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# The dynamics of frailty and change in socio-economic conditions: evidence for the 65+ in Europe

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**Background:** The frailty phenotype for older people is defined as an increased vulnerability to stressors, leading to adverse health outcomes. It is acknowledged as a specific precursor of disability besides chronic diseases that allows for some reversibility in the loss of autonomy. Although the literature on the socio-economic determinants of frailty is emerging in cross-sectional settings, little is known about the dynamics of this relationship over time. This article examines the joint evolution of frailty and change in economic conditions for the 65+ in Europe. **Methods:** Individual and longitudinal data from SHARE (Survey on Health, Ageing and Retirement in Europe) over the period 2004–12 has been used. The sample contains 31 044 observations from 12 002 respondents aged 65 or more. A fixed effect Poisson model is estimated in order to control for unobserved individual heterogeneity. Three types of explanative economic variables have been considered in turn: income, wealth and a subjective variable of deprivation. **Results:** Our results indicate that individuals with worsening economic conditions (wealth and subjective deprivation) over time simultaneously experience a rapid increase in the frailty symptoms. Results also show that the nature of economic variable does not affect the frailty process in the same way. Subjective measure of deprivation seems to better evaluate the household's financial difficulties than objective measure. **Conclusion:** From a public policy perspective, these results show that policies fostering economic conditions of the elderly could have a significant impact on frailty and henceforth, could reduce the risks of disability.

## Introduction

Ageing of baby boomers coupled with an increase in life expectancy and a reduction in fertility rates resulted in a growing proportion of elderly in the European population. This phenomenon combined with mixed evidence regarding trends in healthy life expectancy lead policy-makers to anticipate public health and economic issues.<sup>1,2</sup> Improvements in the functional status of elderly people could help mitigate the rise in the demand of care and long-term care and also health expenditures. In the perspective of developing disability prevention and health promotion strategies for older Europeans,<sup>3</sup> it is particularly important to identify the socio-economic determinants associated with the loss autonomy for better understanding who are the elders at risk of becoming frail.

Frailty is defined as an increased vulnerability to stressors, resulting from a decrease in physiological reserves of multiple body systems. Recent research emphasizes the role of frailty as a specific and independent precursor of the loss autonomy<sup>4,5</sup> that is predictor of adverse health outcomes (falls and fractures, hospitalization, worsened mobility and functional declines, nursing home admissions and death).<sup>6–12</sup> Even if there is no widely accepted measurement of frailty, the frailty phenotype developed by Fried *et al.*<sup>9</sup> is one of the most validated. It gives a standardized and operational definition of frailty.<sup>13,14</sup> It is considered as a distinct health dimension, besides chronic diseases and functional dependency, and as a pre-disability stage.<sup>15,16</sup> Because frailty may be interpreted as a pre-disability stage that is reversible,<sup>17,18</sup> from a public policy perspective it offers opportunities for early detection and prevention.

In Europe, several articles documented the importance of the frailty issue. In France, frail elders will represent more than 3% of the total population by 2060,<sup>19</sup> and the cost of frailty represents

€1500 euros per year/frail elder.<sup>20</sup> Moreover, recent findings using (Survey on Health, Ageing and Retirement in Europe) SHARE data provided evidence that even after controlling for country-level fixed effects, frailty is associated with an average 2% increase in hospital use.<sup>10,11</sup>

Medical literature devotes considerable attention to the potential risk's factors for frailty, but the link between socio-economic variables and frailty among elderly is relatively poorly understood.

Three studies provide evidence of an inverse relationship between socio-economic variables (income and education) and frailty.<sup>12,17,21</sup> However, due to the cross-sectional nature of the dataset, they cannot evaluate the dynamic of the relationship between frailty and socio-economic variables. More recently, Arrighi *et al.*<sup>22</sup> studied the dynamic of the relationship by focussing on frailty transition. They show that across Europe poorer and less educated elders at baseline were more likely to experience health degradations (increase in frailty phenotype) and also less likely to experience health improvements (decrease of frailty phenotype) in the near future. These results indicate the presence of socio-economic gradient for functional health and also demonstrate the importance of considering the dynamic of the frailty phenotype. In 2017, using longitudinal data with the SHARE, Stolz *et al.*<sup>23</sup> focussed on the association between poverty risk and frailty. They defined the poverty risk as a combined measure of low household income (under 60% of the national median income) and limited wealth (belonging to the lowest quintile regarding country-specific household net wealth at least once during the period). Frailty is measured with a frailty index which is a cumulative measure of health deficits (39 items are used). They found that the poverty risk is a strong predictor of frailty. This relationship is mostly explained by psychosocial and material factors. None of these studies investigate the dynamics of the

relationship by evaluating whether change in socio-economic variables over time and more particularly financial variables such as wealth, income or subjective variable of deprivation are associated with changes in the frailty symptoms. This article seeks to address this existing gap in the literature. We hypothesized that the nature of financial variables does not affect frailty symptoms in a similarly way. For instance, we hypothesized that for elderly changes in income are easier to anticipate than changes in make ends needs over-time or changes in wealth. The consequences on health dimension measured by frailty symptoms may differ.

Thereby, the purpose of this research is to contribute to understanding the process of frailty and to identify the role of socio-economic variables in the dynamics of frailty. We use panel data from SHARE. We construct a sample of 12 002 individuals aged 65 and over, we assess for the first time whether annual changes in frailty symptoms are associated with annual changes in socio-economic determinants.

## Methods

### Presentation of the sample

We use data from the SHARE, a multidisciplinary and cross-national panel database containing individual information on health, socio-economic status, social and family relationships for individual aged 50 or over.<sup>24</sup> We use data from Wave 1 (2004–05), Wave 2 (2006–07), Wave 4 (2011) and Wave 5 (2013). We exclude from the analysis the third wave (2008–09) known as SHARELIFE because it focussed on respondents' life histories in a retrospective way. In this article, we exploit the longitudinal dimension of the survey and we restrict to the ten European countries that have participated in all the five waves.

The frailty phenotype is relevant for older people. Since frailty prevalence is very low for middle-aged adults,<sup>25</sup> we restricted the sample to individual aged 65 or more. We base our analysis on an unbalanced panel which amount 67 178 observations. We delete observations for which information on variables of interest are missing, observations where there is just one observation over the period and also observations where the dependent variables are equal to 0 over the period (there is no change different than 0 over the period). This reduces the size of the final sample for estimation to 31 044 observations corresponding to 12 002 individuals (Supplementary appendix tables SA1 and SA6). We discuss the selection in Supplementary appendix tables SA2 and SA3.

### Outcome variable: number of frailty criteria

The concept of frailty used in gerontology literature describes a biologic syndrome of decreased reserve and resistance to stressors, resulting from cumulative declines across multiple physiologic systems and causing vulnerability to adverse outcomes.<sup>7,26</sup> The frailty phenotype<sup>9</sup> has two main advantages when compared with the frailty index<sup>18</sup>: first, it is based upon a theoretical model of change in older adult's physiology while the frailty index is mainly developed from an empirical perspective. Second, the measure of the frailty phenotype requires only a small set of variables, which is more easily reproducible and comparable across surveys, while the frailty index requires a large amount of information (often more than 80 variables).

We used the definition of the frailty phenotype and the operationalization developed by Santos-Eggimann *et al.*<sup>25</sup> with the SHARE survey contents that rest on the five criteria from the Fried model (see Supplementary appendix table SA4). Based on the five features: unintentional weight loss, exhaustion, low physical activity, muscle weakness and slow walking speed, frailty corresponds to the presence of three or more of these features, pre-frailty corresponds to one or two items and none denotes robust individual. As illustrated in table 1, we find a small prevalence of

extreme frailty: <2% of the sample is credited with extreme value of the frailty phenotype at each wave. According to the thresholds given by the Fried model, frail individuals (frailty phenotype  $\geq 3$ ) represent between 13.3% in Wave 1 and 20.8% in Wave 5. Values of the frailty phenotype increase with time spent between waves. The use of categories is designed to help health professionals to take a medical decision on the basis of the cut-points. In our case, we are more interested in the internal dynamics of increase or decrease in the distribution of frailty. We use the number of frailty symptoms [the count of frailty phenotype criteria (0–5)] rather than the frailty phenotype.

## Explanatory variables

### Socio-economic variables

Following Adena and Myck<sup>27</sup> and Arrighi *et al.*,<sup>22</sup> we proxy the economic situation of elderly by three different variables that are correlated: household income, household wealth and a subjective deprivation that indicates if the household is able to make-ends-meet. For household income and wealth, respondents were classified into their respective quartiles of the distribution. To consider a healthy worker effect (suggesting in our case that people with higher levels of the frailty phenotype keep out or drop out of the labour market), we include a binary index of occupational status indicating whether the respondent is active occupied at the time of the survey.

### Other covariates

The literature also emphasizes the role of social capital on health for elderly.<sup>28,29</sup> We include a dummy variable indicating if the respondent divorced or widowed within last 2 years and a variable indicating the respondent's participation to social activities. Health and functional status are also considered by including the number of limitations with activities of daily living (ADL),<sup>30</sup> the number of instrumental ADL (IADL)<sup>31</sup> and the number of chronic diseases. We also control for risk factors such as smoking and alcohol abuse because these behaviours are more prevalent among lower socio-economic group. Supplementary appendix table SA5 provides a definition of explanatory variables, Supplementary appendix table SA6 presents summary statistics for these variables and Supplementary appendix table SA7 shows changes in covariates over the time.

### Empirical model

We use panel data and choose to implement a Poisson fixed effect model to assess whether annual changes in frailty phenotype are associated with annual changes in socio-economic variables during the period. We do not estimate a causal effect but the correlation between economic status and frailty risks. The major advantage of Poisson fixed effects estimator is that by differencing out variability within individuals, it is possible to control for all time-invariant differences across individuals (characteristics that vary across individuals but not over time) such as cohort, genetic and education.<sup>32</sup> It provides consistent estimates and efficient robust standard errors under strict exogeneity assumption and whatever the distribution of  $y_{it}$ .<sup>32</sup> Formerly, for each  $t = 1, \dots, T$ , we assume that  $y_{it}$  has a Poisson distribution with conditional mean:

$$E(y_{it}|X_{it}, \alpha_i) = \alpha_i \exp(\beta X_{it})$$

where  $\alpha_i$  is unobserved and is possibly correlated with  $X_{it}$ .  $y_{it}$  is the dependent variable (i.e. the number of frailty symptoms),  $X_{it}$  is the matrix of the explanatory variables. An alternative econometric approach would use random effects estimators but they assume that the individual specific effects are uncorrelated with explanatory variables. This assumption is strong and has been tested and rejected by performing a Hausman test<sup>33</sup> which suggests that the fixed effect specification was more efficient and therefore the most appropriate method to use.

**Table 1** Distribution of the frailty symptoms between waves

Frailty phenotype	Wave 1	Wave 2	Wave 4	Wave 5	Total
0	1885 (33.9%)	2043 (29.8%)	2114 (21.6%)	1575 (17.8%)	7617 (24.5%)
1	1941 (34.9%)	2447 (35.7%)	382 (39.1%)	3491 (39.5%)	11 699 (37.7%)
2	999 (18.0%)	1306 (19.0%)	2043 (20.9%)	1942 (22.0%)	629 (20.3%)
3	477 (8.6%)	657 (9.6%)	1082 (11.1%)	1056 (11.9%)	3272 (10.5%)
4	220 (4.0%)	322 (4.7%)	568 (5.8%)	618 (7.0%)	1728 (5.6%)
5	41 (0.7%)	89 (1.3%)	141 (1.4%)	167 (1.9%)	438 (1.4%)

**Table 2** Estimation results: odds ratio

Dependent variables frailty phenotype	Model 1	Model 2	Model 3
Make-ends-meet: Ref. easily	Ref.		
With great difficulty	0.939***		
With some difficulty	0.919***		
Fairly easily	0.902***		
Household wealth:		Ref.	
Ref. Q4-higher			
Q1—Poorest		0.982	
Q2—Lower-middle		0.942**	
Q3—Upper-middle		0.929***	
Household income:			Ref.
Ref. Q4-higher			
Q1—Poorest			1.003
Q2—Lower-middle			0.998
Q3—Upper-middle			1.003
Without partner $\leq 2$ years	1.061**	1.060**	1.058*
Ref. No			
Occupational status: at work	1.080	1.081	1.078
Ref. No			
Social activities Ref. No	0.907***	0.906***	0.906***
Drink 3+/week	0.946**	0.948**	0.947**
Drink <3/week	Ref.	Ref.	Ref.
Non-drinker	1.081***	1.084***	1.083***
Current smoker Ref. No	0.975	0.971	0.974
Number of ADL limitations	1.041***	1.041***	1.041***
Number of IADL	1.070***	1.070***	1.070***
Number of chronic diseases	1.054***	1.054***	1.054***
Wave 1	Ref.	Ref.	Ref.
Wave 2	1.157***	1.153***	1.155***
Wave 4	1.548***	1.535***	1.541***
Wave 5	1.710***	1.692***	1.699***
No. of observations	31 147	31 044	31 044
No. of individuals	12 039	12 002	12 002
Hausman test (H0: RE > FE)	0.000	0.000	0.000
Endogeneity (H0: strict exogeneity)	0.772	0.172	0.819

\* $P < 0.10$ ; \*\* $P < 0.05$ ; \*\*\* $P < 0.001$ .

We run our fixed effects Poisson model on an unbalanced panel. Consequently, attrition bias must be tested: individuals may drop out of the panel in a non-random manner resulting in sample selection problem that biased estimators. In particular, our results may be biased by health-related attrition: those who remain in the panel are likely to be younger and healthier. We check this attrition bias by performing a Hausman test that compares the fixed effect Poisson estimator in the balanced sub-panel and the fixed effect Poisson estimator in the unbalanced panel.<sup>34</sup>

## Results

Table 2 displays estimation results. Three specifications have been considered by introducing separately the three socio-economic determinants: first a subjective measure of financial deprivation, second the household wealth and third the household income. All the estimations passed the Hausman, strict exogeneity and attrition tests suggesting that our estimations are consistent.

Estimates from Model 1 show that individuals who fall into categories with higher difficulty to make-ends-meet become significantly frailer. In Model 2, we focus on the household wealth and show similar results. Individuals who turn to higher quartile of wealth into lower quartile of wealth become significantly frailer. These findings indicate that individuals who fall in situation of financial difficulties or becoming less wealthy have a higher risk of being frailer. However, in Model 3, we show that change in income does not affect the number of frailty symptoms.

In the three specifications, we found similar results for other covariates. As expected, variables that are proxies of social capital affect the number of frailty symptoms. The recent loss of a partner increases the frailty process. At the opposite, the participation of social activities significantly prevents from an increase in frailty (or may even contribute to a reversible pathway).

## Discussion

Using panel data from SHARE, this article analyzed the determinants and the role of socio-economic variables in the dynamics of frailty in Europe. We used Poisson fixed effect models that allow control for all time-invariant differences across individuals. Our approach differs from previous studies by evaluating whether changes in financial variables are associated with changes in number of frailty symptoms.

This article provides two main contributions to the literature and confirms the presence of a socio-economic gradient in the dynamic of frailty using the number of frailty symptoms corresponding to the count of frailty phenotype criteria.

First, our analysis indicates that the worsening of economic conditions is associated with the increase in frailty. Subjective measures of deprivation, such as the ability to make-ends-meet, seem to better evaluate the household's financial difficulties than objective measure, such as household income and wealth, because they depend on other factors (access to cheap housing, availability of help from family, friends or neighbour or the availability of free public goods and services, such as healthcare).<sup>36</sup> Second, our analyses provide evidence that elderly people who experience a decline in their social activities face a higher risk of becoming frail. Elders who do not have a living partner are more likely to become frail over a 2-year time period. These results underline the existence of a second source of inequalities associated with the frailty process: individuals who experience some decrease in social capital are more likely to face frailty issues. In other words, social isolation appears to be one of the main determinants of the frailty process.

Our results are in line with Stolz *et al.*,<sup>23</sup> who found using a different measure of frailty that a part of the poverty association was due to material factor such as low-quality accommodation. They evaluated the effect of low economic resources by adopting a combined measure of poverty using household income and wealth. Our results demonstrate the importance to evaluate separately these two effects. We show that the nature of financial objective variables does not affect the frailty process in the similarly way.

Although our results confirm previous empirical evidence of a significant association between household wealth at baseline and frailty, the association between household income and frailty is

non-significant in a dynamic process. This suggests the importance to evaluate independently the effect of income and wealth on the frailty.<sup>23</sup> These results are coherent with life cycle theory<sup>37</sup> that distinct income and wealth effect by indicating that after retirement, income decline and individuals consume out some of the previously accumulated wealth. Individuals aged 65 years old and over are mostly pensioner with little variance in the level of their income over time. This may explain why changes in income are not correlated with frailty. At the opposite, wealth appears as the adjustment variable to make ends meet and thus may be used to invest in personal health care, home adaptations, investments in family and social networks and thus explain the association with frailty.

Although we assume that a lower economic status is associated with a higher risk of frailty, it is likely that frail elders also experience wealth losses due to their frail condition. Less is known about the impact of frailty on economic conditions. In France, the net cost of frailty in terms of ambulatory costs is estimated to be €1500 per year per person, suggesting that frail elders may experience wealth losses.<sup>20</sup> Moreover, one could argue that elders who become frail anticipate that their risks of disability increase, and may start to reduce their wealth (e.g. by giving inheritance to their heirs) to become eligible for public disability allowances. The rationale behind that behaviour is that some people may prefer having public funding sources sponsoring their disability rather than paying themselves for most of its cost. To our knowledge, the presence of these so-called 'spend-down' behaviours has not been documented in the frail elderly population.

From a public policy perspective, our results provide insight that policies fostering economic conditions of the elderly could have a significant impact on frailty and henceforth, could reduce the risks of disability. The role of government or national health fund may act in different way. As it is done for disabled in most OECD countries, a solution to slow down or reverse the process of frailty and loss of autonomy may consist in providing additional or more generous safety nets for the ageing population and more particularly among those who experience economic difficulties.

This financial support may improve the access to basic care or the availability to make ends meet that may reduce the frailty dynamics and the risk of having health adverse outcomes. For instance, Rapp *et al.*<sup>38</sup> demonstrate that financial assistance for Alzheimer's disease reduce emergency rate. Another way may be to improve social protection for frail individuals which have higher expenditures (€750 additional euros for pre-frail individuals and €1500 for frail individuals<sup>20</sup>) by recognition of frailty as a specific health condition and covering out-of-pocket payments due to frailty. Additionally, implementing efficient intervention to prevent or postpone the frailty process could also reduce the health expenditures and adverse outcomes due to frailty.

Finally, these results underline the legitimacy of Social Protection Systems in Europe to moderate the impact of health and economic shocks and to maintain healthy ageing. Specifically, our results plead in favour of home interventions that target isolated elders, and increase or maintain their social capital. Further research will be needed to better understand the relative importance of that key determinant of the frailty process, compared with the influence of financial variables.

## Supplementary data

Supplementary data are available at *EURPUB* online.

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*Conflicts of interest:* None declared.

## Key points

- Socio-economic conditions have been found to be detrimental for frailty among the elderly (65+).
- Changes in wealth and changes in the ability to make-ends-meet are associated with changes in frailty but the association between income and frailty is non-significant in a dynamic process.
- Individuals who experience some decrease in social capital are more likely to face frailty issues.
- Policies fostering economic conditions of the elderly could have a significant impact on frailty and henceforth, could reduce the risks of disability.

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