IRDES
Institut de recherche et documentation en économie de la santé

Frailty Research in Economics, Society and Health (FRESH)

Projet de recherche 2011-2014

RAPPORT FINAL

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ERA-AGE2 – FLARE2 Post-Doctoral Fellowship
IRDES (Paris, FR), SOLIDAGE (U. McGill & U. de Montréal, Québec, CA) & IUMSP (U. Lausanne, SW)

Remis à la CNSA le 06 Octobre 2014

FRESH

Frailty Research
Economics Society and Health

Rappel des objectifs

Le projet FRESH (*Frailty Research in Economics, Society, and Health*) a pour objectif de développer une analyse originale de la perte d'autonomie en introduisant le concept de *fragilité* en population générale. La fragilité fait référence à un état de vulnérabilité aux chocs de santé qui peuvent amener à un processus de perte d'autonomie. Un individu fragile a un processus de résilience plus long qu'un non-fragile, ce qui se traduit par une exposition plus grande à des risques de perte d'autonomie plus élevés pouvant conduire à une situation de dépendance. Revenir d'une situation de dépendance à une situation d'autonomie peut être impossible et le processus de perte d'autonomie s'apparente alors à une « trappe à incapacité ». Compte tenu des coûts importants liés à la dépendance, prévenir ce genre de situation s'avère être un enjeu majeur de politique publique.

En adaptant les outils méthodologiques de l'analyse de la vulnérabilité en économie du développement, le projet FRESH propose d'atteindre deux objectifs : le premier consiste à développer un cadre d'analyse économique pour l'étude du concept, sa mesure et les coûts associés à la fragilité. Le second objectif est d'identifier les déterminants de la fragilité en population générale.

Le projet FRESH s'inspire d'un ensemble de travaux réalisés à partir de l'enquête SHARE ; à partir de laquelle un instrument clinique de mesure de la fragilité a été développé, testé et validé empiriquement. La fragilité y est retenue comme un déterminant important de la limitation fonctionnelle. L'extension à la dimension cognitive et l'exploration des caractéristiques individuelles (variables socio-économiques en données de panel et rétrospectives) et institutionnelles (caractéristiques des systèmes de protection sociale, etc.) dans différents pays en Europe, est une piste de recherche qui mérite d'être explorée.

Ce projet regroupe des chercheurs issus du champ de l'économie, la sociologie et la santé publique dans un réseau international. L'enjeu est d'introduire le concept de fragilité en économie de la santé afin de produire des connaissances nouvelles, par exemple pour l'évaluation des coûts d'une politique de prévention de la perte d'autonomie.

CNSA
Caisse nationale de solidarité pour l'autonomie

Future Leaders flare of Ageing Research

ERA AGE 2
European Research Area in Ageing 2

Avant-propos

Le présent rapport de recherche constitue le compte rendu final du projet FRESH (Frailty Research in Economics, Society and Health) obtenu dans le cadre du projet Européen FLARE2-ERA-AGE et financé en France par la CNSA. Les trois années de recherche ont été conduites au sein de l'IRDES ainsi que dans deux université d'accueil : à SOLIDAGE à l'université de Montréal au Québec, sous le patronage du Pr. François Béland ; et à l'IUMSP à l'université de Lausanne en Suisse, sous le patronage du Pr. Brigitte Santos-Eggimann.

La production scientifique du projet FRESH a été importante, tant sur les aspects qualitatifs que quantitatifs. Deux articles de recherches publiés sous la forme de documents de travail et inclus dans le présent rapport sont aujourd'hui en soumission à des journaux scientifiques de premier plan. Nous avons bon espoir dans leur publication prochaine. D'ores et déjà, ces travaux ont été présentés dans de nombreux séminaires dans le monde et ont suscité l'intérêt de nombreux chercheurs et responsables institutionnels.

Au-delà des publications scientifiques, le projet FRESH a permis le développement d'une stratégie de recherche ambitieuse de la part du lauréat dans le domaine de la prévention et de l'accompagnement de la perte d'autonomie. Dans un premier temps, des projets « compagnons » ont été mise en œuvre à l'IRDES avec le soutien de la CNSA (projet COMPAS sur les dépenses de santé des personnes fragiles) et la CNAV (projet de ciblage des populations fragiles). Dans un second temps, des projets ont été développés dans le cadre de l'université Paris Descartes où le lauréat a accepté un poste d'enseignant-chercheur au LIRAES (Laboratoire Interdisciplinaire de Recherche Appliquée à l'Économie de la Santé). Dans ce cadre, nous avons centré nos recherches sur le processus de perte d'autonomie et obtenu le soutien de notre université et de partenaires publics pour (i) l'organisation d'un séminaire scientifique les 6 et 7 mars 2014 en partenariat avec l'IRDES proposant un état des lieux de la recherche sur la fragilité, (ii) le montage d'une chaire dédiée à l' « économie de la santé et du vieillissement » et adossée au Master 2 « Economie de la santé » de l'université Paris Descartes, et (ii) la direction d'un programme de recherche interdisciplinaire sur la fragilité dans le cadre des investissements d'avenir de Sorbonne-Paris-Cité : « la dynamique du vieillir ». Enfin, les collaborations scientifiques avec d'autres chercheurs se sont d'abord ancrées dans le long-terme (invitation des Prs. François Béland et Brigitte Santos-Eggimann en tant que chercheurs invités au LIRAES en 2015) et se sont développées en Europe (dans le cadre du projet IMI « Frailty dynamics in Europe » porté par l'université de Rome et auquel le LIRAES est rattaché).

En somme, l'obtention du financement FLARE2-ERA-AGE a permis de faire fructifier le projet FRESH dans le cadre des objectifs initialement fixés, mais aussi au-delà, permettant au Lauréat d'asseoir un peu plus sa position de chercheur dans le domaine de l'économie de la santé et du vieillissement, à l'IRDES et dans les réseaux académiques et institutionnels qui traitent de la question de la perte d'autonomie et de l'accompagnement de la dépendance. A tous ces titres, nous pensons que l'expérience FLARE2 a été un succès.

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Résumé

La fragilité est définie comme un état de santé vulnérable résultant de la diminution de la réserve physiologique de la personne âgée. Ce concept gériatrique est ici mobilisé en population générale comme indicateur permettant d'anticiper l'évolution de l'incapacité et d'évaluer l'impact des actions préventives et d'accompagnement de la perte d'autonomie. Dans une étape introductive, l'auteur présente le programme de recherche mené dans le cadre du projet FRESH, ainsi que les programmes de recherche connexes mis en œuvre autour du projet FRESH. Dans le cadre du projet FRESH, deux analyses sont développées à partir des données de l'enquête SHARE sur respectivement sur les causes et les conséquences de la fragilité.

Dans un premier temps, nous étudions les déterminants socio-économiques de la fragilité en Europe. Les différences individuelles dans la dynamique de la fragilité sont analysées au regard de trois piliers de l'action sociale : politique de soutien au revenu, lutte contre l'isolement social, promotion de l'aménagement du logement. Les différences persistantes dans les niveaux de fragilité sont explorées en utilisant les données rétrospectives sur l'histoire de vie (SHARELIFE). Les premiers résultats indiquent la présence d'inégalités sociales de santé sous différentes formes et à différentes époques de la vie. L'importance des systèmes de protection sociale en Europe est reconnue comme un moyen d'accompagner, voire de retarder l'évolution du processus de perte d'autonomie. Plusieurs pistes pour l'action sont mises au jour, des efforts supplémentaires pourraient notamment être mis en œuvre pour les personnes âgées dans le domaine de l'adaptation du logement.

Dans un second temps, nous avons concentré notre analyse sur la demande de santé émanant des personnes fragiles. En particulier, nous avons analysé l'influence de la fragilité dan le recours au système de soisn, en particulier l'hôpital, dans les différents pays d'Europe, en fonction de leurs système d'adressage de la part des soins ambulatoires vers l'hôpital. Nous avons estimé des modèles dynamiques de panel sur la période 2004-2011 à partir des données de l'enquête SHARE. Nos résultats corroborent ceux des travaux précédents sur les déterminants de recours à l'hôpital en dynamique. Ainsi, nous confirmons l'existence d'une dépendance d'état dans le recours à l'hôpital en Europe. Par ailleurs, nous trouvons que la santé est un des principaux prédicteurs de l'hospitalisation ; dans ce cadre, la fragilité joue un rôle déterminant. Enfin, nous montrons que les différences taux de recours à l'hôpital entre pays diffèrent en fonction du type de système d'adressage. Les systèmes où le passage par la première ligne est obligatoire ou fortement encouragé ont des taux de recours à l'hôpital plus faibles que les systèmes où l'adressage est libre. Dans ce cadre, nous discutons les implications de détection et de suivi de la fragilité dans les soins primaires ainsi que les différentes stratégies de réduction des hospitalisations pouvant être prévenues.

Abstract

In a global context of population ageing, gaining better knowledge of the mechanisms leading to loss of autonomy has become a major objective, notably with the aim of implementing effective preventive healthpolicies. Theconceptof'frailty',originallyintroducedinger@on- tology and geriatrics as a precursor state to functional dependency, appears as a useful tool in this specific context. If several approaches co-exist, Fried's model of frailty, based on five physiological criteria, (fatigue, loss of appetite, muscle weakness, slow walking pace, decreased physical activity), appears to be the most operational in measuring frailty and targeting populations at risk of dependency sufficiently upstream in the disablement process. In terms of health economics, the loss of autonomy approach retained here is particularly interested in the economic and social causes and consequences of the onset of frailty in older adults, and examines the challenges not only in terms of health system efficiency but also in terms of social protection. The FRESH research project not only allowed us to investigate the causes and consequence of frailty for social protection systms, it also helped us developp companion research programs and scientific collaborations on frailty.

In the first stage of the FRESH program, the medical concept of frailty is brought in an economic framework in order to investigate the role social policies may play in preventing disability or maintaining life quality of people in a disablement process. Using four waves of panel data from the Survey on Health, Ageing, and Retirement in Europe (SHARE), a frailty index is created as a count measure for five physiologic criteria (Fried model) for respondents aged 50+ in 10 European countries, between 2004 and 2011. The longitudinal dimension is explored in two ways. First, differences in frailty dynamics over a seven-year-time period are analysed through variables that are relevant for social policy (income maintenance, housing adaptation, and prevention of social isolation) in a panel model for count data with fixed effects. Second, the individual fixed effects are decomposed by means of a random effects model with Mundlak specification. SHARE additional retrospective data on life history (SHARELIFE) are then used to investigate differences in frailty levels. The results reveal the presence of various sources of social inequalities over the life- course. Social Protection Systems thus appear to play a major role in accompanying, preventing or reducing the frailty process. Several policy implications are suggested.

In the second stage of the FRESH program, we focused on the influence of frailty on the demand for health care. In particular, hospital services use, which is a major driver of total health expenditures, is expected to rise over the next decades in Europe, especially because of population ageing. The purpose of our study is to better understand the dynamics of older people's demand for hospital care over time in a cross- country setting. We estimated a dynamic panel model of hospital admission for respondents aged 50 or more from the Survey on Health, Ageing, and Retirement in Europe (SHARE), in 10 countries between 2004 and 2011. Following prior research, we found evidence of state dependence in hospital use over time. We also found that rise in frailty – among other health covariates – is a strong predictor of increased hospital use. Finally, we confirm that countries with strong referral scheme appear to have lower rates in hospital use. Our results support promotion of early detection of frailty in primary care, and improvement of coordination between actors within the health system, as potential strategies to reduce avoidable or unnecessary hospital use among frail elderly.

Plan

Note : Conformément aux dispositions mentionnées dans la convention entre l'IRDES et la CNSA, ce rapport comporte les aspects introduction, méthode, résultats et discussion. Pour des raisons de cohérence interne liées à chaque étape de la réflexion, chaque partie est présentée indépendamment des autres dans les 3 publications réalisées dans le cadre du projet FRESH. Les parties 2 et 3 présentent ainsi les données, la méthode, les résultats et la discussion propre à sa problématique.

1. Présentation du programme de recherche sur la fragilité

   QES n° 184, IRDES. *Manuscrit en soumission à un journal sicentifique.*

2. Les determinants socio-économiques de la fragilité

   DT n° 52, IRDES. *Manuscrit en soumission à un journal sicentifique.*

3. Le recours à l'hopital des personnes fragiles

   DT n°1, LIRAES. *Manuscrit en soumission à un journal sicentifique.*

Questions d'économie de la Santé

n°184 - February 2013

Frailty and Preventing the Loss of Autonomy

A Health Economics Approach

Nicolas Sirven (Irdes)

In a global context of population ageing, gaining better knowledge of the mechanisms leading to loss of autonomy has become a major objective, notably with the aim of implementing effective preventive health policies. The concept of 'frailty', originally introduced in gerontology and geriatrics as a precursor state to functional dependency, appears as a useful tool in this specific context. If several approaches co-exist, Fried's model of frailty, based on five physiological criteria, (fatigue, loss of appetite, muscle weakness, slow walking pace, decreased physical activity), appears to be the most operational in measuring frailty and targeting populations at risk of dependency sufficiently upstream in the disablement process.

In terms of health economics, the loss of autonomy approach retained here is particularly interested in the economic and social causes and consequences of the onset of frailty in older adults, and examines the challenges not only in terms of health system efficiency but also in terms of social protection.

Demographic projections for the coming decades are now well known; the number of individuals aged 65 or over will increase and their percentage within the population will increase significantly in France and other European countries. The main cause is the trend towards a higher life expectancy and the generational effect of the baby-boomers.

Expected changes in the health outcomes of these ageing populations, of concern to policy-makers, is a little less well known. The most recent research seems to indicate an increase in severe disabilities in France among the 50-54 age group. This result, corroborated by studies conducted in Sweden and the United States, indicate a downward bias in the rate of progression of life expectancy in good health: on average the younger elderly will have a longer lifespan but a diminished health-span (Cambois, Blachier and Robine, 2012). The main action area envisaged to curb the above trends largely consists in implementing effective prevention policies. The strategy consists in defining and implementing interventions in favour of persons at risk of becoming 'dependent' on the one hand, and on

the other, targeting vulnerable populations sufficiently early and finally, evaluating these interventions in terms of their effectiveness and efficiency.

The challenge consists in ensuring the sustainability of the overall social protection system, not only from the perspective of old age and autonomy, but also that of the National Health Insurance. The need for knowledge is twofold: on the one hand it involves gaining a clearer indication of the overall costs of loss of autonomy and the different financers' contributions (National Health Insurance, National Pension Fund (CNAV), National Solidarity Fund for Autonomy (CNSA), households etc.). The macroeconomic accounting approach (by expenditure items) should be completed by a complementary approach focusing on individual needs in order to obtain a clearer view of the situation experienced by the individuals concerned. On the other hand, the search for sources of efficiency within the health system should permit a better allocation of rare resources. The main focus is on improving the care pathway (healthcare, medical-social and social): 'one of the most likely causes of 'dependant' persons' excessive health expenditures is that the care pathway, involving successive care and treatment regimens, is far from optimal due to belated interventions and the lack of appropriate responses': (High Council for the Future of Health Insurance (HCAAM) 2011, p. 43.) Furthermore, the search for sources of efficiency within an overall framework of prevention can be effectuated outside the healthcare system, for example by more effectively coordinating the different components making up the social protection system (old age, health, work, and family) with social policy.

At the heart of the preceding challenges, gaining knowledge of the processes leading to loss of autonomy constitutes a major objective. Firstly, a better understanding of the mechanisms leading to severe disability could make it easier to detect individuals at risk of becoming dependent both within the health system and within the general population. Secondly, it would take new risk factors into account and finally, by analysing the role played by the socioeconomic factors determining loss of autonomy, it would broaden the scope of possible interventions outside the health system. The recent development of studies on frailty in older adults opens up new possibilities for research.

Several approaches to define frailty

The term 'frailty' used in gerontology and geriatrics literature aims to describe the multi-systemic[1] reduction in functional reserves affecting certain elderly people, and an increased vulnerability to stressors, even minor. This state of physiological instability exposes the individual to the risk of functional de-compensation, loss of autonomy, institutionalisation and death. Several medical approaches to frailty have been presented in the literature in recent years. Two models predominate, depending on whether the authors and professionals refer to the works of Rockwood (1994, 2005) or Fried (2001). The first uses the holistic[2] approach and is based on a very high number of varied criteria (physiological and cognitive) certain of which are fairly imprecise. This approach makes it possible to create frailty indicators that predict elderly persons' institutionalisation and survival rates fairly accurately but not to distinguish between the concepts of frailty, comorbidity[3] and disability[4]. In this respect, the Rockwood model is often referred to as 'black box epidemiology'. The second model, developed by Linda Fried, is based on an analysis of physiological changes in certain individuals, provoked by senescence and age-related functional changes in skeletal muscle. The frailty phenotype identified by Fried consists of the five following dimensions: fatigue or poor endurance, loss of appetite, muscular weakness, slow walking pace, sedentariness or low physical activity.

Context

The study of frailty covers several research topics: the first, FRESH (Frailty Research in Economics, Society and Health), the result of a partnership between France (IRDES Canada (SOLIDAGE, Montreal and McGill Universities) and Switzerland (IUMP, Lausanne), uses SHARE data to identify the individual determinants of loss of autonomy. In a more operational aim, complementary research using the first results of FRESH is being conducted in 2013 to test the feasibility of targeting frail elderly populations from data available from the Retirement and Occupational Health Insurance Funds (CARSAT). This project, financed by the CNAV, is part of the development of frailty observatories. Finally, a third project COMPAS (Connaissance des populations en perte d'autonomie et leurs consommations de soins: Knowledge of Populations with Loss of Autonomy and their Health Expenditures) financed by the CNSA, is based on the introduction of a questionnaire module measuring frailty in the ESPS 2012 survey; the main objective being a better characterisation of frail persons in France, their use of healthcare and their health expenditures.

The Fried model, based on five functional criteria, appears to be more operational than other frailty models

The Fried model takes into account a specific process underlying changes in physiological reserves. By restricting it to the functional aspect, this model has a greater internal coherence and allows the distinction to be made between frailty, comorbidity and disability.

[1] That is to say that several organs function poorly.

[2] An approach that consists in considering the phenomena as totalities.

[3] In medicine, comorbidity refers to the presence of one or more illnesses associated with a specific disease.

[4] In the health domain, disability refers to any restrictions in the ability to carry out an activity normally (or within the limits considered as normal for a human being) following a deficiency (normally as the result of a disease, an accident, ageing etc.).

The Rockwood model is often difficult to use due to the high number of variables required. In contrast, the Fried model based on only five criteria appears to be more operational (low cost, reproducible and comparable as it can be applied to the specificity of many health surveys) and more economical than other frailty models, not only because of the lower number of variables, but also because the variables retained in the construction of the phenotype provide additional information not included in comorbidity and disability measurements. The popularity of the Fried model is also due to its simple construction. A dichotomous variable (sometimes built up from several modalities) indicates whether one of the five criteria under consideration has been met. In general, one considers that the different dimensions all contribute equally so that the frailty score is obtained directly from the sum of the five variables. It thus varies between 0, for a robust individual without deficiencies, to 5 for an individual with simultaneous deficiencies in the five dimensions. In medical practice, where it is useful to have decision-making rules, two thresholds are applied to the frailty score: an individual is considered pre-frail when one or two criteria are met, and frail from three criteria (Table).

The Fried model has two main limitations. First, considering that each criterion contributes identically to the frailty phenotype is a strong hypothesis. The studies conducted at SOLIDAGE in Québec[5] indicate that all the criteria do not contribute equally in defining frailty. Other recent studies based on SHARE data show that the respective contribution of each dimension differs from one European country to the next. Moreover, the Fried model does not integrate a cognitive dimension that nevertheless constitutes a signifi-

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Distribution of the frailty index (Fried phenotype) in the population aged 50 and over in France, 2011

	Population as a whole			Sub-population without limitations in everyday life activities		
	Robust (%)	Pre-frail (%)	Frails (%)	Robust (%)	Pre-frail (%)	Frail (%)
Variables						
Men						
[50-54]	52.6	43.7	3.7	54.2	43.2	2.5
[55-59]	53.6	43.5	3.0	56.2	41.8	2.1
[60-64]	60.1	36.8	3.1	62.3	35.8	1.9
[65-69]	62.9	32.2	4.9	65.0	31.1	3.9
[70-74]	42.9	42.4	14.8	45.3	41.6	13.1
[75-79]	26.0	57.8	16.2	27.3	60.1	12.7
80+	16.5	51.4	32.1	22.2	56.5	21.3
Total Men	49.1	42.7	8.2	52.2	42.1	5.7
Women						
[50-54]	47.5	47.0	5.5	49.3	47.9	2.9
[55-59]	42.8	51.3	6.0	44.7	51.2	4.1
[60-64]	46.9	48.9	4.2	48.6	48.6	2.8
[65-69]	42.7	52.0	5.3	43.2	52.9	3.9
[70-74]	35.0	55.2	9.8	35.6	56.5	7.9
[75-79]	21.6	58.0	20.4	23.7	58.0	18.3
80+	11.8	48.0	40.1	15.6	55.3	29.1
Total Women	37.2	50.9	11.9	39.9	52.0	8.1
Combined						
[50-54]	49.9	45.5	4.7	51.5	45.8	2.7
[55-59]	48.3	47.3	4.4	50.6	46.4	3.1
[60-64]	53.4	43.0	3.6	55.2	42.5	2.3
[65-69]	52.8	42.1	5.1	54.1	42.0	3.9
[70-74]	38.3	49.8	11.9	39.7	50.2	10.1
[75-79]	23.7	57.9	18.4	25.4	59.0	15.6
80+	13.5	49.2	37.3	17.9	55.7	26.4
Total Combined	42.7	47.1	10.2	45.7	47.4	6.9

Adjusted statistics representative of the population in metropolitan France living in ordinary housing in the year 2011.

Robust: frailty index = [0] ; Pr-frail: frailty index = [1,2]; Frail: frailty index = [3,4,5].

Reading. 52.6% of men aged between 50 and 54 have no symptoms of frailty corresponding to the Fried phenotype within the population concerned. 6.7% of women in their 60's (2.8% + 3.9%) who do not self-report functional limitations in activities of daily living (ADL) are frail.

Data: SHARE wave 4 (Irdes).

Data download: www.irdes.fr/Donnees/Qes184_Fragilite.xls

[5] Future publication: www.solidage.ca

cant factor in elderly persons' loss of autonomy. However, the simple addition of cognitive problems as a sixth dimension clashes with the theoretical framework whose coherence lies in the functional approach[6]. Houles *et al.* (2012) recommend not adding cognitive dimensions without more empirical and theoretical references. In general, as gerontology and geriatrics literature has yet to resolve these methodological issues, the Fried model remains more suitable for reasons of simplicity and comparability.

Frailty: a new risk factor among elderly adults, distinct from chronic diseases

The interest in using frailty as an approach to public health and solidarity issues related to ageing is threefold. First, frailty represents a new disability risk factor among the elderly, distinct from the traditional chronic disease factors. Recent empirical studies based on longitudinal general population surveys and clinical tests have revealed an aggravation in health problems (notably functional limitations) within a short period (two years for example) among frail adults in comparison with evolutions in health status observed among initially pre-frail or robust individuals. In addition, the Fried model permits isolating independent risk situations related to chronic illness and activity limitations. Individuals within the general population presenting a risk of functional decompensation that were not previously detectable outside a geriatric assessment for example, can now be identified on the basis of elemental physical tests or simple questions concerning their functional limitations.

[6] Similarly, if measurements of cognitive deficiency are included in the Rockwood model, they do not occupy a specific place.

Using the frailty approach as a means of targeting preventive actions

Using the frailty approach to develop preventive strategies in favour of the elderly seems interesting for several reasons. Firstly, frailty is recognised as a measurement more in line with biological age; it avoids resorting to chronological age which describes heterogeneous health situations and identifies at-risk populations more precisely without stigmatising all members of a same age group. Secondly, whereas chronic disease and activity limitation criteria often appear too late for preventive action, frailty describes the early stages of progressive loss of autonomy whose effects may be reversible. The frailty measurement thus allows envisaging interventions sufficiently upstream of the process, for certain individuals, to prevent or delay disability, or at least diminish its damaging consequences (adapting the home, physical activities, etc.) Finally, frailty is a concept that is directly operational. Specific statistical tools are already in use in clinical practice (Romero-Ortuno *et al.*, 2010) and within the population (Vermeulen *et al.*, 2011) to detect frail adults.

A bridge across several disciplines opening-up the scope of research

The frailty approach creates a bridge between several disciplines concerned with ageing, in particular public health and economics, and opens up new possibilities for research. On the one hand, the frailty indicator enables creating an analogy between the concept of physiological reserve and that of 'health capital'. In the Grossman (1972) model, an individual's health is conceived as a form of capital that depreciates over time. It is the individual's 'health investments' (reducing health risk behaviours, prevention, use of the health system, etc.) that allows the individual to compensate for the natural phenomenon of deterioration and maintain a good health status. Following the model's logic in which an individual's resources (time, budget) are limited, the choice of health investments are subject to a trade-off with other consumption choices. In other words, from an economics point of view, health is determined by budgetary constraints and individual preferences. Applied to the frailty framework, use of the theoretical behaviour model concerning the demand for healthcare (or Grossman model) legitimises taking into account the economic and social dimension in the process leading to the loss of autonomy, and allows us to enrich a purely medical approach through the analysis of individual behaviours. This interdisciplinary bridge opens the way to several research projects.

Two areas of research at IRDES notably based on the SHARE and ESPS surveys

In health economics, loss of autonomy is approached from the socioeconomic causes and consequences of the onset of frailty in elderly adults, both in terms of social protection and health system efficiency. The areas of research developed at IRDES have a twofold objective: on the one hand, to produce applied knowledge on the social and economic dimension of populations experiencing loss of autonomy and on the other, to elaborate and test different methods of identifying vulnerable elderly populations using statistical tools that can also be used to assess the actions implemented. This process relies on the production and exploitation of specific healthcare-related data bases. In particular, two national general population surveys, the European Survey on Health,

Ageing and Retirement (SHARE) and the Health, Healthcare and Insurance survey (ESPS produced by IRDES since 1998), in which a specific questionnaire aimed at the 50+ population was added in 2012 to broach loss of autonomy and related issues.

Analysing the socioeconomic determinants of frailty

The first area of research concerns the socio-economic determinants of frailty in adults aged 50 and over. It involves first testing the existence of a stable relationship between living conditions and degree of frailty. The first results obtained from SHARE panel data indicate that the disablement process is accompanied by financial difficulties (Sirven, 2012); preliminary results from ESPS 2012 cross-sectional data tend to confirm this relationship (Insert 1). These studies provide information on the Social Security system's effectiveness in producing equity in health. They also make it possible to envisage identifying vulnerable individuals from economic data (income, situation vis-à-vis the labour market, healthcare consumption etc.) rarely taken into account in clinical practice regarding frailty. As part of a strategy aimed at targeting vulnerable elderly populations, IRDES is carrying out research financed by the CNAV. Its aim is to elaborate an algorithm to detect individuals at risk of losing their autonomy using individual data contained in the administrative pension insurance[7] databases. As these databases only contain socio-economic data, the SHARE data grouping together elements relating to both frailty and socioeconomic data are used. A model of the determinants of frailty is first estimated from SHARE panel data on comparable variables and populations meeting the same criteria as those in the administrative database. The model predictions are then calculated for individuals belonging in the administrative database which allows us to obtain an estimated frailty score to target individuals.

Gaining better knowledge of frail adults' healthcare consumption

The second research area concerns healthcare consumption among the frail elderly. The self-reported SHARE data provided a first glimpse of this relationship, but the need to have precise data available on reimbursements and healthcare consumption in France led to the inclusion of frailty measurements in the 2012 ESPS survey so as to obtain data matched with Health Insurance files. Here, it involves gaining better knowledge of frail adults' use of healthcare, the ideal situation being to renew the measurements following the survey's biannual rhythm so as to obtain panel data and carry out the analyses in relation to healthcare usage modalities. Furthermore, it is useful to isolate the share of health expenditures due to frailty but independent of chronic diseases to which the National Health Insurance already contributes in preventing loss of autonomy. This research is supported by specific funding from the CNSA[8].

Is frailty one of the determinants of subscribing to private dependency insurance?

The third area of research examines the underlying conditions and development of the private dependency insurance market. A specific questionnaire was developed in ESPS that included both the traditional determinants of dependency insurance (risk aversion, preference for the present) and less traditional determinants such as frailty or individuals' ability to envisage being dependent (for example denial of death and disability, the ability to carry out economic calculations, the fact of having had dependent parents, etc.). Preliminary results seem to indicate that the ability to carry out prospective economic calculations is one of the main factors determining subscriptions to private dependency insurance, before the risk of losing one's autonomy or even the perception of this risk.

[7] http://www.irdes.fr/EspaceAnglais/AboutIrdes/Documents/ResearchProgram.pdf

[8] http://www.irdes.fr/EspaceRecherche/ProgRecherche/ProgrammeDeRecherche.pdf

I1

The socioeconomic determinants of frailty

The frailty index retained here is a synthetic measurement of the Fried phenotype widely used in the literature. Each of the five dimensions of frailty is determined from binary variables indicating whether the individual has the symptom or not. The index is constructed from the sum of these values: a discrete variable with values ranging between 0 – no symptoms, and 5 – all symptoms. The table on page 3 presents the distribution of frailty for the population aged 50 and over in France in 2011 where we observe that women are more affected by frailty than men.

The SHARE panel data for the years 2004-2011 (www.share-project.org) with a cross-section for ESPS 2012 (www.irdes.fr) are used for the socioeconomic determinants of frailty in individuals aged 50 and over. Even if the variables that enter into the composition of the frailty index are not measured in exactly the same way in the two surveys (for example, in SHARE muscular strength is measured with a dynamometer whereas in ESPS it is measured by means of a subjective question), the first results are in fact comparable.

Whatever the database used, the estimations seem to indicate that the frailty process in elderly adults is accompanied by financial difficulties. The use of retrospective data in both surveys also suggests that financial difficulty during the course of a person's life favours the onset of frailty in later life. The studies also underline the harmful effects of at-risk behaviours (alcohol consumption) or loneliness and isolation on the subsequent degree of frailty.

* * *

In a context of population ageing with pessimistic perspectives regarding the evolution of disability, frailty appears as a new knowledge tool at the service of action and notably prevention. This concept, initially devised to detect the risk of disability in individuals and prescribe effective preventive measures where possible, can also be used to target populations faced with loss of autonomy so that effective preventive policies can be implemented. The economic analysis of frailty can thus aim to study the coordination between the health system and the social protection system from the premise that the first is more often called upon than the second when dealing with health issues whereas the most efficient answers can in fact be mixed. The concept of frailty thus extended beyond its purely clinical dimension makes it possible to envisage implementing a combination of policies (prevention, care pathway, private insurance) either through time or simultaneously, and sufficiently upstream of the process leading to loss of autonomy. ♦

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10, rue Vauvenargues 75018 Paris • Tél.: 01 53 93 43 02 • Fax: 01 53 93 43 07 • www.irdes.fr • Email: publications@irdes.fr •
Director of the publication: Yann Bourgueil • **Technical senior editor**: Anne Evans • **Associate editor**: Anna Marek • **Reviewers**: Clément Nestrigue, Michel Naiditch• **Translator**: Véronique Dandeker • **Copy editing**: Franck-Séverin Clérembault • **Layout compositor**: Damien Le Torrec • **Diffusion by subscription**: €60 per annum • **Price of number**: €6 • **ISSN**: 1283-4769.

IRDES

Document de travail
Working paper

On the Socio-Economic Determinants of Frailty: Findings from Panel and Retrospective Data from SHARE

Nicolas Sirven (Irdes)

DT n° 52

Décembre 2012

Institut de recherche et documentation en économie de la santé

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• **Directeur de publication/*Director of publication*** Yann Bourgueil
• **Secrétariat général d'édition/*Publisher*** Anne Evans
• **Relectrice/*Reviewer*** Aurélie Pierre
• **Mise en page/*Lay-out*** Franck-Séverin Clérembault, Damien Le Torrec
• **Diffusion/*Diffusion*** Sandrine Béquignon, Suzanne Chriqui
• **Imprimé par/*Printed by*** RGP (Antony, 92)
• **Dépôt légal** : Décembre 2012 • **ISBN** : 978-2-87812-388-3 • **ISSN** : 2101-6386

Sommaire

Acknowledgements

This work was supported by the National Solidarity Fund for Autonomy (CNSA, France) under The European Research Area in Ageing (ERA-AGE 2) FLARE 2 initiative.

"This paper uses data from SHARE wave 4 release 1, as of November 30th 2012 or SHARE wave 1 and 2 release 2.5.0, as of May 24th 2011 or SHARELIFE release 1, as of November 24th 2010. The SHARE data collection has been primarily funded by the European Commission through the 5th Framework Programme (project QLK6-CT-2001-00360 in the thematic programme Quality of Life), through the 6th Framework Programme (projects SHARE-I3, RII-CT-2006-062193, COMPARE, CIT5- CT-2005-028857, and SHARELIFE, CIT4-CT-2006-028812) and through the 7th Framework Programme (SHARE-PREP, N° 211909, SHARE-LEAP, N° 227822 and SHARE M4, N° 261982). Additional funding from the U.S. National Institute on Aging (U01 AG09740-13S2, P01 AG005842, P01 AG08291, P30 AG12815, R21 AG025169, Y1-AG-4553-01, IAG BSR06-11 and OGHA 04-064) and the German Ministry of Education and Research as well as from various national sources is gratefully acknowledged (see www.share-project.org for a full list of funding institutions)."

The author would like to thank Laurent Davezies (INSEE-CREST, FR) for useful comments on the econometric models; Pr Alberto Holly (HEC, U. Lausanne, SW), Pr. Brigitte Santos-Eggimann (IUMSP, U. Lausanne, SW) and Pr. François Béland (SOLIDAGE, U. Montréal, CA) for general discussions on this work.

On the Socio-Economic Determinants of Frailty: Findings from Panel and Retrospective Data from SHARE

Nicolas Sirven [a, b]

Abstract : Recent studies on the demand for long-term care emphasised the role of frailty as a specific precursor of disability besides chronic diseases. Frailty is defined as vulnerable health status resulting from the reduction of individuals' reserve capacity. This medical concept is brought here in an economic framework in order to investigate the role social policies may play in preventing disability or maintaining life quality of people in a disablement process.

Using four waves of panel data from the *Survey on Health, Ageing, and Retirement in Europe* (SHARE), a frailty index is created as a count measure for five physiologic criteria (Fried model) for respondents aged 50+ in 10 European countries, between 2004 and 2011.

The longitudinal dimension is explored in two ways. First, differences in frailty dynamics over a seven-year-time period are analysed through variables that are relevant for social policy (income maintenance, housing adaptation, and prevention of social isolation) in a panel model for count data with fixed effects. Second, the individual fixed effects are decomposed by means of a random effects model with Mundlak specification. SHARE additional retrospective data on life history (SHARELIFE) are then used to investigate differences in frailty levels.

The results reveal the presence of various sources of social inequalities over the life-course. Social Protection Systems thus appear to play a major role in accompanying, preventing or reducing the frailty process. Several policy implications are suggested.

JEL codes: I12, J14, C23

Keywords: Demand for health, Long-term care, Income maintenance, Health prevention, Panel models for count data, Mundlak device

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Une analyse des déterminants socio-économiques de la fragilité des personnes âgées à partir des données de panel et rétrospectives de SHARE

Nicolas Sirven [a, b]

Résumé : Les études récentes sur la demande de soins de long-terme ont mis en évidence le rôle de la fragilité en tant que précurseur de la perte d'autonomie, indépendamment des maladies chroniques. La fragilité est définie comme un état de santé vulnérable résultant de la diminution de la réserve physiologique de la personne âgée. Ce concept gériatrique est ici mobilisé en population générale et dans un cadre économique afin d'analyser le rôle des politiques publiques dans la prévention et l'accompagnement des personnes âgées dans un processus de perte d'autonomie.

A partir des données de panel et rétrospectives de l'enquête SHARE entre 2004 et 2011, nous étudions les déterminants socio-économiques de la fragilité en Europe. Dans un modèle à effets fixes, les différences individuelles dans la dynamique de la fragilité sont analysées au regard de trois piliers de l'action sociale : politique de soutien au revenu, lutte contre l'isolement social, promotion de l'aménagement du logement. Les différences persistantes dans les niveaux de fragilité sont explorées en utilisant les données rétrospectives sur l'histoire de vie (SHARELIFE) dans un modèle à effets aléatoires avec une spécification à la Mundlak.

Les résultats principaux indiquent la présence d'inégalités sociales de santé sous différentes formes et à différentes époques de la vie. L'importance des systèmes de protection sociale en Europe est reconnue comme un moyen d'accompagner, voire de retarder l'évolution du processus de perte d'autonomie. Plusieurs considérations de politique publique sont discutées.

Codes Jel : I12, J14, C23

Mots-clefs : Demande en santé, Soins de long-terme, Soutien au revenu, Prévention, Econométrie de panel, Spécification à la Mundlak

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"Nothing in life is to be feared,
it is only to be understood."

Marie Curie

1. Introduction

The substantial increase in the number and the share of older people in Europe in the next decades[1] combined with mixed evidence regarding trends in healthy life expectancy[2] lead policy-makers to anticipate serious public health and economic issues (WHO, 2011; OECD, 2011, European Commission, 2012). Research though suggests that there is still room for public policies to meet the challenges of ageing populations, in particular because ageing processes are modifiable (Christensen *et al.*, 2009). Improvements in the functional status of elderly people could improve their quality of life, and help mitigate the rise in the demand for, and hence expenditure on, long-term care. These prospects plead for disability prevention and health promotion strategies for older Europeans (Heikkinen, 2003).

Efficient interventions to prevent, reduce, or accompany the process of loss of autonomy in the elderly population require extensive knowledge of the pathways to disability at old ages. A large body of research has demonstrated the importance of chronic diseases as the primary contributor to disability (e.g. Guccione *et al.*, 1994; Boult *et al.*, 1996). Recent research on the determinants of disability have emphasised both (i) the role of frailty as a specific medical precursor of disability besides chronic diseases (*cf.* Landrum, Stewart & Cutler, 2009), and (ii) the influence of improved socio-economic outcomes in the reduction of disability levels during the period 1980-2000 (Schoeni, Freedman & Martin, 2009).

These findings bring in some hope, first because frailty is a "new" potential candidate for disability prevention and health promotion. Frailty is defined as vulnerable health status resulting from a multisystem reduction in older people's reserve capacity (*cf.* Staudinger, Marsiske & Baltes, 1995; Spini *et al.*, 2007). Evolution of the frailty process leads to adverse health outcomes (such as dependence, falls, need for long-term care, and death, e.g. Klein *et al.*, 2005; Bergman *et al.*, 2007). Frailty is a progressive condition that begins with a preclinical stage (Ferrucci *et al,* 1996; Fried *et al.*, 2001) and allows for reversible pathways (Fried *et al.*, 2004), thus offering opportunities for early detection and prevention. Specific tools for frailty have already been developed to operationalize the concept for health care professionals (Romero-Ortuno *et al.*, 2010) and public health policies (Vermeulen *et al.*, 2011).

A second reason to be confident in the potential health gains from prevention lies in the yet unexplored relationship between social policies features and the frailty process – despite the above mentioned relevance of socio-economic situations in disability pa-

[1] According to the United Nations (UN, 2011), about 30% of the European population will be 65 years old or more by 2060. Similarly, Eurostat projected the number of people aged 80 years or over to almost triple from 21.8 million in 2008 to 61.4 million in 2060 (Giannakouris, 2008).

[2] The literature does not indicate any clear signs of a reduction in disability among older people in Europe: Dolbhammer & Kytir (2001), Nusselder (2003), Mor (2005), Fries (1980, 1989, 2005), Jagger *et al.* (2007), Lafortune & Balestat (2007), and Suhrcke, Fumagalli & Hancok (2010).

thways. Only a few recent studies paid attention to the role of socio-economic factors in the distribution of frailty (Szanton *et al.* 2011; Etman *et al.*, 2012) and they did not specifically consider the role social policies may play in reducing frailty or maintaining life quality of people in a frailty process.

There is thus a need to investigate the influence on frailty of variables that are relevant for social policy. Three main domains of intervention common to most social policies in Europe are under consideration – income maintenance, support for housing adaptation, and actions to prevent social isolation. Although they are believed to help reduce elders' vulnerability by "ensuring people reach later life with reserve, reducing the challenges they face in later life, and providing adequate compensatory supports" (Grundy, 2006), there is not yet empirical evidence on how these three components of social policy are related to frailty.

The present work contributes to the general knowledge of individual situations vis-à-vis the frailty process in the general population, and provides useful guidelines for social policy in Europe. Its ambition is to develop an economic analysis of frailty to provide pathways between the medical literature and the social sciences. More specifically, the following questions are addressed: What are the socio-economic determinants of the frailty process for older adults? What population should be targeted for frailty prevention, and to what extent Social Protection Systems provide adequate support for older adults to face challenges at early stages of the disablement process? This study makes use of individual panel data between 2004 and 2011 from the *Survey of Health, Ageing, and Retirement in Europe* (SHARE) for respondents aged 50 or more in 10 European countries. The longitudinal dimension is explored in two ways. First, differences in frailty dynamics over a seven-year-time period are analysed through variables that are relevant for social policy in a fixed effects model. Second, the individual fixed effects are decomposed by means of a random effects model with Mundlak specification. SHARE additional retrospective data on life history (SHARELIFE) are then used to investigate differences in frailty levels.

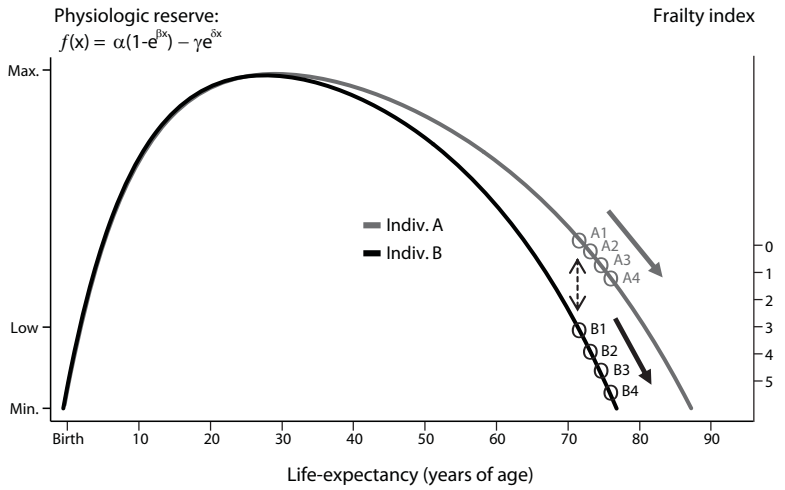
2. Conceptual framework

The medical approaches to frailty provide theoretical connections with the human capital model in standard economics. A general framework is proposed where older people's physiologic reserve is considered as health capital individuals bring to later life, and frailty is defined as a proxy for both concepts. The human capital model thus provides theoretical pathways between the frailty status and individual's socio-economic determinants.

2.1. Medical models of frailty

Separate models of frailty by Rockwood (Rockwood *et al.*, 1994) and Fried (Fried *et al.*, 2001) prevail in the health literature. Although they share certain similarities, they also have specific properties. The Rockwood model defines frailty as an accumulation of deficits resulting from multisystem physiologic or cognitive changes (Mitnitski, Mogilner & Rockwood, 2001; Rockwood & Mitniski, 2007). Unlike the Fried criteria displayed below, the Rockwood model can incorporate the patient's mental health or psychosocial status so that the risk of adverse outcomes can be defined more precisely (Rockwood, Song & Mitnitski, 2011; Mitnitski, Fallah, Rockwood & Rockwood, 2011).

Figure 1. Relationships between physiologic reserve, life-expectancy and frailty for two theoretical individuals



Source: adapted from Berthelot et al. (2012)

The Rockwood model is however typical of the "*black box epidemiology*" perspective since it makes use of a large set of criteria without a theoretical backdrop. This model does not distinguish between the concepts of disability and comorbidities. It is also difficult to implement due to the large number of variables (about 70 variables covering various dimensions of health, diseases, limitations, attitudes, behavioural risks, etc.), and requires additional clinical translation due to its complexity (Rockwood, Andrew & Mitnitski, 2007). The Fried approach to frailty is often preferred in the literature because (i) it is distinct from comorbidity and disability – providing news ways for research and intervention, (ii) it offers ready clinical operationalization, (iii) it is more parsimonious, quite straightforward and inexpensive to apply in general population surveys, and easily comparable across different settings.

The specificity of the Fried model lies in its strict focus on physiologic reserve (Fried *et al.*, 1994; Williamson & Fried, 1996). Leaving aside the cognitive dimension[3], the trade-off between a comprehensive and coherent framework leans here in favour of the latter. The five only dimension of the Fried frailty index (shrinking, weakness, poor endurance and energy, slowness, low physical activity level) are derived from a set of logical pathways starting with senescent musculoskeletal changes leading to sarcopenia, and then to decreased strength and power, lower resting metabolic rate, reduction in total energy expenditure and thus chronic malnutrition, eventually reinforcing sarcopenia, and so on (Walston & Fried, 1999). Fried *et al.* (2001) bring into play "[t]his circle of frailty, representing an adverse, potentially downward spiral of energetics" to illustrate the process of reduction in individuals' physiologic reserve (Walston, 2006).

[3] Mitnitski, Fallah, Rockwood & Rockwood (2011) compare three measures of frailty as predictor to cognitive impairments: a frailty Index based on the Comprehensive Geriatric Assessment evaluated from 47 potential deficits, a Clinical Frailty Score and the Fried frailty phenotype. They found that Frail elderly people have an increased risk of cognitive decline. All frailty measures allowed quantification of individual vulnerability and predict both cognitive changes and mortality.

2.2. From frailty to the economic model of health capital

Figure 1 presents the theoretical relationships between unobserved physiologic reserve and life-expectancy for two theoretical individuals. A reversed scale displays Fried's index which counts the number of frailty criteria associated with individual's physiologic status at old ages. This index thus goes from 0 (non-frail or robust) to 5 (very frail). It is considered in the literature as a good proxy of the individual's physiologic reserve at old ages (Fried *et al.*, 2001, 2004). The general trend of the physiologic reserve follows a biphasic development with two antagonistic processes of increase before decline (Berthelot *et al.*, 2012). In the example, the two individuals, A and B, were born the same day and experienced comparable increases in their physiologic reserves until they reached a peak. Then the decline process started, being much stronger for B – for some reason – and creating a gap between the two physiologic reserves. Eventually B died before A. During the last period of their life, the frailty index appeared higher for B than for A. It has been argued elsewhere that the frailty index (whether Fried's or Rockwood's) is a good proxy for biological age (Mitnitski *et al.*, 2004; Schuurmans *et al.*, 2004).

From a health economics perspective, the physiologic reserve can be associated with the concept of heath capital (Grossman, 1972, 2000; Bolin, 2011); the analogy is especially fitting when it comes to the decreasing process of the physiologic reserve. The standard economic theory considers that each individual is born with a certain amount of health capital, which depreciates with age, and is assumed to produce investments in health in order to align the realised amount of health with the demanded amount. Increasing resources have to be deployed in order to keep the stock of health at a certain level because the rate of depreciation increases over time.[4] Age thus affects the demand for health by making the possession of a certain level of health capital more expensive. As a consequence, the model predicts that health decreases with age, and individuals with more resources have a higher ability to maintain their health stock. In our case, reference to the health capital theory helps bring into play individuals' socio-economic characteristics to explain the differences in the levels (the 'gaps' symbolised by the double arrow in dots in Fig. 1) and the dynamics (the 'slopes' symbolised by the two vectors in Fig. 1) of the physiologic reserves. In this context, Frailty is a proxy for both physiologic reserve and health capital at older ages. The frailty index is measured hereafter using panel data from SHARE.

3. Data

Empirical analyses are usually more relevant for prevention policies when they rely on general population settings. The options to define the working sample here meet this requirement and minimise the potential selection biases. Distribution of the frailty index in the working sample concurs with previous findings in the general population.

3.1. Sources and sample

The *Survey on Health, Ageing, and Retirement in Europe* (SHARE) is a multidisciplinary and cross-national cohort of individual data on health, socio-economic status and social and family relationships of more than 80,000 respondents aged 50 or over (*cf.* Börsch-Supan & Jürges, 2005). Eleven countries contributed to the 2004 SHARE baseline study

[4] As indicated by the estimations of the theoretical physiologic reserve by Berthelot *et al.* (2012).

Table 1. Selected panel sample from SHARE

Country	Wave 1	Wave 2	Wave 3	Wave 4	Total
Austria	633	584	842	442	2,501
Germany	1,145	1,487	1,861	1,166	5,659
Sweden	1,478	1,415	1,945	1,181	6,019
Netherlands	1,427	1,629	2,202	1,433	6,691
Spain	1,088	1,238	2,094	1,075	5,495
Italy	1,398	1,955	2,496	1,642	7,491
France	1,443	1,696	2,459	1,426	7,024
Denmark	928	1,771	2,098	1,464	6,261
Switzerland	534	1,067	1,256	923	3,780
Belgium	2,274	2,232	2,803	1,866	9,175
Total	12,348	15,074	20,056	12,618	60,096

Table 2. Unbalanced sample features in regular panel waves

Country	Repeated observations in three regular panel waves			
	Once only	Twice	Three times	Total
Austria	111	522	1,026	1,659
Germany	269	1,456	2,073	3,798
Sweden	223	1,298	2,553	4,074
Netherlands	263	1,616	2,610	4,489
Spain	363	1,340	1,698	3,401
Italy	358	1,772	2,865	4,995
France	377	1,662	2,526	4,565
Denmark	297	1,880	1,986	4,163
Switzerland	134	1,220	1,170	2,524
Belgium	256	1,556	4,560	6,372
Total	2,651	14,322	23,067	40,040

(Israel took also part in SHARE wave 1 only). They are a balanced representation of the various regions in Europe, ranging from Scandinavia (Denmark and Sweden) through Central Europe (Austria, France, Germany, Switzerland, Belgium, and the Netherlands) to the Mediterranean (Spain, Italy and Greece). Further data were collected in 2006-07 during the second wave of SHARE in these countries and The Czech Republic, Poland, and Ireland. SHARELIFE, the third wave of the project, was conducted in 2008-09 over the same population (apart from Ireland). This time, the respondents were interviewed about their life history. Different fields such as childhood health, education, job career, family life, housing, etc. were surveyed and provide useful information on initial conditions and life course. In 2010, Estonia, Slovenia, Hungary, and Portugal joined SHARE wave 4, which is the third regular panel wave of the survey following the SHARELIFE life history questionnaire.

The sample retained here consists of 17,501 individuals corresponding to 60,096 observations, of which 40,040 belong to the regular panel waves 1, 2, or 4, and 20,056 come within SHARELIFE (Table 1). This sample is restricted to 10 countries in northern (Denmark, Sweden, the Netherlands) continental (Austria, Germany, France, Belgium,

Switzerland) and southern (Italy, Spain) regions of Europe. Excluded countries are those which (i) did not take part in SHARELIFE, making impossible to investigate frailty differences through the lenses of life-history; or (ii) did not carry out three waves of regular panel – the aim here is to avoid a systematic bias due to missing observations for some countries. Among these 10 countries, individuals retained in the sample were those interviewed in SHARELIFE (wave 3) and at least once in a regular panel wave (wave 1, 2, or 4). Finally, only full-rank data matrices are kept at each wave so that observations with missing data are deleted. These two latter rules contribute to consider an unbalanced panel in the analysis (Table 2). Notice that 93.4% of the sample is observed twice (N=14,322) or three times (N=23,067) in the regular panel waves. Only 6.6% of the sample (N=2,651) do not provide any information on the dynamics of the frailty process since they are observed only once besides SHARELIFE.

3.2. The frailty index

Previous studies using SHARE data derive a frailty index based on the five criteria from the Fried model (Santos-Eggiman *et al.*, 2009; Romero-Ortuno *et al.*, 2010; Etman *et al.*, 2012). Operationalization of these criteria required adaptation to the SHARE survey contents for which the definition by Santos-Eggimann *et al.* (2009) was used:

- *Exhaustion* was identified as a positive response to the question, "In the last month, have you had too little energy to do things you wanted to do? (yes/no)."
- *Shrinking* was fulfilled by reporting a "diminution in desire for food" in response to the question, "What has your appetite been like" or, in the case of an uncodable response to this question, by responding "less" to the following question: "So have you been eating more or less than usual?"
- *Weakness* was derived from the highest of four consecutive dynamometer measurements of handgrip strength (two from each hand), applying gender and body mass index cut-offs by quintiles of the distribution.
- *Slowness* was defined using mobility questions: "Because of a health problem, do you have difficulty [expected to last more than 3 months] walking 100 meters" or "… climbing one flight of stairs without resting".
- *Low physical activity* was fulfilled in participants responding " one to three times a month" or "hardly ever or never" to the question, "How often do you engage in activities that require a low or moderate level of energy such as gardening, cleaning the car, or going for a walk?"

Following previous studies, one point was allocated for each fulfilled criterion. In that case, the frailty index is a score ranging from 0 to 5 where each criterion contributes to the score in the same way.[5] It is standard practice in the literature to set cut-off points of this above frailty score: 0 non-frail or robust, 1-2 pre-frail, and 3-5 frail. Although this is especially useful for health care professionals, such an arbitrary dichotomy is not required here. In addition, using the variable without specified thresholds appears judicious to investigate frailty as a progressive condition.

The frailty index is available for the three regular panel waves in SHARE – since SHARELIFE did not gather sufficient measures to compute the index. The distribution

[5] This particular assumption requires to be thoroughly investigated elsewhere. Using SHARE data, King-Kallimanis, Savva & Kenny (2012) found that while a single latent variable model for the Fried frailty phenotype is tenable, the factor loadings and thresholds are not invariant across all countries, suggesting that direct comparisons of the prevalence of frailty across countries may not be appropriate.

Table 3. Distribution of the frailty index between waves and gender
(Percentages displayed below headcounts)

Frailty Index	Wave 1			Wave 2			Wave 4			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0	3,653 64.8	2,649 39.5	6,302 51.0	4,433 63.0	3,213 39.9	7,646 50.7	3,391 58.3	2,343 34.5	5,734 45.4	11,477 62.1	8,205 38.1	19,682 49.2
1	1,414 25.1	2,192 32.6	3,606 29.2	1,810 25.7	2,630 32.7	4,440 29.5	1,561 26.8	2,206 32.4	3,767 29.9	4,785 25.9	7,028 32.6	11,813 29.5
2	400 7.1	1,104 16.4	1,504 12.2	554 7.9	1,295 16.1	1,849 12.3	526 9.0	1,212 17.8	1,738 13.8	1,480 8.0	3,611 16.8	5,091 12.7
3	130 2.3	492 7.3	622 5.0	178 2.5	567 7.0	745 4.9	229 3.9	625 9.2	854 6.8	537 2.9	1,684 7.8	2,221 5.5
4	34 0.6	228 3.4	262 2.1	50 0.7	273 3.4	323 2.1	93 1.6	330 4.9	423 3.4	177 1.0	831 3.9	1,008 2.5
5	3 0.1	49 0.7	52 0.4	6 0.1	65 0.8	71 0.5	19 0.3	83 1.2	102 0.8	28 0.2	197 0.9	225 0.6
Total	5,634 100	6,714 100	12,348 100	7,031 100	8,043 100	15,074 100	5,819 100	6,799 100	12,618 100	18,484 100	21,556 100	40,040 100

Table 4. Prevalence of 2 or more Fried criteria by gender and age class
(Percentages)

	Men					Women					Total				
Country	50-59	60-69	70-79	80+	Total	50-59	60-69	70-79	80+	Total	50-59	60-69	70-79	80+	Total
Austria	14.5	9.9	12.0	26.9	12.8	16.1	17.8	34.8	61.2	25.9	15.4	14.2	25.8	48.2	20.3
Germany	5.4	7.3	12.3	30.9	9.2	9.4	15.4	30.3	59.2	19.2	7.7	11.3	20.8	47.3	14.4
Sweden	3.8	4.6	9.0	24.6	7.5	13.7	14.5	28.9	58.8	21.7	9.3	10.0	19.5	42.4	15.1
Netherlands	6.4	7.0	11.0	21.6	8.8	12.9	16.8	30.3	49.7	20.4	10.1	12.2	20.9	36.3	15.0
Spain	9.4	15.0	26.5	47.4	19.7	30.6	45.9	64.1	81.2	49.9	21.3	31.9	46.0	67.3	36.3
Italy	9.1	12.3	21.3	39.9	15.9	26.8	34.4	57.2	76.9	39.7	19.6	24.1	38.3	58.8	28.6
France	8.0	9.2	22.0	41.8	14.5	20.2	29.0	44.0	70.0	34.2	14.5	20.2	34.2	59.3	25.4
Denmark	6.8	7.8	14.8	23.6	10.1	15.2	16.8	34.8	60.0	24.8	11.3	12.4	25.6	46.5	17.9
Switzerland	6.5	4.1	7.2	20.4	6.9	10.2	13.4	31.0	53.2	20.8	8.6	9.1	19.3	41.0	14.5
Belgium	7.6	9.0	18.4	33.8	13.1	17.4	25.2	43.1	62.3	31.0	12.7	17.6	31.5	49.6	22.6
Total	7.4	8.6	16.5	31.9	12.0	17.5	23.4	41.4	63.7	29.3	13.0	16.5	29.4	50.1	21.3

of the frailty index is hereafter broken by several main variables; time, age, gender, and country of residence (Tables 3-4). In the details, one may notice:

- *A small prevalence of extreme frailty.* Less than 1% of the sample is credited with the extreme value (5) of the frailty index at each wave. According to the thresholds given by the Fried model, only 8.6% of the population is "frail" over the whole period (frailty score ≥ 3). This is certainly due to the death-proximity of individuals with extreme frailty values.
- *However, more than 20% of the population aged 50 or more is potentially involved in a frailty process.* 21.3% of the sample is credited with at least two criteria of the Fried model over the three waves. Values of the frailty index increase (i) with time spent between waves (e.g. 19.7% of the sample have at least two Fried criteria in wave 1 while this figure rises up to 24.8% in wave 4) and (ii) between age cohorts (16.5% of the overall sample is credited with at least two Fried criteria between 60-69 compared to 31.5% for those 70-79 and up to 49.6% for those 80 or more).
- *Women have higher values of the frailty index than men.* 29.4% of women in the sample have a frailty score ≥ 2 compared to only 12.1% of men over the period. These results remain true when decomposed by countries; the general north-south gradient (Northern countries have lower values of the frailty index) is also more favourable for men when it comes to the frailty index.

These descriptive statistics are coherent with general findings from previous studies on frailty (e.g. Santos-Eggiman *et al.*, 2009). The *ceteris paribus* analysis of the socio-economic determinants of frailty aims at providing new evidence on the distribution and the evolution of the frailty process.

4. Methods

Econometric analysis of the frailty index depends on how the response variable is to be considered: it could be defined as (i) a count measure with regard to the number of fulfilled criteria, (ii) a fractional measure if one consider the rate of "successes" or "failures" out of the five binomial "trials" (the 5 Fried criteria), or even (iii) an ordered category response. The three options are reviewed, with special focus on the first one, because of the nice statistical properties of the fixed effects Poisson estimator. The different models are presented below, and their specification follows from the health capital theory and focuses on socio-economic variables that are relevant for social policy.

4.1. Econometric options

Econometric models for a count dependant variable are well-known in health economics when the data are cross-sectional. In comparison, panel data models for count variables are much less widespread in the literature. Just like in the linear case, fixed effects and random effects are competing alternatives, although rejoinder models using *Chamberlain's device* (as suggested by Mundlak, 1978; and generalised by Chamberlain, 1982) can be extremely useful here.

4.1.1. *Estimation strategy*

Let y_{it} denote the discrete count frailty index of individual i, $i = 1,\ldots,N$, at time t, $t = 1,\ldots,T$; and let X_{it} denote the full-rank data matrix of explanatory variables. The

commonly used exponential model for panel count data assumes multiplicative unobserved heterogeneity:

$$\mathrm{E}(y_{it} \mid X_{it},\ c_i) = c_i \exp(X_{it}\beta) \tag{1}$$

where c_i is a permanent scaling factor for the individual specific term. If we suppose

$$c_i = \exp(e_i) \tag{2}$$

then, this implicitly defines a regression model

$$y_{it} = \exp(X_{it}\beta + e_i) + u_{it} \tag{3}$$

Several possible estimators of β are given in the literature depending on various sets of hypotheses (Wooldridge 2010: Chap 18). The econometric options retained below focus on two standard models to be estimated by Maximum Likelihood (ML), the Fixed Effects (FE) and the Random Effect (RE) Poisson models. The latter is a specific case of the former where structural hypotheses are added. Just like in the linear case, the RE model is built upon the FE model. The following assumptions are common to FE an RE Poisson models. First and foremost, the strict exogeneity assumption[6] of the X_{it} conditional on c_i

$$\mathrm{E}(y_{it} \mid X_{it}, c_i) = \mathrm{E}(y_{it} \mid X_{i1}, \ldots, X_{iT}, c_i)\,. \tag{4}$$

Second, following pioneer work by Hausman, Hall & Grilliches (1984), two ancillary assumptions common to FE and RE are usually made, although they are not necessary in the case of FE

$$y_{it} \mid X_i, c_i \sim \text{Poisson}\left[c_i \exp(X_{it}\beta)\right] \tag{5}$$

y_t, y_{ir} are independent conditional on x_i, c_i, with $t \neq r$. (6)

At this stage, the FE Poisson model can be estimated. The main advantages of this model come from the properties of (4) the strict exogeneity assumption. The FE estimator is consistent under (4) only, and the robust variance estimator is valid[7] and allows for any dispersion from the Poisson distribution and arbitrary time dependence, so that (5) and (6) are not requested whenever (4) holds.[8] The *Within* estimator of the FE Poisson

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6 Notice that both FE and RE procedures hinge on the strict exogeneity assumption of X_{it} conditional on c_i. Since it is important to check whether H_0: $E(X_{it}c_i) = 0$ is true, an easy test can be implemented (Wooldridge, 2010: 18.7.4): (i) let W_{it} a subset of X_{it} which potentially fail the strict exogeneity assumption; (ii) include W_{it+1} as an additional set of covariates; (iii) under the null hypothesis of strict exogeneity, the coefficients on W_{it+1} should be statistically insignificant. See Blundell, Griffith & Windmeijer (2002) for count data models where the strict exogeneity assumption is relaxed.

7 When using short panels (T small), FE Poisson provides more efficient estimates than the RE model. In addition, ML estimation of the RE model is calculated using quadrature, which is an approximation whose accuracy depends partially on the number of integration points used.

8 Cameron & Trivedi (1998) note that one of the reasons for the failure of the Poisson regression in cross-section settings, is unobserved heterogeneity. Although neglected unobserved heterogeneity leads to over-dispersion and excess of zeros (Jones, Rice, Bago d'Uva & Balia, 2007), the use of FE Poisson with multiplicative unobserved heterogeneity in panel data is expected to work well whatever the distribution of the dependent variable: "Except for the conditional mean, the distribution of y_{it} need not be discrete; it could be continuous or have discrete and continuous features." (Wooldridge, 2010: 18.7.4) For instance, relaxing distributional assumptions (e.g. through Negative-Binomial modelling) did provide similar results as the FE Poisson.

model has very useful properties and is especially relevant for the analysis of the differences in the changes of the frailty index over time (differences in 'slopes' in Fig. 1).

Nevertheless, the FE Poisson model has two main drawbacks in our case: (i) individuals with $y_{it} = 0$ for all t are removed from the estimation sample because the conditional mean has an exponential form, and (ii) time-constant explanatory variables drop out of the equation – just like in the linear case. However, one may believe that people who never experienced frailty over the period 2004-2011 are of potential interest in the context of disability prevention strategies. The analysis would also benefit from some key variables like date of birth, gender and country of residence, and retrospective conditions. These latter variables would be "silent" in the FE model since the time-invariant effects are taken into account in c_i.

In order to overcome some of the restrictions inherent to the FE Poisson model, an improved version of the RE Poisson model is specified to decompose the individual fixed effects by means of time-invariant variables, and to include individuals for whom $y_{it} = 0$ over the period. Estimation of the standard RE Poisson model requires all the previous assumptions, specifically (5) and (6), plus the two additional assumptions below

$$\mathrm{E}(c_i \mid X_{i1}, \ldots, X_{iT}) = \mathrm{E}(c_i) = 1 \tag{7}$$

$$c_i \text{ is independant of } X_{iT} \text{ and distributed as Gamma } (\delta, \delta) \tag{8}$$

Assumption (8) is the most controversial since it is likely that the unobserved fixed components ci are correlated with the explanatory variables, $\mathrm{E}(X_{it} c_i) \neq 0$, and therefore standard RE estimators will be inconsistent. It is though possible to "soften" assumption (8) by allowing c_i and $\overline{X}_i$ to be correlated;

$$c_i = a_i \exp(\overline{X}_i \gamma) = \exp(\overline{X}_i \gamma + a_i) \text{ with } a_i = \exp(a_i) \text{ and } \overline{X}_i = \frac{1}{T} \sum_{t=1}^{T} X_{it} \tag{9}$$

In that case, the regression model becomes

$$y_{it} = \exp(X_{it} \beta + \overline{X}_i \gamma + a_i) + u_{it} \tag{10}$$

Equation (10) illustrates the implementation in a count data model of the Mundlak (1978) device. Estimation of β by ML is straightforward in the Mundlak model; it follows the standard procedure for a RE Poisson models in which the time averages of individual time-varying explanatory variables $\overline{X}_i$ are included as additional regressors. Choice between the standard RE Poisson model and the Mundlak specification is also straightforward; a basic joint test of coefficients (Wald) for H0: $\gamma = 0$ can be interpreted here as a Hausman test.

The main property of the Mundlak RE model is that the estimated coefficients of the time-varying explanatory variables are the same as those obtained with a FE model. In addition, the list of covariates X_{it} can now be extended to include time-invariant variables, and the estimation sample can be extended to individuals for whom $y_{it} = 0$ for all *t*. As a consequence, the Mundlak RE Poisson model is especially useful in our case because the *Within* estimator still can trace differences in frailty dynamics ('slopes') as in the FE model, while the *Between* estimator provides insights about the differences in the levels of frailty ('gaps') in the whole sample. Finally, the combination of the Mundlak RE Poisson Model and the unbalanced panel sample help considering a much larger set of individual situations within, and outside, the frailty process.

4.1.2. *Strategy for robustness checks*

The strength of the FE Poisson model rests on the fact that it provides consistent estimates and efficient robust standard errors under few assumptions (mainly strict exogeneity) and whatever the distribution of Y_{it}: "We must emphasise that, while the leading application is to count data, the FE Poisson estimator works whenever assumption [(4)] holds." (Wooldridge, 2010: 18.7.4) Nevertheless, in order to gain confidence in the results provided by the previous Poisson models, alternative econometric options may be explored. In particular, one may not be totally satisfied (at least from a conceptual point of view) with a frailty index which is considered as a count variable. First, the response measure is bounded between 0 and 5, suggesting that a binomial distribution would provide additional interesting results (at least for the sceptics). Second, it could be that treating the frailty index as a continuous measure of physiological decline is excessively straightforward. Rather, one may acknowledge that the frailty index actually consists of six ordered categories (from 0 to 5) which depict the latent physiological reserve.

Let us consider first the frailty index as a ratio index counting the number of "successes" or "failures" at each of the five "trials" (i.e. criteria) considered in the Fried model. In that case, a new version of the frailty index would measure the rate of total "successes" or "failures" out of five trials, the response variable being then defined as $0 \leq y_{it} \leq 1$. Papke & Wooldridge (2008) considered a Pooled Fractional Probit model (PFP or PFProbit) to deal with this response variable in a panel setting. The functional form is given by:

$$\mathrm{E}(y_{it} \mid X_{it}, c_i) = \Phi(X_{it}\beta + c_i) \tag{11}$$

where Φ is the the standard normal cumulative distribution function. Although the model is identifiable (through semi-parametric methods) under the strict exogeneity assumption only, we specify a conditional normality assumption *via* a Mundlak device – as we wish to compare the model with Poisson RE-Mundlak estimates. The individual fixed effect is given by

$$c_i = \psi + \bar{X}_i\xi + a_i\,, \tag{12}$$

with $c_i \mid (X_{i1}, ..., X_{iT}) \sim \text{Normal}\ (\psi + \bar{X}_i\xi, \sigma_a^2)$ and $a_i \mid (X_i) \sim \text{Normal}\ (0, \sigma_a^2)$, and where $\sigma_a^2 = \mathrm{V}(c_i \mid X_i)$. Following Papke & Wooldridge (2008), the RE regression model can now be written as:

$$y_{it} = \psi_a + X_{it}\beta_a + \bar{X}_i\xi_a + a_i + \varepsilon_{it} \tag{13}$$

where the subscript a denotes division of the original coefficient by $(1+\sigma_a^2)^{1/2}$. Parameters ψ_a, β_a, and ξ_a can be consistently estimated using a Pooled (Fractional) Probit analysis – a.k.a. Population Average Probit for Fractional Response – using the GEE method (Generalised Estimating Equations). In addition, extension of this framework to consider ordered response is straightforward.

Let us now consider that $y_{it} = j$ if $\mu_{j-1} \leq y_{it}^* < \mu_j$ with $j = 1,\ldots,5$. Under strict exogeneity (4) and the same conditional normality assumptions on the individual fixed effect as previously, the RE Ordered Probit (or OProbit) with a Mundlak device is defined by (*cf.* Greene & Hensher, 2010: 9.2.)

$$\mathrm{E}(y_{it} \mid X_{it}, c_i) = \Phi(\mu_{aj} - X_{iT}\beta_a - \bar{X}_i\xi_a) - \Phi(\mu_{aj-1} - X_{iT}\beta_a - \bar{X}_i\xi_a)\,. \tag{14}$$

Here again, the subscript a denotes division of the original coefficient by $(1+\sigma_a^2)^{1/2}$. Both in the case of PFP and RE Ordered Probit, Xit may contain time-invariant variables, just like in the RE-Mundlak Poisson model. The expected results are believed to be very close to those obtained in the Poisson case since the FE Poisson regression is a special case of the PFP model and the RE Ordered Probit also is a special case of the PFP model (Wooldridge, 2010: 18).

4.2. Models specification

Three sets of variables have been retained with regard to the models to be estimated: time-variant, time-invariant, and retrospective covariates which can be analysed here as specific time-invariant data as far as their time-range does not extend beyond 2004 (start date of wave 1). Descriptive statistics are given in the appendix.

4.2.1. *Time-variant covariates*

These variables focus on three domains of social policy. First, income adequacy is especially relevant in the present context. Recent reforms in Europe lead to less generous public pensions, "notwithstanding a deliberate policy of large increases in minimum income benefits in many countries, leading to a remarkable convergence of relative benefit levels" [9] (Goedemé, 2012). How do older people in a frailty process handle the economic consequences of this context? Income adequacy is assessed from the four response items to the question "Thinking of your household's total monthly income, would you say that your household is able to make ends meet:" "with great difficulty", "with some difficulty", "fairly easily", or "easily." The first response is used as the reference category for the three other binary variables.

Second, the empirical literature suggests that improving home environments enhances functional ability outcomes (Whal *et al.*, 2009), and that these benefits are long-term, and they extend beyond the disabled person to help the health of other family members (Heywood, 2004). The measure of housing adaptation is derived from a positive response (yes/no) to the question "Does your home have special features that assist persons who have physical impairments or health problems?" Unfortunately, the question was only asked repeatedly to respondents who moved to another residence between the regular panel waves. For many whom remained in the same home over the period, the question was not asked at subsequent waves. The within information does not thus extend to all respondents and an alternative model specification should also be considered to analyse the between information.

Third, social isolation is associated with deterioration in health: the loss of a partner generally leads to worse health status – especially among older cohorts (e.g. Liu, 2012), and participation to social activities and other "social capital" variables have a causal beneficial impact on health (Folland, 2007 ; D'Hombres *et al.*, 2010 ; Ronconi, Brown & Scheffler, 2010 ; Sirven & Debrand, 2012). Social isolation is measured through 3 variables. (i) Living without partner since the last two years is a dichotomous variable (yes/

[9] In addition, the reforms have been accompanied by measures aiming at encouraging the development of occupational and personal pension plan since household savings are considered too scarce (Börsch-Supan & Brugavini, 2011). In that perspective, Governments are encouraged at increasing and improving the ability of individuals to make sensible choices, e.g. by fostering individual preparedness, reducing the distortions embedded in pension formulae, or choosing an enhanced choice structure (Fornero, Lusardi & Monticone, 2012). Although public provisions are not designed to fully cover financial needs of older people, income adequacy remains a significant role of social policy.

no) derived from the response to the questions "In which year did you:" "get divorced" or "become a widow(er)?", and the date of interview. (ii) Taking part in social activities is fulfilled from response to the question "Have you done any of these activities in the last month?" Any positive response to the following items "voluntary or charity work, educational or training course, activities of a religious organization, a political or community-related organization" was coded 1, and 0 otherwise. (iii) Because of the potential endogeneity with frailty, the response "Gone to a sport, social or other kind of club" was used separately to define a specific binary variable.

Additional time-variant covariates include a binary index of occupational status indicating whether the respondent is active occupied at the time of the survey. As one may expect to observe a *Healthy Worker Effect* (suggesting in our case that people with higher levels of the frailty index keep out or drop out of the labour market), the occupational status variable has been decomposed by the number of days on sick leave from the questions "In the last 12 months, did you miss any days from work because of your health?" and "About how many days did you miss?" Four categories were derived: never missed work, missed less than 20 days/year, missed 20 days/year or more, and a non-response category; the reference category remains the same: not being active occupied at the time of the survey. Notice that, dummy variables indicating the date of interview were also included to take into account differences in the time-spell between the regular panel waves.

4.2.2. *Time-invariant covariates*

The usual fixed individual covariates include age (year of birth by decades since 1910), gender, education level (highest diploma obtained in three categories: none or primary, secondary, superior, and a non-response category), migration status (whether the respondent is born in the country of residence), and dummies for the country of residence (reference is France). Additional time-invariant retrospective covariates from SHARELIFE include the following:

- *Periods of ill health* or *Ever physically injured*: a binary index of health, taking the value 1 if the respondent reports any periods of ill health over the life-cycle (>1 year) or if she reports any physical injury over the lifecycle (>1 year). Physical disability in late life is indeed found to be associated with health factors in early- and mid-life (Freedman et al., 2008).
- *Financial Hardship*: a dummy indicating if the respondent encountered any periods of financial hardship throughout her life. Physical disability in late life is also found to be associated with financial strain as children and as adults (Szanton, Thorpe & Whitfield, 2010).
- *Health problems during childhood*: (i) retrospective self-rated value of health (SRH) at age 10 was defined as response to the question "(Looking back on your life,) was there a distinct period during which your health was poor compared to the rest of your life?" A binary variable takes the value 1 if the respondent reported that health during childhood was in general excellent or very good, and 0 else (i.e. good, fair, or poor, or spontaneously "Health varied a great deal"); and (ii) illnesses when child: fulfilled as a positive response to any of the questions "Did you ever stay in hospital more than three times within a 12-month period during your childhood" or "Did you ever miss school for a month or more because of a health condition during childhood"(yes/no). This set of covariates reflects what Hass (2008) called 'the long arm' of childhood health on current health status.

Table 5. Determinants of frailty – FE Poisson estimates

Dep. var. is Frailty	Baseline FE Poisson	Alternative specif.		by Euro-region		
		Occupation	Health	North	Conti.	South
Indep. var.	(M1)	(M1.2)	(M1.3)	(M1.4)	(M1.5)	(M1.6)
Time-variant						
Make-ends-meet						
with great difficulty	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
with some difficulty	-0.077***	-0.079**	-0.056***	0.017	-0.102***	-0.080***
fairly easily	-0.098***	-0.096**	-0.056**	-0.018	-0.125***	-0.077**
easily	-0.123***	-0.117**	-0.084***	-0.038	-0.154***	-0.104*
Adapted housing	0.042	0.034	0.029	0.071	0.075	-0.214
Without partner ≤ 2 years	0.162***	0.164**	0.092**	0.194***	0.095	0.251***
Social activities	-0.074***	-0.077**	-0.047***	-0.091***	-0.082***	-0.038
Sport club, etc.	-0.102***	-0.103**	-0.070***	-0.111***	-0.114***	-0.042
Occupational status						
At work	0.101***		0.101***	0.075	0.107**	0.142**
Not at work	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Decomp. Occup. Status						
Missing data wave 1		0.183***				
Never missed work		-0.063				
Sick leave <20 days		0.053				
Sick leave ≥20 days		0.304***				
Health measures						
Poor SRH			0.275***			
Chronic 2+			0.078***			
ADL 2+			0.197***			
Euro-D			0.538***			
Cognitive test			-0.510***			
Time dummies						
Wave 1	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Wave 2	0.083***	0.109***	0.056***	0.138***	0.107***	-0.012
Wave 4	0.347***	0.371***	0.281***	0.364***	0.389***	0.262***
Obs.	26,608	26,608	26,218	7,922	12,535	6,151
Nb. indiv.	10,483	10,483	10,352	3,139	4,895	2,449
H0: Make-ends-meet β=0						
Chi^2 (Wald)	19.38	18.17	10.39	1.51	12.78	7.78
p-value	0.000	0.000	0.016	0.680	0.005	0.051
H0: E(Ci,Xit)=0, Strict Exog.						
Chi^2 (Wald)	7.280					
p-value	0.507					
H0: Sample Attrition is Exog.						
Chi^2 (Wald)	7.88					
p-value	0.247					

Legend: * p<10%; ** p<5%; *** p<1%. Note: Robust standard errors used.

- *Parents' behaviour*: three dichotomous variables (yes/no) are derived from the response items to the question "During your childhood, did any of your parents or guardians:" "Smoke", "Drink heavily", or "Have mental health problems". The implicit idea here is derived from recent work on intergenerational transmission of social inequalities in health (Trannoy et al., 2010).

5. Results

Presentation and interpretation of the results is only detailed for Poisson estimates since robustness checks carried out with PFProbit and Oprobit provide very similar results – as expected. The latter are given in Table 6 for information only. The relationships between the frailty index and the various set of frailty determinants considered above are explored consecutively in a FE Poisson and a RE Poisson model with Mundlak device. The former is used to investigate differences in the dynamics of frailty between 2004 and 2011; some alternative specifications are compared, and the baseline model is estimated on different subsamples. The latter is brought into play to analyse the differences between individuals' frailty statuses. Special attention is hereafter given to the role of retrospective life-history events.

5.1. Differences in the dynamics of frailty

Table 5 displays the estimated coefficients from FE Poisson models. The regressions are based on a sample of 26,608 observations over a time period of two or three waves (unbalanced panel), and individuals for whom yit = 0 for all t are removed from the sample. The strict exogeneity assumption is tested in the baseline model (M1) and the Wald test indicates that in our case this assumption strongly holds. Consequently, the FE estimator has here some nice properties; it is consistent whatever the distribution of yit is, and the robust standard-errors are valid – as indicated in the previous section. Notice that, time dummies appear to be judicious here (coefficients are significant and positive), indicating that values of the frailty index increase over time, and correcting for the time spell between regular panel waves.

Estimates from model M1 provide the following results. First, individuals report increasing financial difficulties as they become frailer. There is indeed a gradient in the coefficients associated with items of the variable and the joint-test (Wald) indicates that the coefficients are simultaneously and significantly different from zero. This finding concurs with the Health Capital model and suggests that household resources could be inadequate as the frailty process evolves. Second, although the coefficient on housing adaptation displays the expected sign, it is statistically insignificant. As stated previously, this result may be associated with the fact that the question is only time-variant for individuals who changed homes between the waves. On the other hand, when the variable is treated with a between estimator in the RE-Mundlak model (i.e. without a time-average control for this specific variable), the coefficient displays a positive sign (IRR = exp(0.232) =1.261) and is highly significant ($p<1\%$) – results not displayed here. This indicates that higher values in the frailty index are associated with adapted housings. Third, social isolation matter: (i) the recent loss of a partner has an important effect in contributing to the increase of the frailty process, the Incidence Rate Ratio is IRR = exp(0.162) = 1.176; while (ii) participation in both types of social activities prevents from increases in frailty (or may even contribute to a reversible pathway). Finally, the coefficient on the occupational status displays a counter-intuitive

Table 6. Determinants of frailty – Poisson, PFProbit and OProbit estimates

Dep. var. is Frailty	Poisson				Pooled Fractional Probit	Ordered Probit
Indep. var.	FE[a]	RE-Mundlak[b]			GEE-Mundlak[a]	RE-Mundlak
	(M1)	(M2)	(M3)	(M4)	(M5)	(M6)
Time-variant						
Make-ends-meet						
with great difficulty	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
with some difficulty	-0.077***	-0.074***	-0.076***	-0.077***	-0.064***	-0.133***
fairly easily	-0.098***	-0.087***	-0.088***	-0.089***	-0.070***	-0.139***
easily	-0.123***	-0.108***	-0.107***	-0.109***	-0.091***	-0.187***
Adapted housing	0.042	0.078	0.075	0.065	0.058	0.129
Without partner ≤ 2 years	0.162***	0.157***	0.157***	0.160***	0.122***	0.244***
Social activities	-0.074***	-0.072***	-0.071***	-0.075***	-0.054***	-0.102***
Sport club, etc.	-0.102***	-0.105***	-0.105***	-0.108***	-0.078***	-0.141***
Occupational status						
At work	0.101***	0.080***	0.081***	0.084***	0.078***	0.172***
Not at work	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Time dummies						
Wave 1	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Wave 2	0.083***	0.073***	0.056***	0.072***	0.054***	0.103***
Wave 4	0.347***	0.295***	0.291***	0.311***	0.231***	0.448***
Time-invariant						
Female				0.621***	0.428***	0.830***
Birth cohort 1950				Ref.	Ref.	Ref.
Birth cohort 1940				0.005	0.015	0.021
Birth cohort 1930				0.276***	0.211***	0.402***
Birth cohort 1920				0.710***	0.565***	1.132***
Migrant				0.082***	0.057***	0.108***
Education						
None or primary				Ref.	Ref.	Ref.
Secondary				-0.059***	-0.047***	-0.082***
Superior				-0.064***	-0.047***	-0.092***
Missing				0.030	0.008	0.047
Country (ref. France)						
Austria				-0.185***	-0.119***	-0.251***
Germany				-0.258***	-0.173***	-0.346***
Switzerland				-0.219***	-0.156***	-0.267***
Sweden				-0.245***	-0.173***	-0.312***
Netherlands				-0.231***	-0.154***	-0.311***
Denmark				-0.030	-0.025	-0.058
Belgium				-0.063***	-0.040**	-0.095***
Spain				0.066***	0.066***	0.165***
Italy				-0.064**	-0.034*	-0.087**
Retrospective						
Periods of ill health						
Adulthood				0.369***	0.270***	0.530***
Childhood-SRH at 10				-0.188***	-0.124***	-0.232**
Childhood-Illnesses				0.130***	0.088***	0.158***
Periods of fin. hardships				0.066***	0.045***	0.094***
Parents' behaviour						
Smoke				0.003	0.001	0.008
Drink				0.096***	0.069***	0.143***
Mental health				0.076**	0.052*	0.106*

Continued on next page...

Table 6. continued

Dep. var. is Frailty	Poisson				Pooled Fractional Probit	Ordered Probit
Indep. var.	FE[a]	RE-Mundlak[b]			GEE-Mundlak[a]	RE-Mundlak
	(M1)	(M2)	(M3)	(M4)	(M5)	(M6)
Constant		0.552***	0.507***	-0.300***	-1.003***	
μ=1						-0.126**
μ=2						1.180***
μ=3						2.134***
μ=4						2.985***
μ=5						4.056***
ln alpha		-2.471-***	-0.770***	-1.461***		
Rho						0.441***
Obs.	26,608	26,608	40,040	40,040	40,040	40,040
Nb. indiv.	10,483	10,483	17,501	17,501	17,501	17,501
Hausman test						
Chi^2 (LR, Wald)	468.89	659.01	1,363.55	394.79	366.23	338.9
p-value	0.000	0.000	0.000	0.000	0.000	0.000
H0: Make-ends-meet β=0						
Chi^2 (Wald)	19.38	17.24	13.95	14.68	18.15	19.07
p-value	0.000	0.001	0.003	0.002	0.000	0.000

Legend: * p<10%; ** p<5%; *** p<1%. Note: Coefficients for time-averages covariates in M2-M6 not displayed here. (a) Robust S.E. (b) Bootstrapped S.E. with 100 replications.

result (which seems to contradict the Healthy Worker Effect) as individuals at work have more chances to see their level of frailty increase over time than people who do not work. This effect is explored more in the details in the following model.

Model M1.2 displays an alternative specification of M1 in which the occupational status is decomposed for individuals at work, according to the number of days in sick leave. This does not affect other coefficients of the model and provides useful additional information. A dummy is inserted to control for the fact that the variable is only available since wave 2. Estimates from M1.2 suggest that the previous counter-intuitive result on the occupational status is driven by individuals reporting being at work at the time of the survey who, at the same time, experienced more than 20 days/year of sick leave. In other words, some people undergo health problems – among which an increase in frailty – while they are still at work.

Model M1.3 provides an alternative specification of M1 in which a set of health measures are inserted as covariates. The idea is to test whether results in M1 hold when the frailty index is "purged" from any influence of other health measures. It may be indeed that the frailty index captures an overall measure of health. In M1.3 the following binary controls (yes/no) are added: poor self-rated health, presence of 2 or more chronic conditions, presence of 2 or more ADL limitations, and presence of depression symptoms from the EURO-D scale. A continuous measure of cognitive performance (Bonsang, Adam & Perelman, 2012) is also added in the set of health covariates. The results reveal that the coefficients on financial difficulties (Wald Chi^2 = 10.39, p-value = 0.016) and other time-varying covariates remain comparable to those obtained in M1, despite the statistical significance of all the health measures in the right-hand side of the equation. This means that the socio-economic determinants are specific to the Fried frailty index and are not the result of a general health measure.

Models M1.4, M1.5 and M1.6 are replications of M1 on a subset of Euro-regions. It is striking that increased financial difficulties associated with the evolution of the frailty process are no longer significant in Northern countries (Denmark, Sweden, the Netherlands), and less significant in Southern countries (Italy, Spain). Although this effect can be due to the reduction in statistical power from smaller subsamples, the coefficients for these two Euro-regions are inferior to those for Continental countries (France, Belgium, Germany, Austria, and Switzerland). It is also noticeable that the loss of a partner does not seem to impact the evolution of frailty Continental countries. Finally, social capital variables appear to lose their explanative power in the case of Southern countries. Interpretation of these results is tricky because it brings into play different and interlinked institutional features in Europe, ranging from the family to the design of Social Protection Systems. Nonetheless, there is clear evidence that each Euro-region (and potentially, each country) should develop a specific social policy strategy for reducing frailty or maintaining life quality of people in a frailty process.

5.2. Differences in the levels of frailty

Table 6 displays estimates from the baseline FE model (M1) and the RE model with Mundlak specification (M2 to M4). As expected, the Hausman test (Likelihood ratio test for M1 and the Wald coefficients joint-test for time-averages in M2-M4) rejects the RE specification. Coherent with econometric theory, coefficients estimates for time-variant covariates are extremely similar between models M1 and M2, and extension of the sample to individuals with yit = 0 over the period (N rising from 10,483 individuals up to 17,501) in M3, does not modify them either. The differences between the levels of frailty now take into account all the different pathways within and outside the frailty process. Model M4 also includes time-invariant covariates to operate partial decomposition of the until-then unobserved individual heterogeneity.

Estimates of time-invariant individual effects in model M4 confirm that women have higher levels of frailty than men (IRR = 1.861), and younger cohorts are unsurprisingly less exposed to frailty. Despite the socio-economic determinants taken into account in the time-varying explanatory variables, (i) migrants have a significant higher level of frailty (IRR = 1.085), while (ii) more educated respondents have significant lower levels of frailty. Cross-country comparison in the conditional levels of frailty indicates that only Spain has a frailer share of its population than the benchmark category – France. Model M4 also incorporates retrospective life-history covariates as time-invariant variables. The estimates concur with previous findings in the literature on the influence of childhood and adulthood health events and financial shocks on late life-health. In the detail, individual reporting health problems in early-life (retrospective self-rated health, or illnesses when child) or in adult-life have higher frailty levels. Other socio-economic factors in M4 provide interesting findings. The influence of periods of financial hardships still remain significant and positively associated with higher levels of frailty (IRR = 1.068), even after health measures over the life-cycle are controlled for. In addition, giving substance to the theory of intergenerational transition of inequalities in health, it seems that parent's behaviour have long term effects on their children – respondents confessing that their parents were heavy drinkers have higher levels of frailty (IRR = 1.101). Finally model M4 provides evidence of socio-economic inequalities (i) in the dynamics of frailty – drawing from *within* estimates comparable to those obtained in M1, and (ii) in the levels of frailty from the *between* estimates of time-invariant covariates.

6. Conclusion

Drawing on the theoretical economic model of health capital, and panel and retrospective data from SHARE, the analysis of some socio-economic determinants of frailty suggested insights for strategies to prevent, reduce, or accompany the process of loss of autonomy in the elderly population. Focus on variables that are relevant for social policy helped established the presence of social inequalities in the frailty process. As suggested by the health capital theory, several indicators of social and economic status appear to be important determinants of frailty. Our findings also concur (i) with recent findings from epidemiology studies on the influence of education in lower levels of frailty, and (ii) more generally, with the literature on social health inequalities in the older population. Beyond this well-established literature in cross-sectional settings, we also found that the evolution of the frailty process goes along with increased financial difficulties of individuals to make-ends-meet. Moreover, the influence of periods of financial hardships in a life-long perspective is significant and positively associated with higher levels of frailty, even after health measures over the life-cycle (adult health, childhood health, and parents' risk behaviour) are controlled for.

These main results, together with other determinants of frailty, complement public health and medical approaches to disability prevention in Europe, and provide insights for social policy to improve older people's quality of life. First, the socio-economic gradient in frailty levels and dynamics suggests that there is room for Governments, if not in providing additional or more generous safety nets for the ageing population, at least in increasing people's ability to anticipate the consequences of physiologic decline at older ages (e.g. through fostering individual preparedness to make sensible choices in terms of savings, home adaptations, or investments in family and social networks, etc.). Second, although most of the research on frailty focused on interventions in a health care environment, empirical evidence in the general population indicates that specific areas of interest – usually unmapped in frailty interventions – should be considered. Our findings suggest that a significant share of the population aged 50 or more experienced a rapid increase in the frailty process during the last period of their working lives. This pleads in favour of more coordinated public policies of labour force participation of the older population with the disability prevention strategies. Third, more efficient prevention could benefit from better targeting of the sub-populations at risk of frailty – especially women, but also recently widowed persons, migrants, and less privileged elders in social and economic terms. Social actions such as participation to social activities could also be implemented in the early stages of the frailty process as a means to simultaneously maintain physical activity and prevent social isolation.

Finally, these results underline the legitimacy of Social Protection Systems in Europe to moderate the impact of health and economic shocks over the life-span and to maintain the reserve capacity individuals bring in late life. There is a potential for further research to unveil the yet under-acknowledged role social policy can play in increasing healthy life years. Special attention could thus be dedicated to the comparative efficiency of the various Welfare States regimes in Europe.

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8. Appendix

Table A1. Overall, between, and within frequencies of time-variant covariates
(Percentages)

Time-variant	Overall	Between	Within
Make-ends-meet			
with great difficulty	7.3	12.7	60.1
with some difficulty	21.4	35.1	62.4
fairly easily	35.4	55.6	63.5
easily	35.8	49.5	71.2
Adapted housing			
No	92.6	93.2	99.2
Yes	7.4	8.3	90.8
Without partner ≤ 2 years			
No	98.2	99.7	98.6
Yes	1.8	3.9	45.4
Social activities			
No	66.6	81.2	83.5
Yes	33.4	46.5	69.2
Sport club, etc.			
No	71.8	85.1	85.4
Yes	28.2	40.9	67.0
Occupational status			
Not at work	73.4	80.2	91.0
At work	26.6	33.8	79.8

Table A2. Overall frequencies of time-invariant covariates
(Percentages)

Time-Invariant		Retrospective	
Sex		**Periods of ill health**	
Male	46.2	Adulthood	
Female	53.8	No	72.6
Birth cohort		Yes	27.4
1920	12.1	Childhood-SRH at 10	
1930	27.1	Less than very good	98.9
1940	38.8	Excellent or very good	1.1
1950	22.1	Childhood-Illnesses	
Migrant		No	93.2
No	93.1	Yes	6.8
Yes	6.9	**Periods of fin. hardships**	
Education		No	65.7
None or primary	46.2	Yes	34.3
Secondary	28.6	**Parents' behaviour**	
Superior	24.7	Do not smoke	35.5
Missing	0.5	Smoke	64.5
Euro-Region		Do not drink	91.3
North	31.8	Drink	8.7
Continental	47.2	No mental health pb.	97.4
South	21.0	Mental health pb.	2.6

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Achevé d'imprimer le 11 décembre 2012
Imprimeries RGP, 92160 Antony
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On the Socio-Economic Determinants of Frailty: Findings from Panel and Retrospective Data from SHARE

Une analyse des déterminants socio-économiques de la fragilité des personnes âgées à partir des données de panel et rétrospectives de SHARE

Nicolas Sirven (Irdes)

Recent studies on the demand for long-term care emphasised the role of frailty as a specific precursor of disability besides chronic diseases. Frailty is defined as vulnerable health status resulting from the reduction of individuals' reserve capacity. This medical concept is brought here in an economic framework in order to investigate the role social policies may play in preventing disability or maintaining life quality of people in a disablement process.

Using four waves of panel data from the *Survey on Health, Ageing, and Retirement in Europe* (SHARE), a frailty index is created as a count measure for five physiologic criteria (Fried model) for respondents aged 50+ in 10 European countries, between 2004 and 2011.

The longitudinal dimension is explored in two ways. First, differences in frailty dynamics over a seven-year-time period are analysed through variables that are relevant for social policy (income maintenance, housing adaptation, and prevention of social isolation) in a panel model for count data with fixed effects. Second, the individual fixed effects are decomposed by means of a random effects model with Mundlak specification. SHARE additional retrospective data on life history (SHARELIFE) are then used to investigate differences in frailty levels.

The results reveal the presence of various sources of social inequalities over the life-course. Social Protection Systems thus appear to play a major role in accompanying, preventing or reducing the frailty process. Several policy implications are suggested.

* * *

Les études récentes sur la demande de soins de long-terme ont mis en évidence le rôle de la fragilité en tant que précurseur de la perte d'autonomie, indépendamment des maladies chroniques. La fragilité est définie comme un état de santé vulnérable résultant de la diminution de la réserve physiologique de la personne âgée. Ce concept gériatrique est ici mobilisé en population générale et dans un cadre économique afin d'analyser le rôle des politiques publiques dans la prévention et l'accompagnement des personnes âgées dans un processus de perte d'autonomie.

A partir des données de panel et rétrospectives de l'enquête SHARE entre 2004 et 2011, nous étudions les déterminants socio-économiques de la fragilité en Europe. Dans un modèle à effets fixes, les différences individuelles dans la dynamique de la fragilité sont analysées au regard de trois piliers de l'action sociale : politique de soutien au revenu, lutte contre l'isolement social, promotion de l'aménagement du logement. Les différences persistantes dans les niveaux de fragilité sont explorées en utilisant les données rétrospectives sur l'histoire de vie (SHARELIFE) dans un modèle à effets aléatoires avec une spécification à la Mundlak.

Les résultats principaux indiquent la présence d'inégalités sociales de santé sous différentes formes et à différentes époques de la vie. L'importance des systèmes de protection sociale en Europe est reconnue comme un moyen d'accompagner, voire de retarder l'évolution du processus de perte d'autonomie. Plusieurs considérations de politique publique sont discutées.

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www.irdes.fr

ISBN : 978-2-87812-388-3 ISSN : 2102-6386

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Laboratoire Interdisciplinaire de Recherche Appliquée en Economie de la Santé (EA 4470)

The Dynamics of Hospital Use among Older People

Evidence for Europe using SHARE data

Nicolas Sirven, Thomas Rapp

Document de Travail No 2014/01

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The Dynamics of Hospital Use among Older People

Evidence for Europe using SHARE data

Nicolas Sirven[1, 2, *] and Thomas Rapp[1, 3]

This version February 2014

Abstract

Hospital services use, which is a major driver of total health expenditures, is expected to rise over the next decades in Europe, especially because of population ageing. The purpose of this paper is to better understand the dynamics of older people's demand for hospital care over time in a cross-country setting. We estimated a dynamic panel model of hospital admission for respondents aged 50 or more from the *Survey on Health, Ageing, and Retirement in Europe* (SHARE), in 10 countries between 2004 and 2011. Following prior research, we found evidence of state dependence in hospital use over time. We also found that rise in frailty – among other health covariates – is a strong predictor of increased hospital use. Finally, we confirm that countries with strong referral scheme appear to have lower rates in hospital use. Our results support promotion of early detection of frailty in primary care, and improvement of coordination between actors within the health system, as potential strategies to reduce avoidable or unnecessary hospital use among frail elderly.

JEL Codes: I12, J14, C23

Keywords: Demand for health; Long-term care; Frailty; Health prevention; Dynamic panel models for binary outcomes.

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Acknowledgements

This work was supported by the National Solidarity Fund for Autonomy (CNSA, France) under The European Research Area in Ageing (ERA-AGE 2) FLARE 2 initiative

"This paper uses data from SHARE wave 4 release 1.1.1, as of March 28th 2013 (DOI: 10.6103/SHARE.w4.111) or SHARE wave 1 and 2 release 2.6.0, as of November 29th 2013 (DOI: 10.6103/SHARE.w1.260 and 10.6103/SHARE.w2.260) or SHARELIFE release 1, as of November 24th 2010 (DOI: 10.6103/SHARE.w3.100). The SHARE data collection has been primarily funded by the European Commission through the 5th Framework Programme (project QLK6-CT-2001-00360 in the thematic programme Quality of Life), through the 6th Framework Programme (projects SHARE-I3, RII-CT-2006-062193, COMPARE, CIT5- CT-2005-028857, and SHARELIFE, CIT4-CT-2006-028812) and through the 7th Framework Programme (SHARE-PREP, N° 211909, SHARE-LEAP, N° 227822 and SHARE M4, N° 261982). Additional funding from the U.S. National Institute on Aging (U01 AG09740-13S2, P01 AG005842, P01 AG08291, P30 AG12815, R21 AG025169, Y1-AG-4553-01, IAG BSR06-11 and OGHA 04-064) and the German Ministry of Education and Research as well as from various national sources is gratefully acknowledged (see www.share-project.org for a full list of funding institutions)."

1. INTRODUCTION

In its base case scenario for economic predictions in Europe (27 countries), the European Commission underlines the huge impact of ageing on long-term care expenditures (EU, 2012). Prediction results show that long term care expenditures, which represented 1.8 point of the EU27 growth domestic product (GDP) in 2010, will increase by 83.1% over the next fifty years. Said differently, an increasing part of countries' wealth will be dedicated to long-term care spending for formal care in the future. In 2060, formal care expenditures may represent up to 4.4 points of the EU27 GDP in the worse scenario. Despite such evidences of increased budgetary needs for long term care expenditures, there is a global consensus towards health care budgets cuts. The economic crisis has urged health care planners reinforcing controls over health care expenditures.

Hospitals services, which are traditionally the major source of long-term care expenditure (Forder, 2009), have been at the core of many recent measures aimed at cutting costs and gaining efficiency. A central aspect is in the management of disease by primary care producers, which can lead to large savings due to prevented hospitalisations (Dusheiko et al., 2011). In that context, most European countries are refocusing health policy on health promotion and disability prevention among older people. Over the past decades, two main systems have emerged in Europe, depending on the role provided to generalist practitioners (GPs) in the access to hospitals (HAS, 2009). On the one hand, some countries (Denmark, United-Kingdom, Italy, Norway, Netherlands) have implemented a "full referral" system

(FRS), meaning that for non-emergency visits, patients experiencing a morbid episode must visit GPs before going to hospitals. On the other hand, some other countries (Sweden, Finland, France, Portugal, Germany, Austria, Belgium, and Spain) have implemented a "partial referral" system (PRS), in which patients can freely decide to go to the hospital without consulting GPs. From an economical perspective, the FRS aims at reducing the demand uncertainty associated with non-planned hospitalisation, which can be very expensive. Previous research provided evidence that almost 5% of the hospitals' production costs were dedicated to the holding of reserve capacity to service this stochastic demand (Hughes and McGuire, 2003). However, less is known about the propensity of the FRS to reduce hospitalisations, compared with the PRS.

The purpose of this paper is to better understand the drivers of older people demand for hospital care over time in a cross-country setting. Specifically, we aim at comparing individual hospitalisation use over time in the FRS and PRS countries.

Modelling individual demand for hospital in the elderly population is a complex process. Three key aspects must be taken into consideration. First, individual hospitalisation should be modelled as a dynamic process. In Britain, previous research provided evidence that past hospitalisation was associated with lower future length of stays in hospitals (Kohn and Liu, 2013). This results was confirmed in Norway, were hospital readmission was lower for patients experiencing longer length of stays (Bjorvatn, 2013). Second, models should control for patterns of primary care providers' visits, as they play a central role in such hospital use dynamics. The quality of the care produced by general practitioners (GPs) in Norway was a key predictor of hospital use (Carlsen et al., 2007). Financial incentive schemes provided to GPs in Italy were associated with lower rates of preventable hospital admissions (Fiorentini et

al., 2011). Third, health covariates should include measures of frailty to get a more accurate assessment of older people's need for care. Frailty is found to be a strong predictor of higher hospitalisation rates for elderly people (McAdams-DeMarco et al., 2013).

Our original contribution is to combine these three key aspects to develop a comprehensive model of older people's hospitalisation use overt time. A general population framework is preferred so as to compare the cross-country efficiency of FRS and PRS settings in Europe. In the detail, we estimated a dynamic panel model of hospital admission for more than 7,500 respondents of the *Survey on Health, Ageing, and Retirement in Europe* (SHARE) in 10 countries between 2004 and 2011. Using the reference methodology defined by Kohn and Liu (2013) we specified a dynamic model for hospitalisation use. Special attention is given to the assumption of state-dependency of medical health care to explain the dynamics of hospital admissions. We explored the role of visits to GPs in the explanation of the hospitalisation dynamic. We also explored to what extent hospital care is a substitute to specialist providers (SPs) service. We controlled for health by using a set of covariates, including a new measure of frailty (Rockwood, 2007; Fried et al., 2001) since frailty is a transitional state from healthy ageing to functional decline (Fried et al, 2001; Lang, Michel & Jerky, 2009). This research addresses an important public policy issue with regard to cross-country organisation of health system. Finding the presence of a preventive effect associated with the FRS would underline the need to improve the integration of elderly people care pathways in countries with PRS.

2. DATA

2.1. Source and sample

SHARE is a multidisciplinary and cross-national cohort of individual data on health, socio-economic status and social and family relationships of more than 80,000 respondents aged 50 or over (Borsch-Supan et al., 2013). Eleven countries contributed to the 2004 SHARE baseline study (Israel took also part in SHARE wave 1 only). They are a balanced representation of the various regions in Europe, ranging from Scandinavia (Denmark and Sweden) through Central Europe (Austria, France, Germany, Switzerland, Belgium, and the Netherlands) to the Mediterranean (Spain, Italy and Greece). Further data were collected in 2006-07 during the second wave of SHARE in these countries, the Czech Republic, Poland, and Ireland. SHARELIFE, the third wave of the project, was conducted in 2008-09 over the same population (apart from Ireland). This time, the respondents were interviewed about their life history. Different fields such as childhood health, education, job career, family life, housing, etc. were surveyed and provide useful information on initial conditions and life course. In 2010, Greece dropped from the survey (as a consequence of the economic crisis) while Estonia, Slovenia, Hungary, and Portugal joined SHARE wave 4, which is the third regular panel wave of the survey following the SHARELIFE life history questionnaire.

– Table I about here –

The sample retained here is balanced; it is made of the three regular panel waves and a retrospective one. It is restricted to the ten baseline countries, which did carry all of the four waves in northern (Denmark, Sweden, the Netherlands) continental (Austria, Germany,

France, Belgium, Switzerland) and southern (Italy, Spain) regions of Europe. Finally, only full-rank data matrices are kept at each wave so that respondents with missing data are deleted. Our final sample consisted of 30,248 observations made of 7,562 individuals repeatedly surveyed each time during the first four waves of SHARE (Table I).

2.2. Description of the variables

Our dependent variable is a dichotomous variable measuring whether, during the last twelve months, the respondent has been in a hospital overnight (Santos-Eggimann et al., 2005).

Our explanatory variables of interest measured whether the respondent has seen or talked to a GP about his/her health; and, has consulted any of the SP mentioned on a list. We also created three lag variables measuring the use of GPs, SPs or hospital during the previous wave. Following prior work (Santos-Eggimann et al., 2009), we derived Fried's frailty measure based on five criteria (exhaustion, shrinking, weakness, slowness, and low activity) corresponding to various subjective and objective health measures in SHARE. The initial score of frailty takes its values in the interval [0;5] since one point was allocated for each fulfilled criterion. In addition to the micro variables, we created an original variable at the macro level describing the hospitalisation referral organization in Europe. This dichotomous variable follows a classification provided by the World Health Organisation and government agencies (WHO, 2005; HAS, 2009). According to these expert authorities, countries are classified among the full referral system (FRS) when the general practitioners coordinate care and referrals and serve as formal gatekeepers to inpatient care, except in emergency cases. Countries with alternative types of health care organisation are classified among those with a partial referral system (PRS). To explore the sensitivity of our results to that classification, we

used a more detailed classification of European countries (EC, 2010; Paris, Devaux & Wei, 2010) that refines the referral schemes in three categories: compulsory referral systems (CRS), financially encouraged referral systems (FERS), and non-compulsory referral systems (NRS).

In addition to these variables of interest, we controlled for several indicators of health status to take into account the need for care. A dichotomous variable was created for each of the following health measure: self-rated health (SRH) being fair or poor; multimorbidity for at least two chronic diseases; two or more functional limitations Katz's activities of daily living (ADLs) and Lawton's instrumental activities of daily living (IADLs); and the Euro-D measure for depressive symptoms (Prince et al., 1999). A composite health index was derived from a multiple component analysis of the previous health measures and a dichotomous variable is created for general "poor-health". This measure provided a good summary of trends in health over the period. Additional covariates include a measure of income adequacy on a four points scale, whether the household is able to make ends meet: 1-with great difficulty, 2-with some difficulty, 3-fairly easily, or 4-easily. Income adequacy is the only measure of economic well-being that is consistent over the different waves of SHARE–as measures of income and assets changed between waves 1 and 2.

3. METHODS

We used a general framework of dynamic panel models for binary outcome. Simple and intuitive estimation procedure suggested by Wooldridge contributed to render these methods increasingly popular in applied economics (Wooldridge, 2005). We followed a seminal

application to health economics that was provided in previous research (Contoyannis et al., 2004) and recently applied to hospital care consumption (Kohn and Liu, 2013). Following that model, we used a dynamic specification by including an autoregressive one-period lag of the hospital use variable to reflect persistence, or state dependence.

Let y_{it} denote the binary outcome of hospital stays for individual i, $i = 1,\ldots,N$, at time t, $t = 1,\ldots,T$. Let X_{it} denote the full-rank data matrix of explanatory variables. We assumed additive unobserved heterogeneity in a dynamic probit model such as:

$$\mathrm{P}(\mathrm{y}_{it} = 1 | \mathrm{y}_{it-1}, \mathrm{X}_{it}, \mathrm{c}_i) = \Phi(\rho \mathrm{y}_{it-1} + \mathrm{X}_{it}\beta + \mathrm{c}_i) \quad (1)$$

where c_i is the unobserved individual specific term and Φ is the normal cumulative distribution function.

Unlike in the static case, dynamic panel models typically rest on sequential moments restrictions (Chamberlain, 1992). However, the usual random effect assumption of strict independence between c_i and X_{it} is too strong in the case of individual micro-data. We therefore allowed some correlation between the unobservable and the explanatory variables in order to retain a more realistic assumption. Following Wooldridge (2005) we assumed:

$$\mathrm{c}_i = \psi + \overline{\mathrm{X}}_i \xi + \xi_0 y_{i0} + \mathrm{a}_i \quad (2)$$

where c_i, the unobserved individual effect is replaced by its linear projection onto $\overline{\mathrm{X}}_i$, the means of the regressors, and where ψ is the intercept, y_{i0} is the initial value of y_{it} prior to the start of the survey, and a_i represents the projection error.

Our assumption is an application of the Mundlak-Chamberlain device where the individual fixed effect is netted out using a constant and a time-trend. An advantage of this methodology is that our models estimates are not subject to omitted variable bias as long as the omitted variables are time-invariant. In other words, controlling for sex, cohort of birth, education, being a migrant, or other individual fixed effects would not modify the parameters of the time-varying variables. Similarly, average partial effects for the explanatory variables can now be interpreted as *within* estimates, just like an alleged "fixed effects probit" model would yield.

The use of y_{i0} prevents from inconsistent estimates – as known as the problem of initial conditions (Heckman, 1981). Although it is general practice to use the first wave observation as the initial value of the dependent variable, life-history data from wave 3 (SHARELIFE) allow us to use retrospective information as a good proxy for y_{i0}. Doing so, we kept the first regular panel wave for the analysis so that $T = 3$ is sufficient for a dynamic estimation. We opted for a binary retrospective index of health, taking the value 1 if the respondent reported any periods of ill health over the life-cycle (>1 year) or if she reported any physical injury over the lifecycle (>1 year).

Lee (2005) points out that dynamic panel models usually rely on the implicit assumption that one lag of the dependent variable is sufficient to fully capture the dynamics of the process (Lee, 2005). However, it may be that some past values of X_{it} may contribute to contemporaneous values of y_{it}, even after y_{it-1} is controlled for. The obvious example in the case of the dynamics of hospital stays is the role alternative health care use play. The literature suggests that access to ambulatory care (visits to GPs and SPs) is a strong driver of

present hospitalisation rates (Carlsen et al., 2007). We can easily extend the specification of (1) to achieve dynamic completeness; under assumption (2), this defines a latent variable regression model:

$$y_{it}^{*} = \mathrm{Z}_{it-1}\delta + \mathrm{X}_{it}\beta + \overline{\mathrm{X}}_i\xi + \xi_0 y_{i0} + \mathrm{a}_i + \varepsilon_{it} \quad (3.1)$$

$$\text{with} \quad \mathrm{Z}_{it-1}\delta = \delta_y y_{it-1} + \delta_{gp} GP_{it-1} + \delta_{sp} SP_{it-1} \quad (3.2)$$

$$\text{and} \quad \mathrm{X}_{it}\beta = \beta_{gp} GP_{it} + \beta_{sp} SP_{it} + Z_{it}\beta_z \quad (3.3)$$

where Z_{it} contains health measures, the variable of make-ends-meet, time dummies (in order to correct for the time-spell between regular panel waves 1, 2, and 4), and the constant ψ. We also assume that $a_i|X_{it} \sim \mathcal{N}(\psi + \overline{\mathrm{X}}_i\xi, \sigma_a^2)$ and $\varepsilon_{it} \sim \mathcal{N}(0,1)$. Practical estimation of δ, β, ξ, ξ_0, and σ^2_a is straightforward using statistical routines for random effect probit models (e.g. -xtprobit- in Stata). Simple structural coefficient tests provide useful guidance for model specification. First, H0: $\rho = 0$ favours the static model, while HA: $\rho \neq 0$ indicates state dependence and supports the dynamic approach. Second, H0: $\xi = 0$ can be interpreted as a pseudo-Hausman test for random effects since H0 indicates absence of correlation between c_i and Z_{it}, which clearly rejects the Mundlak-Chamberlain device in favour of the baseline random effects probit. Third, H0: $\xi_0 = 0$ rejects the influence of initial conditions meaning that a genuinely new process is observed at the beginning of the sample.

We estimated six different models to explore two main research questions. First, we explored the determinants of hospital stays. We ran a static version of the probit model for panel data with the Mundlak-Chamberlain devive (M1), a dynamic version with initial conditions and the lagged dependant variable (M2), and a dynamic completeness version with addition of lags of ambulatory care variables (M3). Second, we explored the role of the referral system.

The dichotomous variable of PRS or FRS country is inserted so as to test the persistence of difference in average rates of hospital stays over time between the two health care referral systems (M4). Two separate models are then estimated for PRS and FRS countries respectively (M5 & M6). Notice that average partial effects (APEs) are presented instead of coefficients for the sake of comparability across models.

The validity of the dynamic panel model estimated on a balanced sample rests on the particular assumption that sample attrition is exogenous, meaning that results derived from a specific sample are independent to the reasons why some respondents dropped out of the survey. Under this assumption, estimates from the balanced and unbalanced samples should not be different. The three waves of regular panel in SHARE are reduced to two repeated observation points when one lag period is considered. As a consequence, the dynamic model cannot be estimated on an unbalanced sample, and the test procedure for exogenous attrition can only be based on the static model M1. In practice, balanced sample observations were duplicated within the working sample and the set of contemporaneous regressors is duplicated for balanced and unbalances individuals. A dummy indicating whether the observation has been duplicated was added as a control variable and the model was estimated over the whole sample. Notice that time dummies were also included among the regressors. Inference on APEs between balanced and unbalanced sub-samples is straightforward within this single model specification.

4. RESULTS

4.1 Descriptive statistics

Figure 1 displays the value of the measures of health care use and health status, for the same individuals over the four waves of SHARE. These measures are only available for the regular panel waves since wave 3 (SHARELIFE) was dedicated to life-history data collection. The general upward trend indicates both need for care and health care consumption increase as individuals are ageing. The left-hand side graph in Figure 1 presents the distribution of the types of care used, with a wide access to GP (on average, 83% of the sample went to visit a GP between wave 1 and 4), and a more restricted consumption of specialist care (46.2% of the sample) and hospital stays (13.2%). Notice that the rapid surge in specialist care use (3.1 percentage points per wave) may be associated with the fast evolution of multimorbidity or other health measures. Regular trends in health care use, in particular hospital stays, could suggest some autocorrelation, so that past care use predicts future use. In our case, a significant serial correlation for hospital stays was found as large as $\rho_{t,t-1} = 0.105$ ($p<0.01$) and $\rho_{t,t-2} = 0.069$ ($p<0.01$) for 1-wave and 2-wave lags respectively. Khon and Liu (2013) have found similar persistence in the dynamics of health care use using British data. This confirmed the choice of a dynamic panel model specification.

– Figure 1 about here –

– Table II about here –

Table II provides an overview of the average values of the variables at different point in time by type of referral system. Four main results can be noted. First, at baseline (wave 1), FRS countries have a lower rate of health care use than PRS countries. These difference remain significant at each wave and the over the whole period. Second, on may notice the absence of significant differences in health status between respondents in PRS and FRS countries at baseline (wave 1). The overall composite health index (MCA) sets 25.6% of people in "poor health" in both country groups (p-value = 0.982). However, this situation changed over time and differences in general health status appeared in wave 2 ($p<5\%$) and increased even more in wave 4 ($p<1\%$) while FRS countries seem to maintain a lower share of individuals with health problems than PRS ones. In the detail, increase in differences in health status over time seems to be driven by increased differences in poor SRH and limitations in IADL and ADL. Although this issue goes beyond the initial scope of this study, it seems important to explore elsewhere why countries with FRS seem to have lower prevalence and incidence of disability. Third, although PRS countries seem to have a higher level in income adequacy at baseline than FRS ones (respectively 3.017 vs. 2.9), the differences seem to vanish over time: no significant differences are found in wave4. Fourth, age and sex are added to provide further demographic description of the sample: one may note comparable gender rates (53% of women, 47% of men) in both country groups, while FRS countries have a relatively younger population (62.5 years of age on average in 2004 vs. 63.3 years of age in PRS countries).

4.2. Conditional evolution of hospital rates

Table III presents the APEs of the determinants of hospital stays. Our findings concur with Khon & Liu (2013) and extend their results in several ways. Our baseline model (M1) estimates suggest that increase in hospital stays between waves is essentially associated with

increase in the need for care; as most health measures are significant, apart from limitations with IADL (>10%) or ADL (<10%). Progression from "good health" towards poor SRH or multimorbidity increases the risk of occurrence of hospital stays by 5% and 3% respectively. Apparition of (more than three) depressive symptoms is associated with some 2% increase. Progression by one point on the frailty scale [0;5] is associated with an additional risk of about 1.6% on average. Notice that the APE for the frailty index suggests that there is still an effect of changes in frailty after control for multimorbidity and limitations with ADL. This autonomous effect of frailty means that a share of the population with increasing risks of incapacity remains overlooked by means of the usual markers for incapacity although these individuals have a higher propensity to experience hospital stays. In other words, the frailty index is an interesting potential candidate for screening sub-populations at risk who would usually fall out of the scope of prevention. Notice that APEs of the above-mentioned covariates remain comparable in other models specification. Consumption of alternative source of care is found to happen simultaneously with hospital stays (APEs for visits to GP and SP are of 6.5% and 11.2% respectively), suggesting strong evidence of multiple care pathways rather than isolated hospital care.

– Table III about here –

Comparison between M1, M2 and M3 rests on three main additional results. First, the Pseudo-Hausman tests for the Mundlak-Chamberlain device in M1 rejects the random effect assumption ($Chi^2 = 21.06$; $p<1\%$). This finding is also consistent in all other subsequent models specifications suggesting interpretation of the results should follow from a hypothetical "fixed effects probit model". Second, M2 suggests that M1 fit can be improved by inserting a lagged dependant variable in the model – as there is evidence of persistence in

the dynamics of hospital stays (APE = 5%; p<1%). Significant influence of initial conditions in M2 and other subsequent dynamic models increase confidence in the dynamic specification of the model as pre-sample individual characteristics influence the dynamics of y_{it}. Third, M3 indicates that although model specification should be dynamic, a lagged dependent variable is not enough to capture the full dynamic of hospital stays. Inclusion of lags of ambulatory care helps increase confidence in the dynamic completeness assumption. In the details, it seems that previous visits to specialists (or regular specialist use) are important factors of reduction in hospitalisation rates.

This last result is here of prior importance since it suggests a potential substitution effect between hospital care and specialist care. One reason is to be found in the different organisation of primary care in Europe: in FRS countries, specialists usually provide care within hospitals, while in PRS countries, specialists are also part the ambulatory care system. This assumption is validated in results provided in Table IV since the APEs for regular specialist care remain negative and significant only in FRS countries, while the effect appears not significant in PRS countries. Notice that the same results are confirmed in our sensitivity analysis, using three categories of referral systems (results not displayed but available upon request).

– Table IV about here –

In the detail, Table IV displays additional results based on model M3, with regard to decomposition referral system effects. The dummy for FRS is inserted in model M4 to test the difference in average rates of hospital stays over the period. Results confirm descriptive statistics for wave 1 (Table II) since countries with FRS have a significantly lower rate of

hospital stays than those with PRS (-1.2 percentage points). From a dynamic perspective, estimations of model M3 over the subsample of respondents in PRS (M5) and FRS (M6) countries suggest that the substitution effect between specialist ambulatory care and hospital stays is essentially found in FRS countries.

4.3. Testing for exogenous attrition

Table V presents the results from the static version of the random effects probit with Mundlak-Chamberlain device. Notice that APEs from the same estimated equation are displayed in column so that equality tests can be displayed on the same row. Our results indicate that each explanatory variable has statistically the same APE in both sub-samples (all p-values >10%). A joint test is also carried out (Wald t-test = -1.80; p = 0.280) and concurs with previous individual tests that attrition in the working sample is exogenous. In addition, the APE associated with the sample dummy is not significant and indicates that conditional rates of hospital stays do not differ between sub-samples. Similar results are obtained from estimation of model M1 without the Mundlak-Chamberlain device so as to get comparable between estimates (joint test Wald t-test = -0.20; p = 0.845). By and large, these tests suggest that attrition in the working sample does not modify the determinants of the hospital care demand function. Previous findings based on the balanced sample are thus liable for interpretation in the general population setting.

– Table V about here –

Table V presents the results from the static version of the random effects probit with Mundlak-Chamberlain device. Notice that APEs from the same estimated equation are

displayed in column so that equality tests can be displayed on the same row. Our results indicate that each explanatory variable has statistically the same APE in both sub-samples (all p-values >10%). A joint test is also carried out (Wald t-test = -1.80; p = 0.280) and concurs with previous individual tests that attrition in the working sample is exogenous. In addition, the APE associated with the sample dummy is not significant and indicates that conditional rates of hospital stays do not differ between sub-samples. Similar results are obtained from estimation of model M1 without the Mundlak-Chamberlain device so as to get comparable *between* estimates (joint test Wald t-test = -0.20; p = 0.845). By and large, these tests suggest that attrition in the working sample does not modify the determinants of the hospital care demand function. Previous findings based on the balanced sample are thus liable for interpretation in the general population setting.

5. CONCLUSION

This study provides new evidence on the determinants of hospital admission rates in the general population over the recent years in Europe. We added three main contributions to the literature. First, our paper is the first to explore the relationship between healthy aging and hospitalisation using a measure of frailty in the general population. Second, we combined the various approaches found in the literature to develop a comprehensive model that explored the dynamics of care use. Third, we introduced an original variable that differentiated two main systems: countries with a full reference system (FRS) and those with a partial referral system (PRS). We compared hospitalisation rates prevalence and incidence between these two systems. We provided evidence that the FRS was more effective to prevent hospitalisation

than the PRS. We also confirmed that frailty increases the risks of hospitalisation in the general population.

Our results support two main strategies that can be observed among European countries. The first one is essentially to promote early detection of frailty at the level of general practice in order to foster differential treatment in primary care. This strategy has been mainly implemented in countries with the PRS. For instance, in France, a Platform for Evaluation of Frailty and Prevention of Disability has been created to identify the early signs of frailty and to design more effective interventions (Subra et al., 2012). The second strategy, consists in improving coordination between actors within the health system (or integrated care), and – what is yet much less of a priority of on-going reforms – to crucially tackle significant health inequalities in access to specialist care among the elderly. This strategy has been mainly developed in countries with the FRS. In the Netherlands, the Prevention and Reactivation Care Program and the Recovery Care Program represent personalised, integrated interventions for the prevention of functional decline after hospital stay, and the improvement of functioning for vulnerable elderly people.

Our results have important health policy implications, as they suggest that offering integrated solutions to frail elderly people would result in overall reduced hospital rates. This paper brings support to the implementation of integrated solutions to prevent elderly people hospitalisations. As frailty usually precedes dependence, health care planners show an increasing interest in developing interventions designed to prevent expensive care trajectories among frail people (De Lepeleire et al., 2009). There has been evidence that such interventions reduced the length of hospitalisations by more than 50%, leading to important cost savings (Brunenberg et al., 2005). Consequently, the assumption that targeting frail

adults could slow down the growth of health care spending among the elderly, mainly through a reduction of hospitalisation rates is appealing and has gained wide acceptance among policy makers. The emphasis is put on the role of GPs to identify frail older people in order to provide early intervention and/or multidisciplinary case management (De Lepeleire et al., 2009). Further research should explore the cost-effectiveness of interventions designed to improve frailty detection in primary care.

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Figure 1: Prevalence and incidence of health status and health care use in Europe

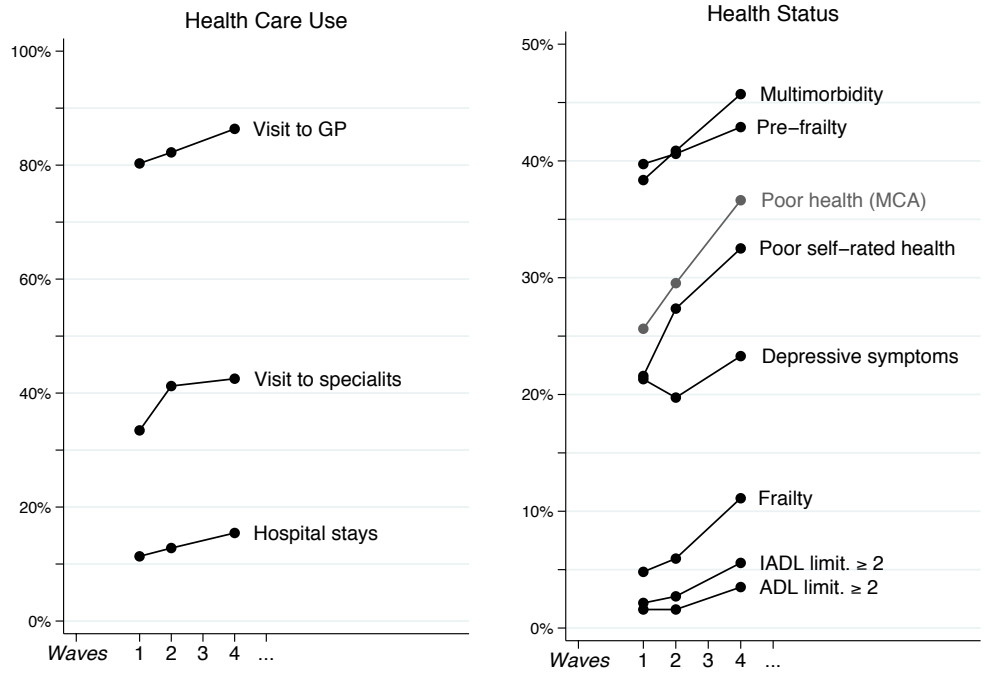

Table I: Sample

Country	Total obs. at waves 1, 2, 3, or 4	Obs. for indiv. surveyed 4 times	Non-missing data		Individuals
			Total Obs. (balanced)	Obs. regular waves	
Austria	9,096	1,900	1,320	990	330
Germany	8,832	3,356	2,756	2,067	689
Sweden	9,518	3,896	3,360	2,520	840
Netherlands	10,271	4,028	3,428	2,571	857
Spain	10,044	3,308	2,176	1,632	544
Italy	11,322	4,840	3,780	2,835	945
France	13,849	4,536	3,252	2,439	813
Denmark	8,295	2,976	2,600	1,950	650
Switzerland	7,188	1,840	1,548	1,161	387
Belgium	14,568	7,096	6,028	4,521	1,507
Total	102,983	37,776	30,248	22,686	7,562

Note: All respondents aged 50+ at start of survey.

Table II: Average values & Two-tailed tests by type of referral system

Variables	All countries				Countries with partial referral system (PRS)				Countries with full referral system (FRS)				Difference between PRS and FRS			
	Wave 1	Wave 2	Wave 4	Overall	Wave 1	Wave 2	Wave 4	Overall	Wave 1	Wave 2	Wave 4	Overall	Wave 1	Wave 2	Wave 4	Overall
Health care use																
Hospital stays	0.114	0.128	0.154	0.132	0.127	0.137	0.167	0.144	0.092	0.113	0.133	0.113	0.035***	0.023***	0.034***	0.031***
Visit to GP	0.803	0.822	0.864	0.830	0.820	0.843	0.877	0.847	0.774	0.788	0.842	0.801	0.046***	0.055***	0.035***	0.045***
Visit to SP	0.334	0.412	0.425	0.391	0.368	0.452	0.445	0.422	0.279	0.346	0.392	0.339	0.089***	0.106***	0.052***	0.083***
Need for care																
MCA Health index	0.256	0.295	0.366	0.306	0.256	0.303	0.385	0.315	0.256	0.282	0.336	0.291	-0.000	0.022**	0.049***	0.023***
Fried's Frailty index [0;5]	0.662	0.718	0.947	0.776	0.661	0.724	0.965	0.783	0.664	0.707	0.917	0.762	-0.003	0.018	0.048*	0.021
Poor SRH	0.216	0.273	0.325	0.271	0.210	0.279	0.339	0.276	0.225	0.265	0.302	0.264	-0.014	0.014	0.037***	0.012**
Chronic 2+	0.384	0.409	0.457	0.416	0.399	0.420	0.482	0.434	0.358	0.389	0.416	0.388	0.041***	0.032***	0.066***	0.046***
Limit. w/ IADL 2+	0.021	0.027	0.056	0.035	0.022	0.027	0.063	0.037	0.021	0.027	0.044	0.031	0.001	0.001	0.019***	0.007***
Limit. w/ ADL 2+	0.016	0.016	0.035	0.022	0.017	0.018	0.042	0.026	0.014	0.013	0.024	0.017	0.003	0.005*	0.018***	0.009***
Depressive sympt.	0.213	0.197	0.233	0.214	0.214	0.202	0.246	0.221	0.211	0.190	0.210	0.204	0.003	0.011	0.036***	0.017***
Resources																
Make-ends-meet	2.973	3.015	3.104	3.031	3.017	3.032	3.093	3.047	2.900	2.988	3.120	3.003	0.116***	0.044**	-0.027	0.044***
Initial coinditions																
Health problems in adult life	0.261	0.261	0.261	0.261	0.265	0.265	0.265	0.265	0.255	0.255	0.255	0.255	0.010	0.010	0.010	0.010
Other indiv. char.																
Female	0.536	0.536	0.536	0.536	0.538	0.538	0.538	0.538	0.532	0.532	0.532	0.532	0.006	0.006	0.006	0.006
Years of age	63.065	65.364	69.649	66.026	63.362	65.500	69.855	66.239	62.571	65.138	69.306	65.672	0.791***	0.362*	0.549***	0.567***

Legend: * p<0.1, ** p<0.05, *** p<0.01.

Table III: Average Partial Effects (APEs) of the determinants of hospital stays

Dep var: Hospital stays (t)	Static model		Dynamic models			
Model specification	M1		M2		M3	
Explanatory variables	APE	S.E.	APE	S.E.	APE	S.E.
Past health care use						
Hospital stays (t-1)			0.049***	0.007	0.052***	0.007
Visit to GP (t-1)					-0.002	0.013
Visit to SP (t-1)					-0.024***	0.009
Contemporaneous altern. care						
Visit to GP	0.065***	0.009	0.077***	0.012	0.075***	0.014
Visit to SP	0.118***	0.006	0.133***	0.007	0.121***	0.009
Contemporaneous need for care						
Frailty index [0;5]	0.021***	0.004	0.025***	0.005	0.025***	0.005
Poor SRH	0.049***	0.007	0.077***	0.009	0.077***	0.009
Chronic 2+	0.031***	0.007	0.025***	0.009	0.025***	0.009
Limit. w/ IADL 2+	0.029*	0.015	0.036*	0.019	0.036*	0.019
Limit. w/ ADL 2+	0.011	0.017	0.027	0.022	0.027	0.022
Depressive sympt.	0.016**	0.008	0.021**	0.010	0.021**	0.010
Contemporaneous resources						
Make-ends-meet	-0.006	0.004	-0.009	0.005	-0.009	0.005
Initial conditions						
Health problems in adult life			0.020***	0.006	0.020***	0.006
Time fixed effects						
Wave 1	ref.	ref.				
Wave 2	-0.004	0.005	ref.	ref.	ref.	ref.
Wave 4	0.006	0.005	0.007	0.006	0.009	0.006
(+ *Mundlak device*)						
Tests on APEs (Chi², p-value)						
Pseudo-Hausmann test	21.1	0.012	36.3	0.000	35.9	0.000
H0: βGPt = βSPt	476.3	0.000	367.5	0.000	238.2	0.000
H0: δGPt-1 =δSPt-1					7.4	0.024
Obs.	22686		15124		15124	

Legend: * p<0.1, ** p<0.05, *** p<0.01

Table IV: Average Partial Effects (APEs) of the determinants of hospital stays by referral system

Dep var: Hospital stays (t)	All countries		Partial referral systems (PRS)		Full referral system (FRS)	
Model specification	M4		M5		M6	
Explanatory variables	APE	S.E.	APE	S.E.	APE	S.E.
Referral system						
Dummy for FRS (ref.)	-0.012**	0.006				
Past health care use						
Hospital stays (t-1)	0.052***	0.007	0.049***	0.010	0.054***	0.012
Visit to GP (t-1)	-0.002	0.013	-0.004	0.018	0.001	0.017
Visit to SP (t-1)	-0.024***	0.009	-0.017	0.011	-0.036***	0.014
Contemporaneous altern. care						
Visit to GP	0.076***	0.014	0.069***	0.019	0.083***	0.019
Visit to SP	0.121***	0.009	0.133***	0.011	0.102***	0.013
Contemporaneous need for care						
Frailty index [0;5]	0.025***	0.005	0.023***	0.006	0.027***	0.007
Poor SRH	0.077***	0.009	0.080***	0.012	0.070***	0.014
Chronic 2+	0.025***	0.009	0.019	0.011	0.034**	0.013
Limit. w/ IADL 2+	0.035*	0.019	0.014	0.024	0.077**	0.030
Limit. w/ ADL 2+	0.027	0.022	0.020	0.027	0.053	0.039
Depressive sympt.	0.020**	0.010	0.036***	0.013	-0.007	0.015
Contemporaneous resources						
Make-ends-meet	-0.008	0.005	-0.012*	0.007	-0.001	0.009
Initial conditions						
Health problems in adult life	0.020***	0.006	0.024***	0.008	0.013	0.009
Time fixed effects						
Wave 2	ref.	ref.	ref.	ref.	ref.	ref.
Wave 4	0.009	0.006	0.016**	0.007	-0.003	0.009
(+ *Mundlak device*)						
Tests on APEs (Chi^2, p-value)						
Pseudo-Hausmann test	35.9	0.000	29.8	0.000	19.7	0.020
H0: $\beta GPt = \beta SPt$	238.2	0.000	155.0	0.000	85.2	0.000
H0: $\delta GPt\text{-}1 = \delta SPt\text{-}1$	7.4	0.024	2.3	0.314	6.9	0.032
Obs.	15124		9446		5678	

Legend: * p<0.1, ** p<0.05, *** p<0.01

Table V: Exogenous attrition tests

Dep var: Hospital stays	Average Partial Effects		Test of APEs equality					
Explanatory variables:	*Selected sample*	*Full sample*	Diff.	S.E. of diff.	Wald t-test	p-value	95% CI	
Health care use								
Visit to GP	0.051***	0.057***	-0.006	0.007	-0.89	0.374	-0.020	0.008
Visit to SP	0.091***	0.092***	-0.002	0.004	-0.35	0.727	-0.010	0.007
Need for care								
Frailty index [0;5]	0.020***	0.019***	0.001	0.002	0.58	0.563	-0.003	0.006
Poor SRH	0.041***	0.042***	-0.001	0.005	-0.19	0.852	-0.011	0.009
Multimorbidity	0.025***	0.025***	0.000	0.005	-0.06	0.954	-0.009	0.009
Limit. w/ IADL 2+	0.016**	0.020**	-0.005	0.010	-0.45	0.653	-0.025	0.016
Limit. w/ADL 2+	0.006	0.009	-0.003	0.012	-0.26	0.799	-0.027	0.021
Depressive Sympt.	0.012***	0.015***	-0.002	0.005	-0.44	0.657	-0.013	0.008
Resources								
Make-ends-meet	-0.001	-0.002	0.001	0.002	0.40	0.691	-0.004	0.006
Joint model controls								
Sample dummy	0.004							
(+ *Wave dummies*)	…							
(+ *Mundlak device*)	…							
Joint test			-0.017	0.016	-1.08	0.280	-0.048	0.014
Obs.	94769							
Obs. by sub-sample	22686	72083						

Legend: * p<.1; ** p<.05; *** p<.01

APPENDIX

Table A1: Descriptive statistics - Dependant variable (Hospital stays) by countries

Countries by referral system	Mean	S.D.		
		Overall	Between	Within
PRS				
Sweden	0.109	0.311	0.188	0.248
Austria	0.211	0.408	0.254	0.320
Germany	0.161	0.368	0.229	0.288
Belgium	0.153	0.360	0.228	0.279
France	0.147	0.354	0.229	0.270
Spain	0.104	0.306	0.187	0.242
Total PRS	0.144	0.351	0.221	0.272
FRS				
Denmark	0.111	0.314	0.198	0.244
Netherlands	0.102	0.303	0.183	0.242
Switzerland	0.114	0.318	0.197	0.249
Italy	0.123	0.329	0.205	0.257
Total FRS	0.113	0.316	0.196	0.248
All countries	0.132	0.339	0.212	0.264

Table A2: Descriptive statistics - Covariates

Variables	Mean	S.D.		
		Overall	Between	Within
Health care use				
Hospital stays	0.132	0.339	0.212	0.264
Visit to GP	0.830	0.376	0.269	0.263
Visit to SP	0.391	0.488	0.345	0.345
Need for care				
MCA Health index	0.306	0.461	0.367	0.279
Fried's Frailty index [0;5]	0.776	1.017	0.822	0.598
Poor SRH	0.271	0.445	0.349	0.276
Chronic 2+	0.416	0.493	0.393	0.298
Limit. w/ IADL 2+	0.035	0.183	0.134	0.124
Limit. w/ ADL 2+	0.022	0.148	0.102	0.106
Depressive sympt.	0.214	0.410	0.311	0.268
Resources				
Make-ends-meet	3.031	0.918	0.780	0.484
Initial conditions				
Health problems in adult life	0.261	0.439	0.439	0.000
Other indiv. char.				
Female	0.536	0.499	0.499	0.000
Years of age	66.026	8.871	8.439	2.736