The “Double Expansion of Morbidity” Hypothesis: Evidence from Italy

by


January 2017

Abstract

The gains in life expectancy (LE) experienced over the last decades have been accompanied by the increases in the number of years lived in bad health, lending support to the “expansion of morbidity” hypothesis. In this paper we revise this theory and propose the “Double Expansion of Morbidity” (DEM) hypothesis, arguing that not only have life expectancy gains been transformed into years lived in bad health, but also, due to anticipated onset of chronic diseases, the number of years spent in “good health” is actually reducing. Limited to the Italian case, we present and discuss a set of empirical evidence confirming the DEM hypothesis. In particular, we find that from 2000 to 2014 the average number of years spent with chronic conditions in Italy has increased by 6.4 years, of which 3.4 years due to the increase in LE and 3 years due to the reduction in the onset age of chronic conditions. Compared to the year 2000, in 2014 this phenomenon has generated an extra public health expenditure of 8.7 billion euros. We discuss the policy implications of these findings.

Keywords: Life expectancy; Double expansion hypothesis; Health expenditure; Italy.

JEL Codes: I10, I11, H51

* Centre for Economic and International Studies (CEIS) Tor Vergata
** University of Rome Tor Vergata, Department of Economics and Finance
† Società Italiana di Medicina Generale (SIMG)
‡ Consiglio Nazionale delle Ricerche (CNR)
1 Vincenzo Atella, Federico Belotti, Joanna Kopinska and Andrea Piano Mortari gratefully acknowledge financial support from Fondazione Farmafactoring. Corresponding author: Vincenzo Atella – atella@uniroma2.it
1. Introduction
Over the last century economic development, improved environmental conditions, better lifestyles, and progresses in health and medicine (particularly with the reduction of infant mortality), have led to a continuous increase in life expectancy at birth in Europe, and in particular in Italy (Atella, Francisci, Vecchi, 2017). This process was more pronounced and sustained in Europe than in many other parts of the world, placing the EU-28 among the worldwide leaders for life expectancy. Between 2002 (the first year for which data are available for all Member States) and 2014, life expectancy in the EU-28 has risen by 3.2 years, from 77.7 to 80.9 years (3.8 years for women and 2.7 years for men). Also the OECD countries featured a similar trend. In Italy, over the past 50 years, life expectancy at birth has increased by about 10 years (1 year earned every 5 lived), reaching 80.9 years in 2014 for the overall population, 83.6 years for women and 78.1 years for men. Looking ahead, EUROSTAT predicts that life expectancy will continue to rise in the European Union in the upcoming decades, reaching 89.1 years for females and 84.6 for males in 2060.

The increase in life expectancy seems to suggest that new generations enjoy better health than older generations. However, since improvements in medical technology have turned many, once deadly, infectious diseases into chronic conditions, being sick does no longer imply a direct risk of death and, therefore, life expectancy as an indicator fails to provide a clear picture of the population's health status (Riley, 1990). In fact, if the probability of death decreases more than the probability of getting sick, the population's overall health status tends to worsen over time. Put differently, the prevalence of chronic diseases in the population may increase due to an increase in life expectancy if the reduction in death rates is not offset by an equivalent decrease in the incidence of chronic diseases. However, according to Bardi and Perini (2013) and Robine et al. (2013), since 2003 many European countries have witnessed a significant decline in healthy life expectancy (HLY) at birth, inverting what had been a continuous growth process. This decline was particularly marked in Italy, with significant differences across geographical areas, and more importantly, across gender: women, tend to live longer, but spend more years in bad health with respect to men.¹

Overall, if the good news is that life expectancy has increased worldwide, the bad news is that HLY is not increasing, and the lengthening of life which we have benefited from so far is not matched by an equal lengthening of life spent in good health. Therefore, if on one hand the longevity is undoubtedly a success for the society, bringing undeniable economic benefits (Breyer et al., 2010), on the other hand, according to many authors, it potentially boosts the risks associated with the incidence of chronic diseases in later life, resulting in an increased demand for long-term health care (Brugiavini, Padula and Pasini, 2010).

¹ It should be noted that the main objective of the Europe 2020 programme is to increase the number of healthy life years by 24 months within 2020.
The idea that over years people may live longer lives with disabilities was already proposed in late 70’s by Gruenberg (1977) and Kramer (1980), who theorized the “expansion of morbidity” hypothesis. According to this theory the longevity would increase due to the progress of new technologies, but the extra years gained would be lived in worse health. Until 2000, a contrasting view was supported by the literature highlighting that the increase in life expectancy was not accompanied by an increase in time lived with disability (Cai and Lubitz 2007) or with moderate limitations (Graham et al. 2004), pointing to the “dynamic equilibrium” hypothesis. On the contrary, from 2000 onwards, life expectancy and HLY trends in OECD countries have been more in line with the “expansion of morbidity” hypothesis, given that the number of years spent with at least one chronic disease has substantially increased.

In the following paragraphs we revise this hypothesis, and present data on a large representative longitudinal sample of Italian patients, which reveals a more worrisome situation, where the number of years spent with at least one chronic disease or disability appears to have risen especially among the younger generations. Indeed the past 15 years have witnessed a progressively anticipated onset of chronic conditions among the young. This epidemiological trend challenges the idea of healthier new generations and induces a new theory about the health status evolution of the population. We thus propose a revisited hypothesis named "Double Expansion of Morbidity" (DEM), which postulates the increase in morbidity not only for the elderly but also for the young.

From this perspective, the combination of social and economic events witnessed over the past twenty years (globalization, demographic change, public and private debt, unemployment and increases in dwelling prices), should be envisaged as rather unique and disruptive, hitting individuals unevenly, depending on the specific moment of their life-cycle and socio-economic conditions. In particular, these events have reduced income levels and its purchasing power and, therefore, future prospects for millions of young people worldwide, thus significantly affecting inequalities between generations.

A survey conducted by The Guardian showed that Millennials – individuals born between 1980 and the mid-90's, otherwise known as Generation Y – are cut off from the wealth generated in Western societies. Furthermore, it is the first time in the history of industrialized countries, with exception of periods of war, that incomes of young adults fell compared to the rest of societies. If thirty years ago young adults earned more than the national average, now in many countries, their wages are 20% lower than the average. According to Luxembourg Income Study data (LIS), in seven major economies in North America and Europe, the income growth of couples aged between 20 and 30 years is below the averages recorded in the last 30 years. In the case of the United States and Italy, Millennials’ disposable income is slightly higher than 30 years ago in real terms, whereas the rest of the population has experienced

---

2 The theory of “dynamic equilibrium” (Manton, 1982) represents a sort of status quo, where despite prevalence increases mortality falls since the prevalence statuses are on average less severe.
substantial gains. In contrast, retirees have seen their incomes rise. Very recently, Chetty et al. (2016) have shown that the US ideal that children have a higher standard of living than their parents is fading away, as the fraction of children who earn more than their parents has dramatically fallen from approximately 90 percent for children born in 1940 to 50 percent for children born in the 1980s. Similarly, for the first time in France, the new pensioners have generated more disposable income than households with a household head aged under 50. In Italy the households aged under 35 have become poorer than those of retirees aged under 80. According to the latest data for the United States, in the midst of the crisis (i.e. in 2013), the income of an average family under the age of 30 was lower than that of a family aged between 65 and 79 years.

The aim of this paper is, therefore, to study and analyze these phenomena and to assess whether and how epidemiological and health expenditure trends may be altered in the next few years with respect to the current institutional main-stream estimates. The following pages present the results of an empirical analysis aimed at understanding the direction of these changes and the trend of some of these factors through the generations. The generational approach gives an innovative perspective to the analysis, which, to our knowledge, has not been explored so far. In the next pages Section 2 presents the main idea behind the Double Expansion of Morbidity hypothesis, while Section 3 discusses the demographic changes occurred in Italy from 1970 and the population forecasts until 2050 from a generational perspective. Section 4 presents the evolution of economic and health conditions across generations, showing that younger generations have been hit more than older generations. Section 5 discusses the effects of the DEM hypothesis on health outcomes and expenditure in Italy, while in Section 6 we present evidence confirming that the DEM hypothesis is driven by changes in health status rather than changes in physician diagnostic behavior. Finally, Section 7 concludes.

2. The “Double Expansion of Morbidity” (DEM) hypothesis

Since the ’70s researchers were debating on population's health and its future evolution. However, due to the lack or limited access to accurate data on levels and changes in morbidity, the relationship between morbidity and mortality has been evaluated only theoretically, giving rise to three major theories:

1. the "compression of morbidity" hypothesis foresaw an improvement in health status giving rise to the idea that individuals would live longer and healthier (Fries, 1980, 1989 and 2002; Hubert et al, 2002);
2. the "expansion of morbidity" hypothesis foresaw a worsening of health status, where individuals would live longer, but the years gained would be spent in worse health (Gruenberg, 1977; Kramer, 1980; Olshansky et al, 1991);
3. the "dynamic equilibrium" hypothesis foresaw a sort of maintenance of status quo (Manton, 1982), where despite increases in morbidity, mortality would fall due to a lower severity of morbidities.
The empirical test of these three theories requires information about the severity of conditions or the disability levels. While chronic diseases have a wide range of collateral consequences, international classifications put disability in the center of these consequences: hence disability is at the same time, an indicator of severity of morbid states and an indicator of quality of lives. Its inclusion in the definition and its measurement as a health indicator has enabled a significant improvement in the ability to understand the health status of the population. In line with these considerations, policymakers have focused on Healthy Life Years (HLY), which measures life expectancy without disability. Moreover, separating the overall life expectancy into years lived with and without disabilities allows researchers to evaluate which of the three theories is the most consistent with the empirical evidence.

In order to grasp a general picture of the evolution of morbidity in the recent decades, we present a set of stylized facts regarding the EU and Italy. According to Eurostat, the burden of chronic diseases expressed in DALY’s (Disability Adjusted Life Years) relative to 2010 is attributable to seven major risk factors: hypertension (12,8%), smoking (12,3%), alcohol consumption (10,1%), dyslipidemia (8,7%), excess body weight (7,8%), low fruit and vegetable intake (4,4%) and insufficient physical activity (3,5%). Moreover, in Italy more than 40% of men and more than 46% of women suffer from at least two chronic diseases, and the number of co-morbid conditions increases with age (Atella, Belotti et al., 2017).

Figures 1a and 1b present the changes in the number of deaths and the number of years lived with disabilities (YLDs) recorder in 25 years (i.e. between 2015 and 1990), for the EU and Italy, respectively. Overall, the number of deaths in the EU decreased significantly for each age group, with the most important gains registered for the infant and early-childhood life expectancy. The only exception is the increase in the number of deaths for the 80+ individuals, which is a mere representation of the fact that on average the moment of death has been postponed and occurs with a relatively higher frequency in that age group. Despite the optimistic evidence on the reduction of age specific deaths, a gloomier picture is depicted for the evolution of YLDs.

3 It refers to the international classification of impairments, disabilities and handicaps (ICIDH) and the international classification of functioning, disability and health (ICF) (WHO, 1980 and 2001).

4 The HLY (Healthy Life Years) - also called Disease Free Life Expectancy (DFLE) - is an important European policy indicator and was selected as part of the Lisbon Strategy (2000-2010) to assess the quality of life and functional health status of Europeans. The HLY is also part of the European Community Health Indicators (ECHI) and was set as the overarching target of the partnership of Innovation Union (research and development component of the strategy Europe 2020) on Active and Healthy Ageing, the target being an increase in HLY in the European Union of two years by 2020. According to the European Commission, the HLY indicator measures the number of remaining years that a person of a certain age is able to live without disability. The HLY is a strong indicator to monitor health as a productivity/economic factor. The "quality of life" concept can be introduced through this indicator, as well. It is used to distinguish between years of life free of any activity limitation and years experienced with at least one activity limitation. The emphasis is not exclusively on the length of life, such as life expectancy, but also on the quality of life. (see the following link: http://ec.europa.eu/health/indicators/healthy_life_years/hly_en.htm).
While the recent decades brought a contemporaneous reduction in both deaths and years lived with disability for the EU individuals aged 39 and younger, all the age groups above 40 saw narrower reductions in mortality accompanied by heavy increases in the amount of years lived in bad health. The evidence presented for Italy is even more pessimistic, with increases of the YLDs reaching already 35+ individuals (five years earlier than for the EU). Overall, the reductions in mortality rates in the recent decades have been undoubtedly driven by the technological progress, both in terms of processes and products, as well as enhanced healthcare organization. The
increases in YLDs result from, on the one hand, the elderly who translate their technology driven life expectancy gains into years lived with chronic conditions and disabilities, and on the other hand, the 35+ individuals, who anticipate the onset of chronic conditions and disabilities mainly due to lifestyle driven deterioration of health status.

Figure 2 – The “Double Expansion of Morbidity” hypothesis: a graphic representation.

While this picture delivers support to the “expansion of morbidity” hypothesis, showing that the price to pay for living longer is indeed the spread of co-morbid conditions for the elderly, it also evidences an additional phenomenon regarding the anticipated onset of chronic conditions for the younger cohorts. In line with these findings, this paper proposes an alternative hypothesis, defined as “Double Expansion of Morbidity” (DEM). The new hypothesis is graphically represented in Figure 2. The first line refers to a situation where at time \( k \) life expectancy (LE) of the population takes the value \( LE_0 \) and the time when the onset of any chronic condition takes place is point \( AO_0 \) (Average Onset). The distance between \( LE_0 \) and \( AO_0 \) is the number of years with at least one disease (YLD). At time \( t + k \) different scenarios can be observed. The first scenario, represented by the blue line, assumes that life expectancy will be prolonged up to \( LE_{EXP} \) with the average onset unchanged \( (AO_{EXP}=AO_0) \). Consequently, the number of years spent with at least one pathology increases (due to higher life expectancy), giving rise to the concept of "Expansion of Morbidity". The second scenario, represented by the first red line, assumes the anticipation of the average onset \( (AO_{2EXP}<AO_{EXP}) \), and a lower growth in longevity (i.e. \( LE_{2EXP}<LE_{EXP} \)). As a result, the phenomenon of "Double Expansion of Morbidity" (DEM) is observed, namely an increase in the number of years with at least one disease due to both a lower average onset age and a higher life expectancy. Finally, the last scenario - the second red line - differs from the previous one by additionally assuming the presence of technological progress: on the one hand the average onset is anticipated as in the second scenario, \( AO_{2EXP}=AO_{2EXP}' \), and on the other hand, longevity is extended, this time more than the previous scenario due to the technological progress, \( LE_{2EXP}'>LE_{2EXP} \). Similar to the previous case, the “Double Expansion of Morbidity” is observed, yet more pronounced since the time spent with at least one disease is longer due to the increased longevity.
The empirical analysis presented in the following pages attempts to provide a range of evidence in order to shed light on what has happened in the last 25 years in Italy and can be expected to occur in the future.

3. The Italian demographic structure and its changes over time: a generational perspective.

From a demographic point of view, the world has changed in a sizeable way over the last 60 years, and these changes have been driven by several cultural, social and economic events (wars, political turmoil, calamities, technological progress, globalization, etc.) which have hit populations at different point in time and over space with a heterogeneous intensity. Furthermore, all these events have hit population differently over their life cycle, thus shaping “generations” in a rather clear-cut way.

From a sociological perspective the concept of “generation” encloses a relatively homogeneous group of people, defined by certain characteristics, normally linked to the birth cohort. A generation can be thus defined as a group of people born in the same period and grown up around the same place, living similar trends and experiences approximately at the same stage of life and through similar channels (for example: internet, TV, mobile phones, etc.). For these reasons, persons belonging to a "birth cohort" tend to share similar features, preferences and values throughout their lives. As individuals get older, the so-called “generation-shaping trends” characterize univocally people of the same generation, since beliefs and expectations tend to evolve in a similar manner among member of a particular generation.

Although it is important to remember that at the individual level everyone is different, the analyses conducted from a generational viewpoint deliver a set of powerful "clues" about the connections with other generations and their possible evolution at different ages. The generational lens also offers the possibility to observe phenomena that otherwise are hard to identify and understand, which at the same time are responsible for individual choices. Accordingly, a generational approach will be adopted in the rest of this paper in order to shed light on changes in several economic and health outcomes and their heterogeneity across different generations. Moreover, this type of analysis will deliver an empirical support to the DEM hypothesis.

Starting from a purely demographic perspective, Figure 3 describes the generational composition of annual cohorts in Italy portrayed from 1970 to 2050 each 20 years. The shape of the population pyramid (not distinguished by gender) in 1970 is structured by a population in gradual expansion, with a high proportion of young people, belonging to the Baby boomers’ generation and Generation X. Yet, 1990’s see a contraction in the share of the young, making the pyramid evolve towards a trapeze. This trend is exacerbated in 2010 and in the estimated 2030 snapshot, where the trapezoid shape becomes more evident with the aging of Baby boomers and generation X. Finally, the snapshot in 2050 shows an utterly accentuated reduction in the share of young people, and a parallel increase in the share of older population.
As far as each Italian generation absorbed historical, cultural and demographic diversities, consistent differences have occurred between them, which shaped different ideological and political behaviors. Moreover, the generations differ in their vision and approach to life choices, such as marriage or work, due to the different economic, sociological and cultural circumstances they meet. For instance, the choice of marriage and having children is increasingly rare and late among newer generations, as is the economic and financial independence, with less job stability and higher probabilities of being left out the labor market for long periods. Moreover, Generations X and Millennials are certainly the most globalized, a factor that causes many consequences, such as bad diet habits and more sedentary lifestyles.
4. The evolution of economic and health conditions across generations: stylized facts

4.1 Changes in socio-economic conditions

The period between 1990 and 2016 is marked by a series of vast and complex events with significant repercussions on the economies of all countries and, in particular, on those in Europe. For instance, the beginning of the 90s gave rise to the end of the fixed exchange rate system after a number of currency crises in Europe, the crisis of the welfare systems after the Maastricht Treaty, the digital technologies revolution in the operation of manufacturing processes and markets, the worldwide spread of the dot.com bubble, the globalization and the Chinese leadership in the international trade context. At the beginning of the new millennium the Euro was introduced, the geopolitical landscape was shaken by the attack to the twin towers, the housing bubble led to the financial crisis in 2007, followed by a period of austerity in Europe. The nature and density of the events are perhaps the best evidence of the stress that national economies, and their inhabitants, have been exposed to for the last 25 years. Looking back, 1990 is perhaps as far away from today as the 1990 has been from the early decades of the twentieth century.

The above-mentioned events affected various generations with various intensities, often leading some of them to experience important changes in their way of living. In this regard, Millennials have experienced the toughest economic conditions, with the crisis of 2007, which is the heaviest one since World War II, occurring at a stage of their life-cycle (around the age of 20-30 years) when normally individuals get financially independent.

For this purpose a first set of evidence on socio-economic and health status changes of the Italian population is presented, based on data collected by a set of repeated sample surveys (Aspects of Everyday Life Survey, 1993-2012) conducted by Italian National Institute of Statistics (ISTAT) and based on "self-reported" information.

Figures 4a and 4b show that important economic indicators have changed in Italy between 1993 and 2012 and that these changes have been heterogeneous among sub-periods and generations. In particular, in 2002, for all generations the percentage of workers with open-ended contract was slightly higher than in 1992, although the changes were not uniform among generations. A different situation emerges when comparing the percentage in 2012 to that in 2002: the younger generations (i.e. the 20- and 30-year age cohorts) are less likely to have an open-ended contract than their peers in 2002, while for the older working generations there has been a sizeable increase. Similar dynamics are observed concerning the percentage of the employed: a significant reduction in the percentage of 30 and 40-year-old employed individuals has been recorded in 2012 with respect to 2002. Figure 4a also reports the changes in the share of people maintained by their relatives. In this case, the situation of the youngest cohorts (30 and 40-year-olds) has

---

5 The sharp increase in the prevalence of 60-year-old employed individuals in 2012, with respect to 2002, to a large extent, is due to the pension reform adopted in the meantime, which basically increased the retiring age.
become rather worrying in the recent years, with their percentage significantly increased in 2012 with respect to 2002.\(^6\)

Figure 4a – Changes in the economic conditions by age cohort (1993-2012).

Figure 4b – Changes in the economic conditions by age cohort (1993-2012).

**Note:** changes refer to two time points of two sub-periods: 1993 vs 2002 and 2002 vs 2012.

**Source:** Own elaborations on ISTAT data – Aspects of Everyday Life Survey (1993-2012)

This evidence is in line with recent evidence produced by ISTAT (2016) on poverty rates of young households, pointing out that the poverty in Italy has changed at a generational level since 2011, when some differences started to emerge between the age cohorts. Interestingly, in a decade the poverty rate among older ages decreased (4.5% in 2015), while increased among the youngest (9.9% for the 18-34 age class and 10.9% for the under 18). Furthermore, the inequality is more contained among the elderly, often pension beneficiaries, whereas it increases among the 18-34 and 55-59-year-olds. Actually, these are the age groups with the highest frequency of cohabitants and households, where the difficulty in the access and

\(^6\) In this specific case, also the prevalence of 60-year-olds is higher in 2012 than in 2002, suggesting that over this period the Italian economic situation has witnessed a general deterioration of its main economic indicators.
permanence in the labor market, especially among the younger, determines very diverse income conditions.

Figure 4b reports the variations in the percentage of economic and job satisfaction among different generations. Concerning the overall economic satisfaction, the changes occurred between 1993 and 2002 (upwards) and between 2002 and 2012 (downwards) are quite uniform among the 4 age cohorts, and without any substantial upheaval. However, the younger generations are the most disadvantaged. Concerning the job satisfaction, the changes between 1993 and 2002 are more similar among cohorts than those between 2002 and 2012. Indeed, the fall in the share of the 30-year-olds in 2012 was double than that of the 40-year-olds and almost quadruple than that of the 60-year-olds.

4.2 Changes in health status
The generational differences do not concern only the economic aspect of individual lives, although recognizing its relevance and, more importantly, its interconnection with other facets that occur in a lifetime. Undoubtedly, one of the most significant changes in the demographic structure of the population in developed countries is related to longevity. For instance, the technological progress recorded since the WWII caused a substantial delay of mortality, partly offset by the increased prevalence of chronic diseases. If initially increases in life expectancy derived from the reduction in precocious deaths at early ages, in the last decades the major contribution came from a higher survival of people over 65.

Parallel to the mortality issue, the health status of the new generations is gaining the upper hand. In terms of population size, the generation of Baby boomers has recently given way to Millennials generation, represented by individuals who grew up in a less healthy environment than that of the previous cohorts. Since their early life, Millennials are more likely to live in polluted environment, concentrated in urban and industrial areas, with scarce green spaces. According to the European Environment Agency (EEA), in the period 1997-2008, from 13 to 62% of the European urban population was potentially exposed to concentrations of particulate matter (PM10) above the limit imposed by the EU for the human health protection (EEA, 2014). Also, since their birth, the cohorts born after 1980 were more exposed to chemical agents and highly processed food, which combined with changes in lifestyle, can lead to substantial increases in the prevalence rates of certain chronic diseases such as diabetes, hypertension, cardiac disease, obesity or various cancers, which are also the main causes of death in the developed countries. According to Blumenthal and Warren (2014), in the US the 30-year-olds are likely to have worse health conditions than their peers in previous generations, and the trends seem to be getting worse.
Concerning health status, significant variations in various aspects of health of Italians are observed in the last 25 years, as shown in Figures 5a, b and c. First, the prevalence of obesity for the age cohorts of 30 and 40 years is noticeably higher in 2012 than in 2002, suggesting that the newer generations have been particularly affected by overweight and obesity problems compared to the older ones (see Figure 5a). Also, the youngest generations seem to be less likely to practice sports, since only the 30-year-olds present a
lower prevalence in 2012 than in 2002. Second, Figure 5b displays the changes in the prevalence of allergies, asthma and cancer between 1993 and 2002, and between 2002 and 2012, respectively. The most worrying picture (in terms of increased prevalence) is, again, observed among the young age cohorts, although the changes in prevalence seem to be attenuated in the second sub-period. Moreover, comparing 2012 with 2002, allergy and asthma problems are likely to be more present also among the older age cohorts. Finally, Figure 5c reports the changes in the prevalence of cardiovascular disease (hypertension, heart failure and angina) and diabetes, highlighting much worse conditions in the last sub-period (i.e. in 2012 compared to 2002), especially for the two youngest age cohorts. Interestingly, in the case of angina, in 2012, the 30-year-old individuals are three times more likely to experience the condition than their 30-year-old peers in 2002, whereas all the rest of the age cohorts in 2012 registered lower prevalence than that in 2002.

Furthermore, regarding heart failure and hypertension, the 30-year-olds in 2012 have a markedly higher prevalence than their peers in 2002, and similar situation is observed among the 40-year-olds. The oldest age cohorts report much lower increases in the prevalence of the diseases in 2012, yet, suggesting a worsening in the health status compared to the changes observed between 1993 and 2002. The changes in the prevalence of diabetes fairly follow those observed for the cardiovascular diseases, where the 30 and the 40-year-olds in 2012 show significantly higher prevalence than that of their peers in 2002.

While compelling, the evidence presented so far is derived from a nationally representative ISTAT survey based on "self-reported" information, which may be strongly affected by measurement errors, especially for health status. For this purpose we carry out an additional set of analysis on “objectively” measured health status data from the HS-SiSSI dataset, run by a group of Italian general practitioners, containing electronic clinical records collected during routine contacts (visits) with patients, available from 2000 to 2014.

Figures 6a-6c report the prevalence percentage change for some chronic conditions for different cohorts of patients (30, 40, 50 and 60 years of age). As for the ISTAT data, the new results show that, for almost all considered diseases, prevalence rates for the 30 and 40-year-olds patients have increased compared to those of their peers in 2002, who belong to the cohorts of 50 and 60-year-olds in 2012. As shown in Figure 6a, the Charlson index (which describes the overall mortality risk resulting from the presence of co-morbid

---

7 This type of evidence is not new in the world of international epidemiological literature. According to Blumenthal and Warren (2014), in the USA the proportion of obese young adults between 18 and 29 years of age has more than tripled over the past forty years, rising from 8% in 1971-1974 to 24% in 2005-2006. At the same time, this group of people reports a significant decline in physical activity in school than the generation of their parents. Millennials were among the first to see the increasing rates of early onset of obesity-related diseases and might not be as healthy or live longer than their parents. Similar problems are found also from the perspective of mental health.

8 The HS-SiSSI dataset is a joint research project between CEIS Tor Vergata and the Italian Society of General Practice (SIMG). A detailed description of the dataset is provided in Appendix A.2.
conditions) has increased in percentage points more for the 30-year-olds than for the other cohorts/generations.

A similar result appears when looking at the prevalence of individuals with at least one chronic illness. Further important differences across generations are found when looking at the changes in prevalence rates of obesity and
overweight, confirming the trend already revealed by ISTAT, where the prevalence of obesity increased by 60% for the 30 year-olds and by 40% for the 40 year-olds, remaining almost unchanged for the older cohorts. In contrast, the changes in disability rates show no significant differences across generations, although very high growth rates have been recorded.

Figure 6b displays the information for a set of cardiovascular diseases and for diabetes. Also in this case, sharper increases are recorded among the 30 year-olds, especially in the context of very common diseases such as diabetes, and particularly, hypertension and coronary heart disease. Regarding hypertension, data report a prevalence of the 30-year-olds in 2014 almost tripled compared to that of the 30-year-olds in 2002, indicating much more worrying situation than that presented in figure 5c. Significant increases are also noted for stroke and dyslipidemia.

Finally, as illustrated in Figure 6c, important increases in the prevalence of thyroid dysfunction and cancer are reported for the 30 and partly for the 40-year-olds. Opposite results are found for depression and asthma. Concerning asthma, it appears that the results reported in figure 5b and those in figure 6c are not very dissimilar, except for the oldest age cohort which shows, after around ten years, much higher increase in 2014 (according to the HS-SiSSI data) than in 2012 (according to the ISTAT data).

Based on these descriptive statistics, it is easy to conclude that all these socio-economic and health factors will play an important role for the future evolution of health status of Millennials – becoming in the near future one of the generations with the highest impact on population – and may result in further problems concerning overall health status and health expenditure of the population.

5. The effects of the DEM hypothesis on health outcomes and expenditure in Italy

The evidence reported so far suggests that younger generations are witnessing relatively worse health conditions than older generations. This implies that, over the last decade, a higher share of young individuals has experienced health problems leading to a reduction of the average onset age of disease at population level. The differential in the average onset age of disease will thus measure the expansion of morbidity within the young generations and, therefore, will deliver an empirical proof of the DEM hypothesis. Furthermore, it will also represent the basis for a well-defined measure of the effect in terms of additional health expenditure. Within this theoretical framework, we limit our analysis to the onset of chronic diseases.

The age of onset of chronic conditions represents a very interesting indicator both from an epidemiological and economic point of view. For a fatal outcome, the difference in time of occurrence is the number of additional years experienced when a certain risk factor is absent, compared to when it is present, and is linked to potential years of life lost before a certain age (due to a particular cause of death) or potential years of life lived in absence of illness.
or disability. One of the main advantages of this indicator is, therefore its easy interpretation. In cases of very common diseases, its measurement is very easy and straightforward and it is more accessible and understandable to policy makers and, therefore, less prone to misinterpretation.

Based on the HS-SiSSI data, it has been possible to compute the average onset age of any chronic condition in the Italian population aged 18 and older between 2000 and 2014. Specifically, Figure 7 reports this indicator together with the trend of life expectancy at birth and the difference between the two. Over the 15-year time span, the life expectancy of Italians rose from 79.8 years in 2000 to 83.2 in 2014, an increase of 3.4 years. At the same time, the average onset age of disease decreased from 56.5 to 53.5 years, with an absolute reduction of 3 years (less than 3 months per year). The difference between the two indicators is measured by the DEM (Double Expansion of Morbidity) indicator, which has been increasing over the years, reaching 6.4 years in 2014. Hence, the increase of the years of life spent with pathologies (23.3 years in 2000 to 29.2 in 2014) is, in a fairly uniform manner, due to both, the increase in life expectancy and the anticipation of the onset of pathologies.

As a further step we quantify the impact of the DEM hypothesis in terms of both changes in the number of new patients diagnosed with any chronic condition and additional health expenditure required to treat them. These results are presented in Figure 8. First, Figure 8a shows the population and patients (people who consume at least one health service in the year) distributions by year of age in 2000 and in 2014. While the population distribution by age has been obtained from the official ISTAT demographic statistics, the patient distribution has been obtained by multiplying the population distribution by the (empirical) probability that they have to resort to health care services (obtained from the HS-SiSSI dataset) in 2000 and 2014, respectively.

---

9 While the population distribution by age has been obtained from the official ISTAT demographic statistics, the patient distribution has been obtained by multiplying the population distribution by the (empirical) probability that they have to resort to health care services (obtained from the HS-SiSSI dataset) in 2000 and 2014, respectively.
and varies between 2000 and 2014. Finally, the histogram bars represent the number of additional patients (by age) treated between 2000 and 2014. These patients represent new patients diagnosed in 2014 with respect to 2000 with any new chronic condition (and exposed to a greater use of healthcare resources) due to either the increase in life expectancy and/or the anticipation in the occurrence of chronic diseases.

The correct estimation of the effect of the DEM hypothesis on the NHS is guaranteed by the fact that the differential in the odds of getting sick (empirical distributions) allows to estimate the reduction in the onset age of disease for each year of age, whereas the difference in population size by year of age allows to take account of the variation in life expectancy. In fact, the increase in life expectancy means that, over time, the alive population for each age increases. Therefore, the product of the probability of having diagnosed a chronic condition and the number of individuals within each year of age manages to capture the effects of both, the increase in life expectancy and the anticipation in the average onset.

Figure 8a – DEM effect on the number of patients by age class

Figure 8b – Total expenditure differentials – 2014 vs 2000

Source: Own elaborations on HS-SISSI (AO e DEM) e ISTAT (Pop) data
Figure 8b, instead, reports the expenditure differential between 2000 and 2014 by patient’s age, where the overall cost in 2014 results about 8.7 billion more than that in 2000. In other words, this number represents the additional expenditure in health care services occurred in 2014 with respect to 2000, due to changes in population levels, population age composition and probability to be diagnosed earlier of any chronic condition. In general, the higher the age class the higher the health expenditure change. Yet, the variations in the costs seem quite uniform among the youngest age classes (18-30 year-olds), then increasing with age (albeit with several exceptions) up until the age of 83, and afterwards decreasing with age.

Interestingly, the major increases in the number of patients are registered for the younger age classes (figure 8a), whereas the major increases in the costs are reported for the older age classes (figure 8b). This relationship is presented in figure 9, which displays the shares of cost and patient differentials by generation, indicating that the cost share increases the older the generation is. On the contrary, the changes in the number of patients is a bit more equally distributed among the generations, with the largest shares for the Baby boomers and the Silent generation followed by the Great generation and Generation X.\(^\text{10}\) In other terms, about the half of the total number of patients, but less than \(\frac{1}{4}\) of the total cost change, belongs to the younger generations (Millennials, Generation X and Baby boomers).\(^\text{11}\) Conversely, more than 75% of the cost differential is ascribed to the other half of the patients (represented by the Silent, Great and Over great generations).

\(^\text{10}\) The slightest shares, both of cost and patient differentials, are observed for the Over Great generation, but this is due to the fact that this generation is underrepresented since only few living persons are present in the dataset, and in general in 2014. Most of these persons are actually centenarian.

\(^\text{11}\) Actually, the shares of Millennials are basically zero for both patient and cost differentials, therefore not presented in the figure.
Figure 10, instead, displays the changes in the age of the first onset by cohort and disease, pointing out that some heterogeneity around the average value does exist. In particular, the first column shows the absolute variations in terms of years, and the second column the percentage changes. In absolute terms the cohort of younger patients (30-35-year-old), alongside the other age cohorts, reports marked reductions in age of the first onset (between 2 and 6 years). Despite the anticipated years of onset are higher for the older age cohorts in most of the cases (except for lung cancer, where the highest anticipation is for the youngest cohort), looking at the percentage changes, the reduction for the youngest cohort is the major one (often above 10%).

**Figure 10 – Reduction (absolute e percentage) in the AO by pathologies between 2002 and 2014.**

<table>
<thead>
<tr>
<th>Absolute variation (years)</th>
<th>Percentage variation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age onset absolute change</strong></td>
<td><strong>Age onset percentage change</strong></td>
</tr>
<tr>
<td>Any Disease - 2002 vs 2014 cohorts</td>
<td>Any Disease - 2002 vs 2014 cohorts</td>
</tr>
<tr>
<td>Age onset absolute change</td>
<td>Age onset percentage change</td>
</tr>
<tr>
<td>Absolute variation (years)</td>
<td>Percentage variation (%)</td>
</tr>
<tr>
<td>Age 30-35</td>
<td>Age 30-35</td>
</tr>
<tr>
<td>Age 35-40</td>
<td>Age 35-40</td>
</tr>
<tr>
<td>Age 40-45</td>
<td>Age 40-45</td>
</tr>
<tr>
<td>Age 45-50</td>
<td>Age 45-50</td>
</tr>
<tr>
<td>Age 50-55</td>
<td>Age 50-55</td>
</tr>
<tr>
<td>Age 55-60</td>
<td>Age 55-60</td>
</tr>
<tr>
<td>Age 60-65</td>
<td>Age 60-65</td>
</tr>
</tbody>
</table>

**Source:** Own elaborations on HIS-SiSSI data
6. Changes in health status vs. changes in physician diagnostic behavior: which one drives the DEM hypothesis?

The evidence presented above provides an overall picture of the Italian population – in terms of life expectancy, health status and disease burden – through its generations. The results discussed so far seem to support the hypothesis that younger generations are likely to live more years with at least one disease than older generations, due to the anticipation of the onset age of chronic diseases. Accordingly, we have defined this phenomenon as “Double Expansion of Morbidity”, pointing out that younger generations live longer, but at the same time spend more years in worse health due to higher longevity and to anticipated disease onset. However, a fair critique to these results, which specifically undermines the DEM hypothesis, could be that the observed anticipation of the average onset age of disease over time does not truly reflect the worsening of health status, but rather is the result of changes in the physician diagnostic behavior or a mix of the two phenomena. While this does not represent a problem if we are only interested in understanding the effect in terms of health expenditure (in fact, irrespective of the reason that determines the increase in the number of patients to be treated, an increase in expenditure takes place), it remains an insurmountable obstacle if we want to prove the worsening of health conditions of the younger generations.

Unfortunately, the HS-SiSSI dataset does not include information on changes in physician diagnostic behavior and/or on the timing of the introduction of new clinical guidelines (that could potentially alter the diagnostic behavior), which could allow us to define a neat identification strategy and to disentangle the role of health status from that of physician behavior. In what follows, we thus present a set of coherent evidence shedding light on this issue. In particular, we start by comparing regional differences in the average onset age through time. As long as changes in the average onset age are
homogeneous across regions, we can easily infer that, if any, the changes are mainly driven by differences in physician guidelines, which are imposed at national level (e.g. new guideline on diagnosis and treatment of diabetes, hypertension and cholesterol introduced between 2000 and 2014). On the contrary, if we observe different trends in the average onset age across regions, then the differences should be attributed to true changes in health status.

The first step in this direction is to replicate the analysis in Figure 8 describing trends by region. Figure 11 shows that a certain degree of heterogeneity exists among regions. Interestingly, the heterogeneity is significantly more pronounced for the onset age trends than for life expectancy, ranging between 50 and 56.9 years of age in 2014. Furthermore, it is interesting to note that while the regional differential in life expectancy between 2000 and 2014 has remained almost constant, the degree of heterogeneity by region has increased over time.

Further details at regional level are reported in Table 1. The first two columns show the average onset age in 2000 and 2014 respectively, while column 3 reports the difference, showing the degree of heterogeneity by region and suggesting that regions follow distinct trends. However, the most marked changes are observed for the Southern regions. Similarly, life expectancy trends are rather different and increasing unevenly among the regions, as shown in columns 4-6. Differently from the case of AO, the major changes are for the Northern regions. Consequently, the overall effect of these changes, summed up as years of DEM (column 7), indicates that Central and Southern regions endure significantly stronger rise of the years lived with at least one disease. Finally, this heterogeneity is observed also

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Piedmont</td>
<td>56.7</td>
<td>55.5</td>
<td>-1.2</td>
<td>79.7</td>
<td>83.2</td>
<td>3.5</td>
<td>4.7</td>
<td>55.2</td>
<td>365.4</td>
</tr>
<tr>
<td>Valle d’Aosta</td>
<td>56.7</td>
<td>55.5</td>
<td>-1.2</td>
<td>78.2</td>
<td>82.9</td>
<td>4.7</td>
<td>5.9</td>
<td>59.0</td>
<td>11.5</td>
</tr>
<tr>
<td>Lombardy</td>
<td>56.1</td>
<td>53.8</td>
<td>-2.2</td>
<td>80.2</td>
<td>83.9</td>
<td>3.7</td>
<td>5.9</td>
<td>67.8</td>
<td>1514.6</td>
</tr>
<tr>
<td>Trentino-Alto A</td>
<td>59.0</td>
<td>56.0</td>
<td>-3.0</td>
<td>80.6</td>
<td>84.2</td>
<td>3.6</td>
<td>6.6</td>
<td>79.9</td>
<td>79.0</td>
</tr>
<tr>
<td>Veneto</td>
<td>56.0</td>
<td>53.5</td>
<td>-2.5</td>
<td>80.5</td>
<td>83.8</td>
<td>3.3</td>
<td>5.8</td>
<td>72.8</td>
<td>780.9</td>
</tr>
<tr>
<td>Friuli-Venezia</td>
<td>55.7</td>
<td>54.2</td>
<td>-1.5</td>
<td>79.9</td>
<td>83.4</td>
<td>3.5</td>
<td>5.0</td>
<td>42.1</td>
<td>160.2</td>
</tr>
<tr>
<td>Liguria</td>
<td>58.4</td>
<td>56.9</td>
<td>-1.5</td>
<td>79.8</td>
<td>83.3</td>
<td>3.5</td>
<td>5.0</td>
<td>30.9</td>
<td>118.5</td>
</tr>
<tr>
<td>Emilia-Romagna</td>
<td>57.3</td>
<td>54.3</td>
<td>-2.9</td>
<td>80.9</td>
<td>83.7</td>
<td>2.8</td>
<td>5.7</td>
<td>62.4</td>
<td>568.9</td>
</tr>
<tr>
<td>Toscana</td>
<td>56.6</td>
<td>54.7</td>
<td>-1.8</td>
<td>80.7</td>
<td>83.8</td>
<td>3.1</td>
<td>4.9</td>
<td>62.9</td>
<td>541.9</td>
</tr>
<tr>
<td>Umbria</td>
<td>57.2</td>
<td>54.6</td>
<td>-2.6</td>
<td>81.0</td>
<td>84.0</td>
<td>3.0</td>
<td>5.6</td>
<td>80.6</td>
<td>143.6</td>
</tr>
<tr>
<td>Marche</td>
<td>57.1</td>
<td>53.5</td>
<td>-3.6</td>
<td>81.7</td>
<td>84.0</td>
<td>2.3</td>
<td>5.9</td>
<td>54.9</td>
<td>171.8</td>
</tr>
<tr>
<td>Lazio</td>
<td>55.5</td>
<td>54.3</td>
<td>-1.2</td>
<td>79.7</td>
<td>83.1</td>
<td>3.4</td>
<td>4.6</td>
<td>78.5</td>
<td>759.9</td>
</tr>
<tr>
<td>Abruzzi</td>
<td>57.0</td>
<td>52.6</td>
<td>-4.5</td>
<td>80.5</td>
<td>83.1</td>
<td>2.6</td>
<td>7.1</td>
<td>51.2</td>
<td>158.5</td>
</tr>
<tr>
<td>Molise</td>
<td>57.0</td>
<td>52.6</td>
<td>-4.5</td>
<td>80.0</td>
<td>82.8</td>
<td>2.8</td>
<td>7.3</td>
<td>41.5</td>
<td>32.7</td>
</tr>
<tr>
<td>Campania</td>
<td>56.5</td>
<td>50.1</td>
<td>-6.4</td>
<td>78.2</td>
<td>81.5</td>
<td>3.3</td>
<td>9.7</td>
<td>63.6</td>
<td>827.6</td>
</tr>
<tr>
<td>Puglia</td>
<td>57.7</td>
<td>53.1</td>
<td>-4.6</td>
<td>80.0</td>
<td>83.2</td>
<td>3.2</td>
<td>7.8</td>
<td>78.9</td>
<td>709.9</td>
</tr>
<tr>
<td>Basilicata</td>
<td>54.1</td>
<td>51.1</td>
<td>-3.0</td>
<td>80.0</td>
<td>83.1</td>
<td>3.1</td>
<td>6.1</td>
<td>77.1</td>
<td>64.5</td>
</tr>
<tr>
<td>Calabria</td>
<td>55.6</td>
<td>52.5</td>
<td>-3.1</td>
<td>79.8</td>
<td>82.5</td>
<td>2.7</td>
<td>5.8</td>
<td>72.4</td>
<td>271.9</td>
</tr>
<tr>
<td>Sicily</td>
<td>56.6</td>
<td>52.4</td>
<td>-4.2</td>
<td>79.2</td>
<td>82.2</td>
<td>3.0</td>
<td>7.2</td>
<td>82.9</td>
<td>810.1</td>
</tr>
<tr>
<td>Sardinia</td>
<td>55.0</td>
<td>54.0</td>
<td>-1.0</td>
<td>79.8</td>
<td>83.2</td>
<td>3.4</td>
<td>4.4</td>
<td>97.6</td>
<td>247.6</td>
</tr>
</tbody>
</table>

**Note:** Δ = value in 2014 – value in 2000, 1 LE 2000 refers to values in 2001 due to lack of data for 2000. 2 Valle d’Aosta and Molise are not representative in HS-SISSI, therefore their values are substituted by those of Piedmont and Abruzzi, respectively. 3 The percentage change is with respect to 2000.

**Source:** Own elaborations on HS-SISSI data and EUROSTAT

Further details at regional level are reported in Table 1. The first two columns show the average onset age in 2000 and 2014 respectively, while column 3 reports the difference, showing the degree of heterogeneity by region and suggesting that regions follow distinct trends. However, the most marked changes are observed for the Southern regions. Similarly, life expectancy trends are rather different and increasing unevenly among the regions, as shown in columns 4-6. Differently from the case of AO, the major changes are for the Northern regions. Consequently, the overall effect of these changes, summed up as years of DEM (column 7), indicates that Central and Southern regions endure significantly stronger rise of the years lived with at least one disease. Finally, this heterogeneity is observed also
looking at the number of new patients and expenditure percentage changes (columns 8 and 9, respectively).

Further evidence on the widening of the gap in the age of onset among regions emerges in Figure 12, which reports how the average age of onset varies over time and across regions with respect to the values recorded in 2000. First, the national AO trend is decreasing since 2002, indicating, for example, that in 2014 the AO is 3 years lower than that in 2000. However, regions follow very heterogeneous paths, which tends to confirm that the AO anticipation should not depend on changes in diagnostic behavior by physicians. Specifically, Lazio follows an opposite direction in the trend until 2005, while remains aligned afterwards. On the other hand, Campania reports much faster reduction than Italy does, distancing itself far away from the rest of the regions. Generally, the anticipation in the average onset age are likely to be higher in the Southern regions compared to the Northern ones, pointing out that the DEM phenomenon hits some areas more aggressively than others.

**Figure 12 – Annual variations in AO over time, by region (reference year 2000)**

![Graph](image)

*Source: Own elaborations on HS-SISSI data*

Furthermore, Figure 13 shows the regional differences in the prevalence of any chronic disease from the national average for three age cohorts (30, 40 and 70-year-olds) in 2000 and 2014, respectively. The prevalence of chronic diseases for the 30 and 40 year-olds is constantly below the national average in the Northern and Central regions (except for Emilia Romagna) and is likely to enlarge the gap in 2014 (with the exception of Umbria and Lazio). On the contrary, the Southern regions report prevalence rates above the national average, except for Calabria and Sardinia (and Apulia for the 30-year-old cohort), regardless of the age cohort. In many cases these differences are more pronounced in 2014, especially for the 40-year-olds. Interestingly, these two outliers worsen their position in 2014, thus aligning with the other
Southern regions: Calabria inverts its situation between 2000 and 2014, passing from a negative to a positive difference, while Sardinia reduces its gap, with respect to the national average prevalence. As expected, the most marked regional differences are observed for the oldest age cohort, where, in 2014, some regions reduce (i.e. Veneto, Emilia Romagna, Umbria, Lazio, Abruzzi, Campania and Sardinia), others increase (i.e. Trentino Alto Adige, Liguria, Puglia and Sicily) and again others invert (i.e. Friuli Venezia Giulia, Tuscany, Marche and Calabria) their differences from the national average.

Figure 13 – Regional differences in the prevalence of any chronic disease from the national average in 2004 and 2014

Source: Own elaborations on HS-Sissi (AO e DEM) e ISTAT (Pop) data

Another indicator that could provide some insights about the health dynamics across generations is the trend in disease incidence. In this regard, Figure 14 reports the evolution of the incidence of some diseases (i.e. dyslipidemia, diabetes and hypertension) by age cohort in the period 2001-2014. The incidence trend can be driven by either GPs’ behavioral changes or actual changes in the health status, without being able to distinguish them, and yet some dynamics are more likely than others according to the driver. For instance, if a physician behavioral change takes place at a certain point in time, a trend shift is expected to emerge, otherwise only gradual and limited fluctuations are more likely to be observed. Furthermore, since the above-presented results point to an anticipation of the onset age in the recent years and especially for the younger generations, it could be claimed that nowadays physicians are more rigorous than in the past. As a result, an increase in the incidence should be expected among all age cohorts.

Looking at trends for dyslipidemia, diabetes and hypertension (Figures 14a, b and c), a decreasing trend is observed for the two older age cohorts and

12 The first available year in HS-Sissi is 2000 but given that a two-year window is necessary to assess whether an individual encounter any disease (e.g. transition from event 0 to event 1) the first useful year to observe the incidence is 2001.
regardless of the pathology. On the other hand, a relatively constant trend is observed for the first two age cohorts: slightly decreasing for the 40-year-olds and fairly constant for the 30-year-olds. This further evidence suggests that no important changes have occurred in physician diagnostic behavior.

Source: Own elaborations on HS-SiSSI data

The decline is partly driven by the panel structure of the data, as far as its sample tends to get older in time (the new patients cannot entirely offset the aging pattern), meaning that once transiting from healthy to ill the probability on new incidence reduces in the succeeding years.
These results suggest, albeit indirectly, that an anticipation of the onset age is not ruled out at all. And, if it could be a result of GPs’ behavioral changes occurred between 2007 and 2008, when an upward shift is observed at least for the older cohorts, unlikely it could be afterwards.

Overall, the presented evidence seems to support the idea that the DEM hypothesis is driven by changes in health status and not in physician behavior. However, for a more reliable identification of these effects, we run a multivariate analysis, where we regress the average regional onset age on a set of covariates with an attempt to disentangle its main drivers. We divide the potential determinants into socio-economic conditions, life-style patterns, health-care delivery as well as demographic and environmental characteristics. Table 2 reports the marginal effects both in years and in months (column 2 and 4, respectively) and the (semi-)elasticities (column 3) of the estimated determinants. All results are obtained using a panel fixed effect estimator, where the reference unit is the region.

First, according to the socio-economic conditions the age of onset can be either negatively or positively affected. In particular, the higher the activity rate (employment) the higher the average onset age; in elasticities terms, one percentage point increase in activity rate postpones the age of onset by 0.25%. Conversely, the proportion of individuals maintained by the family is associated with an anticipated onset age, where a one percentage point increase in the former is associated with a 0.05% anticipation in the latter. A not significant effect is found for income and education, where higher proportion of university degrees in a region does not seem to have any differential impact.

Second, life-style behaviors are likely to play an important role in affecting health status. Specifically, one percentage point increase in the average regional body mass index leads to 0.05% reduction in the average age of onset (see column 3). Also, the proportion of smokers seems to reduce the average onset age, although the estimated coefficient is not statistically significant. On the other hand, regions with major regular sports practice and regular consumption of fish among individuals tend to postpone the average onset age, whereas the habit of daily lunches in bars and restaurants and irregularities in water supply increase the probability to register the average onset of diseases at earlier ages.

Unsurprisingly, also demographic characteristics are reflected in the average onset age: one percentage point increase in the population density is associated with 0.06% decrease in the average onset age, and for example, one percentage increase in the prevalence of young population (aged 15-40) translates into a 1.2% reduction, otherwise almost 8 months less (see column 4), of the average onset age.

Finally, health-care aspects, such as preventive screening rate and anti-flu vaccination rate are not likely to (statistically) affect the age of onset, while one percentage point increase in the average number of GP contacts is associated to 0.013% reduction in the onset age. On the contrary, the average
number of GP prescriptions does not appear to significantly affect the average age of onset.

### Table 2 – Determinants of the age of onset

<table>
<thead>
<tr>
<th>Variables</th>
<th>Marginal effects</th>
<th>Elasticities and semi-elasticities</th>
<th>Marginal effects in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per capita income (euro)</td>
<td>0.000</td>
<td>0.0215</td>
<td>0.00</td>
</tr>
<tr>
<td>Labour activity (%)</td>
<td>0.138***</td>
<td>0.252***</td>
<td>1.66***</td>
</tr>
<tr>
<td>Maintained by family (%)</td>
<td>-0.026***</td>
<td>-0.047***</td>
<td>-0.31***</td>
</tr>
<tr>
<td>University degree (%)</td>
<td>-0.010</td>
<td>-0.017</td>
<td>-0.12</td>
</tr>
<tr>
<td>Avg. bmi</td>
<td>14.426***</td>
<td>-0.0516*</td>
<td>-0.34*</td>
</tr>
<tr>
<td>Avg. bmi (squared)</td>
<td>-0.291***</td>
<td>-0.018</td>
<td>-0.12</td>
</tr>
<tr>
<td>Smokers (%)</td>
<td>-0.010</td>
<td>-0.018</td>
<td>-0.12</td>
</tr>
<tr>
<td>Regular sports practice (%)</td>
<td>0.019*</td>
<td>0.034*</td>
<td>0.23*</td>
</tr>
<tr>
<td>Lunch in bars/restaurants (%)</td>
<td>-0.053**</td>
<td>-0.096**</td>
<td>-0.64**</td>
</tr>
<tr>
<td>Regular consumption of fish (%)</td>
<td>0.011**</td>
<td>0.019**</td>
<td>0.13**</td>
</tr>
<tr>
<td>Irregularities in water supply (%)</td>
<td>-0.012**</td>
<td>-0.023**</td>
<td>-0.14**</td>
</tr>
<tr>
<td>Avg. demographic density (n./km2)</td>
<td>-0.012***</td>
<td>-0.0562**</td>
<td>-0.14**</td>
</tr>
<tr>
<td>Population aged 16-40 (%)</td>
<td>-0.639***</td>
<td>-1.166***</td>
<td>-7.67***</td>
</tr>
<tr>
<td>Population aged 41-50 (%)</td>
<td>-1.080***</td>
<td>-1.973***</td>
<td>-12.96***</td>
</tr>
<tr>
<td>Population aged 51-65 (%)</td>
<td>-0.332***</td>
<td>-0.606***</td>
<td>-3.98***</td>
</tr>
<tr>
<td>Population aged 66-75 (%)</td>
<td>-0.177*</td>
<td>-0.323*</td>
<td>-2.12***</td>
</tr>
<tr>
<td>Population aged 76-85 (%)</td>
<td>-0.055</td>
<td>-0.100</td>
<td>-0.66</td>
</tr>
<tr>
<td>Population aged 86+ (%)</td>
<td>-0.971***</td>
<td>-1.774***</td>
<td>-11.65***</td>
</tr>
<tr>
<td>Preventive screening rate</td>
<td>0.009</td>
<td>0.017</td>
<td>0.11</td>
</tr>
<tr>
<td>Anti-flu vaccination rate</td>
<td>0.004</td>
<td>0.007</td>
<td>0.05</td>
</tr>
<tr>
<td>Avg. no. of GP contacts (n.)</td>
<td>-0.000*</td>
<td>-0.0125*</td>
<td>-0.00*</td>
</tr>
<tr>
<td>Avg. no. of GP prescriptions (n.)</td>
<td>-0.000</td>
<td>-0.0059</td>
<td>-0.00</td>
</tr>
<tr>
<td>Constant</td>
<td>-79.779</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Estimates are obtained using panel data fixed effect estimator by region and year fixed effects.  
*** p<0.01, ** p<0.05, * p<0.10  
**Source:** own elaborations on HS-SiSII, ISTAT-Health for All, Ministry of Economy and Finance

### 7. Conclusions

To be done
References


Manton KG (1982), Changing concepts of morbidity and mortality in the elderly population. Milbank Memorial Fund Q / Health Soc 60:183-244.


Appendix 1

A.1 Definition of generations

According to the PEW Research Institute (2015), a commonly accepted definition of the generation exists, which subdivides the living population in six main generations. Figure A.1 provides a visual description of this classification.

First, the oldest living generation is represented by the Greatest generation, formed by those born before 1928 — individuals who in 2014 had over 86 years, fought the world wars and had a strong sense of duty and civic responsibility, imposed in a certain way by the epoch in which they grew up.

Next, there is the Silent generation, composed of people born between 1928 and 1945 (aged between 68 and 86 years in 2014). The term "silent" that characterizes this generation mainly stems from having had to endure the consequences of the WWII and the economic depression during the first few years of life, without being responsible for it.

Third, the Baby boomers is a generation of people born during the second World War (so-called Baby Boom period), in a period that goes from 1946 to 1964 (aged between 49 and 67 years in 2014). In the years following World War II, many Western nations have endured a peak in births as they overcome the economic difficulties experienced in wartime. The last birth cohort of Baby boomers, 1964, instead coincides with a sharp decrease of fertility, also due to the introduction of the contraceptive pill. This new generation of Baby boomers has experienced an unprecedented level of economic growth and prosperity throughout its life cycle. It entered the world at a time of relative difficulty, but thanks to mass education, heavy government subsidies, increase in property prices and technological improvements it was a wealthy and successful generation. Many Baby boomers are now retiring, with many more comforts and conveniences than the generations before them could ever enjoy.

The cohorts born after the Baby boomers are described as the generation X, with births recorded between 1965 and 1980 (aged between 33 and 48 years old in 2014). Compared to the generation of Baby boomers, the rate of births in the generation X was noticeably lower. Generation X has been shaped by global political events that occurred during the youth of this generation. Events like the Vietnam war, the fall of the Berlin wall, the end of the cold war, and the Thatcher Government-epoch in the United Kingdom have helped shape the culture and education of generation X. Compared to previous generations, generation X is more open to diversity and has learned that differences exist in areas such as religion, sexual orientation, class, race and ethnicity. Also, this generation is better educated than the previous one.

The fifth generation is that of Millennials, born between 1981 and 1997 (aged between 17 and 32 years old in 2014), with its first birth cohorts entered into adult life in the new millennium. The Millennials are also described with the term of generation Y. The Millennials basically are the children of Baby boomers.

Finally, the successors of the Millennials are defined as the generation Z (born between 1998 and 2014) and are represented by children and adolescents, in many cases, grandchildren of the Baby boomers.
A.2 The HS-SiSSI database

A network of more than 1000 GPs, spread over the entire national territory, have subscribed to the project for digitalizing the medical records of their patients, thus allowing to build, since 1998, a GP database with medical information of more than a million and a half patients.

In 2014, 900 GPs have been identified, selected from the whole national territory according to the size of the geographical macro-area (North-West, North-East, Centre, South, Islands). The 900 GPs ensure the best quality of information which is used to carry out consistent and comprehensive epidemiological research. For the selection of this group a composite quality score has been computed, assessed for each GP. The territorial distribution of the GPs' patients is coherent to that of the Italian adult population conducted by ISTAT, with no relevant differences neither in terms of geographical area proportion nor in terms of aggregation by age class.

The collected information by the GPs concerns the everyday practice and vary by demographic and medical content (e.g. diagnosis, lab studies, recoveries, etc.), prescription information, data on risk factors and health variables (e.g. BP, BMI, smoking, etc.).

All these data are linked to an anonymous and univocal code for the patient’s identification according to standard criteria generally used in relational datasets. The registration of the pharmaceutical prescription is carried out by means of a list of products codified by commercial denomination and pharmaceutical type, ATC and ministerial code, and active ingredient. The medical checks are coded according to the NHS price list as issued in the Official Journal (Gazzetta Ufficiale). Pathologies are coded on the basis of the International Classification of Diseases, 9th revision (ICD9CM). The quality and reliability of the information has been proved through various comparative studies with current data sources or cross-section surveys (e.g. ISTAT data - investigating aspects of everyday life, OSMED).