality and demographic data from 1 January 2010 to 31 December 2014 to generate outcomes on 1-, 3- and 5-year hospital, care home admissions and mortality.

The electronic Frailty Index

The eFI is based on the internationally established cumulative deficit model, and it assigns a frailty score to an individual calculated using 36 variables from primary care data including symptoms, signs, diseases, disabilities and abnormal laboratory values, referred to as deficits [12]. The eFI score is the number of deficits present, expressed as an equally weighted proportion of the total. An individual with a single deficit would be assigned an eFI of 1/36 (0.03); another with nine deficits would be assigned an eFI of 9/36 (0.25). The eFI score is then used to categorise individuals as: fit (eFI value of 0–0.12), mild (>0.12–0.24), moderate (>0.24–0.36) or severely frail (>0.36) [7]. The eFI deficits and prevalence in the SAIL databank are presented in Table S1

Datasets

Our cohort was created using data held within the SAIL databank. The databank contains the Welsh Longitudinal General Practice (WLGP) primary care dataset, enabling us to calculate the eFI and provide evidence of care home admissions using Read codes (specifics in Table S2). We used the Emergency Department Data Set (EDDS) and the Patient Episode Database for Wales (PEDW) for details of events in accident and emergency departments and emergency hospital admissions, respectively. We used the Annual District Death Extract (ADDE) to determine deaths. We used the Welsh Demographic Service (WDS) dataset to check if individuals had moved out of Wales in the follow up period and to confirm the date of death.

ResearchOne is a database consisting of anonymised clinical and administrative data from around six million patients held on the TPP SystmOne clinical system [13]. The THIN database contains anonymised EHRs from over 500 UK primary care practices using the Vision clinical system [14].

Participants: SAIL cohort

We included individuals aged 65–95 on 1 January 2010 registered at a practice contributing data to the SAIL databank. Patients moving out of Wales after this date were censored.

Statistical analysis

Key outcomes were 1-, 3- and 5-year emergency hospitalisation, care home admissions and mortality. We also include the median, lower and upper quartiles for the length of stay for emergency hospitalisation. We investigated 1-year mortality following hospital admission using Cox models to generate hazard ratios (HRs), taking the fit category as our reference. Adjusted HRs included age and sex as covariates. For 1-year mortality following an emergency hospital admission, we created a restricted cohort of individuals identified in the analysis for 1-, 3- and 5-year emergency hospitalisations.

The longitudinal data in SAIL enabled us to identify when deficits were recorded. Using this, we calculated the times taken for individuals to transition between frailty statuses. We calculated the medians, lower and upper quartiles for the frailty transition times over 10 years. We used R version 3.4.3 for all analyses.

Results

Comparison with the original eFI validation

The baseline characteristics shown in Table 1 allow an initial comparison of cohorts.

Table 1. Baseline characteristics for the SAIL, ResearchOne and THIN databases

Characteristic	SAIL cohort	Research One development cohort	Research One internal validation cohort	THIN external validation cohort
Number of individuals	469,000	207,814	207,720	516,007
Age (years): mean (SD)	74.9 (7.4)	75.0 (7.2)	75.0 (7.3)	75.0 (7.3)
Gender				
Male	45%	45%	45%	44%
Female	55%	55%	55%	56%
eFI score: mean (SD)	0.13 (0.10)	0.14 (0.09)	0.14 (0.09)	0.15 (0.10)
Males: mean (SD)	0.12 (0.09)	0.13 (0.09)	0.13 (0.09)	0.14 (0.10)
Females: mean (SD)	0.14 (0.10)	0.15 (0.10)	0.15 (0.10)	0.16 (0.10)
eFI score 99th centile	0.42	0.49	0.49	0.42
Frailty category				
Fit	52%	50%	50%	43%
Mild	33%	35%	35%	37%
Moderate	12%	12%	12%	16%
Severe	3%	3%	3%	4%
Number of medications: mean (SD)	8 (8.3)	8 (8.0)	8 (8.1)	9 (6.8)
Social deprivation	Townsend quintiles[1]	Townsend quintiles	Townsend quintiles	Townsend quintiles[2]
1 (least deprived)	21%	28%	28%	27%
2	20%	18%	18%	24%
3	19%	23%	23%	20%
4	18%	16%	16%	16%
5 (most deprived)	16%	15%	15%	11%

[1]6% of individuals had a missing deprivation quintile. [2]2% of individuals had a missing deprivation quintile.

1-, 3- and 5-Year outcome comparisons between SAIL and existing results from ResearchOne and THIN

We focus on the adjusted HRs, presented in Table 2, to highlight differences between the cohorts. We include the demographics for the independent variables (age and sex) in Table S3. There is an increase in age and percentage of females as the frailty severity increases, which may explain the differences between the unadjusted and adjusted HRs (unadjusted HRs in Table S4). The resulting trend in HRs for the SAIL cohort largely agrees with the ResearchOne database. There is generally a small increase in the adjusted HRs from the SAIL databank, indicating a higher rate of an adverse outcome in Wales. This is quantified using a fixed effects meta-analysis of the HRs (detailed in Table S5).

The length of the stay for hospital admissions shows the median length of stay increases as the frailty severity increases. Specifically, the median (mean [standard deviation], Lower Quartile, Upper Quartile) length of stay was: 4 days (10.8 [25.3], 1, 11) for fit individuals, 5 days (11.0 [24.2], 1, 12) for mild frailty, 5 days (12 [24.9], 1, 14) for moderate frailty and 7 days (13.1 [22.4], 2, 15) for severe frailty.

Novel frailty outcomes using the SAIL databank

1-Year mortality following hospital admission

We analysed the 1-year mortality following an unplanned hospitalisation by linking hospital admissions with mortality data. Unadjusted HRs (95% confidence interval), compared with people who were defined as fit, were 1.24 (1.21, 1.27) for mildly frail individuals, 1.73 (1.68, 1.77) for moderately frail individuals and 2.34 (2.25, 2.44) for severely frail individuals. Corresponding HRs adjusted for sex and age were 1.05 (1.03, 1.08), 1.24 (1.21, 1.28) and 1.51 (1.45, 1.57), respectively.

Frailty transitions

Frailty transition times were calculated using data from 1 January 2000 to 31 December 2009. As the eFI uses cumulative deficits, people only transition to a higher frailty status. The median (Lower quartile, Upper quartile) transition times (in days) were: 2,165 (1,510 and 2,831) from fit to mild; 1,155 (756 and 1,610) from mild to moderate; and 898 (584 and 1,275) from moderate to severe.

Discussion

Our validation of the eFI in the SAIL databank demonstrates consistency of findings with the original eFI study. Additionally, we provide new evidence that the eFI is a useful predictor of increased mortality risk in the year following incident hospital admission.

The results also identify some important differences. Baseline characteristics indicate that SAIL participants were, on average, from areas of greater social deprivation, and were at increased risk of mortality. These findings provide evidence to support the presence of health inequalities in later life, potentially driven through the wider determinants of health. These are the environmental conditions, and the wider set of systems shaping the conditions of daily life such as economic

Table 2. Adjusted 1-, 3- and 5-year hazard ratios for outcomes of mortality, unplanned hospitalisation and care home admission. The hazard ratio comparator is fit older people, adjusted for age and sex

	Mild	Moderate	Severe
1-Year mortality			
SAIL databank	2.04 (1.96, 2.13)	3.41 (3.27, 3.57)	5.32 (5.03, 5.62)
ResearchOne	1.92 (1.81, 2.04)	3.10 (2.91, 3.31)	4.52 (4.16, 4.91)
THIN	1.86 (1.78, 1.95)	3.02 (2.88, 3.16)	4.50 (4.26, 4.76)
3-Year mortality			
SAIL databank	1.83 (1.79, 1.87)	2.98 (2.91, 3.06)	4.59 (4.44, 4.75)
ResearchOne	1.77 (1.71, 1.83)	2.78 (2.68, 2.89)	3.99 (3.79, 4.20)
THIN	1.73 (1.68, 1.77)	2.70 (2.63, 2.77)	4.06 (3.93, 4.19)
5-Year mortality			
SAIL databank	1.80 (1.77, 1.83)	2.85 (2.80, 2.91)	4.31 (4.19, 4.42)
ResearchOne	1.72 (1.68, 1.77)	2.64 (2.57, 2.72)	3.83 (3.68, 3.99)
THIN	1.66 (1.63, 1.69)	2.54 (2.49, 2.60)	3.84 (3.74, 3.94)
1-Year first emergency admission			
SAIL databank	1.93 (1.90, 1.96)	3.15 (3.09, 3.21)	4.80 (4.67, 4.93)
ResearchOne	1.93 (1.86, 2.01)	3.04 (2.90, 3.19)	4.73 (4.43, 5.06)
THIN	2.03 (1.96, 2.10)	3.50 (3.38, 3.63)	5.58 (5.34, 5.84)
3-Year first emergency admission			
SAIL databank	1.86 (1.84, 1.88)	2.89 (2.85, 2.92)	4.25 (4.16, 4.34)
ResearchOne	1.78 (1.74, 1.82)	2.63 (2.55, 2.71)	3.76 (3.60, 3.94)
THIN	1.89 (1.85, 1.93)	3.03 (2.96, 3.11)	4.66 (4.51, 4.80)
5-Year first emergency admission			
SAIL databank	1.85 (1.83, 1.87)	2.81 (2.78, 2.84)	4.10 (4.02, 4.18)
ResearchOne	1.71 (1.68, 1.74)	2.5 (2.44, 2.56)	3.43 (3.31, 3.58)
1-Year care home admission			
SAIL databank	1.70 (1.51, 1.91)	2.65 (2.34, 2.99)	4.56 (3.93, 5.28)
ResearchOne	1.89 (1.63, 2.15)	3.19 (2.73, 3.73)	4.76 (3.92, 5.77)
3-Year care home admission			
SAIL databank	1.52 (1.43, 1.63)	2.27 (2.11, 2.44)	3.71 (3.39, 4.07)
ResearchOne	1.67 (1.56, 1.80)	2.60 (2.40, 2.82)	3.55 (3.19, 3.96)
5-Year care home admission			
SAIL databank	1.50 (1.43, 1.57)	2.18 (2.07, 2.30)	3.55 (3.31, 3.82)
ResearchOne	1.59 (1.51, 1.67)	2.30 (2.18, 2.44)	3.12 (2.88, 3.38)

and social policies, development agendas and societal norms. The role of the wider determinants of health across the life course are well-established, including the observation that people living in more deprived areas are likely to develop disability, health problems and die younger [15–17]. It is possible that the findings reported represent the impact of wider determinants in frailty, which could have important policy implications.

There was a consistent trend across all cohorts having increased HRs as frailty severity increases. The HRs show that there is an increased risk of death following hospitalisation depending on the level of frailty. Existing evidence indicates that hospitalisation is a marker of adverse health trajectory and mortality in older people [18], and the eFI may help identify a high risk population.

The frailty transition times show a reduced time between subsequent frailty categories. This emphasises the importance of preventative measures to reduce the chance of transitioning to severe frailty and subsequently being at a higher risk of an adverse event.

Strengths and limitations

Utilisation of linked longitudinal data was a strength of this study, allowing us to adjust for outward migration, investigate mortality following hospitalisation and transition times between frailty categories, which were not possible in the original study. Limitations include reliance on general practitioners coding deficits and the accuracy of Read codes in determining care home residency. Furthermore,we were unable to formally investigate social and economic factors within our study due to the aggregation of deprivation to an area level.

Conclusions

We externally validated the eFI using a population-wide cohort confirming previous findings that the eFI is a robust predictor of adverse outcomes. We report novel findings indicating that the eFI identifies people at increased risk of mortality following a hospital admission, and new information on frailty transition times. These findings have important policy implications in terms of advance care planning and introducing preventative measures.

Supplementary data: Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

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Ethical approval: The data used in this study are available in the SAIL databank at Swansea University, Swansea, UK. All proposals to use SAIL data are subject to review by an independent Information Governance Review Panel (IGRP). Before any data can be accessed, approval must be given by the IGRP. The IGRP gives careful consideration to each project to ensure proper and appropriate use of SAIL data. When access has been approved, it is gained through a privacy-protecting safe haven and remote access system referred to as the SAIL Gateway. SAIL has established an application process to be followed by anyone who would like to access data via SAIL (https://www.saildatabank.com/application-process).

This study has been approved by the IGRP as project 0699.

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