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Ageing, Frailty and Health Care Expenditures

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In the context of an ageing population and rising health care expenditures, frailty emerges as an interesting notion regarding the consequences of ageing for both health professionals and regulatory policies. It is defined as a decrease in the resistance of the person dealing with stress, which increases her vulnerability and exposes her to the risk of adverse health outcomes, such as falls, and progression towards functional dependence. So far, some of the rise in health expenditure was often attributed to a mechanical effect of age, which failed to take into account the concept of frailty in multivariate analyses. The same age category could indeed conceal different individual situations. Could frailty contribute to reveal these differences?

Using data from the Health, Health Care and Insurance Survey (*Enquête santé et protection sociale*, ESPS) matched to data from the Health Insurance, we test the hypothesis that frailty is one of the determinants of the elderly people's individual health costs. The analysis thus shows that, in 2012, the average amount of outpatient (ambulatory) health expenses of people aged 65 and over increases with the level of frailty.

Frailty depicts a decrease in resistance to stress that increases a person's vulnerability when exposed to a risk of pejorative events and progression to dependence. From a biological perspective, the frailty phenotype is the result of reduced physiological reserves (including nutrition, muscle and cognition), because of illness, ageing or environmental factors. The foundations of the frailty phenotype were identified in the 2000s by harnessing the data of a North American epidemiological study (Insert 1).

Originally, the concept of frailty has been developed to highlight different situations in populations of older individuals with a priori identical observable characteristics. Spurred on by geriatricians, medical science has been developing more appropriate health measures for the elderly, for two decades at least, especially to refine medical decisions among patients with chronic diseases or disabilities. When a person exhibits frailty without comorbidity or functional limitations being diagnosed, it means individuals have a high health risk and this justifies launching preventive actions (Bergman *et al.*, 2002; Clegg *et al.*, 2013).

The innovative character of the frailty phenotype is based on the combined use of relatively simple health criteria but, since they are

often considered separately, they cannot by themselves present the predictive effect they have when associated to each other. Although quite familiar in medical science, frailty was hitherto absent from analyses seeking to explain differences in health expenditure between individuals. And yet, when frailty is not factored in, increased spending can be mechanically attributed to an age effect – as frailty is more common among older people. Could the inclusion of the frailty concept lead to reassessing the link between age and health-care consumption?

The main hypothesis we are testing here is that frailty is one of the determinants of individual health-care expenditure for the elderly. This hypothesis has relatively far-reaching implications in the debate on the economic costs associated to the ageing population phenomenon. The arguments underpinning the main hypothesis are detailed below.

The stakes of frailty in health economics

The value of the frailty phenotype should be put into perspective in the debate on health expenditure arising from an ageing population. Health expenditure analysis models are important tools for understanding, monitoring and regulating the consequences of ageing on healthcare systems. They have shown that, when advancing in age is concomitant with sufficient improvements in ageing populations' health, then the ageing of the population has no effect on health spending. Other factors can then be highlighted, namely changes in individual preferences or technical progress. Thus, the dissemination of medical innovations has accompanied baby boomers' ageing, which lead to a rise in health spending, to the extent that technical progress increases the cost of medical care (Dormont *et al.*, 2006).

Methodologically, whether the analytical framework is transverse or longitudinal, the point is to clearly specify the effects that can be confused with advancing age. Observations have been concurrent: once isolated from the effects of other dimensions usually taken into consideration (health, social, economic and demographic features or even individual preferences), age remains associated with higher health expenditures (Yang *et al.*, 2003). But should we be content with measures implemented on account of age, health measures particularly? The last-year-of-life and time-to-death have been used in analyses only to address the lack of health data in administrative care reimbursement databases (Zweifel, *et al.*, 1999). In surveys, richer in health measures, is the need for care of the elderly adequately grasped with ordinary variables? Is the impact of age reduced if older people's health needs are duly understood? That is, if the main hypothesis is verified, namely that frailty partly accounts for health spending on the elderly, what share of spending remains accountable solely to the impact of age?

Several reasons can be put forward to explain why frailty can induce higher health spending amounts. The first hypothesis suggests that elderly people's perceived state of frailty makes them express greater need for care. Besides being controversial, frailty is a relatively recent concept and almost always confused with age. Recognition by health professionals is therefore not systematically guaranteed, which can cause patients to legitimately request extra care. It is also easy to understand that health professionals, whom may not always be able to identify frailty, recommend additional tests, visit to specialists, or have recourse to more generous medication.

A second hypothesis suggests that frailty could result from medical treatment. Medical studies suggest that polypharmacy or misuse of drugs may induce frailty in the elderly (Herr *et al.*, 2015). It is also conceivable, in some cases, that people made weaker by heavy medical procedures (*e.g.* chemotherapy against cancers) are sent home fairly quickly, and their need for additional care is due to their frailty. This may be additional outpatient treatment designed to complement hospital treatment.

Without testing all of these assumptions, this study aims to verify whether frailty and health costs are indeed related and, if necessary, assess the contribution of frailty to the various expenditure items.

Source and method used to take frailty into account in econometric models

Data from IRDES Health, Health Care and Insurance Survey (*Enquête santé et protection sociale*, ESPS) permit to obtain an overview of the distribution of health spending in the ambulatory sector and of their composition regarding at least 65-year old seniors living in ordinary households in France in 2012 (Source Insert). Descriptive analysis ensures that sensitive individuals have higher outpatient expenses and allows identifying areas in which these expenses are greater. Ceteris paribus analysis (all things being equal) is used to decompose the variance of expenditure according to several individual determinants, including frailty. Hospital health expenditure has not been

Source

The data from the 2012 Health and social protection survey (*Enquête santé et protection sociale 2012*, ESPS)

The Health and Social Protection Survey (ESPS), led by the I*nstitut de recherche et documentation en économie de la santé* (Irdes) since 1988, collects every two years individual data on health, health coverage, social situation and resort to care. The sample is representative of the population living in private households in metropolitan France. In 2012, with support from the National Solidarity Fund for Autonomy (*Caisse nationale de solidarité pour l'autonomie*, CNSA), a module for measuring frailty according to Fried's phenotype was introduced in the investigation. Various tests and comparisons were conducted and the measurement of frailty has been validated for the 65-year olds and over sample (Sirven, 2014). Furthermore, the investigation is paired with care consumption data from the health insurance. It is thereby possible to determine a way to measure respondents' ambulatory spending. This includes expenditures that individuals have presented for redemption by the health insurance and concerns benefits linked to (i) practitioners and health workers – general practitioners, specialists, dentists, nurses, etc., (ii) biology acts, (iii) health services – pharmaceuticals, instruments and processing equipment, optics, prosthesis, transportation, and (iv) emergencies without hospitalization (*see* www.irdes.fr).

used in this study, given that collecting information through different information systems is not a method warranting full comparability with ambulatory expenses. This methodological choice suggests the influence of frailty on health expenditure is minimized here, since hospital costs are higher than average and that frail elderly people have a higher rate in hospital use.

Multivariate analysis can point out the effect of a specific key (like frailty) independently from the effect of other determinants (age, gender, chronic illness, etc.). The rich content of the ESPS questionnaire was used to take into account a broad set of demographic, social, economic and health variables. Health measures play a decisive role because, implemented together, they must approach the need for care. The effect of frailty on health spending is meaningful only in so far as it is independent of all other possible health measures. These cover the field of chronic diseases and functional limitations, but distance to death has also been added, approached via a retrospective measurement of the death risk within the year in consideration, and a number of additional variables such as: perceived state of health, having a long-term illness, instrumental limitations of activity, depressive symptoms, and self-assessed measurement of cognitive problems. Then we test the effect of adding frailty on the explanatory quality of the spending model.

The average amount of health spending for 65-year old and over seniors increases with the frailty level

Descriptive analysis provides a first insight into spending amounts for the 65-year old and over according to their level of frailty and the type of care consumed (Figure). These values, though representative of the 65-year old and over, are not adjusted for socio-demographic effects or for the effects of other health measures. However, they are quite enlightening. First, total average expenditure increases with frailty level. Then the obvious differences in the amounts are mainly found in the auxiliary care personnel (nurses, physiotherapists, etc.) and in health services (pharmaceuticals, medical equipment, processing equipment, optical, prosthesis and transport). Regarding these two major items, high frailty levels are associated with higher spending. A priori, no major differences in the amounts paid to practitioners have been observed. Yet, details show there is a volume effect for GPs, but not for specialists: frail individuals consult a GP about twice more often (9.5 per year) than robust ones (5.3 times per year). These observations are consistent with the initial hypotheses that suggest frailty causes additional costs, but it is however not possible to put forward any particular explanatory mechanism. Ceteris paribus analysis refines and confirms the differences in the amounts of expenditure according to frailty levels (Table).

By way of interpretation, let us first recall the average amount of outpatient spending on 65-year olds and older in 2012 was approximately € 2,600 per person. Several consistent estimates in models 1-4 post a range of average additional cost for expenses associated with frailty at between € 1,770 and € 1,270 per year per person. There is also an additional cost of pre-frailty estimated between € 830 and € 570. The lower limits of these estimates are provided by the best model (Model 4 B), and higher limits by the base model (Model 1 B). Despite a reduced impact of frailty expenditure in models that better control the need for care, the impact of frailty remains significant. If you want to keep up a general idea of the cost of frailty, we could say that in 2012 a pre-frail individual spent about € 3,200 in ambulatory care, as against nearly € 4,000 by a frail person. Note these amounts are lower than the descriptive analysis because they

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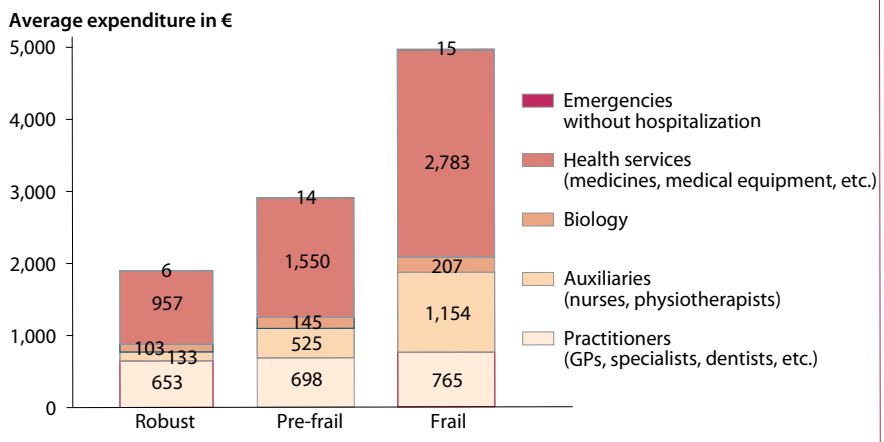
Expenditure by type of outpatient treatment – metropolitan France, 2012



Note: A sample of 65-year old and over elderly people living in private households. Weighted statistics.

Reading: Among the 65-year olds and over, living in private households, frail individuals spent an average of € 5,000 in ambulatory care in 2012, hence nearly € 3,000 in health services (medicines, medical equipment, etc.). These statistics are representative of the population living in private households in metropolitan France, but are not adjusted for individuals' demographic, socioeconomic, and health characteristics.

Source: IRDES, ESPS and Health Insurance.

Data available for download

Context

This work was supported by funding from the National Solidarity Fund for Autonomy (*Caisse nationale de solidarité pour l'autonomie*, CNSA) within the research project called Knowledge of population loss of autonomy and their health care consumption (*Connaissance des populations en perte d'autonomie et leurs consommations de soins*, Compass) between 2012 and 2015. It has notably been used in the production of frailty data as part of the Health, Health Care and Insurance Survey (*Enquête santé et protection sociale*, ESPS). This work has also received support from the seventh draft of the European framework (FP7 / 2007-2013) "Innovative Medicines Joint Initiative Undertaking under grant Agreement", number 115.62, between 2015 and 2018.

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Health expenditure determinants (marginal effects in 2012 euro). Generalized linear models (GLM)

Dependent variable: Amount of outpatient expenses [1]	Model (1)		Model (2)		Model (3)		Model (4)	
	Frail		Frail		Frail		Frail	
	(A) Without	(B) With	(A) Without	(B) With	(A) Without	(B) With	(A) Without	(B) With
Robust		*Ref.*		*Ref.*		*Ref.*		*Ref.*
Pre-frail		**833.55*** **		**791.38*** **		**581.04*** **		**570.55*** **
		(194.82)		**(193.59)**		**(171.04)**		**(171.17)**
Frail		**1,772.01*** **		**1,449.55*** **		**1,391.88*** **		**1,273.05*** **
		(441.30)		**(371.76)**		**(423.90)**		**(417.52)**
Age	23.44* (12.54)	8.96 (12.13)	19.59 (12.27)	7.84 (12.06)	23.10* (11.79)	10.98 (11.24)	22.01* (11.78)	10.87 (11.23)
Female	-86.98 (182.01)	-174.17 (179.01)	-113.27 (180.69)	-179.11 (179.10)	-217.64 (179.00)	-255.19 (175.32)	-228.12 (179.32)	-259.57 (175.90)
Living in couples	-316.34* (184.73)	-269.37 (180.58)	-365.32** (183.62)	-313.57* (180.56)	-204.47 (175.44)	-180.47 (172.19)	-234.36 (174.31)	-206.37 (171.58)
Has additional insurance	108.36 (392.51)	253.37 (350.91)	68.21 (399.06)	206.10 (360.37)	440.77 (323.31)	515.17* (286.90)	407.61 (328.19)	484.78* (293.00)
Preference for the present	-55.71* (32.67)	-49.02 (30.48)	-57.88** (31.75)	-51.25* (30.06)	-32.04 (29.45)	-32.38 (28.43)	-33.60 (29.21)	-33.33 (28.26)
Preference for risk	-122.46*** (39.91)	-87.44** (37.42)	-115.39*** (39.55)	-86.75** (37.54)	-48.30 (42.37)	-33.78 (38.79)	-44.95 (42.62)	-31.74 (39.22)
Number of chronic diseases	244.48*** (51.71)	175.80*** (51.35)	259.92*** (50.49)	196.03*** (50.32)				
Number of Activities of Daily Living (ADLs) restrictions	478.09*** (85.57)	352.18*** (84.63)	474.50*** (84.88)	372.58*** (83.95)				
Distance to death (months)			240.33*** (69.40)	197.22*** (60.92)			163.30*** (47.63)	140.27*** (44.89)
Poor health (synthetic index by multiple correspondence analysis)					2 288.75*** (244.71)	1 837.75*** (225.21)	2 236.81*** (241.94)	1 829.2*** (224.75)
Number of Observations	1,284	1,284	1,284	1,284	1 284	1 284	1 284	1 284
Quality rating								
Copas[2]	0.279	0.564	0.125	0.436	0.828	0.794	0.893	0.890
Pregibon[2]	0.022	0.227	0.000	0.001	0.459	0.398	0.560	0.630
Hosmer & Lemeshow[2]	0.892	0.321	0.807	0.821	0.866	0.572	0.940	0.590
Deviance	14,106.1	13,653.6	14,081.0	13,563.3	13,652.4	13,412.3	13,439.7	13,223.5
LR-Test[2] (H0: A is better than B)		0.000		0.000		0.000		0.000
Multicollinearity								
VIF	1.090	1.195	1.081	1.180	1.088	1.206	1.077	1.186
Kappa	1.620	2.118	1.623	2.134	1.595	2.143	1.598	2.153

* p<0.1; ** p<0.05; *** p<0.01. (1) The dependent variable is the amount of ambulatory spending by 65-year and older seniors in 2012, living in private households in metropolitan France. Survey weights are used. Marginal effects are in 2012 euro; standard deviations of marginal effects are given in brackets. (2) Critical probabilities.

Reading: In model 1A, an additional year led to additional expenditure of € 23.44, significantly different at the 90% threshold confidence degree. In model 1B, which takes frailty into account, an additional year leads to additional expenditure of € 8.96, not significantly different at the 90% threshold of confidence. Model 1 B thus indicates that in 2012 pre-frail individuals spent more (an extra € 833.55) on outpatient care than did robust individuals. The Pregibon test suggests the model is incorrectly specified (p <10%).

Source: IRDES, ESPS 2012.

Data available for download

have been netted of the concurrent effects of other health conditions frail patients may suffer from, which increase expenses.

The levels of income, education or social participation do not impact ambulatory health spending, but age does, and frailty permits to grasp the need for care

Two major effects are to be considered when the focus is on variables other than frailty. One first effect concerns all the "socio-economic" variables such as income, education and social participation levels, for which no association was observed with the amount of outpatient expenses, frailty being included in the models or not. No social inequalities were found in 65 and older outpatient spending. One reason is that 98.4% of the population under consideration has at least one contact with the ambulatory care system during the year, and that levels of low but non-zero expenditures (related to low levels of use) predominate. Similarly, owning complementary health insurance does not impact expenditure (p <10%) because only 6.1% of the sample is not covered. Note, however, that the levels of coverage offered by the private health insurance are not known.

A second impact has to do with the influence of variables such as individual preferences and age: the better controlled the need for care is by the inclusion of health variables, the more it decreases. This is a classic effect in econometrics where poor specification of the model can introduce a bias in the analysis. Using a battery of tests on the model residuals can guide the

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The frailty phenotype

Different approaches to frailty emerged in medical science over the past twenty years. All offer a multidimensional measure of frailty, based on a combination of criteria selected and weighted "by expert opinion". In this context, it is worth acknowledging Fried's approach made some effort to ensure consistency among several elements that contribute to the loss of functional autonomy process (Fried et al., 2001). The theoretical model is deliberately restricted to the physiological aspects; the phenotype is distinct from cognitive problems and has no explicit social dimension; so it is very specific. This is the main feature that allows considering frailty according to Fried as an innovative element of the analysis.

For the sake of comparison, the main alternative frailty model proposed by Rockwood et al. (1994) takes various health measures into account, including chronic diseases and functional limitations, so that the contribution of this frailty health expenditure index indeterminately aggregates the effect of the usual health variables with the specific effects of an hitherto "overlooked" health dimension. More recently, models combining health and social dimensions have emerged, explicitly conferring a social dimension to frailty.

Previous work had shown that the Fried frailty phenotype, though it resorted exclusively to health variables, was strongly correlated with social and economic measures (Sirven, 2013). The use of such general measurements of "vulnerability" in health spending patterns mix the respective contributions of the different components of health and of the economic and social dimension, thereby making it impossible to separate the need for care from dimensions more often associated with access to and use of the health care system.

The Fried phenotype allows, however, conceptually separating frailty from other health problems usually taken into account to measure the need for care. Frailty is defined by the presence of at least three criteria, including: unintentional weight loss, reported fatigue, low physical activity, slow walking speed and muscle weakness. Individuals with one or two of these criteria are called pre-frail. This is the concept of frailty as Fried understood it that is considered in this study. Under this classification, 43.6% of the population aged 65 and over living in private households in France are pre-frail, and about 15% frail (Sirven and Rapp, 2016).

Method

The distribution of health spending generally accounts for values very much concentrated on relatively low spending levels, and less frequent values as expenditure increases. A logarithmic scale of expenditure is generally used to meet the central tendency feature of the average. In an econometric model of spending, it is possible, for the sake of higher accuracy, to choose to give an exponential form to the effects of explanatory variables. In this case, results are very sensitive to the choice of explanatory variables and on assessors' form of the variance. Generalized linear models (GLM) are often preferred because they are more versatile and adapt better to the data. Furthermore, these models can be estimated beforehand in semi-parametric form that defines the parameters of the functional form linking explained and explanatory variables (the econometric literature generally suggests an exponential relationship) and of assessors' form of variance (a gamma function is most often used). Once the structural form of the model had been set, several specifications were assessed and compared. A series of tests on the model residuals can determine what choice of explanatory variables is best suited to the nature of the data.

Furthermore, to reduce the risk of multicolinearity induced by the presence of too many health variables, a data reduction procedure was conducted via the multiple correspondence analysis (MCA). This option, (comparable to a partial least squares regression, PLS) is equivalent to using a synthetic dichotomous variable of health measures. In the end, four sets of health variables are added one after the other and compared: (i) functional limitations and chronic diseases, (ii) distance to death, and (iii) the composite index of health including functional limitations and chronic diseases. Each time, a model is estimated with and without (iv) frailty. In the detail of model specification, the following variables are added: age, gender, living with a partner, owning additional insurance, preference for the present and a measure of risk aversion. Other explanatory variables were taken originally into account and eventually dropped from the analysis because they played no role in the statistical models: level of education, income per unit of consumption in quartiles, being prone to procrastination as regards financial difficulties in life, and taking part in community activities. The choice of specification and expenditure patterns estimates are detailed elsewhere (Sirven and Rapp, 2016).

Comparing various assessments. A battery of statistical tests is proposed to compare different assessments. Critical probabilities associated with different statistical tests (Copas, Pregibon, Hosmer & Lemeshow) are increasing functions of the specification relevance of each model (the threshold being 10%, by agreement). The "deviance" or square root of the sum of the residues is a decreasing function of the assessment quality. Moreover, the critical probabilities of LR-tests provide information on adding frailty to health spending modeling (H0: frailty adds nothing to the model). Finally FIV and Kappa tests feature relatively low values, suggesting that multicollinearity poses no problem in the estimates. All of these tests suggest models that incorporate better control of need for care are more efficient and that frailty improves the specification of all models. Given the whole set of the presented diagnoses, model 4 B offers the best assessment (Table).

interpretation. So, when the need for care is accounted for by some health variables only, the impact of age remains significant, suggesting that the ageing of the population does affect, albeit to a modest extent, the amount of average expenditure. However, when the need for care is correctly specified in models, the effect of age is reduced and becomes insignificant. Besides its importance in the debate on the impact of population ageing on health spending, that last point highlights the relevance of the survey data compared to only administrative sources in which the need for care might not have been adequately grasped – for example when approached by distance to death alone.

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The addition of frailty (and pre-frailty) into health care spending patterns significantly improves the quality of estimates. By supplementing the standard specifications, frailty plays this role of omitted variable: it provides additional information to standard measures of elderly people's need for care. Moreover, while age can account for a residual share of outpatient care expenditure in standard models, adding frailty makes it insignificant. The growth of health spending with age, which is generally highlighted, is therefore mainly due to frailty, which provides insight into the need for care. If future work corroborates this result, implications for public policy could be profound: while the ageing of the population is a long-term trend that is difficult to change, improving the health of an ageing population provides a degree of latitude exploitable in the shorter term. ♦

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