Forecasting European elderly population health status. An investigation using a dynamic microsimulation model.

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1 Introduction

The impact of ageing population represents a serious concern in Europe. The latest EU official reports confirms that in 2060 the median age for males and females is projected to reach 45 and 47 years, which represents, respectively, a positive shift of 12.5% and 4.6% with respect to 2013 (EC, 2015). Most importantly, evidences on future projections reveal that the age structure of the European population will be subject to a dramatic change in the coming decades, with an increasing share of elderly people. Such changes are mostly governed by changes in life expectancy (LE), fertility dynamics and migration flows. The analysis of past trends in the euro-area Member States shows that LE at birth has been steadily increasing in all Member States since 1960, with diminishing gap between males and females particularly pronounced over the last twenty years. According to the EC (2015), the growing trend of LE is confirmed to persist over the next decades with differences across the Member States. However, in several cases the gains in LE were not associated with improvements in the individual health status. Such a demographic dynamics will dramatically impact the performances of EU healthcare systems, which were already deteriorated by the financial and economic crisis started since 2007 (OECD, 2014; Atella et al., 2014). As a consequence, the health spending has been significantly reduced, exacerbating inequalities. According to OECD, between 2009 and 2012 health expenditure in member states decreased by 0.6% each year, compared with annual growth of 4.7% between 2000 and 2009 (OECD, 2014). At the same time, additional concerns derive from a health perspective. Since the crisis has also changed the structure of mortalities and increased the presence of a number of diseases (obesity, diabetes, alcohol, drug dependence, mental distress), the assessment of ageing population and its impacts on healthcare systems cannot disregard the analysis of co-morbidity and other individual factors affecting the individuals' health (Atella et al., 2017; Ruhm, 2015, 2016)

In this context, the need for reliable quantitative tools able to assess the impact of demographic changes on health status, health care demand and governments' budget appears a key requirement to shed light on the future needs of ageing populations and to support policy makers in tackling the coming societal challenges. However, this requires sophisticated and complex modelling methods that account for the evolution of health, economic and demographic variables at the individual and cohort levels.

Microsimulation models (MSMs) have emerged as a useful tool to answer these questions. Among this class of models, the Future Elderly Model (FEM) (Goldman et al., 2005), using the Health and Retirement Study data, has been extensively used to explore a variety of policy questions over the last decade in the United States.[1] Furthermore, opportunely adapted versions of the FEM have been increasingly employed in other countries (for a recent application, see National Academies of Science (2015) or Chen et al. (2016)).

In this paper we develop the EU-FEM, a European version of the well-known Future Elderly Model (FEM), to project the dynamics of population and health status for 10 EU countries. Given the high level of disaggregation of the data employed and

[1] Some important applications based on the FEM include the consequences of delaying disease and disability (Goldman et al., 2013), the costs of obesity in older Americans (Lakdawalla et al., 2005), future disability trends (Chernew et al., 2005), fiscal consequences of worsening population health (Goldman et al., 2010), the costs of cancer (Bhattacharya et al., 2005), the health and economic value of preventing disease after age 65 (Goldman et al., 2006), the value of cardiovascular risk reduction (Goldman et al., 2006, 2009), long-term health outcomes from medical innovation (Lakdawalla et al., 2009; Goldman et al., 2005), the health consequences of price controls (Lakdawalla et al., 2009), and the financial risk in Medicare spending from new medical technologies (Goldman et al., 2005).

the specific modelling framework for prevalences of several specific diseases, we explain the mechanisms through which the health status and, more generally, the LE patterns appear divergent (as also singled by several recent studies in the EU context).

2 Model description

The model we use in this paper stems from the Future Elderly Model (FEM), developed to examine health and health care costs among the elderly Medicare population (Goldman et al., 2005). The main feature of the FEM is that it uses real individuals, rather than synthetic cohorts, allowing for larger heterogeneity in behaviour than would be allowed by a cell-based approach (Li and O'Donoghue, 2013). Individuals, in a given year, have a probability to change their condition (status) given a set of specific events corresponding to real life events such as marriage, divorce, fertility, education, labour force participation, illness and, finally, death. Thus, the individuals observed in the base file are progressively moved forward through time by making these major life events occur to each individual, according to the probabilities of such events happening to real people with specific characteristics within that particular country. Within a dynamic micro-simulation model, the characteristics of each individual are updated for each time period on the basis of estimated transition probabilities. Hence, micro-simulation models offer a conceptually and analytically superior tool to implement alternative health policy scenarios and produce accurate projections. In particular, our model represents a valuable instrument to be used for "what if" scenarios analysis and other *ex-ante* health policy evaluations, considering that - to the best of our knowledge - no similar tools exist for analysing the European context.

The EU-FEM model has three core components. The *initial cohort module* predicts the health outcomes of new cohorts of 51 year-olds based on historical trends and correlation between multiple outcomes. It allows us to generate new cohorts as the simulation proceeds, so that to obtain outcomes for the age 51 plus population in any given year.

The *transition module* calculates, for binary outcomes, the probabilities of entering and exiting different health states. The common set of covariates for the transition module includes, past health conditions, disease prevalence, geographical dummies (Italy is the reference), education, gender (female is the reference), gender interacted with education, and age polynomials. BMI and income are estimated as continuos outcomes, while ordered models are used to estimate smoking status, Activities of Daily Living (ADL) status and Instrumental Activities of Daily Living (IADL) status.[2] Within this framework it is possible to take into account a great deal of heterogeneity and feedback effects. In the *policy outcomes module*, individual-level outcomes are aggregated to obtain policy outcomes such as expenditures and disease prevalences.

The simulation starts in 2011 with an initial population aged 51 or more. Outcomes are predicted using the estimated transition probabilities. The survivors make it to the end of that year, at which point we calculate policy outcomes for the year. The simulation process then moves to the following year, replenishing the model with a new cohort of 51 years old, whose health profile comes form the initial cohort module.

[2]ADL are routine activities that people tend do every day without needing assistance (eating, bathing, dressing, toileting, walking and continence). IADL are the activities that people do once they are up, dressed, put together. They include cooking, driving, using the telephone or computer, shopping, keeping track of finances, managing medication and pain status.

These entrants, along with the survivors from the last period, constitute the new age 51 plus population, which then proceeds through the transition model as before. This process is repeated until we reach the final year of the simulation. In what follows, we give a synthetic overview of each component of the model.

3 Simulation results

Simulation results are obtained up to 2050 for a set of indicators, and precisely, chronic disease prevalence, LE, disability free life expectancy (DFLE), quality adjusted life years (QALY). Furthermore, we have been able to obtain detailed trends for disabilities (ADLs and IADLs), which help explaining the changes in the health of older people in the EU.

Validation of the EU-FEM has occurred at every step of the data creation and simulation process. Initial cohorts are internally validated using the raw data that was used during creation of the cohorts. External validation uses sources that were not directly used during the cohort generation process. For internal validation of the transition module, a cross validation of the transitioned variables compare the simulated to raw data. The transitioned variables are also externally corroborated with other forecasts. The policy outcomes are externally validated when possible to administrative data.

Preliminary results show that, if current trends will continue, future elderly generations will experience worse health and individuals with a lower level of educational attainment will be disproportionally negatively affected.

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