A frailty indicator for old people in a Local Health Unit in the Veneto region: a proposal based on multiple outcomes

Authors:

Margherita Silan[1] margherita.silan@studenti.unipd.it
Giovanna Boccuzzo[1] boccuzzo@stat.unipd.it
Giulio Caperna[2] giulio.caperna@ec.europa.eu
Nicolò Preo[1] nicolopreo@gmail.com

[1] Department of Statistical Sciences, University of Padua, Via C. Battisti 241, Padova, Italy
[2] Joint Research Centre of the European Commission.

Extended abstract:

Population aging, which is common in developed countries, raises new challenges for health services related to health and social assistance of frail individuals. Indeed, one of the main goals of the National Plan for Chronic Disease (Ministero della Salute 2016) consists in the creation of tools that stratify the population according to health and care needs exploiting existing administrative health data flows. In this framework, the identification of frail individuals assumes a crucial role. Indeed, this work started from the request of the local health unit Ulss 15 "Alta Padovana" in Veneto Region.

The main aim of this work consists in the construction of a composite indicator that may be helpful to identify frail old individuals in the whole population. The identification of frail subjects, using a common criterion, is not trivial; indeed there are several possible definitions of frailty in literature, which makes it difficult to find a unique operative criterion.

Nevertheless, there are some key points on which the experts' opinions converge, such as frailty's multidimensionality (Gobbens et al., 2010), and the fact that it is a degenerative process that consists in the reserve capacity for dealing with stressors decline (reduced homeostasis). Moreover, frailty can be detected also because it causes an increased susceptibility to adverse outcomes (Falasca et al., 2011) as death, emergency hospitalization and others. Indeed, given the absence of a unique and shared definition for frailty, the ability to predict adverse outcomes is considered the highest standard for a successful definition of frailty (Rockwood, 2005).

Data we used come from healthcare databases of former Local Health Units (LHU) 15 ("Alta Padovana", now part of "Ulss 6 Euganea") in the Veneto region in years 2012 to 2015, with respect to over-65 years old people. In particular we performed a deterministic record linkage of several data sources: health registry, hospital discharge records, participation in the prescription charges, accident & emergency data, territorial drug prescriptions, home care services and mental health services. As a result, we got two final datasets, one for training and one for validation:

- Training dataset contains all the relevant characteristics and events that happened to the considered population in the two years period 2012-2013, as explanatory variables, and outcomes observed in 2014.
- Validation dataset contains explanatory variables observed in 2013-2014 and outcomes observed in 2015.

Our composite indicator for frailty is based on the fact that frail individuals have a higher susceptibility to adverse outcomes related with frailty condition. This topic has already been

addressed in the article by Silan et al. (2019), where a composite indicator for frailty is proposed using administrative health data-flows from LHU 15. However this composite indicator was considering only two outcomes, death and emergency hospitalization. Since frailty is considered to be a multidimensional concept that involves several functional domains, these two outcomes may not be enough to fully represent and quantify frailty. Thus, a fundamental step is to identify a set of outcomes that should be considered in the conceptual framework for the definition of a frailty composite indicator. After a deep literature analysis, we ended up with a set of five outcomes: death, emergency hospitalization, fracture, disability and dementia (the last two being considered as incidence, not prevalence).
However, these outcomes have different risk factors, thus the selection of a unique and parsimonious set of variables to construct the composite indicator is not trivial. The variables selection process is based on the ability of each variable to predict the considered outcome. Indeed, outcomes are not directly included in the computation of the composite indicator, but they are fundamental in the variables selection process.
In order to select a parsimonious set of variables able to predict the chosen outcomes and, at the same time, limit the risk of over-fitting, we followed a three steps procedure for each outcome:

1. we created 100 balanced samples (containing the same amount of subjects that experimented the outcome and of subjects that did not experiment it);
2. we estimated a logistic regression model with stepwise selection criterion for every sample;
3. we computed the appearance percentage (percentage of times that the variable was included in the final models estimated) for every variable.

At the end of this procedure we could assemble a unique table that contains the appearance percentage for every variable and for every outcome. Thus, we selected explanatory variables with mean appearance percentage (among outcomes) higher than 60%.
The final set of variables considered for the composition of the frailty indicator counts 8 variables, (both ordinal an dichotomous): age (as 6 five-years age classes, with mean appearance percentage equal to 100%), invalidity (98%), use of home care services (76.5%), cancer (75.8%), depression (75%), poliprescription (as an ordinal variable, with 3 classes, 74.2%), anemia (66.6%), and accesses to first aid (as an ordinal variable, with 4 classes, 65.6%).
Variables are aggregated by using partially ordered set theory (poset), which allows to combine the different kinds of variables (dichotomous and ordinal) that reflect both events and characteristics of individuals, without any need for assumptions about weights, linearity or interactions among variables. This method fully exploits the ordinal information of the whole population and represents an extremely powerful tool to compute a frailty indicator. Each subject of the population is identified by a profile corresponding to its own characteristics with respect to the considered set of variables. The intuition behind this method consists in ordering individuals according to their frailty level, thus individuals' profiles are assigned to an approximation of their rank (De Loof, 2011), that is specific for the population to which they belong. The rank is then normalized to make it vary between 0 and 1 and it becomes the frailty composite indicator.
Figure 1, represents the empirical cumulative distribution functions of the frailty indicator with respect to the whole population (black line) and to different values of age (colored lines, according to legend). From the observation of the black line, we see that the majority of the population has low values of the frailty indicator, indeed, we expect majority of elderly to be not frail. Values of the indicator increase with the age variable, which is included in the computation of the frailty indicator.

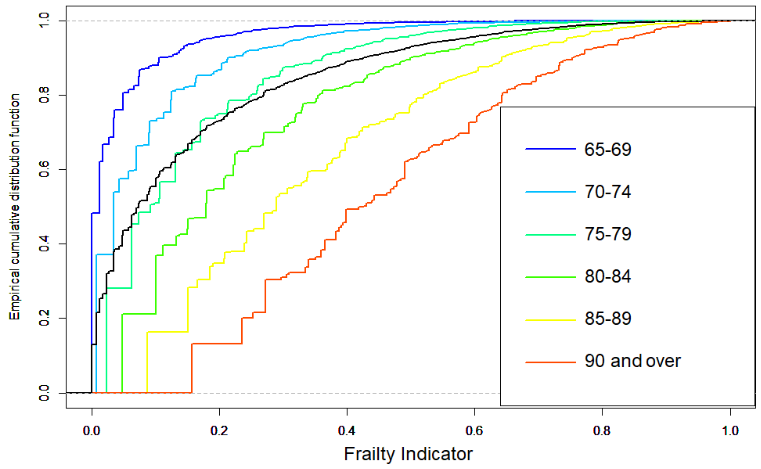

Figure 1: Empirical cumulative distribution function of the frailty indicator by age.

Moreover, the frailty indicator assumes different values also for individuals with and without other chronic conditions such as diabetes (Figure 2) , even if diabetes was not directly included in the computation of the frailty indicator. This gives an important hint about the selected set of variables: even if the set of chosen variables to compute the frailty indicator is quite small, it is extremely powerful because it is able to summarize and represent in the frailty indicator also other health characteristics that are not directly considered.

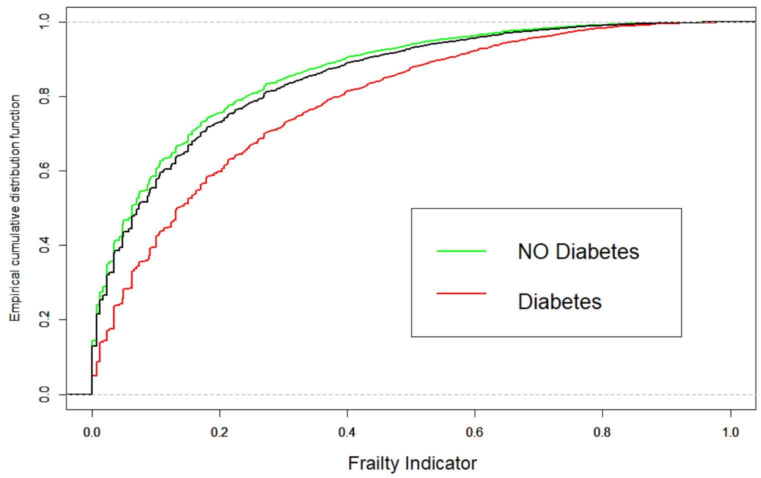

Figure 2: Empirical cumulative distribution function of the frailty indicator by presence of diabetes.

Table 1 reports the Area Under the ROC Curve (AUC) for the five considered outcomes observed in the validation dataset. We can see that this indicator has a good performance in terms of AUC for death, disability and dementia, while a less satisfactory performance in correspondence of emergency hospitalization and fracture (that are outcomes also related to accidental circumstances).

Death	**Emergency Hosp.**	**Disability**	**Fracture**	**Dementia**
0.835	0.743	0.807	0.637	0.784

Table 1: Area Under the ROC Curve (AUC) for the five considered outcomes observed in 2015

In conclusion, our proposal of a frailty indicator provides a score for all over-65 years old in former LHU15 that provides a graduated classification of individuals, and it simplifies a complex and multidimensional concept as frailty is without dichotomizing it. Our frailty indicator needs a small number of variables that are easy to collect from administrative databases. The parsimonious set of variables is also able to predict simultaneously the five outcomes we considered and summarize health conditions of subjects of the population. Moreover, once the frailty indicator is available, this could become also an individual variable to use for further analysis.

An important further development of this work would be an user-friendly application that simplify the computation of the frailty indicator. Moreover, the research is proceeding with the validation of the frailty indicator and its application to different populations and time periods.

References:

De Loof, K., De Baets, B., & De Meyer, H. (2011). Approximation of average ranks in posets. *Match Commun Math Comput Chem*, *66*, 219-229.

Falasca, P., Berardo, A., & Tommaso, F. D. (2011). Development and validation of predictive MoSaiCo (Modello Statistico Combinato) on emergency admissions: can it also identify patients at high risk of frailty?. *Annali dell'Istituto superiore di sanità*, *47*, 220-228.

Gobbens, R. J., Luijkx, K. G., Wijnen-Sponselee, M. T., & Schols, J. M. (2010). In search of an integral conceptual definition of frailty: opinions of experts. *Journal of the American Medical Directors Association*, *11*(5), 338-343.

Ministero della Salute (2016), *Piano Nazionale della Cronicità*, http://www.salute.gov.it/imgs/C_17_pubblicazioni_2584_allegato.pdf. Last access: 31 October 2019.

Silan, M., Caperna, G., & Boccuzzo, G. (2019). Quantifying Frailty in Older People at an Italian Local Health Unit: A Proposal Based on Partially Ordered Sets. *Social Indicators Research*, doi.org/10.1007/s11205-019-02142-8.

Rockwood, K. (2005). What would make a definition of frailty successful?. *Age and ageing*, *34*(5), 432-434.