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The "Double Expansion of Morbidity" Hypothesis: Evidence from Italy

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Abstract

The last few decades have been characterized by an increase in the number of years lived in bad health, lending support to the "Expansion of Morbidity" hypothesis. In this paper we propose the "Double Expansion of Morbidity" (DEM) hypothesis, arguing that not only life expectancy gains have been transformed into years lived in "bad health", but also, due to an earlier onset of chronic diseases, the number of years spent in "good health" is actually reduced. Limited to the Italian case, we present and discuss a set of empirical evidence confirming the DEM hypothesis. In particular, we find that from 2004 to 2014 the average number of years spent with chronic conditions in Italy increased by 7.2 years 2.3 years of which are due to an increase in life expectancy and 4.9 years due to a reduction in the age of onset of chronic conditions. Compared with 2004, in 2014, this phenomenon generated extra public health expenditure of nearly 6.3 billion euros. We discuss the policy implications of these findings.

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

JEL Codes: I10, I11, H51

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1. Introduction

The last century has witnessed a continuous increase in life expectancy (LE) at birth due to economic development, improved environmental conditions, better lifestyles, and progress in health and medicine (in particular, the reduction of infant mortality) (Atella et al., 2017). This process has been particularly pronounced and sustained in Europe compared with many other parts of the world, placing the EU-28 among the worldwide leaders for LE.[1] Although the lengthening of life is good news from an individual and societal point of view, it may imply a series of important consequences in different spheres and stages of an individual's life and, at aggregated level, for the whole economy. For example, spending the extra years of life gained in bad or good health can have non-trivial effects on health care expenditure and, in particular, on its public component which has long represented an important topic in the policy debate on how to ensure the long-term sustainability of public finances (European Commission, 2015).

In this respect, it is widely recognized that LE has mainly increased due to medical technologies which have turned many, once lethal or disabling, diseases into chronic conditions (Crimmins and Beltrán (2011), Cutler et al., (2016) and GBD (2016)). As highlighted by Cutler et al. (2016), several studies show that healthy life expectancy based on presence of disability has increased over time (Crimmins et al. 1989, 1997, 2001, 2009, Manton et al. 2008, Cai and Lubitz, 2007). However, when healthy life expectancy is based on the presence of diseases the literature comes to an opposite conclusion, given that the prevalence of chronic diseases and the proportion of the population with multiple chronic diseases has increased over time (Crimmins & Saito (2000), Crimmins and Beltrán, (2011) and Atella et al., (2017)). This finding is in line with the "Expansion of Morbidity" hypothesis (Gruenberg, 1977; Kramer, 1980; Olshansky et al., 1991) which foresaw a worsening of the overall population health status with individuals living longer but in worse health.

In this perspective, the present study explores the phenomenon of healthy life measurement based on the presence of diseases as in Crimmins and Beltrán, (2011). In fact, while disability is viewed as an expression of poor health, or of particular health conditions, prevalence of disease is a wider

[1] Between 2002 (the first year for which data are available for all Member States) and 2014, LE in the EU-28 rose by 3.2 years from 77.7 to 80.9 years (3.8 years for women and 2.7 years for men). OECD countries also showed 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 by 2060.

portray of overall health status (Mont, 2007). Moreover, same illnesses in an interaction with different environments may give or give not rise to disabilities (Freedman, Agree, Martin, & Cornman, 2006).

The main contribution of this paper is to revisit the "Expansion of Morbidity" hypothesis, showing that individuals tend to live longer with diseases not only as a consequence of the lengthening of LE, but also because of the younger age at which they are diagnosed with the first chronic disease (i.e., an earlier onset of chronic disease). We then formulate a "Double Expansion of Morbidity" (DEM) hypothesis which posits a longer coexistence of morbidity due to prolonged longevity and occurrence of the first chronic disease earlier in life. Finally, we test this hypothesis by computing at population level the algebraic difference between two indicators: the change in LE and the change in the average age of first chronic disease onset, both measured with regard to a base year. The DEM hypothesis holds if LE increases and the average age of first chronic disease onset decreases over time.

Using a large representative longitudinal sample of Italian patients for the period 2004-2014, containing detailed patient level data, we show that the number of years spent with at least one chronic disease have risen over time, especially among the younger generations. Indeed, over the period of investigation we observe both a continuous reduction in the age of onset of chronic conditions among the young and an expansion of life expectancy. As corollary, this epidemiological trend challenges the idea of healthier new generations.

In what follows, Section 2 introduces the DEM hypothesis as a generalization of the "Expansion of Morbidity" hypothesis. In Section 3 we define our indicator of average age of onset (for all chronic diseases and for specific chronic diseases) and discuss its main properties. In Section 4 we present the data and discuss the descriptive statistics. In Section 5 we present the main results of our empirical analysis documenting the existence of the DEM hypothesis in Italy and its effects on public health expenditure. In Section 6 we further speculate on the possible determinants of the earlier onset of chronic diseases. In particular, we investigate whether this phenomenon is driven by changes in physician diagnostic behavior (i.e., earlier diagnoses) or changes in the population health status, or a combination of the two. The evidence we report seems to suggest that the earlier onset of chronic diseases is actually driven by changes in population health. Finally, we conclude that under the DEM hypothesis, several existing health policies and management practices should be revised to guarantee the reverse of the potential worsening of the population health in order to guarantee future health system sustainability.

2. "Double Expansion of Morbidity" (DEM) hypothesis: definition and preliminary evidence

Since the '70s, researchers have been debating on the future evolution of the population's health. However, due to a lack of or limited access to accurate data on levels and changes in morbidity, the relationship between morbidity and mortality has been initially evaluated only from a theoretical point of view, giving rise to three major theories:

1. the "Compression of Morbidity" (CM) hypothesis which foresaw an improvement in health status giving rise to the idea that over time individuals would live longer and healthier (Fries, 1980, 1989 and 2002; Hubert et al, 2002);

2. the "Expansion of Morbidity" (EM) hypothesis which foresaw an overall worsening of health status given that 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" (DE) hypothesis which 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.

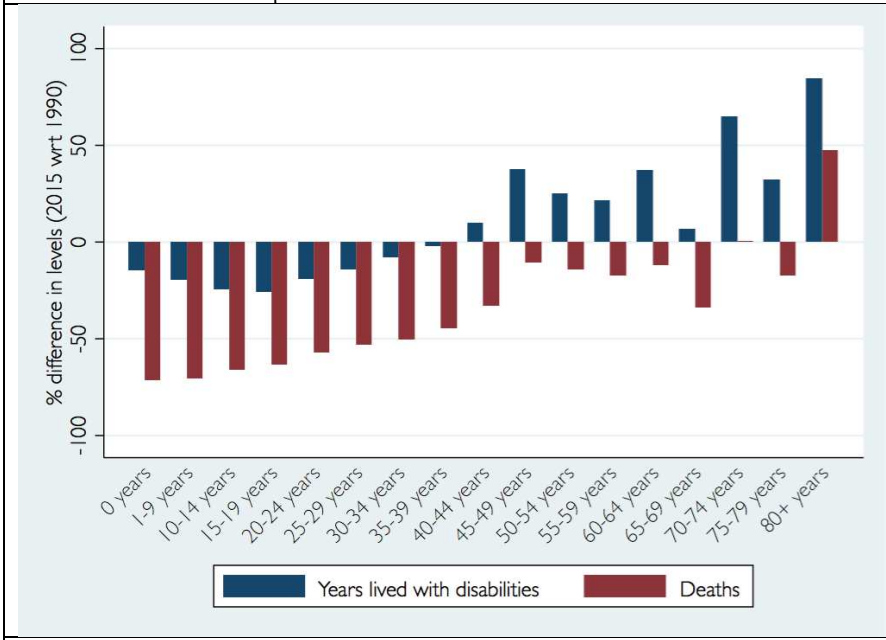
Due to data limitations on disease prevalence at international levels, researchers have commonly attempted to test these theories by employing the indicators based on disability status such as YLDs to disentangle how much of the overall LE gain is lived with and without disabilities. Figures 1 presents the changes in the number of deaths and the number of years lived with disabilities recorded between 1990 and 2015 in the EU. Overall, the number of deaths decreased significantly for each age group, with the most important gains registered for infant and early-childhood LE. The only exception is the increase in the number of deaths for 80+ individuals which is a mere representation of the fact that, on average, the time of death has been postponed and occurs with a relatively higher frequency in that age group. In the EU as a whole, individuals aged 40 and above recorded substantial increases in the amount of years lived in bad health (disability).[2]

On the one hand, these patterns result from the reductions in mortality rates which have been frequently featured in the literature and explained by the technological progress, both in terms of processes and products, as well as by enhancements in healthcare organization and management. On the other hand, the increases in YLDs are caused by elderly individuals who translate their technology-driven LE gains into years lived in bad health. Also middle-aged patients face an increased number of years lived with disabilities from

[2] The same graph reproduced for Italy presents an even gloomier picture, suggesting an earlier increase in YLDs, i.e. for those aged 35 or more.

1990 to 2010. The contemporaneous postponement of deaths towards older ages and increase in years lived with disabilities at younger ages point to a novel pattern of health status evolution where both phenomena contribute to widening of the window during which individuals are exposed to diseases and/or disabilities.

Figure 1. Differences in age-specific years lived with disabilities and number of deaths in 2015 compared with 1990 for EU.



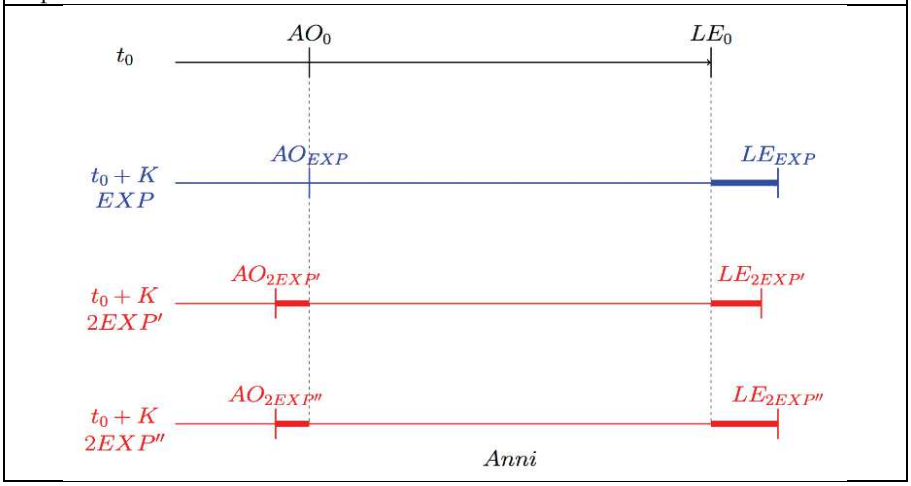
Source: *Institute for Health Metrics and Evaluation - 2016*

This dual mechanism is what we define as the DEM hypothesis and represent in Figure 2. The black top line is a benchmark setting where at time *0,* a population features an average age of onset of any chronic condition AO_0 and a life expectancy LE_0. The distance between LE_0 and AO_0 is the average number of years spent with at least one chronic disease or disability (YLDs).[3] The blue line describes the "Expansion of Morbidity" hypothesis (EM) according to which after *K* periods the most plausible scenario is that life expectancy is lengthened up to LE_{EXP} with the average age of onset unchanged ($AO_{EXP}=AO_0$). According to the latter, the number of years spent with at least one disease/disability only increases due to higher life expectancy. An alternative is represented by the red lines referring to the DEM hypothesis which assumes that after *K* periods not only is the life expectancy postponed, but also the average onset occurs earlier ($AO_{2EXP}<AO_{EXP}$). Depending on the possible patterns of the technological

[3] Even though we do not have explicit information on disability, the onset of chronic diseases is likely to produce potential disabilities which are expected to increase over the years.

progress, the DEM hypothesis envisages two variants, one with a shorter life expectancy (i.e. $LE_{2EXP'}<LE_{EXP}$), and one with a longer one ($LE_{2EXP''}>LE_{2EXP'}$).

Figure 2 – The "*Double Expansion of Morbidity*" hypothesis: a graphical representation.



The empirical validation of the hypothesis depicted in Figure 2 requires the measurement of both LE and AO over time. If the data feature an increase in both LE and AO over time, then the "dynamic equilibrium" or the "compression of morbidity" are in place; if LE increases over time whereas AO remains constant, then it is plausible to talk about "expansion of morbidity". Finally, if LE increases and AO decreases over time, the "double expansion of morbidity" is likely to be in place. In fact, as far as all hypotheses point to an increase in life expectancy ($\Delta LE>0$), the DEM hypothesis is validated iff after K periods $\Delta AO<0$ and $\Delta LE>0$ both hold.

3. Average age of disease Onset (AO)

In order to construct the AO indicator, we focus on diseases and conditions that represent "absorbing" states for the individuals, defined in clinical literature as "chronic". Hence, the AO indicator represents the moment of transition from good to persistently bad health status.[4]

3.1. Definition of AO

We define the age of onset of a single disease as the age at which the individual is diagnosed with a specific chronic disease for the first time.

[4] In the rest of the paper, we will interchangeably use disease, condition and chronic disease as synonyms.

Therefore, the age of onset of the first disease of individual *i* is formulated as follows:

$$a_i^{fo} = min\{a_i^1, \dots, a_i^j, \dots, a_i^J\} \quad (1)$$

where $\boldsymbol{J}$ is a set of chronic diseases, a^j is the age of onset of disease *j*, and $j \in \boldsymbol{J}$. It then follows that a_i^{fo} represents the minimum age at which individual *i* is affected by any of the $\boldsymbol{J}$ chronic diseases. Consequently, the average age of onset of the first encountered disease of a population at time *t* is calculated as:

$$AO_t = \frac{\sum_{i=1}^{N_t^{fo}} a_{it} | a_{it} = a_i^{fo}}{N_t^{fo}} \equiv \frac{\sum_{i=1}^{N_t^{fo}} a_{it}^{fo}}{N_t^{fo}} \quad (2)$$

where N_t^{fo} is the number of individuals who deal with their first disease at time *t* and a_{it}^{fo} is the age at time *t* when the first disease occurred.

If only one disease is considered, Equation 1 becomes $a_i^{fo} = min\{a_i^j\} \equiv a_i^j$ and Equation 2 can be rewritten as:

$$AO_t \equiv AO_t^j = \frac{\sum_{i=1}^{N_t^j} a_{it} | a_{it} = a_i^j}{N_t^j} \equiv \frac{\sum_{i=1}^{N_t^j} a_{it}^j}{N_t^j} \quad (2')$$

From Equation (2) it follows that the AO indicator can be decomposed by any socio-demographic characteristic (e.g. gender, age class or geographical area) available in the data at individual level. For example, for the age class disaggregation, Equation 2 should be rewritten as:

$$AO_{ct} = \frac{\sum_{i=1}^{N_{ct}^{fo}} (a_{ict} | a_{ict} = a_i^{fo})}{N_{ct}^{fo}} \quad (3)$$

where $c=1,..,C$ is the age class and N_{ct}^{fo} is the number of individuals in age class *c* with their first onset at time *t*. Clearly, the overall AO_t can be also expressed as in Equation 3:

$$AO_t = \frac{\sum_{c=1}^{C} AO_{ct} \cdot N_{ct}^{fo}}{N_t^{fo}} = \frac{\sum_{i=1}^{N_t^{fo}} (a_{it} | a_{it} = a_i^{fo})}{N_t^{fo}} \quad (4)$$

where $\frac{N_{ct}^{fo}}{N_t^{fo}}$ is the share of individuals in class c with first onset at time t (which represents a weighted AO, where the weights are the numbers of individuals in each age class).

3.2. Limitations of the AO indicator

It should be acknowledged that, despite its simplicity, the AO is subject by construction to some limitations and its interpretation may change depending on the specific context in which it is applied.

First of all, the interpretation of AO depends on the set of diseases $\boldsymbol{J}$. Suppose that we construct disease group specific AO indicators (e.g. respiratory, cardio-vascular, musculoskeletal, etc.). In such a case, the age of onset of the first encountered disease among group g for individual i,$a_i^{fo_g}$, can be expressed as:

$$a_i^{fo_g} = min\left\{a_i^{1_g}, \dots, a_i^{j_g}, \dots\right\} \tag{5}$$

where a^{j_g} is the age of onset of disease j belonging to group g, $g \in \boldsymbol{J}$. Therefore, the average age of onset of the first encountered disease among group g at time t is:

$$AO_t^g = \frac{\sum_{i=1}^{N_t^{fo_g}} (a_{it} | a_{it} = a_i^{fo_g})}{N_t^{fo_g}} \tag{6}$$

where $N_t^{fo_g}$ is the number of individuals that had their first onset among the diseases of group g at time t.

Accordingly, Equation (1) can be expressed as:

$$\underbrace{a_i^{fo}}_{\substack{age\ of\ onset\ of\ the\ first\ met\ disease;\ i.e.\ the\ minimum\ age\ of\ onset\ among\ all\ diseases}} = min\underbrace{\left\{a_i^{fo_1}, \dots, a_i^{fo_g}, \dots, a_i^{fo_G}\right\}}_{\substack{age\ of\ first\ onset\ of\ disease\ group\ 1,\dots g,\dots G;\ i.e.\ the\ minimum\ age\ of\ onset\ of\ a\ given\ group}} \tag{7}$$

and Equation (2) can be replaced with:

$$AO_t = \frac{\sum_{i=1}^{N_t^{fo}} a_{it} | a_{it} = a_i^{fo}}{N_t^{fo}} = \frac{\sum_{i=1}^{N_t^{fo}} a_{it} | a_{it} = min\left\{a_i^{fo_g}, \dots, a_i^{fo_g}, \dots, a_i^{fo_G}\right\}}{N_t^{fo}} \tag{8}$$

which is equivalent to:

$$AO_t = \frac{\sum_{i=1}^{N_t^{fo}} a_{it}^{fo}}{N_t^{fo}}$$

Therefore, if $\boldsymbol{J}$ includes more than one disease, the average age of disease onset indicates, in a given year, the average age at which individuals encounter their *first* disease. This implies that the average age of individuals encountering their first disease at time *t* does not necessarily coincide with the average age of the incident patients for these diseases at any point in time.[5] It follows that any other disease belonging to $\boldsymbol{J}$, but encountered by the individual after the first one, is not considered for the computation of the indicator. Similarly, if individuals encounter two or more diseases at the same time, they are accounted for only once in the AO indicator. Conversely, if the AO indicator is computed for one disease only, it measures the average age of the incident patients in a given year for the specific disease *j*.

Moreover, the AO indicator is sensible to the set of diseases considered, both in terms of their relative prevalence and age specificity. Inclusion of high frequency diseases characteristic of the young is likely to drive down the AO level, or conversely, the inclusion of high-prevalence elderly states is likely to postpone the average AO. As such, the AO indicator is thus sensitive to changes in the age and health status composition of the underlying population where the changes over time may reflect both the changes in the number of cases relative to each age or the changes in age at which the diseases occur.

In order to compare the average age of onset of the first chronic disease over time and across space and quantify the length (in terms of years) of the chronic condition, we address the abovementioned issues by holding constant both the set of diseases $\boldsymbol{J}$, and the age structure of the underlying population, fixing it to a base year.

By studying the evolution of the AO of the first chronic morbidity, we provide an in-depth analysis of the link between age/life expectancy and health status. 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 without an illness or disability. Therefore, the AO of chronic conditions can be very informative from both an epidemiological and an

[5] By incident patients we mean all those individuals who have been diagnosed with at least one chronic disease in a given year, independently of whether this chronic disease is the first or a subsequent one. Similarly, incident cases stand for the number of chronic disease diagnoses in a given year. Thus, if an individual is diagnosed with two chronic diseases at time *t,* then she/he represents one incident patient and two incident cases.

economic perspective since it allows for a better understanding of the effect of population health on the demand for health care and health expenditure today and its future evolution. Moreover, being a representation of the average age at which a population transits from good to bad health status, the AO has a straightforward interpretation from a policy perspective.

4. The data

The main data sources for our empirical analysis are the Health Search (HS-SiSSI) database (for the AO indicator) and Eurostat (for the LE indicator).

HS-SiSSI is a unique source of data collected by General Practitioners (GPs) containing Electronic Clinical Records (ECRs) for a representative sample of the Italian patient population. The ECRs contain detailed information on prescribed drugs, laboratory tests, outpatient visits and hospitalizations for over 2 million patients, managed by over 1000 GPs. A representative panel is constructed by selecting a longitudinal balanced sample of 900 GPs.[6] The HS data guarantee no selection issues both in terms of GPs and patients. Although GPs participate in HS on a voluntary basis, they are selected to reflect the Italian patient distribution by age, sex and region and on the basis of their ability to produce accurate, consistent records of their patients' medical and clinical history. Moreover, all Italian residents, irrespective of their health status, are obliged to select a GP, and this selection is commonly based on the geographical proximity (i.e. if an Italian changes residence, the legislation requires that a new GP has to be assigned). Pathologies are coded on the basis of the International Classification of Diseases, 9th revision (ICD-9 CM). The quality and reliability of these data have been assessed through various comparative studies with existent administrative datasets and surveys (e.g. Health Search (2008; 2014)

The data at patient level are linked to information on prices and tariffs from the NHS price list as issued in the Italian Official Journal (Gazzetta Ufficiale) and with a series of information on socio-economic characteristics (income, education, etc.) at a more aggregate level (municipality, province or region).

We limit the analysis to the period 2004-2014 and to individuals aged between 15 and 94. Moreover, we select individuals who have not revoked their GP and are observed for at least 2 years. The sample constructed according to this procedure includes about 11.9 million observations and is representative of the population of Italian GP patients, with the only exception being the two smallest Italian regions, Molise and Valle d'Aosta, for whom the information collected is insufficient.[7] The complete set of ICD-9

[6] The unbalanced nature of our dataset is mostly due to population mortality.
[7] These two regions account for about 0.7% of the Italian population.

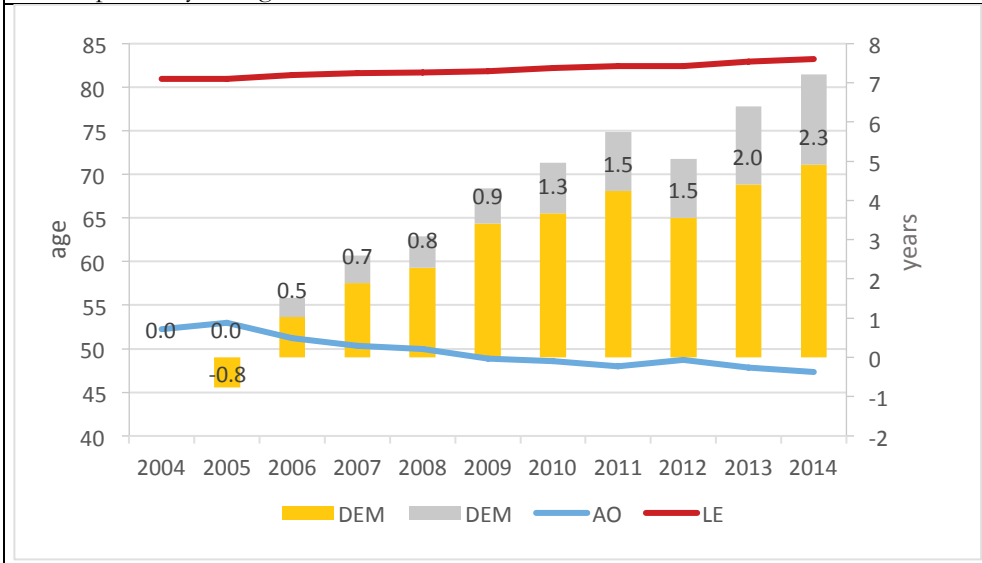
codes of the diseases considered for the calculation of the AO indicator is described in Appendix 1.

Finally, the data for the LE indicator come from Eurostat, where for Italy data on life expectancy by age, sex and region are available from 2001 onwards.

5. Health outcomes and expenditure in Italy: testing the DEM hypothesis

Based on the HS-SiSSI and Eurostat data, we first obtain the LE and AO trends between 2004 and 2014, for the Italian population aged between 15 and 94.

Figure 3 – Trend in LE and AO of chronic diseases (2004-2014). DEM effect decomposed by changes in LE and in AO w.r.t. 2004.



Source: *our estimates on HS-SiSSI and* Eurostat *data.*

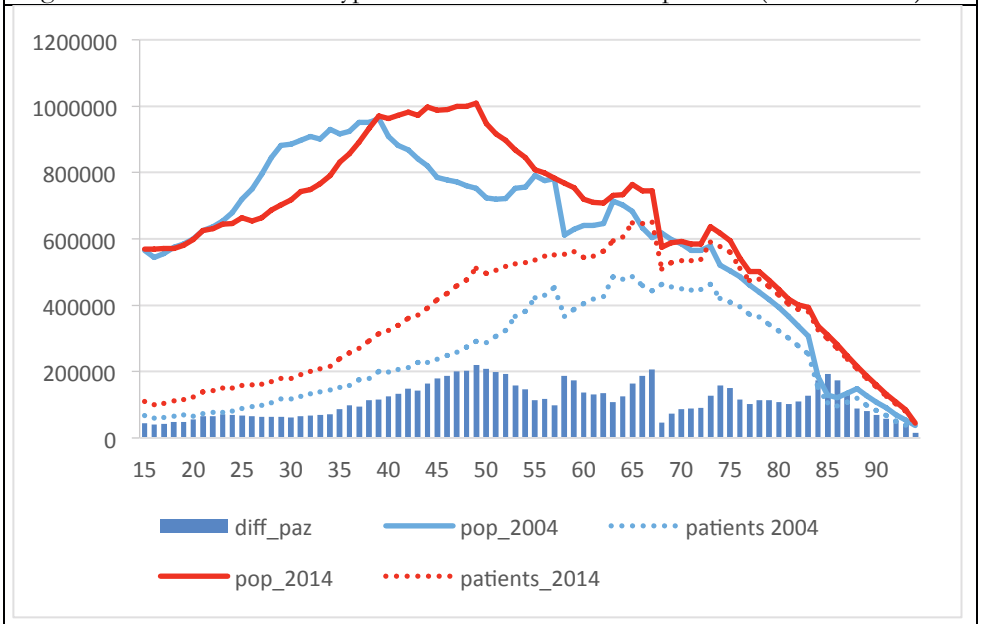
Figure 3 reports the evolution of both LE and AO (solid lines) together with the yearly absolute changes (bars). Over the 11-year time span, the life expectancy of Italians rose from 80.9 years in 2004 to 83.2 in 2014 which represents an increase of 2.3 years ($\Delta LE > 0$). At the same time, the average age of onset of the first chronic disease decreased from 52.2 to 47.3 years, with an absolute reduction of 4.9 years (about 6 months per year) (ΔAO<0). The algebraic sum of the two values shows that over the period 2004-2014, on average, the Italian population increased the number of life years spent with some chronic conditions by 7.2 years (see Appendix 2), moving from 28.7 to 35.9 years. Furthermore, the contemporaneous presence of $\Delta LE > 0$

and $\Delta AO < 0$ is compatible with the DEM hypothesis. Finally, we can see that the increase in the number of years of life spent with pathologies is prevalently due to a reduction in the AO indicator (about 68%).[8]

5.1. The effect of the DEM hypothesis on health care expenditure

As a further step, we provide insights into the potential economic effects of the DEM hypothesis by quantifying the changes in the number of patients diagnosed with chronic conditions (as defined for the overall AO indicator) and the additional health expenditure required to treat them.

Figure 4 – Effect of DEM hypothesis on the number of patients (2014 vs 2004)



Source: *own elaborations on HS-SiSSI (AO e DEM) e ISTAT (Pop) data*

Figure 4 shows the population and patient distributions, defined as those who consume at least one health service per year, by year of age in 2004 and in 2014.[9] The number of patients increases with age and with the size of the population per year of age, and varies between 2004 and 2014. The histogram bars represent the number of additional patients (by age) treated between 2004 and 2014 who were diagnosed after 2004 with any new chronic

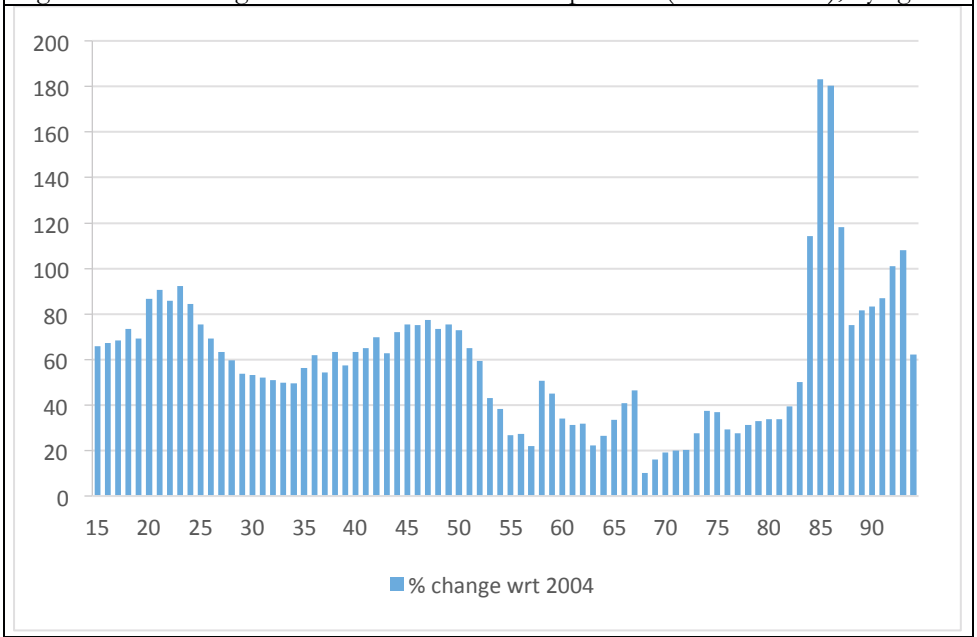
[8] We provide a more in-depth discussion on the AO construction and results in Appendix 2, where we compare the core AO measure with an additional set of AO measures adjusted for the temporal change in age structure of the population.

[9] While population distribution by age has been obtained from the official ISTAT demographic statistics, 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 2004 and 2014, respectively.

condition (hence exposed to a greater use of healthcare resources). The new diagnoses possibly reflect both additional patients resulting from increased life expectancy and/or additional patients resulting from the early onset of chronic diseases. In fact, the increase in life expectancy means that, over time, the living population for each age increases. Therefore, the product of the probability of being diagnosed a chronic condition multiplied by the number of individuals within each year of age captures the effects of both the increase in life expectancy and the earlier onset of the first chronic disease.

The largest increases (in absolute terms) in prevalence are recorded for the middle age classes (between 45-54 and 59-68), as shown by the histogram bars in Figure 4. As expected, the figure shows an increase in prevalence at retirement age and above. More surprisingly, in the 45-54 age class, the number of new patients compared with 2004 is not far from the one observed at older ages. This results suggests that chronic disorders are likely to hit younger individuals more often than in the past.

Figure 5 – Percentage increase of the number of patients (2014 vs. 2004), by age

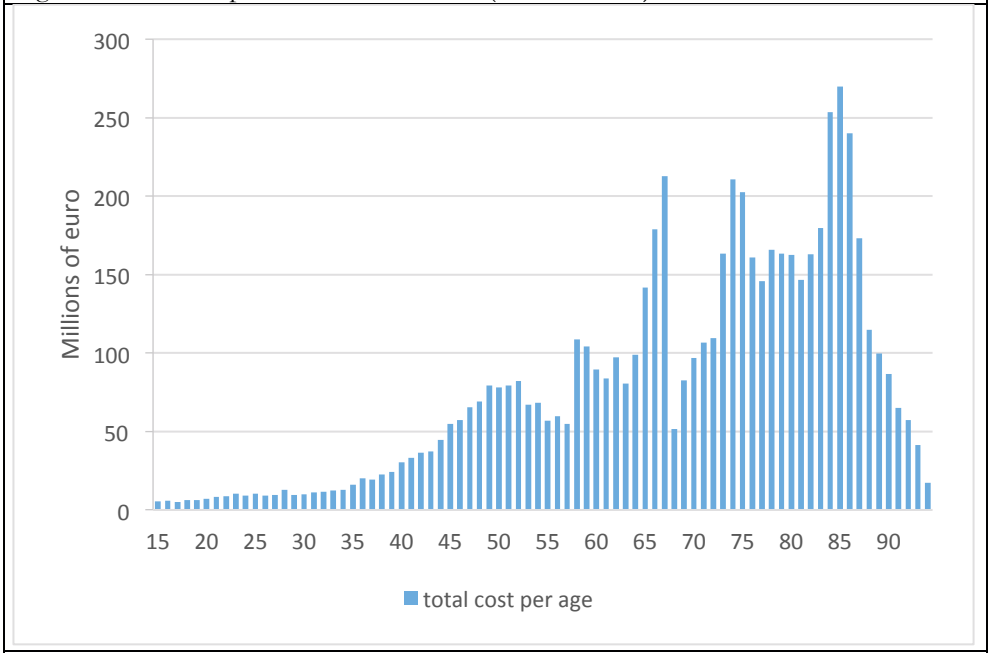


Source: *own elaborations on HS-SiSSI (AO and DEM) and ISTAT (Pop) data*

Additionally, in percentage terms, the changes appear even more pronounced (see Figure 5). In 2014, the number of patients aged 20-24 with at least one chronic disease has almost doubled compared with 2004. Similarly, the number of patients aged 45-50 has increased more than 70% between 2004 and 2014. Overall, the change in the number patients is quite pronounced for younger patients. It then flattens and becomes moderate up to the age of 83, after which it turns very significant. The important increases in the number of 84+ patients are most likely related to the considerable increments in life expectancy.

Finally, Figure 6 shows the expenditure differentials at each age between 15 and 94, calculated through the product of the number of additional patients in 2014 compared with 2004 and the unit health costs per age in 2014. Summing up all these extra costs, the total amounts to nearly 6.3 billion. This can be interpreted as the potential additional expenditure in health care services that is faced in 2014 compared with 2004, due to changes in population size, population age composition, number and age composition of patients, life expectancy and probability to be diagnosed earlier with any chronic condition. Broadly speaking, the older the patients, the greater the health expenditure change. Yet, the variations in the costs seem reasonably uniform among the youngest age classes (15-30 year-olds), then increasing with age (albeit with several exceptions) up until the age of 85 and decreasing afterwards.

Figure 6 – Total expenditure differentials (2014 vs 2004)



Source: *own elaborations on HS-SiSSI (AO and DEM) and ISTAT (Pop) data*

Not surprisingly, the most pronounced increases in the number of patients are registered for the younger age classes (Figure 5) whereas largest increases in costs are reported for the older age classes (Figure 6).

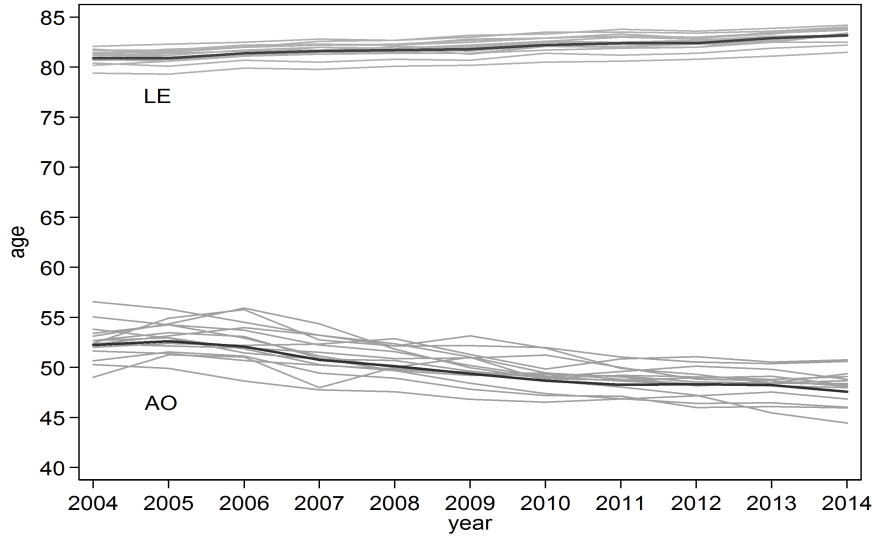
6. Changes in health status *vs.* changes in physician diagnostic behavior: what really drive of the DEM?

The evidence presented above provides an overall picture of the Italian population in terms of life expectancy, health status and disease burden. The

results discussed so far seem to support the DEM hypothesis that today's younger individuals are likely to spend more years with at least one chronic disease than it was in the past, due to the earlier age of onset of chronic diseases. However, a fair critique to these results could be that the observed lower AO age of disease over time does not truly reflect the worsening of health status, but rather changes in physician diagnostic behavior or a mix of the two phenomena. As long as the only interest is in understanding the effect in terms of health expenditure (whether an increase in expenditure will take place with earlier diagnosis or an earlier onset), the driver of the DEM hypothesis is not an issue. However, it represents an obstacle if we want to prove that health conditions worsen in younger generations.

Unfortunately, the dataset does not provide 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 disentangle the role of health status from that of the physicians' behavior. In what follows, we thus present a set of complementary evidence that sheds 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 AO 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 guidelines on diagnosis and treatment of diabetes, hypertension and cholesterol introduced between 2004 and 2014). On the contrary, if we observe different trends in the AO age across regions, then it is plausible to treat the differences as attributable to changes in health status.

Figure 7 – LE and AO trends at national and regional level

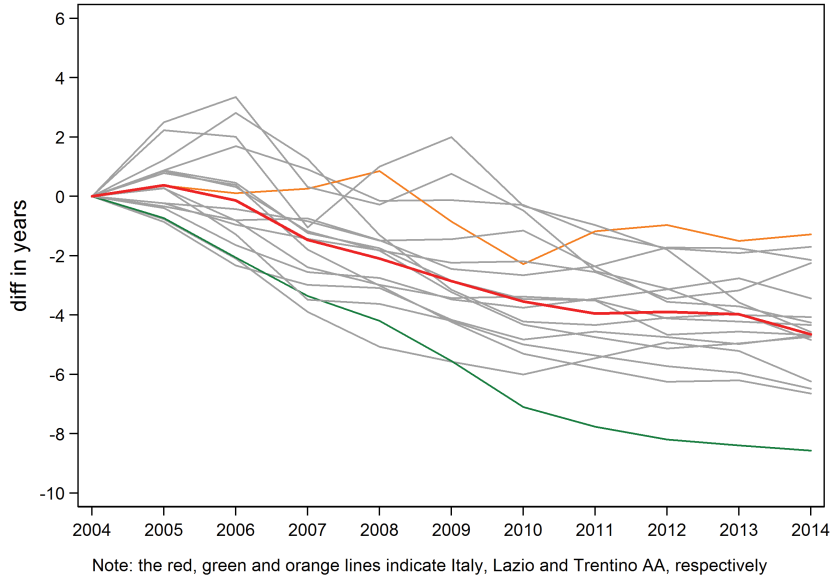


Source: *Own elaborations on HS-SiSSI data*

In Figure 7 we thus present region specific trends in AO and LE. We find a substantial degree of heterogeneity among the Italian regions with the differences being considerably more pronounced for the onset age trends than for LE, ranging between 43 and 51 years of age in 2014. Furthermore, it is interesting to note that while the regional differentials in LE between 2004 and 2014 were almost constant, the regional average onset differentials varied substantially over time. When analyzing specific regional trends, the most marked changes are observed for Lazio, Liguria and some Central and Southern regions (see Table A.2 in Appendix 3). Life expectancy trends are much less heterogeneous among the regions, with respect to AO. The overall effect of LE and AO changes, summed up as years of DEM, suggest that Central and Southern regions saw a significantly stronger rise of the years lived with at least one disease, with Lazio being in pole position.

Further evidence on the widening of the gap in the age of onset among regions emerges in Figure 8 which reports how the average age of onset varies over time and across regions with regard to the (regional) values recorded in 2004. First, the national AO trend is steadily decreasing (with the exception of the period 2011 - 2013), indicating, for example, that in Italy in 2014, the AO is 4.9 years lower than in 2004. Specifically, Lazio shows the most pronounced decrease in the average age of onset amounting to more than 8 years. On the other hand, Trentino Alto Adige reports much slower reduction than Italy does, distancing itself from the rest of the regions. Moreover, between 2004 and 2009, some regions (mostly from the North) have even experienced an increase in the AO (above its level in 2004).

Figure 8 – Annual variations in AO over time, by region (base year 2004)



Source: *Own elaborations on HS-SiSSI data*

Another indicator that provides insights into the health dynamics across the Italian population is the trend in disease incidence by age class. For instance, if physician diagnostic behavior changes at a certain point in time, a trend shift is expected to emerge in the incidence; otherwise, only gradual and limited fluctuations are more likely to be observed. Furthermore, we break down this indicator by age class in order to control for population age composition over our 11-year period. Since the incidence rates for diabetes and hypertension are narrower in elderly patients, we limit our analysis to the younger age classes. Figure 9 reports the evolution of the incidence of diabetes (panel *a)*) and hypertension (panel *b)*) among patients up until the age of 44, separately by 5-year age classes. A slightly decreasing trend is observed for the 40-44 age group whereas it is fairly constant among the younger age groups, whether it is diabetes or hypertension. These results seem to provide evidence of no significant change in physician diagnostic behavior over time thus lending support to the hypothesis of a reduction in the onset age.

Finally, we run a multivariate analysis where we regress the average regional onset age on a set of covariates in an attempt to disentangle its main drivers. We divide the potential determinants into socio-economic conditions, life-style patterns and health-care delivery as well as demographic and environmental characteristics.[10] All results are obtained using a panel random effects estimator where the reference unit is the region.[11] The full set of estimation results is described in Table A.3 in Appendix 4.

First, in terms of socio-economic characteristics the higher the per capita income, the higher the average onset age; in elasticity terms, one percentage point increase in income delays the age of onset by nearly 0.18%. Conversely, the employment rate is negatively correlated to the average age of onset where a one-percentage point increase in the former is associated with a 0.18% decrease in the latter. No statistically significant effect is found for education where a higher proportion of university degrees in a region does not seem to have any differential impact.

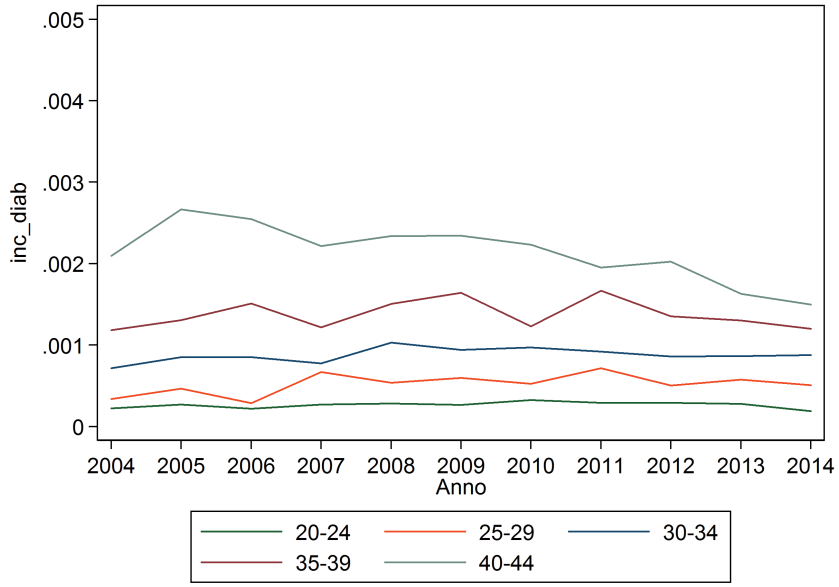
Second, life-style patterns are likely to play a role in affecting health status. Specifically, one percentage point increase in the average regional rate of obesity leads to 0.05% reduction in the average age of onset and is double (0.1) when the overweight rate is taken into account. On the other hand, regions with major rates of people practicing regular sports seem to have a lower average onset age but this effect does not appear to be statistically significant.

[10] Table A.3 in Appendix 4 reports the marginal effects in years (Column 2) and the semi-/elasticities (Column 3) of the estimated determinants.

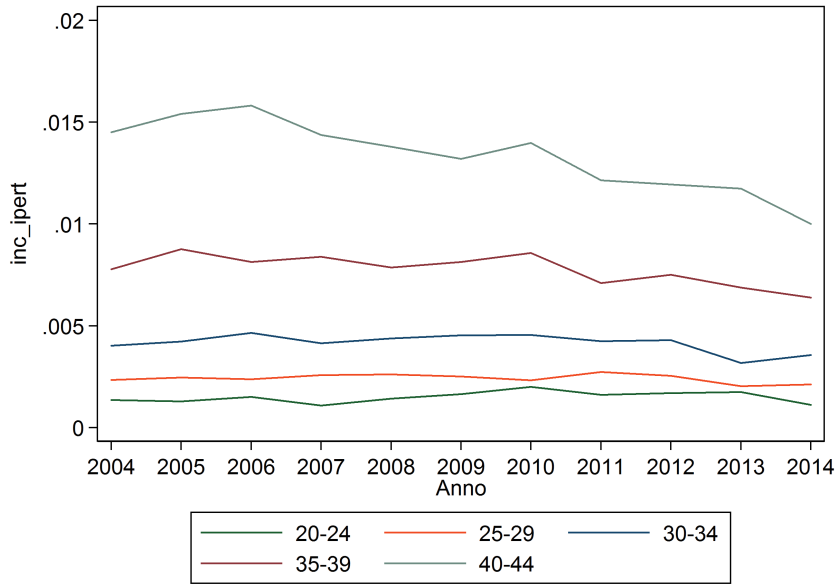
[11] We ran both fixed and random effect estimators. However, the Hausman test failed to reject the null hypothesis that regressors are not correlated to the unobserved individual effect (Prob>chi2 = 0.995).

Figure 9 – Incidence rates by age class (2004 – 2014)

Panel *a)* Diabetes



Panel *b)* Hypertension



Source: *Own elaborations on HS-SiSSI data*

Demographic characteristics are reflected in the average onset age, although marginally: one percentage point increase in the population density is associated with a 0.04% decrease in the average onset age whereas the prevalence of the different age groups of the population does not exercise any significant effect.

Finally, health-care aspects (preventive screening rate and anti-flu vaccination rate) and quality of public service provision (irregularities in water supply above the national level), are not likely to (statistically) affect the age of onset.

7. Conclusions

The main goal of this work is to introduce and document a new hypothesis on the evolution of morbidity status and life expectancy over the last few decades using information on a large representative longitudinal sample of Italian patients. We find support for the "Double Expansion of Morbidity" (DEM) hypothesis showing that the number of years spent with at least one chronic disease has risen especially. This new epidemiological trend challenges the idea of healthier new generations and induces us to look differently at the future evolution of the health status in the population.

According to our results, not only have life expectancy gains been transformed into years lived in bad health, but also, due to the onset of chronic diseases occurring earlier in individuals' lives, the number of years spent in "good health" is actually reduced. With regard to Italy, we find that from 2004 to 2014, the average number of years spent with chronic conditions increased by 7.2 years, 2.3 years of which are due to an increase in LE and 4.9 years due to a reduction in the onset age of chronic conditions. These figures translate into a sizeable increase in the number of chronic patients in 2014 compared with 2004, revealing a large percentage increase among younger patients. Back-of-the envelope calculations suggest that the potential health care expenditure required to satisfy healthcare needs of the additional chronic patients in 2014 amounts to 6.3 billion euros. Albeit quite approximate, this estimate of the extra healthcare cost points to the fact that issues concerning the health status of individuals deserve increasing attention. Whether or not there is a lower cost for younger patients, the disease burden increases with age and costs will increase in the future.

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Appendix 1 – AO index construction

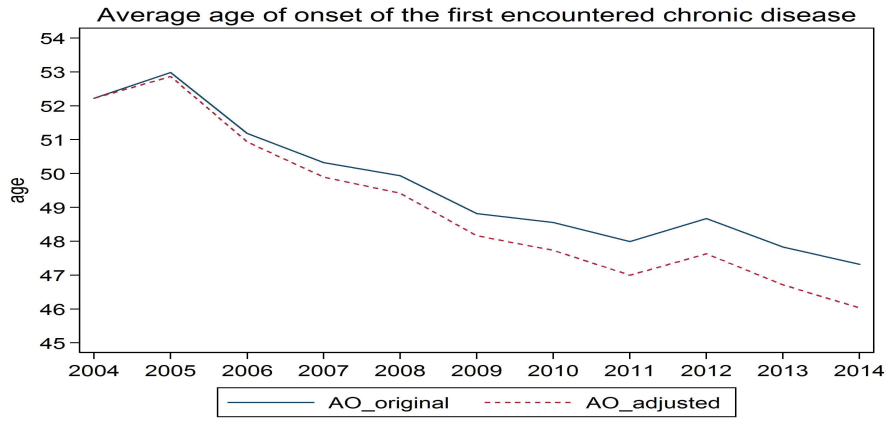
Table A.1 – Description of chronic pathologies included in the AO index

Pathology		*Icd-9-code*
Metabolic diseases	***240-279***	
Diabetes type 2		*250*
Diabetes type 1		*250*
Dyslipidemia		*272*
Hypothyroidism		*243-244*
Thyroid disorder		*240-246*
Respiratory diseases	***460-519***	
Asthma		*493*
COPD		*491.2, 496*
Emphysema		*492*
Cardio-vascular diseases	***390-459***	
Hypertension		*401-405*
Congestive heart failure		*428, 402.91, 404.91, 402.01, 402.11, 404.01*
Ischemia		*410-414*
Stroke		*436*
Atrial fibrillation		*427.3*
Varicose veins		*454*
Cerebrovascular disorder		*430-438*
Bypass or coronary angioplasty		*v45.81, v45.82*
Vascular diseases		*440-448*
Musculoskeletal disorders	***710-739***	
Arthritis		*715, 716.1*
Arthrosis and other arthritis		*716.5, 716.6, 716.8, 716.9*
Rheumatoid arthritis		*714.0, 714.1, 714.3*
Osteoporosis		*733.00-733.03, 733.09*
Left/right hip arthrosis		*715.35*
Bilateral hip arthrosis		*715.95*
Left/right knee arthrosis		*715.36*
Bilateral knee arthrosis		*715.96*
Other chronic diseases		
HCV		*070.54, 070.44, 070.70, 070.71*
Cirrhosis		*571.4, 571.5, 571.8, 571.9*
Retinopathy		*362*
Kidney disorder		*582, 583, 585-587*

Appendix 2 - Trend of the average age of onset and disease specific onset age

In this section, we present the trend of the average age of onset for some of the most common chronic conditions. However, given the ageing of the Italian population, an increasing age of onset may occur due to ageing rather than due to an actual delay of the average age of onset over time. Therefore, alongside the original indicator (as presented in Section 3), we also use an adjusted one by normalizing the AO indicator by the Italian population distribution (by age and sex) in 2004 (i.e. the first observed year). Binding the AO indicator to the 2004 population distribution allows us to prevent the trend of the AO indicator from the bias linked to the ageing of the population observed through the years.

Figure A.1 – Trend of the AO of chronic diseases in the period 2004-2014



Source: *own elaborations on HS-SiSSI data*

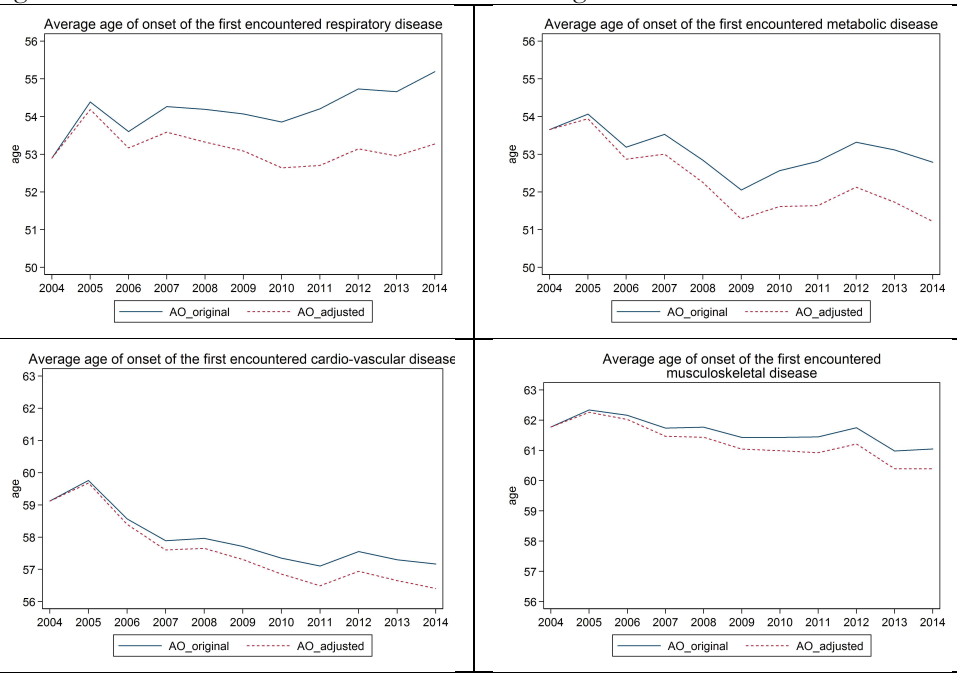
Note: *the chronic diseases' group includes: arthritis, asthma, chronic HCV, cirrhosis, congestive heart failure, COPD, diabetes - type 1 and 2, hypertension, chronic eye, coronary, kidney and thyroid diseases, osteoporosis, retinopathy, stroke. The ICD-9-codes are shown in Table A.1 in Appendix 1.*

Figure A.1 displays the trend of the average age of onset of the first encountered disease among a set of chronic diseases in the period 2004-2014. The blue line indicates the average age of onset in its original form (as in Equation 3) whereas the red dashed line indicates the adjusted average age of onset. Both lines show a decreasing trend of the AO indicator, meaning that nowadays individuals are likely to encounter their first chronic disease earlier than in the past. The average age of onset is 52.2 years in 2004 and falls to 47.3 in 2014 without taking into account the ageing factor. When looking at the adjusted indicator (i.e. net of ageing), the average age of onset falls faster over the years and reaches its minimum age (46 years) in 2014. This trend suggests that in 2014 individuals on average encounter for the first time a chronic disease 4.9 years earlier than in 2004 which also means 4.9 years more of medical care needs. The protraction of the chronic morbidity condition is

even more pronounced when ageing is taken into account and adds 1.3 years to the 2014-2004 difference (i.e. 6.2 years more in 2014 compared with 2004).

Some further evidence of the average age of onset of some of the most common diseases, grouped into broad categories, is shown in Figure A.2. The first two groups, respiratory and metabolic disorders, occur in a relatively earlier stage in individuals' lives than the latter two, cardio-vascular and musculoskeletal pathologies. The only group that shows an increasing trend in the average age of onset is the respiratory one, although when taking ageing into account, its direction is inverted. On the other hand, the AO of the metabolic disorder group displays first a decreasing (up until 2009) then a slightly increasing (up until 2012) and again a decreasing trend, without reaching its initial level. Finally, both cardio-vascular and musculoskeletal disorder groups show decreasing trends of the average age of onset, thus confirming the DEM hypothesis. As long as the pathologies of these two groups in general are likely to occur at an older age, the differences between the original and the adjusted AO are relatively small.

Figure A.2 – Trend of the AO of some disease categories

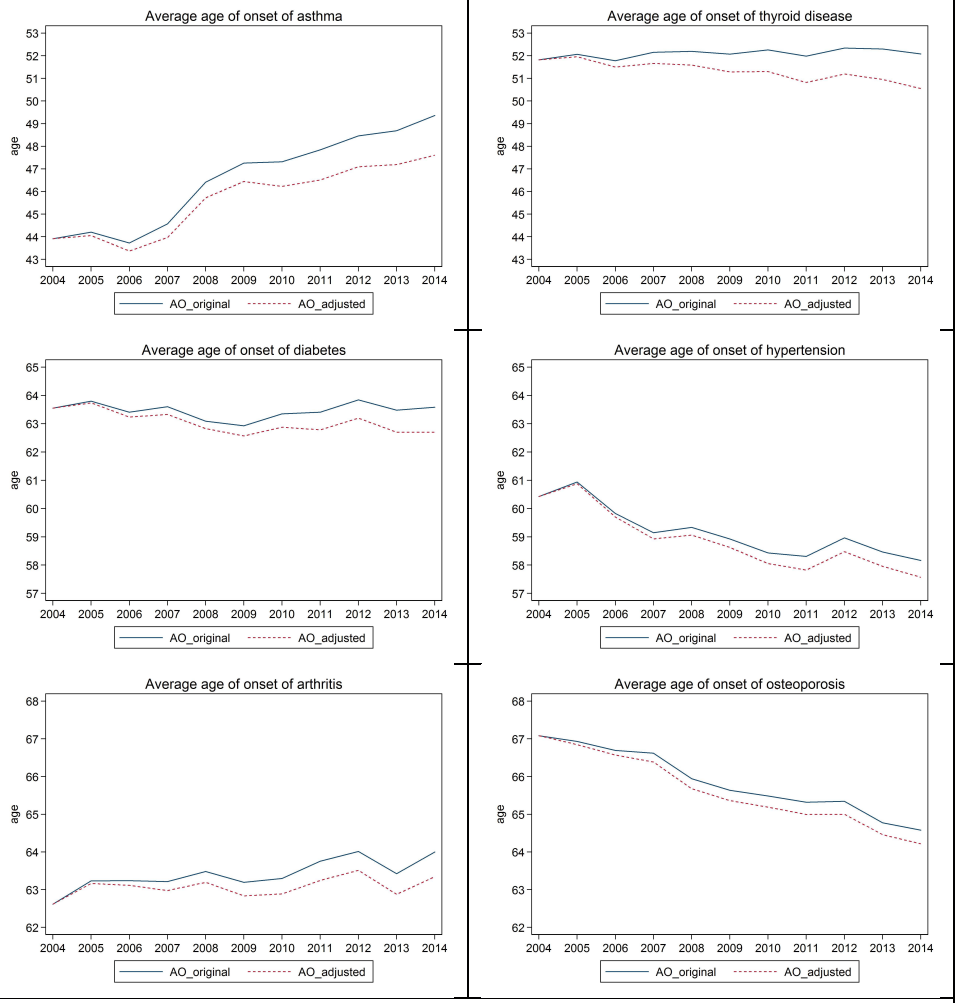


Source: *own elabrations on HS-SiSSI data*
Note: *the pathologies and their respective ICD-9-codes, included in the four disease groups, are shown in Table A.1 in Appendix 1.*

Finally, Figure A.3 shows the AO trends of some of the pathologies that are included in the above-mentioned disease groups. The average age of onset of asthma is steadily increasing over time, regardless of whether we look at the original or the standardized AO indicator. The onset age of thyroid disease and arthritis also seem to increase slightly, although the trend of the first one reverses when ageing is taken into account. Diabetes first shows a slightly

decreasing and then an increasing trend, but these variations are marginal. Conversely, the onset of hypertension and osteoporosis, on average, is likely to occur at an earlier age in recent years.

Figure A.3 – Trend of the AO of some disease categories



Source: *own elabrations on HS-SiSSI data*
Note: *the ICD-9-codes of the pathologies are shown in Table A.1 in Appendix 1.*

Appendix 3 – Regional variation in the average age of onset and life expectancy between 2004 and 2014

Table A.2 – AO, LE and DEM by region, 2004 vs 2014

Region	*AO 2004*	*AO 2014*	*Δ AO*	*LE 2004*	*LE 2014*	*Δ LE*	*DEM*	*Δ patients (%)*[1]	*Δ costs (mln)*
Piedmont	*53.5*	*52.1*	*-1.4*	*79.7*	*83.2*	*3.5*	*4.9*	*43.5*	*354.7*
Lombardy	*53.4*	*48.6*	*-4.8*	*80.2*	*83.9*	*3.7*	*8.5*	*49.8*	*1313.0*
Trentino-Alto A.	*51.4*	*49.8*	*-1.6*	*80.6*	*84.2*	*3.6*	*5.2*	*44.2*	*53.4*
Veneto	*52.5*	*47.9*	*-4.6*	*80.5*	*83.8*	*3.3*	*7.9*	*44.6*	*509.4*
Friuli-VG	*55.1*	*50.9*	*-4.2*	*79.9*	*83.4*	*3.5*	*7.7*	*29.7*	*125.5*
Liguria	*58.0*	*50.5*	*-7.5*	*79.8*	*83.3*	*3.5*	*11.0*	*34.0*	*123.3*
Emilia-Romagna	*52.3*	*45.8*	*-6.5*	*80.9*	*83.7*	*2.8*	*9.3*	*39.6*	*333.5*
Tuscany	*54.0*	*48.9*	*-5.1*	*80.7*	*83.8*	*3.1*	*8.2*	*35.2*	*338.7*
Umbria	*54.6*	*48.3*	*-6.3*	*81*	*84*	*3*	*9.3*	*53.7*	*111.5*
Marche	*52.5*	*50.1*	*-2.4*	*81.7*	*84*	*2.3*	*4.7*	*32.9*	*110.4*
Lazio	*56.2*	*47.7*	*-8.5*	*79.7*	*83.1*	*3.4*	*11.9*	*76.9*	*671.7*
Abruzzo	*50.7*	*46.3*	*-4.4*	*80.5*	*83.1*	*2.6*	*7.0*	*37.0*	*116.0*
Campania	*43.4*	*41.4*	*-2.0*	*78.2*	*81.5*	*3.3*	*5.3*	*28.2*	*456.3*
Apulia	*51.6*	*44.8*	*-6.8*	*80*	*83.2*	*3.2*	*10.0*	*50.2*	*544.6*
Basilicata	*48.8*	*44.2*	*-4.5*	*80*	*83.1*	*3.1*	*7.6*	*43.5*	*43.9*
Calabria	*51.7*	*45.5*	*-6.2*	*79.8*	*82.5*	*2.7*	*8.9*	*79.6*	*274.8*
Sicily	*51.8*	*44.9*	*-6.9*	*79.2*	*82.2*	*3*	*9.9*	*46.7*	*521.2*
Sardinia	*51.3*	*49.3*	*-1.9*	*79.8*	*83.2*	*3.4*	*5.3*	*79.6*	*266.4*

Note: **Δ**=value in 2014 – value in 2004. [1] The percentage change is with respect to 2004.
Source: *Own elaborations on HS-SiSSI data and EUROSTAT*

Appendix 4 – Estimation results on the determinants of the regional variation in the average age of onset between 2004 and 2014

Table A.3 – Elasticities and marginal effects

Variables	Marginal effects	Elasticities and semi-elasticities
Per capita income (1000 euro)	0.7757***	0.1756***
Employment rate (%)	-0.2053*	-0.1785*
University degree rate (%)	0.0372	0.0078
Obesity rate (%)	-0.2422**	-0.0491**
Overweight rate (%)	-0.1457**	-0.1033**
Regular sports practice (%)	-0.0257	-0.0144
Irregularities in water supply above the national level	-0.5711	-0.0113
Avg. demographic density (n./km2)	-0.0080***	-0.0384***
Population aged 16-40 (%)	-0.2041	-0.1258
Population aged 41-50 (%)	-0.6417	-0.1953
Population aged 51-65 (%)	0.5178*	0.1931*
Population aged 66-75 (%)	0.4384	0.0901
Population aged 76-85 (%)	-1.0073	-0.1451
Population aged 86+ (%)	0.1526	0.0073
Preventive screening rate	0.0237	0.0028
Anti-flu vaccination rate	-0.0059	-0.0073
Constant	73.4250*	
Observations	198	
R-squared within	0.72	
R-squared between	0.94	
R-squared overall	0.87	
Number of regions	18	

***Note**: Estimates are obtained using panel data random effect estimator by region and year fixed effects. *** p<0.01, ** p<0.05, * p<0.10*

***Source**: own elaborations on HS-SiSSI, ISTAT-Health for All, Ministry of Economy and Finance.*

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