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Disability-free life expectancy of Italian older adults: trends, inequalities, and applications

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Index

Summary

During the last decades, Italy experienced a substantial increase in life expectancy and decreasing fertility levels, boosting a severe population ageing process, which raised concerns about the sustainability of the socioeconomic and healthcare systems. The eventual threat to these systems is strongly dependent on the quality of the years gained thanks to the longevity revolution, and thus on the health status of mid-to-older adults. Health is a multidimensional concept, and the functional health (and disability) status is among the most important dimension to be considered. In fact, it is an important determinant of individuals' autonomy and of the capability to actively participate to the familiar, social, and economic context. Whether the ageing of the population can undermine economic and social sustainability can be unravelled by examining the (un)healthy ageing process and, thus, through health expectancy indicators, such as disability-free life expectancy (DFLE). These indicators are common metrics used to summarise both mortality and health (disability) risks into a synthetic indicator. It is therefore crucial to analyse the trends, the role of the drivers, and the inequalities of such indicators. Demographic changes in terms of mortality and fertility also have consequences from an intergenerational perspective. Decreasing fertility rates and increasing life expectancies affect the coexistence-life-time of grandparents and grandchildren. Any changes in the timing and length of grandparenthood can affect the health state in which grandparents' years are lived and, consequently, the quality and the direction of intergenerational exchanges. Italy is a country in which grandparents constitute a fundamental resource of care and families are the main source from which they receive care when needed. For these reasons it has therefore become crucial, particularly for this country, to study their health evolution.

In this context, this thesis has several objectives, each of which is addressed in a specific chapter. First, it aims to detect the long-trend of DFLE in Italy using multi-state models and to disentangle the different contributions to the trend given by the changes in the disability-specific-mortality (both from being disability-free and with disability) and by the dynamics of disability onset and recovery. Second, to shed light on the intersections of gender, socioeconomic, and territorial inequalities in DFLE in Italy, and to analyse the drivers of these

inequalities, in terms of the different age-specific mortality and disability risks. Third, to provide estimates of the evolution over two decades of the length of life to live as grandparents free from disability (the disability-free grandparenthood indicator) and to understand how its progression over time is driven by changes in the age-specific survival and grandparenthood-disability prevalence.

Through the application of a variety of demographic and statistical methods (discrete-time event history, multistate incidence-based life tables with the Markov Chain matrix approach, Sullivan method, and decomposition techniques) to different cross sectional and longitudinal data sources representative of the whole Italian population, this thesis provides DFLE estimates at mid-to-older ages for Italian men and women over the last decades, detailing different sources of inequalities (such as gender, education, and region of residence) and focusing also on a less common intergenerational perspective (such as that of grandparenthood).

In the studies presented in this thesis, it is found that during the last decades DFLE at mid-to-older ages has progressed, but not always as favourably as life expectancy. In recent years women and men show trends in DFLE (and in the proportion of DFLE over life expectancy), at those ages, resulting in disability compression, whereas both experienced periods of disability expansion in the past. The decomposition of DFLE evolution over time reveals that the changes in the transition in and out of disability are the most important driving forces of its changes and the greatest contributions are given especially by changes in the probability of recovery from disability.

Notable differences in DFLE at older ages are found within the country, between genders and educational groups. Although at the national level older women and men share similar DFLE, these estimates hide important geographical and social inequalities. Compared to men, women's health disadvantage completely counterbalances their life expectancy advantage, resulting in equal or lower DFLE for some educational levels and in some regions. Moreover, for both gender, educational inequalities in health are dramatically accentuated compared to those in mortality, and the disadvantage in DFLE accumulates over education and region of residence. Differences in disability risks are the major drivers for the educational inequalities in DFLE, throughout the country and for both genders.

In a context of increasing life expectancy and DFLE at older ages, Italian grandmothers and grandfathers have gained years of coexistence-life-time with their grandchildren in good functional health, i.e. being disability-free. Women can expect to live more years as disability-free grandmothers, when compared to men, with an increasing gender gap favouring women over the last two decades. Nevertheless, the share of disability-free grandparent years on overall years as grandparents is lower for women than for men. The increase of disability-free grandparenthood years over the last decades is shown to be primarily led by the sharp improvement in survival and health conditions and, for men, slowed down by the postponement in the transition to grandparenthood to older and older ages.

The indicators presented in this thesis offer valuable information that can be used to monitor the evolution of healthy ageing, to compare the health and mortality risks of different populations and subgroups, and to estimate how alternative social and health policy strategies may be reflected in terms of risks and health conditions of the population, and thus in the indicators.

1. Introduction

This thesis is structured in five chapters. First, it opens in the next pages with an introductory chapter (1) aimed at introducing the reader as best as possible to the sequent applicative chapters of this thesis (2, 3, 4) and to the final chapter (5) in which the results and limitations of the thesis and some implications are finally discussed.

This introduction consists of six sections: background (1.1), literature review (1.2), presentation of the thesis objectives (1.3), an in-depth explanation of the data sources (1.4) and methods (1.5) used in the chapters and, finally, the outline of the thesis (1.6), introducing more specifically chapters from 2 to 5.

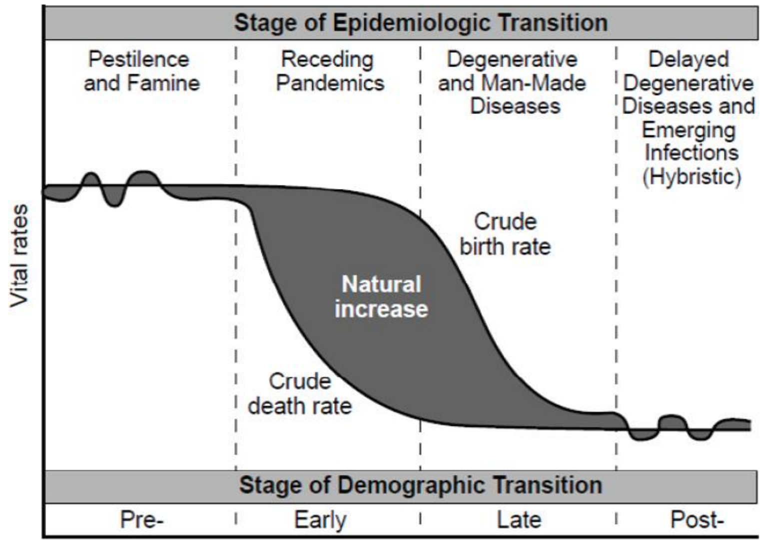
1.1 Background

This section sets the background as an introduction to the demographic evolution of the country from the point of view of mortality, health, fertility, ageing, their inequalities, and the effect of these dynamics on intergenerational overlaps. In particular, it opens with an overview of the longevity revolution, the demographic and health transition (1.1.1) and the evolution of life expectancy (1.1.2) in the world and specifically in Italy. Next, the demographic ageing of the country is examined (1.1.3), with elements of population structure. In addition to the forces from the top of the age pyramid given by the longevity revolution, the dynamics leading to the forces from the bottom of the pyramid, i.e. those of fertility (reduction and postponement of births), are also addressed here. Thereafter ageing is discussed in terms of the possible conflict between an individual success and a collective problem (1.1.4), strongly linked to the theories of expansion, compression, or dynamic equilibrium of poor health in light of increasing life expectancy (1.1.5). The general and specific topics of health and disability are then comprehensively addressed, moving from conceptual definitions to matters relating to their measurement (1.1.6). Finally, the grounds are also set for the inequalities in health and mortality (1.1.7) and the effect of demographic dynamics on intergenerational overlaps (1.1.8), necessary to discuss Chapters 3 and 4, respectively, in depth.

1.1.1 Longevity revolution and the demographic, epidemiological and health transitions

In the human history prior to the mid-18th century, the average length of life probably never exceeded 30 years. However, roughly 250 years ago, a human longevity revolution (Butler, 2008) began to take place, although with noticeable fluctuations in certain periods. Since then, Europe entered a phase characterised by a major and sustained rise in life expectancy: the first stage of the demographic transition. The demographic transition is the historical process that enabled humanity to shift from an ancient demographic regime, where high fertility rates compensated for losses caused by high mortality rates, and towards a new demographic regime characterised by low fertility and mortality rates (Notestein, 1945). As a direct result of this transition, the age structure of populations that experienced the shift is significantly altered in the new regime (Coale, 1984). Economic, social, and political transformations, along with the Industrial Revolution, improved living and health conditions, better nutrition, and medical advances have been the primary drivers of the demographic transition's progression through its various stages. The extraordinary success in mortality reduction was primarily achieved by profound changes in the population's epidemiological profile, particularly stemming from the prevention and treatment of infectious diseases. In 1971, Omran introduced the "epidemiologic transition" theory, aimed at describing the epidemiological transition experienced by human populations "epidemiologic transition" theory (Omran, 1971). He combined various factors that influenced the historical evolution of mortality, dividing it into three distinct periods (see Figure 1.1). First, the age of pestilence and famine, characterised by high and fluctuating mortality rates and with an average life expectancy of about 30 years. Second, the age of receding pandemics, during which epidemics peaks became less frequent and life expectancy started to increase sharply and reaching more than 50 years. Finally, the age of degenerative and man-made diseases, when life expectancy steadily increased and surpassed 50 years, with mortality rates continued to decline sharply and then stabilised at low levels. If this scenario were indeed the case for the evolution of population mortality, it would have implied that during the 1950s and 1960s, the predicted increase in chronic diseases among the older population would have hindered any further rise in the average life expectancy. A few years later, an additional fourth phase of the epidemiologic transition was introduced, in which further progress would possibly been achieved by the postponement at older ages of the age at death of those who suffer from chronic diseases and by individuals adopting healthier behaviours (Olshansky & Ault, 1986; R. G. Rogers & Hackenberg, 1987). Omran's prediction of mortality risks stabilising in the last phase was contradicted, particularly by the extraordinary reductions in cardiovascular diseases during the 1970s (the cardiovascular revolution). A few years later, Frenk et al. (1991) introduced a broader “health transition” theory, which incorporated not only the evolution of epidemiological health trends but also the evolution of societal responses. This theory divides the past and future evolution of human mortality into three phases: the first phase that corresponds to the first two stages of Omran's epidemiological transition, the second phase marked by decline in cardiovascular diseases, and finally, future phases characterised by reduced cancer-related death risks and possibly changes in the senescence processes, as further suggested by Horiuchi (1999).

Figure 1.1: Demographic transition and Omran's epidemiologic transition

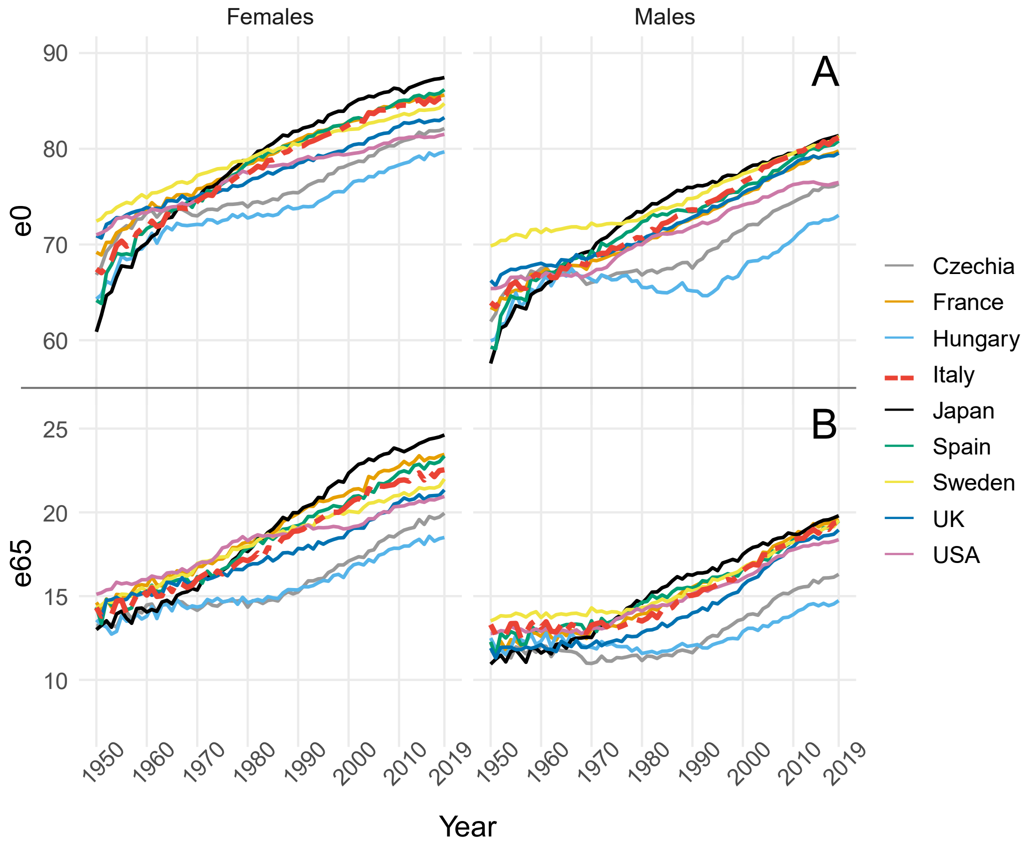


Note: original image from Rockett (2000)

1.1.2 The evolution of life expectancy

Since the beginning of the demographic transition, there has been a steady increase in the average lifespan, albeit with some fluctuations. Most economically and socially developed countries have seen life expectancy at birth more than double. The rate of increase in life expectancy around the world has been so exceptional that in the record-holding country in each year, women's life expectancy has steadily increased by almost 3 months per year for 160 years (Oeppen & Vaupel, 2002). However, in the 20th century, substantial discontinuities in the trend of mortality reduction occurred due to the two World Wars and the Spanish flu, which affected some countries. Until the Second World War, all additional years of life gained were mostly owing to significant decreases in infant and child mortality (Caselli & Egidi, 1991; Raleigh, 2019). Figure 1.2 illustrates the changes in life expectancy at birth (e0, Panel A) and age 65 (e65, Panel B) for men and women in selected countries between 1950 and 2019. In the second half of the 20th century, mortality did not stabilise, and not only did life expectancy at birth continue to increase, but there was also a remarkable increase in remaining life expectancy at older ages. During the thirty years following the Second World War, the rise in life expectancy was largely due to a decrease in mortality in adulthood. However, from the mid-1970s, with the advent of the cardiovascular revolution, mortality rates at older ages began to decrease, so that also older ages started to contribute to an increase in (remaining) life expectancy (e.g. for Italy, see Nigri et al., 2022). Consequently, life expectancy at age 65 also showed a remarkable increase during this period for both genders (Figure 1.2, Panel B). Since then, among the various countries of the world, Japan has made major progress in terms of life expectancy. Despite being traditional leaders in this area, the United States and some Northern European countries were surpassed by more dynamic countries like Italy and Spain (Figure 1.2, Panel A and B). Japan finally emerged as the country with the highest life expectancy (87.4 years for females and 81.4 years for males in 2019). Italy's evolution over time has been characterised by an upward trend that followed a relatively constant pace, with an increase of approximately two months per year. While there has been a general trend towards a slowdown or stagnation in life expectancy growth in recent years in both leading countries and those with lower life expectancies (such as Central and Eastern Europe), Italy and Japan are among the exceptions, with their trend continuing to increase until 2019 (Raleigh, 2019).

Figure 1.2: Life expectancy at birth (e0) and age 65 (e65) of females and males between 1950 to 2019 in selected countries



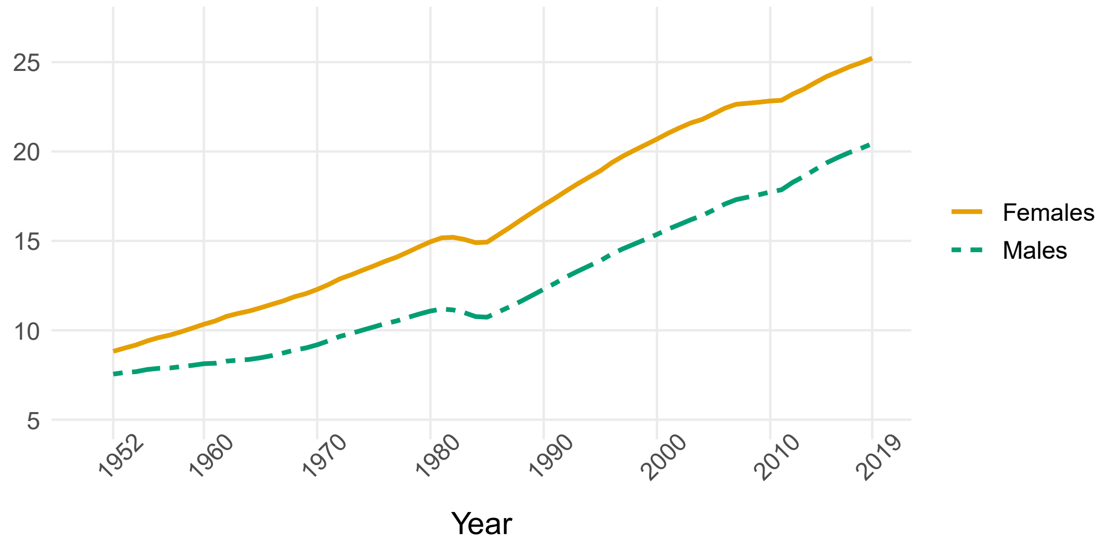
Note: own elaborations from Human Mortality Database (HMD, (Barbieri et al., 2015)) data; selected countries: Czechia, France, Hungary, Italy, Japan, Spain, Sweden, UK, USA

When compared to other countries around the world, Italy has experienced a remarkable increase in life expectancy from 1950s. Additionally, it is noteworthy that there has been a significant reduction lifespan inequalities, indicating that Italians not only live longer than they did in the past, but their lifespans are also becoming more predictable (Permanyer & Scholl, 2019). As highlighted by Nigri et al. (2022), before the 1970s, mortality before the age of 5 made the greatest contribution to life expectancy increases in Italy. However, since then, the primary contributions have been observed in older age groups, especially over age 60, due to the reductions in mortality from cardiovascular diseases and cancer. Lifestyle-related causes of death (e.g. external causes), characterising mortality at younger age, also played an important role, particularly for men during those years. Furthermore, a reduction in mortality from digestive diseases, possibly due to improved nutrition-related lifestyles (Vercelli et al., 2013), has also contributed to increased life expectancy. The Italian case is also characterised by a noteworthy negative contribution to life expectancy increase given by the increase in respiratory infectious diseases in recent years. Interestingly, it was actually observed even before the onset of the Covid pandemic and could have been an early warning indicator for it. Italy has made remarkable progress in improving its life expectancy, moving from being one of the countries with relatively low life expectancy to becoming one of the leaders. In 2019, Italian females had a life expectancy of over 85 years, while males had a life expectancy of 81 years (HMD). In most economically and socially developed countries, as well as in Italy, the continuous decrease in death risks (especially for the older population) was one of the most important contributions to the steady increase in the average lifespan of both genders since the early 1970s (Rau et al., 2008; Vaupel, 1986). In those countries the average death rate over the age of 80 declined by 1 to 2 percent per year. In these countries, since the 1960s, the pace of decline in the average mortality rate for women over the age of 80 has been declining to 1-2 per cent per year (for men, to 0.5-1.5 per cent) (Kannisto et al., 1994). This has resulted in a substantial rise in the number of individuals reaching older ages and, along with decline in fertility rates, has led to an increase in the mean age of the population and an age structure dominated by the older ages.

1.1.3 Population ageing

To assess the process of population ageing in Italy, we examine the proportion of individuals aged 65 and over, as well as its trend over time. Figure 1.3 illustrate this indicator from 1952 to 2019 in Italy for both women and men. Its evolution reveals a sharp and exceptional increasing trend. From shortly after the end of the Second World War to 2019, the share of population aged 65 or over rose from only about the 8% to about the 23%. In fact, it was in the years following the Second World War that the rapid and dramatic increase in the older population began, leading to the percentage more than doubling in the following 50 years. This extraordinary growth and the achievement of such a high proportion have meant that Italy's percentage in 2019 is the highest compared to all other European countries (Eurostat, 2021) and among the highest in the world (United Nations, 2022).

Figure 1.3: Share (%) of males and females aged 65 and over from 1952 to 2019 in Italy

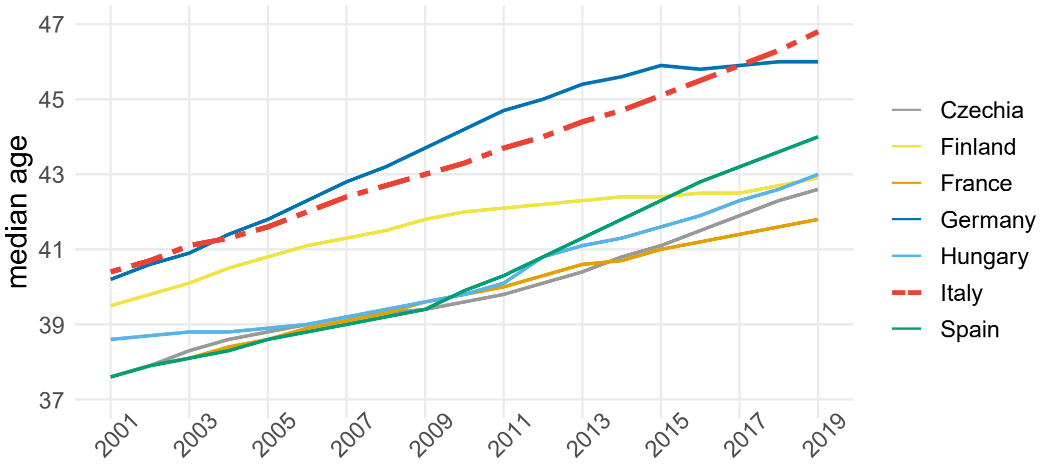


Note: own elaborations from National Institute of Statistics (Istat) data (dati.istat.it)

Another interesting structural indicator in this context is the population median age. Figure 1.4 shows its trend in a selection of European countries over the last two decades. In 2001, the median age of the Italian population was already higher than that of all other European countries, and equal to just over 40 years. After 2003, it was exceeded only by Germany, which held the highest value and maintained this leading position until 2016.

However, the median age of the Italian population continued to increase continuously (and quite linearly) growth and regained the top rank in 2018, reaching over 47 years in 2019. Between 2001 and 2019, the median age of the Italian population increased by more than 7 years, with an average yearly increase of 0.35 years, which is higher than the European average increase of 0.25 years per annum (rising from 41.9 to 44.1 years between 2012 and 2022 (Eurostat, 2023)).

Figure 1.4: Median age of the population between 1950 and 2019 in selected European countries



Note: own elaborations from European Statistical Office (Eurostat) data (Eurostat, 2022); selected European countries: Czechia, Finland, France, Germany, Hungary, Italy, Spain

Population ageing is the result of various combined factors that alter the age structure of the population. The steep decline in mortality and the increase in life expectancy are consequences of profound economic and social changes. On the one hand, population ageing is the outcome of this decline in mortality and higher chances of survival at older ages. On the other hand, another incredible boost to population ageing comes from variations in fertility levels and timing (also a consequence of the profound economic and social changes). The population ageing process is driven by both the upper and the lower part of the population age pyramid, namely the increase in the number of older individuals (at the upper part of the age pyramid) and the constant or decreased total fertility rate (TFR), resulting in a shrinking in the number of younger individuals (in the lower part of the pyramid) (Caselli & Vallin, 1990; Grundy & Murphy, 2017).

The population of the most economically and socially developed countries, particularly Italy, has experienced a downward trend in births and total fertility rate. Already since the second half of the 19th century, the spread of new hygienic and sanitary practices, the improved health of mothers and children, and the processes of modernisation and urbanisation, favoured declines especially in infant mortality. This period has seen massive demographic, economic, and social changes, the driving factors of the demographic transition. These transformations have also played a key role in shaping reproductive choices and behaviour at the turn of the 19th and 20th centuries, and therefore in the reduction in births starting in Europe after 1850 , albeit with varying timings and intensities across different countries (Livi Bacci, 2016). Since 1880, approximately a decade after mortality levels started to decrease sharply, the birth rate in Italy started to drop (Istat, 2019). This trend accelerated during the two World Wars (Caldwell, 2006), and persisted throughout the early 20th century. The average number of children per woman in Italy, measured by the TFR, has decreased substantially during this period, as in the rest of Europe. The TFR reached values extremely close to the replacement threshold and equal to around 2.3 in 1953. Figure 1.5 shows the historical evolution of TFR in Italy from 1952 to 2019.

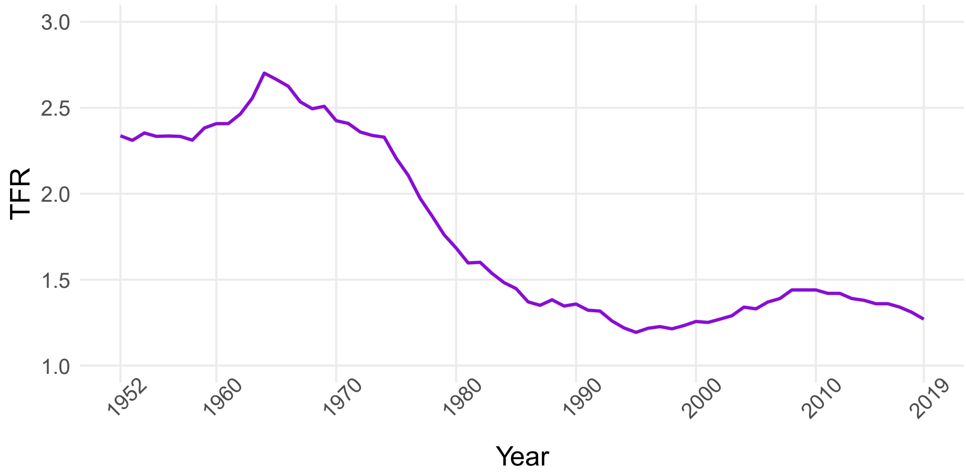
Despite considerable territorial differences (Zambon et al., 2020), Italy appeared to have attained an equilibrium representative of the final phase of the demographic transition, with low levels of mortality and fertility, and a TFR of around the replacement threshold (Istat, 2019) by the end of Second World War. In the late 1950s and early 1960s, as part of the post-war economic boom, Italy witnessed a new boost in life expectancy given by the rise in survival at older ages. This period also saw a global "baby boom" in many countries, with a surge in births and TFR due to the recovery from the war and post-war years' fertility postponement of war and post-war years (De Sandre et al., 1997). In Italy, the TFR increased from 2.3 to 2.7 between 1958 and 1964, the highest level since the 1950s (Figure 1.5). However, the baby boom ended in all European countries in the late 1960s and early 1970s, and the TFR in all European countries dropped sharply. Once again, social and economic changes, including the women's rights movement in the '68 era, were the primary drivers of this decline of the so-called "second demographic transition" (Lesthaeghe, 2011), which has continued to this day. The Italian TFR fell below the replacement level in 1977, reaching a low of 1.68 in 1980. During the 1980s and early 1990s, the decline was more pronounced, hitting the "lowest-low fertility" threshold (Kohler et al., 2002) of 1.3 children per woman, and reaching a record of less than 1.2 in 1995 (Figure 1.5), the second-lowest in Europe after Spain (Perez & Livi-Bacci, 1992).

To be noted that, to consider specifically the fertility replacement level, it may be more appropriate to consider the Net Reproduction Rate (NRR) instead of the TFR, being the former a combination of both fertility and mortality. In fact, fertility is at replacement level unambiguously if and only if NRR = 1.0 (Espenshade et al., 2003). This value has been reached by Italy some years before the TFR being equal to 2.0. Nevertheless, in the course of this discussion it was considered more useful to analyse the TFR for its easier interpretability and for its greater adaptability as an introductory element both for the evolution of the age structure of the Italian population over time and as an element characterising specifically fertility evolution in the country.

The sharp drop in the birth rate over the years is also compounded with another key trend: the increase in the mean age of the mother at birth of the child (MAB), as shown in Figure 1.6 for Italy from 1954 to 2019. In 1980 the MAB in Italy was 27.5, rising to a level of 32.1 in 2019. It is worth noting that this increase would be even more strong net of the change in TFR. In fact, as the MAB tends to increase with higher parity, if the MAB trend were observed at a constant TFR (which instead decreases from 2.5 to 1.2), the increase would have been even stronger and faster.

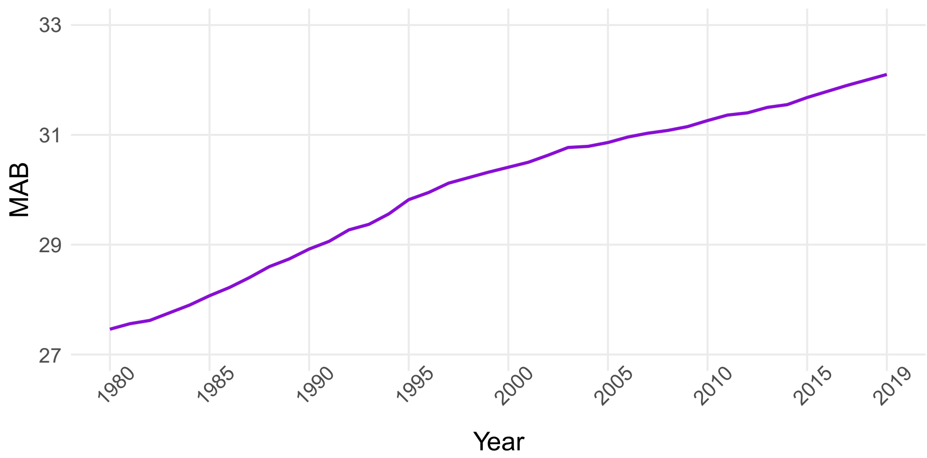
This shift towards a higher MAB is another manifestation of the country's social changes and, particularly, of the shifting in the timing of the various life stages and the “demographic stretch” (Pablos-Mendez et al., 2015). This concept has previously discussed by Lee and Goldstein (2003), who speculate on how survival gains influence and completely reshape the life cycle. According to this view, each stage and boundary of the life cycle expands in relation to extent of increase in life expectancy. When it comes to fertility, the decreasing TFR and increasing MAB imply that Italians have fewer children and, if they do become parents, they do so later in life. This process provides a fundamental boost to the population ageing process by shrinking more and more the amount of younger population.

Figure 1.5: Total Fertility Rate (TFR) in Italy from 1952 to 2019



Note: Own elaborations from Istat data (dati.istat.it)

Figure 1.6: Mean Age at Birth (MAB) in Italy from 1980 to 2019



Note: Own elaborations from Human Fertility Database (HFD, Jasilioniene et al., 2016) data

1.1.4 Individual success vs collective issue?

Undoubtedly, the longevity revolution is one of humanity's greatest accomplishments. The lengthening of the average lifespan has occurred alongside a decrease in the variability around this value, as measured by indicators such as the lifespan variation indicator (Aburto et al., 2020). From an individual perspective, the uncertainty about the time horizon that each individual has over the life course has been reduced and one can expect - with good confidence - to reach older and older ages. From a collective perspective, there is growing concern about whether longer lifespans and the resulting population ageing are sustainable or whether they instead pose threats to the economic and social systems (discussed, among others, by Christensen et al., 2009; Harper, 2014; Istat, 2020). Concerns include whether intergenerational equity is compromised and whether appropriate welfare can still be guaranteed for all generations that coexist in the same years (Walker, 1990). The economic impact of ageing on society can be very relevant, as it can alter the demand for products and services such as increasing provision of health and social care. In a country like Italy, where there is a well-known lack of state support and facilities for the older population, most needs are met by families, to the extent of having a “familistic” welfare system (e.g. Kalmijn & Saraceno, 2008; León & Migliavacca, 2013). Families may find themselves increasingly constrained by the burden of care (Pivodic et al., 2014), providing assistance to their older members, partly replacing the state's lack. With a continuous increase in the share of the older population share, the question is whether, and until when, the Italian welfare system can bear its pressure. Specifically, the question is whether the increase in survival can be sustainable or, on the contrary, it can definitively undermine the socio-economic system.

To fully comprehend the impact of ageing on the system, it is not sufficient to only examine the percentage of the older population or the structural old-age dependency ratios. Rather, it is crucial to consider the possibility that ageing may not only be a challenge for societies, as it may also offer opportunities for all in the case of successful achieving healthy ageing. Thus, understanding the quality of additional years of life, the health conditions, and their dynamics, especially at older ages, is the key to understanding whether the lengthening of life is an absolute success. In fact, since the late 1970s, concerns started to emerge as to whether the extension of life was “a failure of success” (Gruenberg, 1977) or not. Ageing and increased life expectancy pose several questions concerning the implications for society, among which there is the potential and crucial consequence on population health. It is known, in fact, that age is one of the most important determinants of health and it may be reasonable to assume that a higher share of older individuals leads to a higher prevalence of poor health conditions in the population. However, it is still arguable whether increased life expectancy translates into more years lived in poor health conditions or not, meaning whether the life years gained thanks to the longevity revolution are of good or poor health quality. In fact, if instead of being concentrated at older and older ages (as in the case of the risk of death) the age at onset of poor health conditions typical of senescence remained constant (or even worsened over time), the years gained through the longevity revolution would be years lived in poor health. Both from an individual perspective, in terms of quality of life and wellbeing, and from a collective perspective, in terms of the resources required to meet population needs, these scenarios have quite different implications.

1.1.5 Expansion, compression, or dynamic equilibrium of morbidity

Since the late 1970s, there has been an ongoing debate on the link between the increase in life expectancy and the health status of the population. Three distinct scenarios have been proposed to explore the potential changes in population morbidity as a consequence of the increase in life expectancy: the compression, expansion, and dynamic equilibrium of morbidity (Fries, 1980; Gruenberg, 1977; Kramer, 1980; Manton, 1982; Olshansky et al., 1991).

The more optimistic view is that of morbidity compression, which theorises that improvements in survival are followed by improvements in health conditions. This relationship is possible if the factors that have allowed the reduction of mortality levels are also followed by medical advances in the treatment of diseases (leading to an increased probability of recovery), less exposure to risk factors for poor health, and increasingly healthier lifestyles, preventing and postponing the onset of poor health conditions later and later in life. Originating in the early 1980s, this theory linked an hypothesised fixed limit of the maximum length of life to the postponement of the onset of disease to later ages (Fries, 1980). In this way, poor health would be compressed into a shorter period just before death and reducing the prevalence of poor health at the population level. The population’s lifespan and healthy lifespan curves would undergo, over time, a rectangularisation: more and more people would reach, with increasing certainty, the maximum age set as the limit to life expectancy, while in addition, spending life in good health for an increasing number of years, until that very limit age. If then the assumption that the average lifespan is fixed at a certain limit is released, and it is considered that the maximum lifespan may increase further, it is possible to distinguish between absolute and relative compression of morbidity (Fries, 1983). The former occurs when the delaying process of illness onset outpaces the mortality one and, together with an increase in the years lived in good health conditions, the years lived in poor health conditions decrease. The latter, in contrast, takes place when the opposite actually occurs, and the years of life spent in a morbid condition remain constant or increase together with increasing in life expectancy and years lived in good health conditions.

The more pessimistic view is the theory of the expansion of morbidity, which hypothesises, instead, that the additional years of life gained with life extension are inevitably of poor health quality. According to this theory, advances in the medical field would primarily result in increased survival with chronic conditions, necessarily followed by an increase in the prevalence of poor health in the population (Gruenberg, 1977; Kramer, 1980). With the aim of placing this theory in opposition to Fries' one, it has later been called "morbidity expansion" theory (Olshansky et al., 1991). In addition to the improved survival of those with chronic diseases, another mechanism of morbidity extension can be the shift from fatal to nonfatal diseases (decline in the fatality rates of diseases), that cause disability and chronic conditions. With elements of both the compression and expansion hypotheses, a third explanation for how population health may evolve as a result of longer life expectancy has been offered: the dynamic equilibrium theory (Manton, 1982). According to this theory, the delay in chronic disease progression rates is only partially responsible for the decline in mortality and rather it is primarily due to a delay in the onset of more severe conditions. The decline is theorised being connected to disease redistribution from more severe to increasingly less severe stages. In this scenario, the proportion of life years affected by severe disease stabilises or declines with an increase in life expectancy, while the proportion affected by less severe disease rises.

This means that individuals would live more years with mild illness. Another interpretation of this theory is that there may be an equilibrium between life expectancy and the years spent in good health conditions, increasing simultaneously at the same rate.

To address the issue of the consequences of increasing life expectancy on population health and to understand the prevailing theory between the compression vs expansion vs dynamic equilibrium, health expectancy indicators have been introduced. Health expectancies are the most frequently used indicators to study trends and characteristics of survival quality. If total life expectancy at each age is composed of time spent in different health states until death, then the durations in different health states are the health expectancies. These indicators are essential to assess whether the extra years of life are spent in good health and whether life expectancy is increasing faster than the decline in the rates of poor health conditions. Depending on the aspect of health of interest, different health expectancy indicators can be considered. For example, if disability is the dimension of health under study, then disability-free life expectancy may be the indicator of interest. For a more detailed explanation of the historical introduction of these indicators, the computation, and the various methodological aspects, see sections 1.5.1 and 1.5.2. Here, an overview of the usefulness of these indicators in the debate between compression, expansion, and dynamic equilibrium of morbidity, in light of increasing life expectancy, is outlined. Specifically, if the question is whether the consequence of increased survival is an expansion of disability, and, in particular, of the years lived with disability, then, besides disability-free life expectancy (DFLE), the proportion of DFLE on total life expectancy (generally called the health indicator, H) needs to be monitored (see Table 1.1). In case of steady increase in life expectancy, if H increases, the scenario is compatible to a disability compression. Absolute compression of disability requires simultaneous drop in DLE, while the constancy or even rises in DFLE indicates that the compression is relative. If, on the other hand, H decreases an expansion of disability occurs. This expansion is defined to be absolute if DFLE does not increase but rather remains constant or even decreases, while it is relative if DFLE increases. Finally, if H remains constant there is a dynamic equilibrium between the evolution of mortality and disability risks.

Table 1.1: Linking health expectancies indicators to theories of compression, expansion, and dynamic equilibrium

	Disability-free life expectancy (DFLE)	Life expectancy with disability (DLE)	Proportion of disability-free life (H)
Compression of disability			
Absolute	↑	↓	↑
Relative	↑	**= or** ↑	↑
Dynamic equilibrium	↑	↑	**=**
Expansion of disability			
Absolute	**= or** ↓	↑	↓
Relative	↑	↑	↓

Note: In the case of equilibrium, the same relationships apply but changes between mild and severe disability can also be considered. Scheme from Kreft & Doblhammer (2016).

1.1.6 Health and disability, from concepts to measurements

Despite the concept of mortality being clear, there is not a unified definition of health. In its Constitution, the World Health Organization (WHO) defined health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (World Health Organization, 1948). This definition was very innovative at that time, characterising health as: anatomical, physiological, and mental integrity; absence of risk of illness or premature death; the ability to ensure one's social roles; the ability to manage stress; a feeling of well-being. The main strength of this definition is the ability to consider the concept's multidimensionality and its dynamic nature in both time (personal and calendar time) and space (for different societies). Furthermore, it emphasises the importance of moving beyond the notion of health as simply a "mere absence of disease" , which was the dominant paradigm of the time. Instead it emphasises the social dimension, the networks, in supporting and influencing the individual. On the other hand, this definition suffers from many limitations (Huber et al., 2011). First, as mentioned in earlier sections of this thesis, since its introduction in 1948, population health and the nature and pattern of diseases have changed significantly.

Since then, indeed, there has been a substantial decrease in infant mortality, infectious diseases, external causes of death, and causes typically associated with younger age groups. Later on, the number of individuals potentially living with chronic conditions increased significantly. It is becoming increasingly unlikely that these conditions lead rapidly to death, while it is becoming more and more likely for individuals to live many years with these conditions but still living a fulfilling life. It is important to note that this definition is also at risk of mixing the concepts of health and well-being. The major limitation is an operational one, as the WHO has developed several systems to classify diseases and describe aspects of disability, functioning and quality of life. However, there is a lack of a “standard” reference to a “complete” state of health, which remains neither operational nor measurable.

The first step towards an operational definition is to specify the different dimensions that constitute the global concept of health suggested by the WHO. There are various approaches and perspectives that are commonly used to measure these dimensions. The two main approaches are objective (which involves using specific instruments to measure health) and subjective (which relies on people's own assessment of their health). The objective approach in measuring health is closely related to the concept of the absence of diseases and functional limitations, which are measured using specific tests and instruments. This approach tends to reduce the subjective component, although it is usually not entirely eliminated. For example, even going to the doctor to undergo a diagnostic test involves a certain degree of subjectivity, and the doctor's own subjective judgment cannot be entirely removed. Additionally, there may be possible discontinuities comparing objective health states, such as when diagnostic advances modify the ability to detect a disease. Tools used to measure objective health include, but are not limited to, health examination surveys (population-based surveys on which information is collected by questionnaires and also through physical examinations and collection of biological samples (Tolonen et al., 2017)), disease registers, pharmaceutical expenditure, and hospital statistics. However, for population studies, these sources may be unavailable (or difficult to access) and limited to specific population subgroups (e.g. hospital statistics only refer to the population that has accessed the hospital). Therefore, self-reported (subjective) health measures from survey data are usually the main source of information in demographic research, even though objective health measures are becoming increasingly available. When adopting the subjective approach in health measurement it is important to consider that individuals' perceptions of own health are strongly influenced by their life history, experiences, values, ambitions, knowledge, health information and education, in addition to the underlying health status (Tissue, 1972). The role of own expectations and comparison with peers is of crucial, as the perception of own health and the elements that people consider when assessing their health can change over time and with age. As a subjective assessment, the elements considered can change, indeed, from person to person, and each one may use a different standard as a reference (Jylhä, 2009). Finally, reporting own health status involves three stages: perception, evaluation, and subsequent declaration - each of which can produce different outcomes. The process, thus, can be different for different subpopulation (Lazarevič, 2023; Lazarevič & Brandt, 2020) such as gender (Anson et al., 1993) and education (Gumà-Lao & Arpino, 2023), among others. Nevertheless, subjective health measures, such as self-rated health, have been found to be a powerful predictor of future health and use of health services (Jylhä, 2009), as well as mortality among the elderly (Egidi & Spizzichino, 2006; Jylhä, 2009; Mossey & Shapiro, 1982).

In health measurement, there are different perspectives that can be adopted, such as medical (or biological), social (or functional), or global. From a medical or biological perspective, poor health is defined as a deviation from the physiological or psychological norm as consequences of the morbid process of a disease or other medical conditions. In this way, the focus is on the disease, referring to the diagnosed pathology. From a social or functional perspective, poor health is defined as the inability to perform "normal" daily activities, and the focus is on the social consequences of the disease or accident. Finally, from a global perspective, the focus is on the (subjective) assessment of individuals' overall (global) health status.

Individual age is known to be one of the major determinants of poor health and older ages are frequently characterised by an increased vulnerability to diseases, functional declines, and cognitive impairments. Older individuals are, indeed, the largest consumers of healthcare resources, they frequently experience comorbidities and disabilities that represent the physical and mental decline typical of the last phase of life.

This thesis focuses on functional limitations and disability, as a crucial dimension of mid-to-older individuals’ health state. Therefore, it is followed a perspective based on the consequences that poor health conditions have on individuals’ functioning. Considering the functional health status and the disability of individuals has several advantages because it provides: information on the health status that goes beyond the medical and disease-oriented measures and that focuses more on the consequences of diseases; crucial prognostic information on multiple negative health-related outcomes of diseases; the basis to estimate the type and amount of care needed (also in the immediate future) and to inform policy decisions (Ferrucci et al., 2007; Guralnik & Ferrucci, 2003; Marengoni et al., 2011). Disability summarises the balance between the negative impact of multiple morbid conditions (of varying severity) and the overall health, vitality, and functioning of the individual. Functional health is a major determinant of individuals' quality of life (Newsom & Schulz, 1996), especially for mid-to-older ones, affecting their autonomy and capability of being involved in social, familiar, and economic contexts. Monitoring population health using this dimension can indicate potential strains on both economic and healthcare systems, but also on families, particularly within a familistic welfare system like that of Italy.

The conceptualisation of functional limitations and disability has not always been straightforward in the past, and the definition adopted today by the WHO is a result of a long path. Until the mid-20th century, having a pathology was considered a synonym for having functional limitations, but Saad Nagi's groundbreaking work differentiated between the consequences of pathologies and their actual functional consequences.

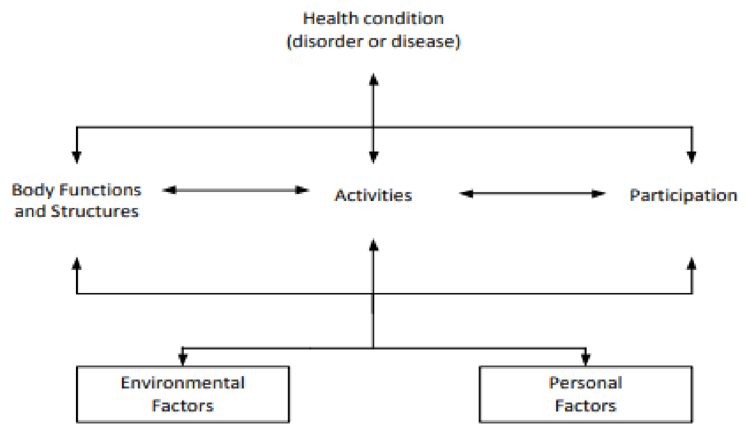
Nagi's model, proposed in 1965, defined disability as “the expression of physical or mental limitations in a social context” (Nagi, 1965), and he later expanded this to include limitations in “performing socially defined roles and tasks expected of an individual within a sociocultural and physical environment” (Nagi, 1991). Nagi’s models focused on the consequences of limitations rather than their underlying causes and on how they affect individuals’ capacity to perform specific tasks. Therefore, individuals' functional health, that relates to the consequences of the disease, injury, malformation, or ageing, can be measured using activity scales. This proposal formed the theoretical basis for the implementation of the International Classification of Impairments, Disabilities and Handicaps (ICIDH) (World Health Organization, 1980), introduced in 1980 by the WHO as a tool for classifying the consequences of diseases, injuries, and other disorders and their implications for individuals' lives.

The ICIDH distinguishes three different concepts and terms: impairment, disability, and handicap, linked in a chain in which: an impairment produces a disability which in turn produce an handicap. The term "impairment" refers to “abnormalities” in the structure, appearance, and function of organs and systems, that result from any cause. It is the “external” expression of disease, accident, malformation, or ageing that relates to the alteration of a structure or function. The term “disability” reflects the consequences of impairments in terms of functional performance and activity of individuals, representing disturbances at the level of the person. It is the “objective” form of the disease, accident, malformation, or ageing, which concerns the partial or total reduction in the ability to perform activities considered “normal”. Finally “handicap” concerns the disadvantages experienced by the individual as a result of a disability, reflecting the interaction with and adaptation to the individual's surroundings. This term refers to the limitation or impediment of a “normal” social role (in relation to age, gender, social and cultural factors), thus implying a social disadvantage and for this reason, it is the “social” form of illness, injuries, malformation, or ageing (World Health Organization, 1980).

The definitions in ICIDH have several limitations, including their primary focus on deficits. Moreover, the interpretation of disability can vary depending on the context and, often, it is the context that plays a critical role in determining an individual’s ability or limitation.

The aim of overcoming the drawbacks of the definitions in ICIDH classification led the WHO, in 2001, to produce a new definition and classification of disability: the International Classification on Functioning, Disability and Health (ICF) (World Health Organization, 2001). Since its implementation, ICF has become the international standard for measuring and classifying health and, in parallel, functional limitations or disabilities. At the theoretical base of the ICF model, there is also the innovative “disablement process” proposed by Verbrugge and Jette (1994), describing “how chronic and acute conditions affect functioning in specific body systems, generic physical and mental actions, and activities of daily life” and “the personal and environmental factors that speed or slow disablement, namely, risk factors, interventions, and exacerbators”. The adoption of the ICF by the WHO led to a conceptual evolution and marked a substantial political and social change compared the previous classification. In the ICF the medical model and the social model are replaced (or rather integrated) in a multidimensional “biopsychosocial” model. Considering the different biological, social, and individual dimensions, this model provides a more complete picture. This new classification has a various purpose. First, it aims at providing a systematic coding model for health information systems (as the previous classification) and a reference that enables the understanding of health and related states while also linking determinants and consequences. It also aims at making data comparable in time and space, namely in different geographical and cultural contexts. This is possible through the use of a common language in the description of health and health-related states so that communication between different sectors and disciplines can also be facilitated. This model considers together conditions, determinants and consequences of health and disability. Having a well-defined and comprehensible structure, ICF organises a wide range of information concerning the functioning of individuals and its restrictions. Moreover, the main strength of this classification is in how the dimensions are related to each other: the health state of a person is analysed in a dynamic interaction between all components of the model (Figure 1.7). The contextual, environmental, and personal factors are emphasised as mediators in interaction with all components of functioning and disability and, therefore, with the health conditions, the body, the activity and participation (World Health Organization, 2001). The importance of considering the effect of context and other individual characteristics on the individuals’ health derives from the fact that physiological limitations are only one of the components that generate functional limitations. Thus, the role of contextual factors in the physical, cultural, and policy environments are emphasised. In summary disability is seen in this model as a multidimensional concept in which each dimension can be measured separately and may have different effects on the person based on the interactions with the other dimensions. Because of this strong interrelation, interventions on one dimension could affect one or more of the others. In this perspective, functional limitations are defined by a deficiency in one or more dimensions.

Figure 1.7: Interaction between ICF components



Note: Original scheme from ICF practical manual (World Health Organization, 2013)

In addition to the complexity of disability's definition, many instruments for its measurement have been developed to date. These different instruments can be distinguished by the domains of functioning included, by levels of severity or duration of disability, by the goal of measuring capacity or performance (without personal assistance or with equipment), or even by the symptoms of disability (pain, weakness, endurance) (Van Oyen et al., 2018). In line with Nagi's model, Katz et al. (1963) developed activity grids to organise and harmonise the information, for example to be used in population surveys. They identified various elementary activities of daily living based on the observation of children's autonomy development, such as feeding, dressing and undressing, bathing or showering, moving from bed to chair, going to the bathroom, etc. The Activity of Daily Living (ADL) scale, present today in many surveys, originated from this activity grid. Lawton & Brody (1969), moreover, introduced a grid for the instrumental activities, and the related Instrumental Activity of Daily Living (IADL) scale. This scale considers activities that enable the individual to live independently (specifically at older ages) and mainly investigates eight dimensions: using the telephone, shopping, eating meals, taking care of the house, doing laundry, using transport, taking own medication, and managing one's finances. In surveys, individuals are asked: "Do you have difficulty doing ___ (each activity listed) due to health reasons?", with possible answers “yes” or “no”; if the individual answers “yes”, there can be a subsequent question asking the extent of difficulty.

Over time, other survey instruments were developed, increasing the number of questions on disability, often by adding more and more tasks to perform. However, adding more questions and activities increases the burden on respondents and the cost of the survey. As a result, there was the need to create, in a parsimonious and concise manner, a single question that could fully capture the concept of disability (Verbrugge et al., 1999). To meet this need, a global one-item survey instrument was proposed to measure disability, called the Global Activity Limitation Indicator (GALI), whose conceptual framework for development is the ICF (Robine et al., 2002, 2003). The single question asked is: “For at least the past 6 months, to what extent have you been limited because of health problems in activities people usually do? Would you say you have been:” with possible answers “severely limited”, “limited but not severely”, or “not limited”. GALI, using the term “activities people usually do”, implicitly refers to the ability to perform and socially participate in a variety of environments and non-specific domains of life, such as employment, school, housework, and leisure. As such, it is a self-reported global measure of participation restriction (Van Oyen et al., 2018). Furthermore, GALI meets several conceptual criteria of ICF such as: the correlation with health problems as the main cause of disability, the long-term duration of disability (at least 6 months) and the measure of its severity (severely or not severely). GALI is part of a coherent set of indicators to monitor health in Europe (Robine et al., 2003), called the European Minimum Health Module (MEHM) (Eurostat, 2017). The MEHM consists of three one-item survey instruments covering self-rated health, the presence of chronic morbidities, and functional limitations. The MEHM, including GALI, is used in most European surveys, such as the European Health Interview Survey (EHIS) and the Survey of Income and Living Conditions (SILC), besides its use in many national surveys. A systematic review by Van Oyen et al. (2018) assessed the validity and reliability of the GALI and found that it is both a consistent predictor of health and mortality outcomes and health expenditure, and it is a reliable indicator. This review found that GALI "fits all conceptual characteristics specified for a global measure on participation restriction” and that “in none of the studies, included in the review, there was evidence of a failing validity”.

1.1.7 Inequalities in mortality and health

Population's health has progressively improved in recent decades. In most countries, along with a rise in life expectancy and a decline in mortality, morbidity also experimented overall decreases (for most diseases and especially the more fatal ones) both in terms of incidence, prevalence, and its negative impact on quality of life (Lopez et al., 2006). However, not all populations have benefited in the same way from the same progresses. In fact, there are relevant differences in health and mortality outcomes among populations and in different population subgroups. In this section, three sources on inequalities are discussed, namely the gender, territorial, and socioeconomic inequalities, which have characterised, and still characterise today, the distribution of health and mortality, mainly focussing on Italy.

It is widely recognised that health and mortality are characterised by gender inequalities. Women live longer than men, at all ages, but spend a higher portion of their life in poorer health states (Case & Paxson, 2005; Di Lego, Lazarevič, et al., 2020; Oksuzyan et al., 2010). In most countries of the world, research on gender differences has revealed the so-called “health-survival paradox”: women use more health services and report worse self-rated health than men at all ages but are less likely to die than same-aged men throughout life. As detailed, among others, by Case & Paxson (2005) and Di Lego, Lazarevič, et al. (2020), it is possible to further explore this “paradox”. On the one side, males’ excess mortality may be explained by biological factors (such as in Christensen et al., 2000) and acquired risks (such as in Preston & Wang (2006) and Trias-Llimós & Janssen (2018)), being among the major explanations of sex differences in mortality (Luy, 2003). In fact, Zarulli et al. (2021) analysing the contributions of the different age classes to the sex gap in life expectancy, and their evolution since the 19th or 20th century in different countries, conclude that “the sex gap in life expectancy appears to be rooted in biological differences between males and females, modulated by social norms, constraints, incentives, roles, and epidemiological contexts that permit behavioural and environmental differences that affect health". On the other side, females' excess morbidity may be mainly partially explained by the types and severity of diseases. First, among the two sexes, there is a different distribution of diseases. As reported in several studies based on both subjective and objective measures of health, females are more likely than males to suffer from chronic conditions, causing a lower health-related quality of life and poorer self-rated health, but those conditions are less likely to contribute to an increased risk of mortality (Case & Paxson, 2005; Crimmins et al., 2011; Grundy, 2006). Second, males are more likely to suffer from cardiovascular and respiratory diseases and be more exposed to accidents and homicide, largely impacting survival (Verbrugge et al., 1987), especially at younger ages. In fact, Feraldi & Zarulli (2022), analysing the contributions of causes of death to the sex gap in life expectancy in different countries covering a timespan from the late 1990s to recent years, found that neoplasms, cardiovascular diseases, and external causes of death are the main contributors disadvantaging males. Furthermore, between the two genders, there may be differences in health perception (see the discussion of subjective health in the previous section), because of biological factors and as consequence of widespread and prevailing gender norms, and in health reporting (Verbrugge et al., 1987).

Extensive evidence also shows that health, both in terms of length and quality of life, and its improvements, are not equally distributed within the countries. In Italy, the territorial differences in several dimensions (such as the economic and health ones) are rooted in the country's history since its unification in 1861. As a result, Italy is marked by significant territorial inequalities that, although have been reduced over time, still exist today (Caselli et al., 2021). The territorial dimension has always been a crucial role in interpreting economic and social phenomena in Italy, as in demographic studies focused on mortality (Caselli et al., 2003; Caselli & Egidi, 1980; Caselli & Reale, 1999; Lipsi & Caselli, 2002). Regional differences in mortality are generally caused by a combination of different factors at macro and micro levels (Luy & Caselli, 2007). At the macro level, the varying demographic structure of the territories, their economic conditions, the social and health resources, and factors more closely related to geographical differences (e.g. climate or urbanisation), all contribute to these differences. At the micro level, regional differences results from different share and distribution of individual socio-economic factors, lifestyles, and, finally, also from biological and genetic factors, caused by the heterogeneity of the populations living in the different regions (Luy & Caselli, 2007).

The principle of ensuring high-quality healthcare for everyone, irrespective of where someone lives, has always existed in Italy. The country has indeed established a national healthcare system of a universalistic nature since 1978. Over the years and reforms, the system is becoming more and more market-oriented, and greater degree of autonomy is given to the regions (so that the system is actually decentralised at the regional level, with the reform of the "Articolo Quinto" of the Italian Constitution). The territorial uniformity in healthcare provision is thus limited to the Essential Levels of Care (an examination of health policies since the post-war period in Italy is provided in Egidi & Reynaud, 2005). A detailed overview of how health and mortality are not uniquely distributed over the whole national area in Italy can be found, respectively, in Franzini & Giannoni (2010) and in Chapter 2 of Caselli et al. (2021).

Important disparities in health and mortality persist among different socioeconomic groups in Italy, reflecting a pattern that has persisted throughout its history. At the global level, the World Health Organization recognised in its constitution of 1948 that the attainment of the highest possible standard of health is a fundamental human right, irrespective of race, religion, political beliefs, economic or social status. Later on, for the international movement on the contrast of health inequalities, there have been two crucial documents. First, the Alma-Ata declaration later emphasised the importance of national and international efforts to safeguard and promote the health of all (World Health Organization, 1978). Second, UK's Black Report, named after Sir Douglas Black, also highlighted the need to examine the causes and implications of health differences between social classes and to propose further research (Department of Health and Social Security, 1980). These documents played a critical role in advancing the global movement to combat health inequalities. Since then, numerous studies worldwide have shown the existence of significant socioeconomic inequalities in health and mortality, highlighting the need to address them as a major challenge for public health (Marmot, 2005). Consequently, to this aim, it has been recognised interventions need to be implemented not only within the health sector, but also on the broader economic and social contexts. Improving overall socioeconomic conditions, and educational level in particular, is crucial (Baker et al., 2011; Zajacova & Lawrence, 2018). Achieving health equity and reducing health inequalities have also been one of the pillars of the United Nations in the 2030 Agenda (Sachs, 2012; United Nations, 2015). To quantify socioeconomic inequalities in health and mortality, various individual characteristics can be considered, such as level of education, income, occupation, and more. Among these, education-related indicators are among the most often considered. There are several advantages to considering the level of education in health disparities measurements. Education is closely linked to one's socioeconomic background (Chandola et al., 2006) and can determine opportunities for employment and income, which in turn affects the standard of living and quality of life (although with gender differences). Educational disadvantages (or advantages) cumulate over time and have a lifelong effect. The causal relationship between the level of education and health is complex. Nonetheless, education is found to be associated with several factors, such as the material, psychosocial and behavioural ones that, in turn, influence health (Thrane, 2006). For example, better educated tend to have better health information and healthier lifestyle, better cognitive abilities (even at an older age), and increased ability to relate effectively to healthcare facilities. Furthermore, at the operational level, the advantage of considering education is that it is the most easily accessible information on individuals’ socioeconomic status, which also usually remains stable at a specific level beyond a certain age (usually it is stable at age 30), unlike other indicators such as income which can be greatly volatile (by its very nature). To date, it is more than established that people with lower socioeconomic status suffer from poorer health outcomes, including dying earlier and prematurely, having greater uncertainty about the age at death and, among the various dimensions of health, having worse functional health and more severe disabilities. These disparities not only represent a significant challenge to improving the overall health of the country (Woodward & Kawachi, 2000), but they are also inherently unfair, unethical, and contrary toon of Italian constitutional priorities (as stated in Article 32 of the Italian Constitution). Despite the progress made over time, persistent socioeconomic and territorial variations in health and mortality highlight that there is still much work to be done to promote health equality across Italy. Caselli et al. (2021) recently reviewed the evolution of socioeconomic inequalities in health and mortality in Italy, revealing significant educational gaps and thus the need for further action to tackle these disparities in several indicators. The international literature suggests that southern European countries exhibit smaller socioeconomic inequalities in mortality when compared to other countries, as in Mackenbach et al., 2017. However, this is not necessarily the case for morbidity (as in Mackenbach, 2006 and Solé-Auró & Gumà, 2022), making this discrepancy an interesting are for further study. In a later section of this thesis (section 1.2) a literature review on health expectancy includes a discussion on socioeconomic inequalities, and thus on inequalities in both mortality and morbidity, simultaneously.

1.1.8 Intergenerational overlaps

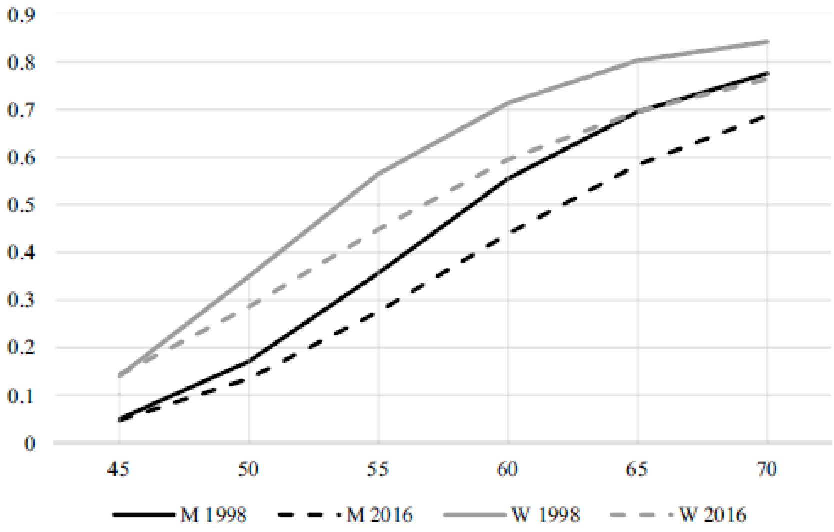
The changes in mortality and fertility that most countries of the world have experienced in recent centuries (as detailed in the first sections) have significantly impacted populations' age structure. The implications of these changes manifest at different levels, including the level of kinship structures. Demographic changes, indeed, affect the length of time that individuals spend in different family roles. While the effect of demographic changes on intergenerational overlaps had rarely been taken into account (Murphy, 2011), it is recently receiving more attention. The demographic transition caused some types of kinship to become more common (i.e. vertical ones, meaning intergenerational ties spanning more than one generation) and others less so (i.e. horizontal ones, meaning having a large number of siblings or cousins). One of the most common forms of family structure becomes the “beanpole” rather than the “pyramid” (Bengtson, 2001). The former is a long and thin multigenerational family, in which individuals have more vertical ties to their primary relatives as they age, but fewer ties to both horizontal close relatives and extended relatives of all types.

Changes in demographic regimes may act differently from one generation to the next, and one of the intergenerational relationships most affected by these changes, and for which peculiar effects can be observed, is grandparenthood. For example, improvements in survival increase the number of living grandparents with whom grandchildren overlap their lives; reductions in fertility decrease the number of grandchildren living at the same time as the older generations; fertility reduction together with fertility delay also has the effect of decreasing the number of people who becomes parents and grandparents during their lives. The length of time of the intergenerational overlap between grandparents and grandchildren can increase due to improved survival of the older generation, but this increase may be offset by reduced and delayed fertility to older ages, cumulated over two generations, affecting the transition to grandparenthood and its timing to older and older ages (Di Gessa et al., 2022; Hagestad & Lang, 1986).

Together with changes in the key demographic components (mortality and fertility), multigenerational family structures, and grandparenthood, in particular, have undergone significant changes during the past century. Skopek (2021) details how the demography of grandparenthood and multigenerational relations have changed from the 1950s to recent years in some European countries. First, the author shows that all of the countries have experienced a significant decline in the "supply" of grandchildren and in the number of family links people experience during their lives. Second, the average age at grandparenthood has increased steadily and the prevalence of grandparents in the populations has decreased substantially across all age groups, but particularly at younger ages. Third, there doesn't appear to be a clear pattern in the trend of "multigenerational lifetime exposure", i.e. the expected length of life lived as a grandparent, and in the age-specific probability of having living grandparents. Skopek’s study confirmed that while reductions in mortality increased the years of life shared by grandchildren and grandparents, large delays in the age of transition to grandparenting and reductions in the number of grandchildren have an offset force on these positive effects of decreased mortality to a considerable extent. In fact, the author finds that, although the number of years grandparents and grandchildren spend together has increased since the 1950s, over the past 40 years, the amount of time spent together has remained around the same and, in some cases, has decreased. This scenario leaves open the possibility that multigenerational exposure will begin to increase again in the future, in the case of mortality continuing to decrease and fertility trends being reversed (Goldstein et al., 2009) or remaining at the same low levels.

Because of its familistic welfare and social system, as well as the inadequacies of public childcare, Italy is undoubtedly one of the countries where grandparents are a crucial resource for the provision of informal childcare (Bordone et al., 2017; Zamberletti et al., 2018), but also social and economic support to their adult children (Albertini, 2016). Moreover, Italy, given its cultural traits and lack of older people's care facilities, is also a country where families tend to be the primary sources of support and care for older people (Kalmijn & Saraceno, 2008). These elements underline how crucial the study of grandparenthood is, especially in a country like Italy. The critical relevance of the topic for the country also prompted a special collection of the scientific journal Genus dedicated to grandparenthood in Italy (Glaser et al., 2022). In the collection, Cisotto et al. (2022) analysed the trends and changes in the demography of grandparenthood in Italy over the last two decades. As found by the authors, Italians become grandparents rarely and later in life compared to the past. The median age at transitioning to grandparenthood in Italy has been postponed by around three years from 1998 to 2016, both for men (59 to 62) and women (54 to 57). The authors also reported the probability of becoming a grandparent by age in 2016 compared to 1998, as depicted in Figure 1.8 for the two genders.

Figure 1.8: Probability of becoming a grandparent in 1998 and 2016 by age and gender



Note: M = men, W = women. Original image from Cisotto et al. (2022)

Nonetheless, thanks to the offsetting effect of the longevity revolution on fertility changes, the number of years grandchildren and grandparents spend together during their lives has increased over the past 15 years in the country (Cisotto et al., 2022).

The ageing of the population and the "demographic stretch" (mentioned in previous sections) also have effects on kinship relationships, such as the ageing of intergenerational relationships and the postponement of the entry into specific family roles, such as becoming grandparents. In turn, the postponement of the mean age at transitioning to grandparenthood can have substantial effects on the time quality of intergenerational overlap and can occur at ages when health is an important and common concern (Margolis & Wright, 2017). Moreover, for understanding the experience of grandparenthood, for both grandparents and their families, the length of time of healthy grandparenthood may be more important than the overall length of grandparenthood. The length of time that a grandparent is healthy or unhealthy strongly impacts the significance of the overlap and the activities performed during grandparenthood. Most importantly, the health of grandparents could determine the direction of intergenerational transfers and affect whether grandparents are potential providers or recipients of care (Grundy, 2005). When in good health, grandparents can potentially provide intergenerational transfers by supporting their adult children or taking care of their grandchildren. Conversely, when they are unhealthy, they are more likely to require care, which could place a significant burden on their adult children and may impact, in turn, their employment (Moussa, 2019) and fertility decisions (Rutigliano & Lozano, 2022). The length of time in which individuals are both grandparents and healthy (disability-free) is determined by three components, namely mortality, morbidity, and fertility-cumulated over two generations. These components, and their dynamics, are known to vary between the genders. Women, in fact, when compared to their counterparts, typically marry younger (with older men), have children (therefore, grandchildren) earlier, and have poorer health during their longer lifespans (Case & Paxson, 2005; Di Gessa et al., 2022). This implies that women may expect to live more grandparent years than men; however, older women, having poorer health than men, may have equal or shorter periods as healthy grandparents. In Italy, the health of grandparents has only been studied to a limited extent, and there is still no evidence addressing the average number of years as healthy grandparents (Margolis & Wright, 2017).

1.2 Literature review on disability-free life expectancies

One of the best features of health expectancy indicators is that they are comparable between groups with different age structures. This makes them particularly suitable for comparisons over space, time, and between different subpopulations. Starting from time trends, Spiers et al. (2021) carried out a systematic review of trends in health expectancies between 1970 and 2017, covering several countries in the world. They found that life expectancy increased faster than healthy life expectancy in most of the countries under study, with some exceptions. Their review shows, therefore, a scenario of expanding poor health in several high-income countries. More optimistic results are found by Robine et al. (2020), in the International Handbook of Health Expectancies (Jagger et al., 2020). They reviewed the research on the evolution of health expectancy, with a special focus on DFLE, throughout the world, concluding that most countries experienced either a relative compression or a dynamic equilibrium of disability. In particular, they highlight that, in the context of increasing life expectancy, most countries experienced a relative compression of disability, both at birth (UK, Spain) and age 65 (US, UK, Sweden, Denmark, Norway, France, Spain, China, and Australia). A dynamic equilibrium of disability has been observed at birth in the US since 1970 and at age 65 in France. In contrast, the countries with the greatest LE, i.e. Japan, Hong Kong, and Singapore, experienced an expansion of disability. The number of years lived with disability has remained nearly constant in the United States, Denmark (for severe disability), and Australia, while it has increased slightly (meaning an absolute expansion of disability) in the United Kingdom, Sweden (for men), the Netherlands, Catalonia (Spain), Japan, Hong Kong, and Singapore, and decreased slightly (absolute compression of disability) in Denmark (for mild disability) and Norway. However, the number of years with severe disability increased overall (UK, France, Japan, Hong Kong, and Singapore), including years with limited mobility (Sweden, Catalonia, Singapore, and, for women exclusively, India) and years needing care (UK, France, Japan). Nevertheless, a relative compression of the most severe disability was found in the United States for men and in Australia for women, whereas the other gender (US women and Australian men) indicated a dynamic equilibrium. It is noteworthy, however, that the countries in this review are only the USA, part of the European countries, Japan, China, Singapore, Hong Kong and Australia. A fundamental share of the planet is still missing from the overall picture, such as India, Africa, South America, the middle east, and eastern European countries. Finally, for Italy, the country under study in this thesis, there are no studies included in the review.

On the discussion of mortality and life expectancy evolution in Italy, there are several studies published in the literature (among others, Lipsi & Caselli, 2002; Luy et al., 2019; Nigri et al., 2022; Vercelli et al., 2014), but evidence of a long-term trend in DFLE are scares and sparse. Frova et al. (2010), albeit covering past trends, show that in Italy disability-free life expectancy at the age of 30 has increased from around 43 and 46 years to 46 and 49 years for men and women, respectively, in the decade 1994-2005. In a study proposing an adjustment in the old-age threshold by health status, Demuru and Egidi (2016) analysed the trend of life expectancy without limitations at age 65 from 1991 to 2013. The authors show that the number of years to live without functional limitations has continuously increased since 1991 for both genders, more for men than women. Additionally, over the study period, they find that the number of years spent with functional limitations increased slightly among women. Overall, the authors show results that point towards a scenario of relative morbidity compression, meaning that the number of years without functional limitations increased more than the number of years with disability. More recently, Caselli et al. (2021), showed that from 2010 to 2017 the DFLE at age 65 increases for both genders. In fact, the DFLE increases from approximately 9 years for both genders in 2010 to 9.3 and 10 years in 2017 for women and men, respectively. Men experienced a greater increase both in absolute terms and as a proportion of life expectancy. It is evident that (probably because of data availability) evidence on long trend in health (or disability-free) life expectancy is very fragmented in the country, as far as is known while writing this thesis. Moreover, it is worth noting that there are no studies providing estimates based on longitudinal data for Italy, which would be more accurate than those based on cross-sectional one (as explained in the methods' section 1.5).

When assessing the existing evidence on inequalities in DFLE, studies examining socioeconomic and gender inequalities are taken into consideration, as they are of relevance in introducing the applications that are presented in the following chapters. Since measures of health expectancy summarise a combination of mortality and morbidity risks, differences in these indicators provide a good summary of the effects of inequalities in healthy and unhealthy life spans.

Socioeconomic differentials in health expectancy summarise the impact of social factors on life expectancy in its healthy (disability-free) and unhealthy (with disability) life years. The differences in mortality and morbidity by socioeconomic status, which translate into differences in health expectancy, have long been acknowledged. Socioeconomic differences have were already shown in Sullivan's 1971 article (Sullivan, 1971), particularly, between “racial” groups in the United States. A large number of studies have dealt with socioeconomic inequalities in healthy living in a wide variety of countries. Two reviews by the REVES network on the topic of socioeconomic inequalities can be identified in the literature. The first one (Crimmins & Cambois, 2002) covers a period up to 1999 and finds that belonging to an advantaged socioeconomic group corresponds to a longer and healthier life compared to disadvantaged ones. Furthermore, they highlight that socioeconomic differences in health expectancy are of greater magnitude than differences in total life expectancy. Indeed, inequalities in mortality and morbidity combine to create larger socioeconomic differences in expected healthy years than in total life years. People in disadvantaged socioeconomic groups have shorter life expectancies, shorter health expectancies, and usually also longer unhealthy lifespans. The second review from the REVES network examined 56 studies published in the period 2000-2018 addressing differences in health expectancies for different socioeconomic groups, covering around 20 countries (Cambois et al., 2020). The studies under review used various measures of socioeconomic status to stratify the population, although most studies were based on educational attainment. Most of the studies used measures of disability and thus analysed differences in DFLE. The different socioeconomic and health measures used in the studies limits the comparability to some extent. Nevertheless, the result from this literature also shows that social inequalities in disability-free (or healthy) life expectancy are wider than in life expectancy. In fact, those at the bottom of the social ladder experience a double disadvantage of spending more years with disability (or in poor health) in shorter lifespans. These results are consistent among the different socioeconomic status indicators and the extent of the inequalities also depends on the health indicator used, showing particularly large gaps for disability. Socioeconomic differences, moreover, are generally of different magnitude between the two genders, with men having the largest gaps compared to women. However, it should be mentioned that almost all estimates in this review were produced in specific countries (as in the case of the DFLE trends review), thus missing part of the potential picture of socioeconomic inequalities in DFLE prevalence around the world.

With regard to gender inequalities, something has already been discussed in the previous sections (see section 1.1.7 on inequalities in mortality and health). Regardless of the health indicator used to calculate health expectancy (including DFLE), women can expect to live a shorter portion of life in good health when compared to men (Di Lego, Di Giulio, et al., 2020; Di Lego, Lazarevič, et al., 2020; Oksuzyan et al., 2010). Pongiglione et al. (2015) systematically review existing studies on different types of inequalities in health expectancy among the older population, confirming the evidence of inequalities associated with several factors, such as gender and educational attainment. Regardless of the health dimension considered for health expectancy, all studies included in their review found that women have longer life expectancies and higher percentage of life lived in poor health (or with disability) than men. The educational gradient affects both life expectancy and health expectancy across studies reviewed, in line with the conclusions of Crimmins & Cambois (2002) and Cambois et al. (2020).

1.3 Objectives of the thesis

Within the context outlined in the previous sections, this thesis aims to achieve six main objectives relating to trends, inequalities, and applications of DFLE in Italy.

The first objective is to provide long-term trend estimates of DFLE, based on longitudinal data, up to the most recent years. The second objective, linked to the first one, is to explain the country's DFLE evolution by quantifying and analysing the contributions given by underlying changes in the dynamics of disability onset, recovery, and disability-specific-mortality (both for those who are disability-free and those with disability), using a novel application of decomposition methods to multistate estimates. The third objective is to shed new light on gender, socioeconomic, and territorial inequalities in DFLE and their intersections, with cumulative factors that could potentially produce a multiplicative burden in terms of disadvantages in healthy lifespans. The fourth objective is to explain these gender and socioeconomic gaps in DFLE by examining the different age-specific contributions of mortality and disability risk differences. Finally, the fifth and sixth objectives are to provide estimates of the evolution over two decades of the length of life to live as grandparents free from disability (the disability-free grandparenthood indicator), by gender, and to disentangle its progression according to changes in survival, due to the longevity revolution, and changes in grandparenthood-disability prevalence, due to improvements in health and the postponement and reduction in fertility.

1.4 Data sources

To achieve the objectives listed in the previous section, the analyses conducted in the next chapters of this thesis are based on three different data sources. These sources are surveys that are all representative of the Italian population living in households, thanks to appropriate sampling strategies and the use of sample weights in the analysis. The surveys, carried out by Istat, are: European Union (Italian) Statistics on Income and Living Conditions (SILC), Aspetti della Vita Quotidiana (AVQ, Aspects of Daily Living), and Famiglie e Soggetti Sociali (FSS, Family and Social Subjects).

The last two, AVQ and FSS, are part of a larger system of the Italian multipurpose household surveys. In the 1980s there has been an exponential growth of social statistical information in the country. During this period, multi-purpose household surveys have been introduced and gradually become a complete system of social surveys. The aim to survey the quality of life of citizens begins to gain importance and, in fact, the demographic information on individuals has been supplemented more and more with a whole other set of broader information, such as that on the social context and the families (Istat, 2010). The design of the first household survey, with a multipurpose connotation, was carried out in the late 1980s, and in the early 1990s, named the Multipurpose Survey System. This system, still present today, consists of seven social surveys: the annual survey "Aspects of Daily Living", the quarterly survey "Travel and Vacations", and five thematic surveys that are carried out every five years, covering the major social aspects and respectively "Health Conditions and Use of Health Services", "Citizens and Leisure", "Citizens' Safety", "Family and Social Subjects", and "Use of Time". The system represents an integrated set of surveys that use common sample designs, definitions, classifications, and methods to ensure the comparability of estimates (Istat, 2006). Among them, the annual "Aspects of Daily Living" survey provides a basic set of indicators each year on several dimensions of citizens' lives. These dimensions are then deepened in the surveys taking place every five years, as, for example, the "Family and Social Subjects" survey for issues related to family networks.

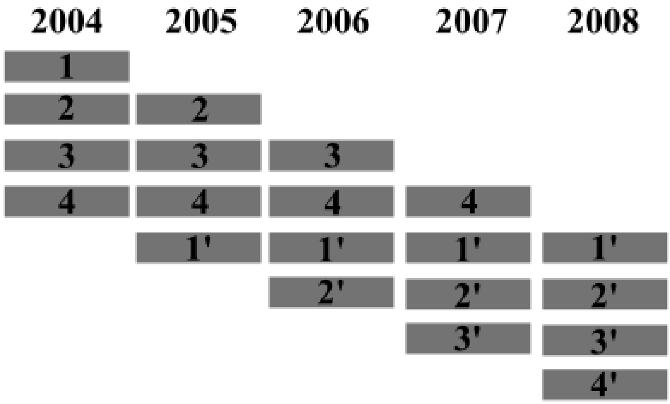
1.4.1 European Union Statistics on Income and Living Conditions

At the European level, it became clear in the early 2000s that it is crucial to have precise and comparable statistical information on the economic conditions of households and individuals living in different countries. In order to address this need, Eurostat, and the national statistics offices in European countries, started to collect a variety of information on the living circumstances of European households. The European Union Statistics on Income and Living Conditions (EU-SILC) project was formally launched in 2004 in fifteen nations, expanded in 2005 to all EU-25 Member States, together with Norway and Iceland and expanded again to Bulgaria in 2006 and to Romania, Switzerland and Turkey in 2007 (Eurostat, 2016). Each country has a degree of freedom on how to collect data, but each one must provide a common (harmonized) output, defined by Eurostat (Arora et al., 2015), specifying social, economic, demographic and health dimensions of interest (although there may be differences among states on how these are measured and collected). The main focus of the EU-SILC survey is on the economic conditions of the population and, in particular, on household incomes and poverty. Along with information of this kind, however, the survey also collects a great amount of valuable information on the wider living conditions of individuals and households (Istat, 2010). These include health conditions, education, employment, family structure, economic difficulties, and so on. This makes it possible, first of all, to analyse the economic context of households in a multidimensional way (such as the multidimensional poverty index (Alkire et al., 2014)). Second, in the context of the topic of interest for this thesis, the multidimensionality of the topics explored in the survey makes it an additional and crucial source of accessible information on demographic and health-related issues, as well. Moreover, the survey annually includes some ad-hoc modules that cyclically explore specific thematic areas.

The reference population of the survey are individuals living in households and residing in Italy, even if temporarily abroad. Therefore, households that habitually live abroad and individuals living in institutions (such as hospices, religious institutions, etc.) are excluded. The survey unit is the “de facto” family, meaning a group of persons bound by marriage, kinship, affinity, adoption, affective ties, cohabiting, and having their usual residence in the same municipality.

The interview is administered to all individuals aged 16 or over in the reference year. The survey design of EU-SILC integrates a cross-sectional and a longitudinal component. For Italy, the sample for each longitudinal survey occasion is a rotational panel (see Figure 1.9) consisting of four rotational groups, each of size equal to a quarter of the total sample size. Each group remains in the sample for a maximum of four consecutive years, each year the sample is renewed with the entry of a new group and the total sample is completely renewed every four years.

Figure 1.9: The rotational design of EU-SILC



Note: own elaboration based on SILC design

With regard to sample size, to have comparability in terms of precision of the estimates among the different European countries participating in the survey, Eurostat imposes a minimum. In the case of Italy, the size of the national sample exceeds the minimum requirements set by Eurostat (in order to guarantee also the information needed for sub-national levels). For example, the required vs actual sample size in 2014 was: 7250 vs 12182 families and 15500 vs 24956 individuals in the cross-sectional component; 5500 vs 9550 families and 11750 vs 19747 individuals in the longitudinal component (Istat, 2021).

Regarding survey techniques, from 2004 to 2010, interviews were conducted in face-to-face mode with a pencil-and-paper questionnaire (PAPI). Since 2011, interviews have been conducted in a face-to-face computer-assisted mode (CAPI). Furthermore, the recruitment, training and conduction of the survey went from being carried out through the municipal survey network to being outsourced to an external company. From 2016 to today, there is a mixed technique using computer-assisted (CAPI) and telephone interviews (CATI), in addition to face-to-face interviews for only a small subset of the sampled households (Istat, 2021).

Of interest to this thesis topic, the survey also collects information on the health status of the population and, specifically, EU-SILC (and IT-SILC, for Italy), embedded in the questionnaire the MEHM set, including the GALI question on longstanding activity limitations. One of the main added values of this survey for being used in health-related studies in Italy is its longitudinal component. For the country, in fact, this survey is among the only few possibilities to follow the health status of individuals over time and, thus, to deepen the dynamic of health, its transition and deterioration over age, in such a way that is representative of the entire Italian population and over a long-time span that covers the last two decades.

1.4.2 Aspetti della Vita Quotidina

The Aspetti della Vita Quotidina (Aspects of Daily Living, AVQ) survey has, since 1993, represented the core and unifying element of the multipurpose system of Istat's sociodemographic surveys. Having an annual frequency, it is, in fact, used to construct the main time series on multiple aspects of Italians' daily life, without going into the details in specific areas which are, instead, explored in depth in the five-year thematic surveys. The main area covered in the AVQ survey is, as the name implies, the daily life of individuals and households. This is considered as a comprehensive domain in which the roles and activities of individuals intersect and merge (Istat, 2010). Among the topics investigated, there are: school, work, family life and relationships, housing and the area in which people live, leisure time, political and social participation, health, lifestyles and use, access, and satisfaction with services. It is possible, in this way, to grasp important aspects related to the quality of life, not only based on direct observation of behaviour, but also from people's perceptions and self-assessments.

The reference population consists of the family “de facto” residents in households in Italy and their members. Individuals living permanently in institutions (nursing homes, convents, etc.) are therefore excluded. Information is provided directly by all individuals aged 14 and over, while children and young people under 14 are interviewed in proxy mode (a parent or an adult member provides the information on their behalf). Certain survey questions, due to the sensitivity of the subject matter, provide the option of non-response. The survey is conducted annually, usually in March since around 2009 (previously, it was conducted in December 1993, November from 1994 to 2003, in March in 2005, and in February from 2006 to 2008) and it involves a sample of about 24 thousand households and over 50 thousand individuals. The interview involves the use of two questionnaires: one by direct interview and one by self-compilation. The survey technique adopted was PAPI until 2016. In 2017, a mixed survey technique, sequential Computer Assisted Web Interviewing (CAWI) and PAPI, was adopted for the first time. In this mix technique, all sample households are web-interviewed and subsequently, non-responding households are surveyed with PAPI interviews. However, in order to keep the effect of the introduction of the web technique under control, for the first mixed technique edition, a sample of households interviewed directly with the PAPI technique was planned, as in previous editions. From 2019, the direct interview part is carried out with a mixed CAWI/CAPI-PAPI technique.

Relating to the health domains covered in this survey, since 2008 AVQ also includes in its questionnaires the complete 3-questions-set MEHM, thus including the GALI question on functional health.

1.4.3 Famiglie e Soggetti Sociali

In 1983, in order to document the social and demographic changes which have profoundly altered not only the various phases of individuals' lives but also the patterns of family life transformations observed in Italy in those decades, the survey “Strutture ed i comportamenti familiari” (Family Structures and Behaviours) was carried out. This was the first survey that investigated in depth the study of the family structure together with family relationships and the support system. The 1983 survey has also been the precursor of the multipurpose survey components on families, under analysis in a chapter of this thesis. The survey launched in the country already in the 1980s collected information on new family forms (such as unions), and the life cycle of women, with a focus on past fertility and marriage histories. In 1998, the collection of information on the family and its transformations was systematised within the new multipurpose system of social surveys, through the specific five-yearly thematic survey "Famiglie e Soggetti Sociali" (FSS, Family and Social Subjects). This survey deepens the study of the organisation of the family through the analysis of its internal structure and the role of the individuals that compose it. The aim is to place the individual within his or her various life contexts: the family, the kinship network, the network of friendships and solidarity, the broader context of his or her social relationships, the work and school environments, leisure time, family habits and traditions (Istat, 2010).

The FSS editions have been in 1998, 2003, 2009 and 2016. The reference population, as in all multipurpose surveys, consists of the family "de facto" residents in households in Italy and their members. The sample size was about 20 thousand households and almost 50 thousand individuals in the first surveys and later reduced to about a total of 32 thousand individuals in 2016. The survey technique adopted has been PAPI for all occasions.

Health information has been collected in the FSS survey ever since its first occasion in 1998 when respondents were asked about the presence of chronic diseases that include permanent disability; since the 2009 edition, the entire set of MEHM questions is included in FSS.

1.5 Methods for disability-free life expectancy and decompositions

Starting from life expectancy, it has long been used as an indicator of population health and consists of a summary measure of mortality, that is independent of the age structure of the population. It represents the number of remaining years, at a given age, that an individual can expect to live if it is assumed that the age-specific mortality risks observed in that year remain constant for at least a hundred years (or the generation extinction time). As discussed in previous sections, as the demographic transition unfolded, infectious diseases, which were the leading cause of death at the beginning of the transition, became to be less and less threatening. In countries in the final stages of the health transition, with longer life spans and ageing populations, chronic and degenerative diseases have increased, and thus the urge has grown to go beyond and extend the life expectancy indicator to find a population health indicator that combines both mortality and health conditions (Saito et al., 2014).

The concept of health expectancies was first proposed by Sanders (1964) and then by Sullivan (1971). The latter provided some preliminary estimates of DFLE and a methodology applicable to any state of health, generally defining the indicators as health expectancies. Since that time, health expectancies have become increasingly popular and have seen various applications. The health expectancy indicator is a summary measure of health and mortality risks faced by the population in a specific year and it is independent of population's age structure. Health expectancy (or DFLE) is defined as the number of remaining years, at a given age, that an individual can expect to live in a healthy (disability-free) state, if the age-specific prevailing mortality and morbidity (disability) risks observed in that year remain constant for at least a hundred years (or the extinction time of the generation). The definition (equivalently to that of life expectancy while considering not only mortality but also morbidity risks by age) allows partitioning, at any age, the number of remaining years into years in the specific health (disability) states, adding the qualitative dimension to the quantity of life. There are as many indicators of health expectancy as dimensions of health. This thesis is devoted to the study of disability (as highlighted in section 1.1.6) and, thus, to the study of DFLE indicators.

In DFLE computations, it is possible to distinguish, primarily, two methodologies according to whether measures of prevalence or incidence of disability are available. The prevalence-based and the incidence-based multistate methods are those used in this thesis and are both introduced and discussed in the following sections.

1.5.1 Prevalence-based method

In his first application, Sullivan (1971) proposed the computation of DFLE based on disability prevalence. This method uses a simple modification of the conventional life table, in order to compute the expected duration of the particular conditions of interest in the population, for example, the duration of the disability-free life. The data needed to calculate these indicators are the life table functions and the age-specific prevalence of the disability-free, for that year, in the population of interest. The key information to be derived from the life table is the average number of life years lived (L_x) in successive age intervals from a cohort of individuals that experience, during their lifetime, the age-specific mortality rates observed in the year. L_x also represents the age distribution of the stationary population associated with the table. Within each age interval, L_x is multiplied by the prevalence of disability-free at that age (π_x^i) in that year:

$$L_x^i = L_x * \pi_x^i$$

As a result, a series of disability-free life years, L_x^i, for each age interval is obtained. If these quantities are then summed for all ages and divided to life table survivors at age x (l_x), as in the computation of life expectancy, it is possible to obtain a disability-free life expectancy at age x $(DFLE_x)$:

$$DFLE_x = \sum_x \frac{L_x * \pi_x^i}{l_x}$$

In this way, life expectancy is specified into the years to live disability-free. If life years with disability and DFLE are computed (and if the disability status is dichotomous, meaning individuals can be either disability-free or with disability), then total life expectancy at each age is partitioned based on the two disability states.

Moreover, to account for the variability around this measure, it is possible to compute DFLE's confidence intervals. First, it is necessary to assume that the total number of individuals with disability within each age interval follows an independent binomial process with constant probability. Under this assumption, the variance of the prevalence at each age ($Var(\pi_x^i)$) is computed as:

$$Var(\pi_x^i) = \frac{\pi_x^i * (1 - \pi_x^i)}{N_x^i}$$

With N_x^i being the unweighted number of survey's respondents in the stratum. From the variance of the prevalence, the variance of DFLE at each age ($Var(DFLE_x)$) is computed as:

$$Var(DFLE_x) = \frac{\sum_x {L_x}^2 * Var(\pi_x^i)}{l_x^2}$$

Finally, to have approximate 95% confidence intervals for $DFLE_x$:

$$CI(DFLE_x) = DFLE_x \pm 1.96 * \sqrt{Var(DFLE_x)}$$

A statistical foundation of Sullivan's method is given by Imai & Soneji (2007).

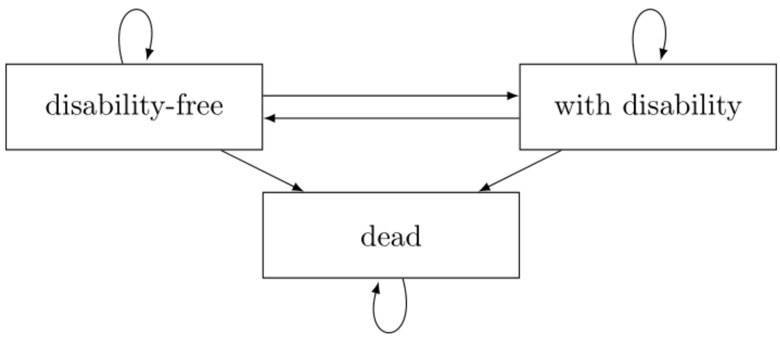
Since this method is based on mortality tables, then DFLE inherits the underlying assumptions on population stationarity (Preston et al., 2001), namely the constancy over time of age-specific risk of death, constancy over time of birth rate and zero net migration rates at any age. These assumptions also imply the constancy over time of the age-specific survival function, the crude death rate equal to the crude birth rate (total number of births equal to the total number of deaths), and thus the constancy over time of the total size of the hypothetical cohort. The only additional assumption of DFLE, other than those inherited from the life table, is the stationarity of the age-specific prevalence of disability. The latter is necessary for the same reason as the other stationarity assumption, specifically for cross-sectional prevalence (referring to different cohorts) to be used for the hypothetical cohort of the table. Thus, if the assumptions of stationarity of death and disability risks are plausible, Sullivan's method provides a consistent indicator of DFLE. Contrarily, if the assumptions are implausible, Sullivan's estimates are not consistent, as this method is unable to detect sudden changes in the risks (Mathers & Robine, 1997). Parallel to these rather stringent assumptions and the inability to capture DFLE during periods of sudden changes in risks (the major drawbacks), this method has wide applicability given that it requires generally available and easily accessible data inputs. Other drawbacks of this method rely on those derived by the use of prevalence measures, particularly the fact that prevalence are strongly affected by the past (health or disability) history of the population. When comparing two populations (or subpopulations or the same population over time), it is important to consider that they may have the same prevalence of a health condition, but differ in terms of incidence, lethality, and mean duration of the condition. Therefore, the same prevalence can arise from very different situations.

1.5.2 Multistate-based method and transition probabilities

The multistate-based DFLE computations are based on the incidence of disability rather than on its prevalence. Multistate method (or Markovian increase-decrease models) have been applied since the 1950s in the social sciences, and early applications include, for example, the works of Prais (1955), A. Rogers (1975), A. Rogers & Ledent (1976), Schoen (1975), Schoen & Woodrow (1980), Willekens (1980), Willekens et al. (1982). The application of this method to health expectancies (and thus also to DFLE) allows for more precise estimates with less stringent assumptions compared to the Sullivan method. The most important added value of this method is the possibility of studying and basing the expectancy estimates on the dynamics of population health (disability), its changes, and the risks of death faced by individuals in different health states.

A common reference for multistate models in health expectancy estimation is the bidirectional illness-death model, represented in Figure 1.10, in which individuals, in the age range considered, can either be: disability-free, with disability, or in the absorbing state dead. This means that the state space is represented, in this case, by the combination of the ages and states (e.g. having 50 years and being disability-free, having 50 years and being with disability, having 50 years and being dead ,…, up to the last age). In this model, a Markov chain is defined to model the transitions of individuals, over their life course, between the transient ("disability-free" and "with disability") states and the absorbing one ("dead").

Figure 1.10: An example of the bidirectional illness-death model



Note: original depiction from Chapter 2 of an illness-death model having two transient states, "disability-free" and "with disability", and one absorbing state, "dead"; the transition from being "disability-free" to being "with disability" is also called the onset of disability; the transition from being "with disability" to being "disability-free" is also called the recovery from disability.

The movements across the states (transitions) are governed by the transition probabilities. Individuals, between two specific ages, can stay in the same state (e.g. disability-free), move to another transient state (e.g. with disability) or move to the absorbing state (e.g. dead, meaning dying), and the process continues over individuals' life course. Formally, the transition probabilities are based on the conditional probability of being at a specific age ($x+1$) in a specific state (e.g. i), conditionally on the previous state (e.g. j) in the previous age (x):

$$p_{i,j} = P(\, i \mid j\,, X = x)$$

In the state space considered here, for each age (and covariate), the transition probabilities are:

$$P(disability\text{-}free \mid disability\text{-}free, X = x)$$

$$P(disability\text{-}free \mid with\ disability, X = x)$$

$$P(with\ disability \mid with\ disability, X = x)$$

$$P(with\ disability \mid disability\text{-}free, X = x)$$

$$P(death \mid disability\text{-}free, X = x)$$

$$P(death \mid with\ disability, X = x)$$

It should be noted that the underlying assumption is that the discrete Markov process is, in this case, of the first order. The first order Markov process assumption implies that the transition probabilities depend only on the state in which the individual is, regardless of the previous paths. In fact, it is here assumed that the process depends only on the state in the present time with no memory of any past transitions.

The first step for computing DFLE in the multistate framework is to model the probabilities of transition between different states, requiring the availability of longitudinal data. A commonly used method for estimating these probabilities is discrete-time event history based on parametric models, such as the multinomial logistic regression (Agresti, 2012). Within this model, the probability of being at a specific age (x+1) in a specific state (e.g. i) is estimated as a function of the previous state (e.g. j) in the previous age (x), and, eventually, some covariates (such as age and sex, for example). The first order Markov process assumption implies that, if age is defined as the metric of time, individuals make only one transition (i.e., remain in the same state or transition to another state) between two consequent ages (one year).

Once these transition probabilities among the states are estimated, it is possible to compose them to form a block diagonal transition matrix $P[p_{i,j}]$. From P it is possible to compose the U matrix, consisting of only (non-null) transition probabilities between transient states (disability-free and disability, thus excluding the transition probabilities to the death states). The U matrix is the base to derive several quantities of interest (see, for example, Dudel, 2021; Kemeny &

Snell, 1976), including the average time spent in a specific state (conditionally or unconditionally on the origin state), such as DFLE. Specifically, the time spent in any non-absorbing (transient) state starting from any transient state can be computed from the fundamental matrix N, defined as:

$$N = [I - U]^{-1}$$

where I is an identity matrix. The column sums of N give, at any age, expectancies conditional on transient states of origin (disability-free and with disability). In this way, the discrete-time multi-state expectancies' computation end-of-interval transitions. To adopt the more conventional (in life tables terms) hypothesis that the event occurs at mid-interval, the column sums is subtracted by 0.5, in case of single ages. In general terms, van Raalte & Caswell (2013) suggest to deduct half of the age interval from the calculated expectancy (see also Caswell, 2001 and Dudel, 2021). More recently, Schneider et al. (2023) also proposed a novel use of rewards-based multistate life tables to consider more flexible transitioning timing. The unconditional expected time can be then computed as the weighted average of conditionally expected time on origin states, with weights being the observed share of individuals in the transient states, at the starting age.

The main strength of the multistate life table method, when compared to the prevalence-based one, in addition to having less stringent assumptions, is especially its ability to consider the implications of age-related health decline and improvement to the average lifespan in a health (disability) state.

1.5.3 Decompositions

As introduced by Canudas-Romo (2003) "In general, to decompose means to separate something into its constituent parts or elements or into simpler compounds. The decomposition methods used in demography also follow this separation principle by dividing demographic variables into specific components". In demographic studies, decomposition methods are indeed widely used for understanding the mechanism producing differences in summary demographic measures (such as, for example, life expectancy or TFR) between different populations, subpopulations of the same population, or the same population over time. These methods are particularly useful as they allow explaining differences in summary measures through the underlying differences in the components used for their computations and, specifically, to attribute differences in the former to contributions provided by differences in the latter.

Historically, it is possible to trace two main research questions in the context of decomposition in demography, especially in the study of mortality and life expectancy. The earliest method aimed at distinguishing the different contributions given by the direct changes in rates versus the changes in the composition of the population, as already in Kitagawa (1955) and later in Das Gupta (1978). The second method, rather than addressing the differences in composition between groups, was proposed to quantify the contribution of the parameters to the variation in the summary measure as function of these parameters. Considering, for example, life expectancy as the summary measure of interest, different analytical solutions have been proposed for its decomposition to answer this second question, in continuous (e.g. Pollard, 1982, 1988) or discrete (e.g. Arriaga, 1984) time settings.

In this thesis, two main decomposition approaches are used and, thus, introduced here: the linear integral method (Horiuchi et al., 2008) and the stepwise decomposition algorithm (Andreev et al., 2002). Both methods aim at answering the second question, are placed in a discrete time setting and are flexible to decompose various summary measures.

Formally, let $\theta_1, \dots, \theta_n$ being the vectors of parameters (e.g. age-specific mortality rates, probabilities of death, disability prevalence) in the two populations to be compared (including the same population at different times) and being the input for the computation of the summary measure $\varphi = f(\theta_1, \dots, \theta_n)$ of interest (e.g. life expectancy or DFLE). If the objective is to explain the observed differences in φ among the two populations, then, using decomposition methods, it is possible to attribute the differences in φ to the contributions of the specific differences in θ among the two populations. Even if the summary measure φ is not an additive function of its parameters θ, the contributions of the parameters, computed through the decomposition, are instead additive, which is one of the most important features of these methods. Take life expectancy as an example of a summary indicator for which the interest is to decompose an observed difference between two populations. Let's imagine constructing life expectancy in the two populations as a function of age-specific mortality rates (its inputs). Then, it is possible to establish the age distribution of the contribution to life expectancy differences in the two populations given by the differences in their mortality rates, through means of decomposition. It is possible to answer other questions such as "which ages have contributed most to the evolution of life expectancy over time in recent years?" i.e. "which ages have seen the greatest improvements in terms of the evolution of mortality risks?".

The first method used in this thesis is the continuous change or linear integral model developed by Horiuchi et al. (2008), which is also equivalent to the life table response experiment (LTRE) developed by Caswell (1996). The reference will always be to mortality and life expectancy, but other dimensions may also apply. At the basis of this method, there is the assumption that the summary measure to be decomposed is a differentiable function of its inputs, and that mortality can vary continuously or gradually along the dimension on which one wants to decompose life expectancy, such as time. Suppose to divide this dimension (e.g. time) into a number of small intervals and estimate the changes needed for mortality rates to vary from the value observed in one population to the other, e.g. at the beginning and end of the time interval. These small variations in life expectancy can be approximated by a linear combination of the partial derivatives of life expectancy with respect to its rates. If these variations are then aggregated by numerical integration along the dimension of interest (in this case time), the contribution of each input can be obtained, i.e. the contribution that the variation in rates at each age gives on the observed variation in life expectancy between the two years.

The second decomposition method used in this thesis is the stepwise decomposition, first described by Andreev et al. (2002) and later also formally explained by Jdanov et al. (2017). In this method, to decompose the summary function, the parameters are exchanged between the two populations, one element at a time. Following each exchange, the summary function is recalculated, and, in this way, the contribution of the parameters is estimated. The idea behind the first steps of this decomposition resembles the counterfactual approach, in which the question relates to what value life expectancy would have if the reference population experienced the age-specific rate observed in the other population. The application of this method consists, specifically, in altering the elements of the input parameters one by one, e.g. starting by inverting the rates between the two populations in the first age class, calculating then the relative life expectancies with this alteration, and, finally, the contribution of the first age class is given by comparing the original life expectancy with the one calculated with the alteration of the input in the first age class. If this procedure is then performed for each age class, one at a time, the contributions made by each age class to the life expectancy differential between the two populations are obtained. The contributions of the changes in the rates in each age group that are obtained in this way, when added together, result in exactly the observed differential between life expectancies in the two populations (just like the contributions from the linear integral decomposition). A disadvantage of this methodology is that, analytically, the contributions may differ slightly depending on which population is taken as the reference (whether the first or the second) and depending on the order in which the inputs are replaced (e.g. increasing or decreasing ages), although several simulations have shown that the differences may be negligible (Andreev et al., 2002), and the result may be averaged over the applications of different orders.

Both these methods, linear integral and stepwise, can be extended to include other parameters (for example, mortality rates by causes of death) or to calculate the contributions to differentials in other summary measures, including health expectancy, as explained in detail by van Raalte & Nepomuceno (2020) using the DemoDecomp R package by Riffe (2018).

1.6 Outline of the thesis

During the three years of my PhD course in the School of Statistical Sciences - curriculum Demography - I had the opportunity to deepen my knowledge, particularly, on the topics of mortality, health, inequalities, and intergenerational relationships. I devoted this thesis to the study of health expectancies, and specifically applied to the dimension of disability, as detailed described in previous sections. In the context of the introduction provided so far in this chapter, this section is dedicated to the presentation of the thesis outline.

Chapter 2 “A Multistate Analysis and Decomposition of Disability-Free Life Expectancy Trends in Italy 2004-2019”, provide an analysis of the evolution of DFLE around retirement age in the last decades in Italy, making use of the multistate incidence-based methodology and the Markov Chains approach, applied to SILC data for Italy, to understand whether the country experience a compression, expansion, or equilibrium of disability. In this chapter, the linear integral decomposition is, then, innovatively applied to the evolution of multistate-based DFLE to infer the role of the underlying dynamics of onset of and recovery from disability and the dynamics of disability-specific mortality in DFLE change. This study reaches the first and second objectives of this thesis (see section 1.3). It was carried out together with Tim Riffe (University of the Basque Country UPV/EHU, Leioa, Spain and Ikerbasque Basque Foundation for Science, Bilbao, Spain) and Angelo Lorenti (Max Planck Institute for Demographic Research, Rostock, Germany) and the manuscript will be soon submitted to a journal in the field of demography.

Chapter 3 “Gender and educational inequalities in disability-free life expectancy among older adults living in Italian regions” aims to shed light on the gender, social, and territorial inequalities that feature the DFLE in the country, while also aiming to disentangle the underlying age-specific differences in risk of death and disability among gender and social groups, reaching the third and fourth objectives of the thesis. AVQ data and life table from Istat are employed in the application of the prevalence-based method to DFLE computation, and in the stepwise decomposition of gender and educational gap in DFLE. It was carried out together with Cosmo Strozza (Interdisciplinary Centre on Population Dynamics, University of Southern

Denmark, Odense, Denmark), starting from my European Doctoral School of Demography (2019/2020) thesis. The reference manuscript has been published in December 2022 in the journal Demographic Research.

Chapter 4 “Trends over two decades of disability-free grandparenthood in Italy and its gender differences” is devoted to the application of prevalence-based health expectancy methodology to a particularly important issue in the Italian context, namely disability-free grandparenthood, using Istat life tables and FSS data. In this work the focus is on the evolution of period life expectancy as a grandparent free from disability for older adults over the past decades, decomposing this evolution into the contribution of changes over time in mortality and disability-grandparenthood risks, and highlighting gender differences. This work reaches the fifth and sixth objectives of this thesis and was carried out with Elisa Cisotto (Free University of Bozen/Bolzano, Bressanone, Italy) and Alessandra De Rose (Sapienza University of Rome, Rome, Italy). The referenced manuscript is currently under review for publication in the journal Demography and the preliminary version of this paper is published in the proceedings of the 51st Scientific meeting of the Italian Statistical Society (SIS).

Finally, Chapter 5 “Discussion and conclusions” jointly discuss the results of the above-mentioned applications, the limits, and the implications of the results.

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2. Multistate analysis and decomposition of disability-free life expectancy trends in Italy 2004-2019

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Abstract

During the last decades, Italy experienced a substantial increase in life expectancy and sustained population ageing, raising concern about whether these phenomena are associated or not with morbidity compression. Disability status is a major determinant of active participation in the familiar, social, and economic context for mid-to-older adults and health expectancies summarise mortality-morbidity risks into synthetic indicators. We aim to trace the long-term trend of disability-free life expectancy (DFLE) in Italy over the last decades and to disentangle its different drivers in terms of changes in disability-specific mortality (both from being disability-free and with disability) and in the dynamics of disability onset and recovery. We draw on the longitudinal component of IT-SILC (2004-2019), estimate transition probabilities using discrete-time event history models, derive DFLE between ages 50 and 79 using incidence-based multistate life tables, and decompose DFLE evolution over time through a novel application of the linear integral decomposition methods to multistate models. DFLE at mid-to-older ages has progressed in recent decades, but not always as favourably as life expectancy. DFLE trends (in absolute terms as well as in proportion to life expectancy) show that Italian women and men around retirement ages experienced disability compression, whereas both had experienced periods of disability expansion in previous years. Decomposing the evolution of DFLE over time reveals that changes in the transition in and out of disability are the most important driving forces of these patterns, while changes in disability-specific mortality contribute to a smaller extent. The changes in the probability of recovery specifically provide the greatest contribution to DFLE evolution, especially in more recent years.

2.1 Introduction

The share of population in mid-to-older ages has increased rapidly in Italy in recent decades, due both to steadily increasing longevity and sustained low fertility. This ongoing changes in population structure has had and will have lasting implications for Italian society in general and the economic and healthcare systems in particular. Much is known about mortality trends and levels, but less about long term population health, especially in terms of its dynamics. Clearly mortality and population health are strongly related to each other, but we do not know (i) whether improvements in health and mortality move in the same direction and the same relative speed (dynamic equilibrium, Manton, 1982), or (ii) whether survival increases faster (expansion of poor health, Gruenberg, 1977; Kramer, 1980) or slower (compression of poor health, Fries, 1980, 1983) than improvements in health. We answer these questions focusing on Italy, the country with the highest share of older population (65+) in Europe and among the firsts in the world. First, we estimate recent trends (from 2004 to 2019) in disability-free life expectancy (DFLE) by gender through incidence-based multistate life tables. This rich model allows us to directly assess which of the scenarios of expansion, compression, or dynamic equilibrium of disability has prevailed in the last decades in Italy. Second, we measure and report the main health and mortality drivers of changes in DFLE, using a novel multistate decomposition approach.

We begin by providing a background, describing the data source and the disability status measurement, then we describe the methods for transition probability estimation and expectancies estimation, as well as the decomposition technique. We then analyse the long-term trend of disability-free life expectancy (DFLE) and life expectancy with disability (DLE) between ages 50 and 79, covering the period 2004-2019. We further examine these trends to address the question of compression, equilibrium, or expansion of disability over the recent decades in Italy. Next, we decompose DFLE changes over time into the age-specific contributions of the changes in the transition probabilities.

2.2 Background

In the last decades, most countries of the world saw a dramatic increase in life expectancy (either at birth or at mid and older ages) with an increase in the record-holding country of almost 3 months per year (Oeppen & Vaupel, 2002). The increase for Italy was particularly remarkable, reaching levels that rank among the highest in the world (United Nations, 2022). In the last two decades, Italian women and men have gained about 3 and more than 4 years of life expectancy, respectively (Caselli et al., 2021). Italy also ranks among the countries with lowest fertility in Europe, with a TFR of 1.27 in 2019 (Istat, 2019). The combination of the longevity revolution and the sustained low fertility levels boost a rapid population ageing process (Grundy & Murphy, 2017; Istat, 2020). Italy experienced a steep increase in the share of older individuals, becoming in 2020 the first country in Europe (and second in the world, just after Japan) by the share of the population aged 65 and over (23.2%) (Eurostat, 2021; United Nations, 2022). This has major implications for Italian society and has caused great concern in the country regarding the sustainability of its social, economic and healthcare systems (Christensen et al., 2009; Harper, 2014; Istat, 2020). One of the major concerns are the consequences on the overall health levels of the population. The question is whether increasing life expectancy is followed or not by improvements in population health.

To go beyond the analysis of life expectancy and assess the health changes linked to population ageing, health expectancy indicators are needed. Those indicators specify the health status (and, thus, the health-related quality) in which life years are lived (Robine et al., 1999). Health expectancies have the advantage of combining both mortality and morbidity risks into a synthetic indicator, also allowing for age-standardised comparisons between different populations (or the same population over time) on both dimensions.

Functional limitations and disability status are major determinants of the quality of life for mid-to-older individuals. Disability status, is, in fact, an indicator of autonomy and limitations in daily activities, and can be a crucial determinant of a person's actual capability of being involved in the familiar, social, and economic context (Newsom & Schulz, 1996). Therefore, disability status also indicates the ability to engage in the labour force during the years around retirement. It also focuses on the functional consequences of diseases, and it can inform on the type and amount of care needed (Ferrucci et al., 2007; Guralnik & Ferrucci, 2003), both from the economic and health systems, but also from the families. Finally, disability is also one of the most consistently measured dimensions of self-reported health for older individuals, when compared to other dimensions (e.g. global self-rated health), as it is the least sensitive to reporting bias or subjective perception (Robine et al., 2020). For these reasons, disability-free life expectancy (DFLE, the average number of years free from disability) is one of the most useful and used indicators among the other health expectancies.

Three theories exist on the potential pattern of morbidity relative to survival. Firstly, the theory of expansion of morbidity (Gruenberg, 1977; Kramer, 1980) argues that increasing life expectancy is linked to an expansion of morbidity in the population, given the increase of the older population that is more exposed to the risk of poor health conditions and the increased survival of individuals with underlying diseases and poor functional health. A more optimistic view, the dynamic equilibrium theory (Manton, 1982), agrees with an expansion of morbidity but only for less serious diseases while postponing to older and older ages the progression to more severe conditions. Finally, according to the compression of morbidity theory (Fries, 1980), the extension of life is complemented by the postponement of all degenerative processes, and physical and mental deterioration, towards older ages.

Robine et al. (2020), revising the existing evidence on the evolution of DFLE all over the world, found that most countries experienced either a relative compression or a dynamic equilibrium of disability. In contrast, a systematic literature review by Spiers et al. (2021) concludes that the increase in life expectancy in good health and without disability has not kept pace with the increase in overall life expectancy. When compared to other European countries, Southern ones, including Italy, are generally found to have lower mortality but poorer health profiles and higher probabilities of health deterioration (Eikemo et al., 2008; Solé-Auró & Gumà, 2022).

Despite several studies reporting the evolution of mortality and life expectancy in Italy (among the most recent, Nigri et al., 2022), there are only a few studies that explore trends in DFLE for the country. Frova et al. (2010) found that, between 1994 and 2005, both life expectancy and DFLE increased, and that the gender differences in DFLE gradually reduced. Moreover, Demuru & Egidi (2016), found that DFLE at age 65 from 1991 to 2013 underwent a relative morbidity compression, since the number of years without functional limitations increased more than the number of years with disability. More recently, Caselli et al. (2021) showed that DFLE at age 65 between 2010 and 2017, increased (from around 9 years for both genders to 9.3 and 10 years for women and men, respectively), with that of men increasing faster.

To our knowledge, all previous studies are based on cross-sectional data and are limited to the analysis of health prevalence and related measures. Instead, we use longitudinal data to follow individuals over time and evaluate health changes as they age and ultimately base our estimates on multistate life tables. Therefore, we are able to better evaluate the recent trends in population health trend by also using the decomposition to understand the role of health and mortality dynamics in producing changes in DFLE over time in the country.

2.3 Data and methods

Data

The study draws on the longitudinal version of the European Union Statistics on Income and Living Conditions (EU-SILC) for Italy. The EU-SILC is the reference source for comparative statistics on income and living conditions for all countries in the European Union. It is also the source used by Eurostat to calculate Healthy Life Years (HLY), as a way to monitor population health in Europe. Member States conduct the survey annually, collecting nationally representative household and personal data. The longitudinal version of EU-SILC is based on a four-year rotational panel; each year, a new sample representative of the whole Italian population enters the study, and it is followed for four years. We use data covering the period 2004-2019. From these waves, all individuals aged 50 years and over are selected and classified by gender and functional health (disability) status.

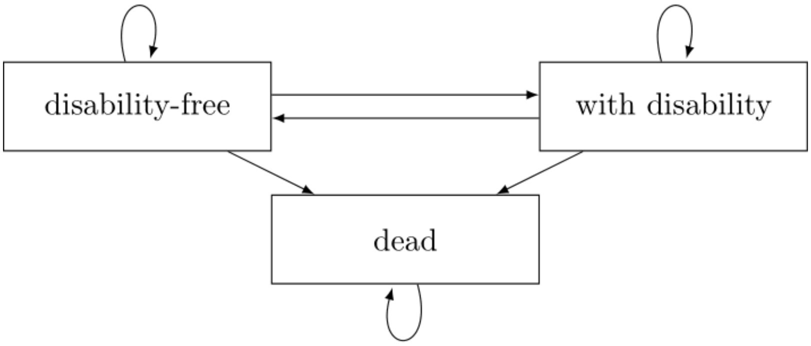
Functional health status is determined through the self-rated long-term limitations in activities because of health problems, using the harmonised question from which the Global Activity Limitation Indicator (GALI) is estimated: “For at least the past 6 months, to what extent have you been limited due to a health problem to perform the activities that people usually do?", where those declaring themselves to be "Severely limited" or "Limited, but not severely" were defined as being with disability, and those declaring "No limitations" were considered disability-free.

Methods

Transition probabilities

To study the dynamic of disability accounting for differential mortality risks, we use Markov-chain multistate models. Individuals change or remain in the same health states as they age, and eventually die or are censored at age 79. The health states are called transient states (i.e. individuals can change health states), while death is the absorbing state (i.e. a permanent condition). Therefore, the state space is given by the combination of the absorbing state and the transient states. We draw on the bidirectional illness-death model, in which individuals, in the age range considered, can either be disability-free, with disability or dead (see Figure 2.1). The health transitions at consecutive ages are estimated using discrete-time event history models based on multinomial logistic regression (with spline of age), through which we estimate the probability of transit among the states. More specifically, we consider the potential permanence in each disability states (namely stay disability-free or with disability) and the possible transitions between the two (transient) disability states and to the (absorbing) death state (namely the onset of disability, recovery from disability, and the disability-specific transition to death). In each model, stratified by gender, we control for educational attainment (based on the highest ISCED level attained, classified as "low" for those who have lower secondary education or less, "mid" for those who have (upper) secondary education, and "high" for those who have more than secondary education) and geographical area of residence (classified as North, Centre, and South).

Figure 2.1: States and transitions in the bidirectional illness-death model



Note: Squares represents the transient (disability-free and with disability) and the absorbing (dead) states, while arrow represents the possible transitions. Note that no arrows leave the absorbing state.

Survival probabilities estimated using survey data are generally less accurate (and typically higher) than those obtained through population registers and provided in the vital statistics and thus need to be adjusted before any comparison with population-level data. Indeed, survey data usually consider only individuals living in households and do not include the institutionalized population. Moreover, loss to follow-up may be more common among unhealthy individuals than among healthy individuals. To adjust our estimate and to obtain a meaningful benchmark with population-level data, we match the transition probabilities with the corresponding survival probabilities of the official period life tables published by the Italian National Institute of Statistics (Istat), using an approach similar to the correction proposed by Dudel & Myrskylä (2017). Specifically, the matching procedure is implemented so as not modify the relationship between the disability trajectories and the trajectories from the two disability states to death, but only to scale the overall levels of estimated probabilities to match the official life tables' survival probabilities. The procedure leans on the idea that, at each age, the survival probability is a weighted average of the disability-specific survival probabilities, with weights given by the prevalence of individuals, at that age, being in each disability status. Thus, averaging the survival probabilities estimated with our models should result in a value close to the one provided by Istat's life tables. When this is not the case, and the estimated average survival does not match the official one, the solution we propose is to calculate the ratio between the two probabilities, to be used as a scaling factor to be applied to all transition probabilities estimated in the models to normalise them. It is noteworthy that this approach does not assume constant mortality across disability states and genders. An example of its application is provided in the Supplementary Materials.

Formally, individuals alive at each age x can either be disability-free or with disability. At age $x + 1$, they can stay in the previous disability state, transition to the other disability state, or die. Then, for each age and level of the covariate of interest, (e.g. gender) we have four transition probabilities from and to transient states:

$$P(disability\text{-}free \mid disability\text{-}free, X = x)$$
$$P(disability\text{-}free \mid with\ disability, X = x)$$
$$P(with\ disability \mid with\ disability, X = x)$$
$$P(with\ disability \mid disability\text{-}free, X = x)$$

and two transitions probabilities to the absorbing state:

$$P(death \mid disability\text{-}free, X = x)$$
$$P(death \mid with\ disability, X = x)$$

The unconditional survival probability from age x to age $x + 1$, is thus equal to:

$$P(alive| \ X = x) =$$
$$\{P(with\ disability \mid X = x) * \ [P(disability\text{-}free \mid with\ disability, X = x) +$$
$$P(with\ disability \mid with\ disability, X = x)]\} \ +$$
$$\{P(disability\text{-}free| \ X = x) * \ [P(with\ disability \mid disability\text{-}free, X = x) +$$
$$P(disability\text{-}free \mid disability\text{-}free, X = x)]\}$$

That is, the unconditional probability of surviving from age x to age $x + 1$ can be expressed as a weighted average of the probabilities of transitioning to (or remaining in) the health states (and thus not transiting to the death state), weighted by the prevalence of individuals in the two health states. Once $P(alive \mid X = x)$ is estimated, it is used to compute the scaling factor by dividing it to the corresponding probability from official life tables. This scaling factor is then applied to all transition probabilities so that our adjusted estimate of $P(alive \mid X = x)$ is matched with that of official life tables.

This correction approach exploits the empirical distribution of states at each age, which differs from the Dudel & Myrskylä (2017) approach which matches the marginal distribution of the states within the Markov chain. As a consequence, our approach does not "transmit" the scaling correction that occurred at earlier ages, as in their procedure. The life table distribution is the limiting distribution for both methodologies, thus the two produce very close (if not equal) results, but our proposal has the advantage of being s faster but still accurate approximation of the Dudel & Myrskylä's (2017) procedure.

Expectancies estimation

Starting from these adjusted transition probabilities we derive disability-free life expectancy (DFLE) and life expectancy with disability (DLE) between ages 50 and 79, by gender, between 2004-2007 and 2016-2019, through Markov Chain multistate incidence-based life tables. We first use the estimated transition probabilities to build the transition matrix, *U*, then transpose and invert *U* to obtain *N*, the fundamental matrix (Kemeny & Snell, 1983). From the fundamental matrix, we finally derive all the relevant quantities, such as the unconditional average time spent in the two transient states; a detailed overview is provided by Dudel (2021). Confidence intervals for the expectancies are obtained through non-parametric bootstrap; we use 1000 replications of the SILC data through a sampling procedure that preserves the observed longitudinal structure.

Decomposition

Finally, we use demographic decomposition to determine the different age-specific contributions of the changes in the transition probabilities to the observed changes in DFLE over time. We decompose DFLE evolution using a decomposition approach that focuses on the forces of attrition (transitions between disability states, and mortality) and that preserves the composition of the transition probabilities. Specifically, for purposes of decomposition, we calculate DFLE using the following four probabilities, each a vector over the full age range.

$$P(disability\text{-}free \mid with\ disability, X = x)$$

$$P(with\ disability \mid disability\text{-}free, X = x)$$

$$P(death \mid disability\text{-}free, X = x) = 1 - P(with\ disability \mid disability\text{-}free, X = x) - P(disability\text{-}free \mid disability\text{-}free, X = x)$$

$$P(death \mid with\ disability, X = x) = 1 - P(disability\text{-}free \mid with\ disability, X = x) - P(with\ disability \mid with\ disability, X = x)$$

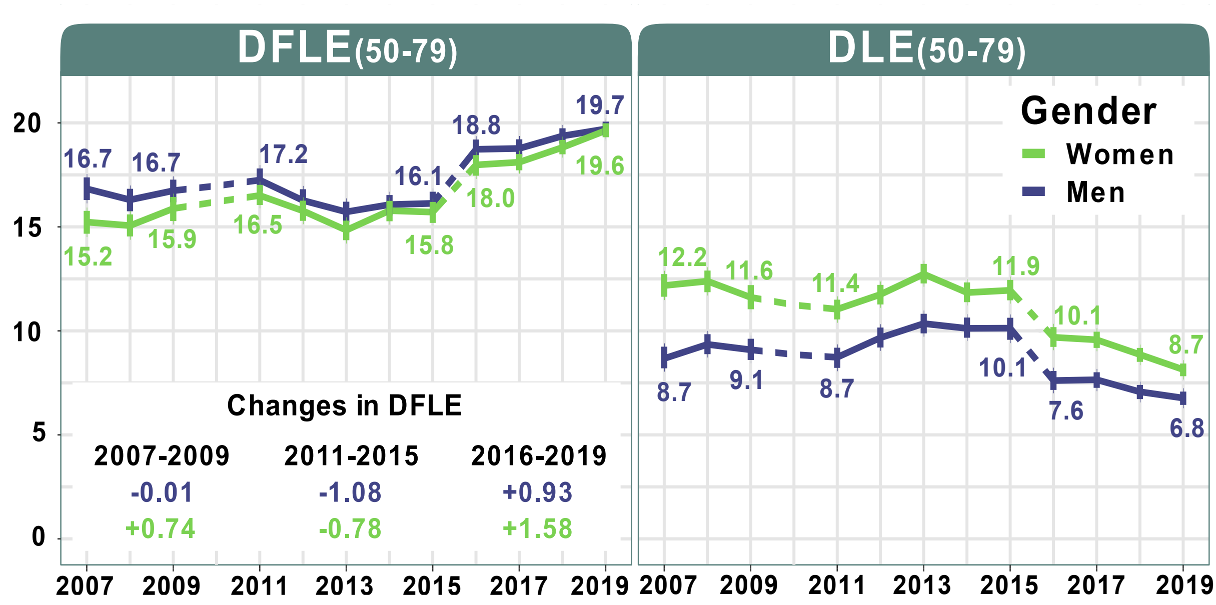
These four vectors are organised into a single vector, θ, which contains all parameters required to calculate the matrices U, N, and our final DFLE estimate. Given the function DFLE = $f(\theta)$, we are then able to decompose the difference in DFLE implied by two versions of θ, in our case relating to different time period. Given this setup, we are able to apply the pseudo-continuous decomposition approach proposed by Horiuchi et al (2008) and implemented in the R package DemoDecomp (Riffe, 2020). The result of the decomposition is a vector of age-specific contributions from each difference in the parameter vector θ to the difference in DFLE, which can then be aggregate along selected dimensions to present.

2.4 Results

DFLE trend

DFLE between ages 50 and 79 for Italian men and women in 2007 was around 16.7 and 15.2, respectively (Figure 2.2). Focusing on the long trend in these two indicators up to 2019, we can observe that DFLE of both women and men increased, reaching almost 20 years for both genders (19.7 for men and 19.6 for women). In the same period, DLE between ages 50 and 79 decreased, faster for women than for men (from 12.2 and 8.7 to 8.7 and 6.8 years, respectively).

Figure 2.2: Trend in life years disability-free (DFLE) and with disability (DLE), age 50-79, men and women, 2007-2019



The two periods indicated with dashed lines (between 2009 and 2011 and between 2015 and 2016) denote data and comparability issues, that will be further elaborated in the limitations section. Given these breaks in DFLE trends, we consider separately the changes in DFLE in three different periods: between 2007 and 2009, between 2011 and 2015, and between 2016 and 2019. First we evaluate whether each period is characterised by a scenario of the compression, expansion, or dynamic equilibrium of disability. We do so by considering together the evolution of DFLE, DLE and the proportion of disability-free years over total life expectancy (H indicator), as detailed in Table 2.1.

In the first period (2007-2009), the DFLE of women increased (+0.7 years) while that of men remained almost constant. In the same period life expectancy increased for both genders but faster for men than for women. Consequently, in this period DFLE of men increased and the H indicator decreased (Table 2.1). These changes represent a scenario compatible with the absolute expansion of disability. The more favourable evolution of DFLE, DLE and H indicator for women, instead, is compatible with an absolute compression of disability, given the increase in DFLE, decrease in DLE and increase in the H indicator (Table 2.1).

In the second period (2011-2015), DFLE decreased for both genders and especially between 2011 and 2013. The change between 2011 and 2015 is slightly larger for men (-1 year) than for women (-0.8 years). For both genders, given that life expectancy increased in the same period, the decrease in DFLE is accompanied by an increase in DLE and a decrease in the H indicator, implying an absolute expansion of disability (Table 2.1).

In the last period (2016-2019), both older women and men experienced an increase in DFLE (from 18.0 to 19.6 and 18.8 to 19.7, respectively). In this way, men recovered the loss of disability-free years experienced in previous years, while women continued the progress in DFLE observed in the first period (2007-2009). Given that in this period, together with an increase in DFLE, the DLE decreased, and the H indicator increased, we observe an absolute compression of disability for both genders (Table 2.1).

Table 2.1: Observed changes in the indicators of interest (DFLE, DLE, LE and H) between ages 50 and 79.

	2007	2009	↑↓=	2011	2015	↑↓=	2016	2019	↑↓=
					Women				
DFLE	15.2	15.9	↑	16.5	15.7	↓	18.0	19.6	↑
DLE	12.2	11.6	↓	11.0	11.9	↑	10.1	8.1	↓
LE	27.4	27.5		27.5	27.6		27.7	27.8	
H	55.5	57.8	↑	59.9	56.9	↓	65.0	70.7	↑
					Men				
DFLE	16.7	16.7	=	17.2	16.1	↓	18.8	19.7	↑
DLE	8.7	9.1	↑	8.7	10.1	↑	7.6	6.8	↓
LE	25.4	25.8		25.9	26.2		26.3	26.5	
H	65.7	64.8	↓	66.4	61.5	↓	71.1	74.5	↑

Note: values of DFLE, DLE and H indicators are reported for the analysed periods. Arrows indicates whether the indicator has increased (↑), decreased (↓), or remained stable (=) over the period.

Decomposition

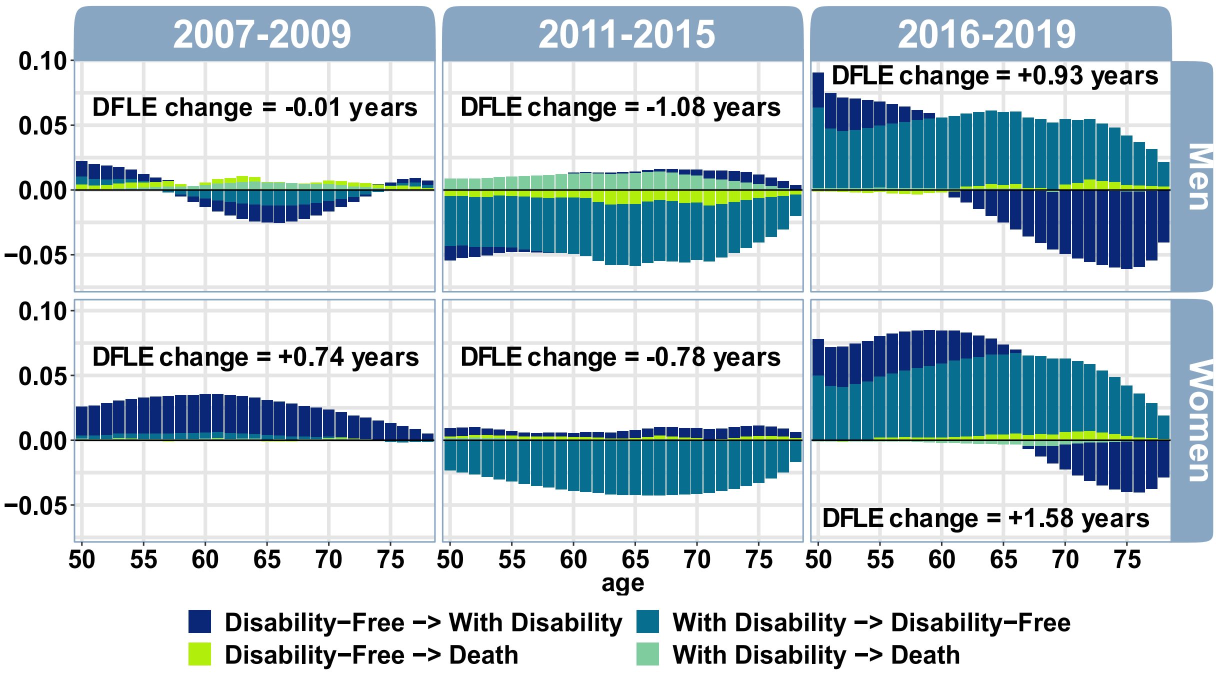
The decomposition of the observed changes in DFLE, over the three periods, allows understanding the impact of the dynamic over time of disability (recovery and onset), and disability-specific mortality (from being with disability and disability-free) on this indicator. The age-specific contributions of the changes in the transition probabilities to the changes in DFLE evolution of the changes in the transition probabilities, for the three different periods, are shown in Figure 2.3. Values greater than zero denote positive contributions to the evolution of DFLE, indicating that the transitions under consideration have driven DFLE towards higher values over time. Conversely, negative values represent contributions towards a decline in DFLE.

In the first period (2007-2009), men experienced a stagnation in DFLE. Their survival probabilities from being with disability and disability-free improved, positively contributing to DFLE change. This improvement was however offset by two negative contributions. First, a decrease in the recovery probability (from being with disability to being disability-free) between around age 60 to age 70. Second, an increase in the probability of disability onset (from being disability-free to being with disability) in the same ages. In contrast, these two transition probabilities contributed positively up until age 57 and after age 75. Over the same period, women experienced a rather small increase in DFLE almost entirely driven by the positive contribution of the decrease in the probability of disability onset, i.e. the probability for women of becoming with disability in 2009 was lower than that in 2007.

In the second period (2011-2015), both women and men experienced a decrease in DFLE, equal to -0.8 years and -1 year, respectively. In this period, for both genders, the major negative contribution to DFLE trend was given by the decrease in the recovery probabilities at all ages. For men, the increased probability of death for the disability-free also contributed negatively, while improved survival from being with disability contributed positively to DFLE evolution of this period. The latter contribution indicates that men with disabilities in 2015 had a better chance of survival than in 2011. This contributed positively to DFLE change as individuals with disabilities who survive longer also had opportunities to recover, and thus to add disability-free years to their remaining lifetime. Women experienced a slight increase in the probability of recovery at all ages, giving a small but positive contribution, which partially offset the other negative contributions.

In the last period (2016-2019), both men and women experienced an increase in DFLE, larger for women (1.6 years) than for men (0.9 years). The different transition probabilities contributed similarly for the two genders in this period. Specifically, both genders gained DFLE years mostly because of the large positive contribution of the probability of transitioning to disability-free state from being with disability, indicating a relevant increase in the recovery probability from 2016 to 2019 (at all ages but decreasing at older ages). Another relevant contribution to the increase in DFLE, for both genders, comes from the transition from being disability-free to being with disability, that was positive at younger ages and negative at older ages. In particular, for men, the probability of the onset of disability declined up to the age of 60 and then rose, while for women the decline occurred up to the age of 66 and rose thereafter. There is a relevant gender difference in the extent of the negative contribution at older ages of the probability of disability onset. Men also experienced large increase in the probability of disability onset at older ages, resulting in an overall smaller increase in DFLE in this period. In this period as well, the changes in the transition probabilities to the dead state (from being disability-free and from being with disability) contributed only slightly to DFLE evolution for both genders. For women, the transition probability to death from being disability-free contributed positively (even if to a smaller extent), indicating an improvement in the survival of the disability-free between around ages 60 and 75. For men, the survival of the disability-free contributed negatively (again, to a smaller extent) up to around age 60 and positive afterwards, indicating lower probabilities of survival before and higher afterwards. For women, the transition probability to death from being with disability, made a small and negative contribution, indicating that the survival of women with disability slightly worsens in the last years of the study. The survival probability of men with disability remained unchanged in this period.

Figure 2.3: Age-specific contributions to DFLE (50-79) change, 2009-2007, 2015-2011, 2019-2016, men and women



2.5 Conclusion and discussion

In a context like the Italian one, with an extraordinary history of increasing life expectancy and a rapidly ageing population, this article traces the long-time trend of DFLE, from the early 2000s up until the most recent years, among Italian men and women between ages 50 and 79. Together with the trend in DLE, the information on DFLE allows us to assess whether the country experienced an expansion, compression, or dynamic equilibrium of disability over the last decades in this age range. This is crucial to understand whether the ageing population is sustainable (socially and economically) for the country. Furthermore, in this article, we decompose DFLE changes over time with the aim of understanding the reason behind the evolution of DFLE. We express the contributions to DFLE in terms of the underlying changes in disability-specific mortality and in the dynamics of disability onset and recovery.

During the last two decades, DFLE around retirement age progressed, even if not always as favourably as life expectancy. Between ages 50 and 79, women and men show disability compression in more recent years, whereas both experienced periods of disability expansion previously. Specifically, between 2007 and 2019, women consistently show evidence of absolute compression of disability in the age range considered, except for the period from 2011 to 2015 when they experience an absolute expansion of disability. At the same ages, men experienced an absolute compression of disability limited to the years between 2016 and 2019, while they experienced absolute expansions of disability in earlier years. The trends observed in DFLE from mid-to-older ages exhibit a more favourable trend for women than for men. In fact, if the gender gap, disadvantaging women, in DFLE was around one and a half years in 2007, the two genders shared similar DFLE in 2019, narrowing the gap to almost zero years. Through the decomposition of its changes, we shown that the evolution in DFLE (increase and decrease) is driven by changes in the transition in and out of disability. On the contrary, the changes in the probabilities of death contribute to a small extent. The improvement (worsening) in the recovery probability and the decrease (increase) in the onset probability are the most important forces for the increasing (decreasing) DFLE around retirement age. Women are particularly advantaged over men in terms of the greater decrease in the probability of disability onset.

Comparison with evidence in the literature

The disability compression we found in the most recent years is in line with results for other countries (such as the review of Robine et al. (2020)) and specifically for Italy (such as the more recent of Caselli et al. (2021)). Nevertheless, all the studies referring to Italy are based on cross-sectional data and analyse prevalence-based measures.

More unexpected finding was that of the expansion of disability in previous years. This finding is nevertheless supported by the evidence of rising activity limitations found by Mackenbach et al. (2018), referring to European countries (including Italy), using the same data source (SILC). An expansion of disability was also found in France by Cambois et al. (2013) when considering a similar age range spanning mid-to-older ages. Specifically, the authors observed that, in the early 2000s, while the trend in DFLE from age 65 onward showed a dynamic equilibrium, DFLE between 50 and 65 declined (for various dimensions of disability). This may suggest that, even for Italy, the improvements found in the literature relating to not-truncated DFLE (e.g. 65+, as in Caselli at al. (2021)) may be mostly attributable to greater improvements in disability at older ages (80+) than at younger ones (50-79), with the former outweighing the latter.

Specifically, we observed an expansion of disability for both genders in 2011-2015, with a particularly sharp decline from 2011 to 2013. This period is marked by major economic shocks due to the Great Recession, which began in 2008 in the US and then spread to other countries of the world. Egidi & Demuru (2018) highlighted the consequences of the recession on mortality and health in Italy, in line with our results. The Italian context was characterised by incredible drops in GDP per capita and surges in the unemployment rate from the early years of the recession, which continued to worsen at even higher paces between 2011 and 2013. Egidi & Demuru found a stalling and in some cases even a worsening, of severe functional limitations. This is true especially among younger-to-older adults, while the older individuals were less affected. Finally, the authors highlight the concerning decrease in the use of preventive and health care services. This may be linked to the costs associated with these services, which may have represented too heavy a burden for those who were hit the hardest by the recession. These points bring light to the detrimental impact of the recession, together with the implementation of economic measures such as austerity, on the overall welfare and wellbeing of individuals.

Limitations and strengths

This study presents some notable advantages and some limitations. First of all, there is no longitudinal survey focusing on health and disability in Italy and the only data sources specifically designed for the study of health and its determinants at the national level (for example the European Health Survey and the survey Aspects of Daily Living) are cross-sectional. SILC is a longitudinal data source conducted by Istat at the national level that also includes some questions on health conditions. There are several advantages to drawing on a longitudinal data source, like SILC, in DFLE computation, compared to a cross-sectional one. It allows considering the dynamics of (un)healthy ageing, by estimating the transition probabilities among disability states and the disability-specific mortality. From these transition probabilities, it is possible to compute multistate estimates of health expectancies (in this study, disability-free estimates), resulting in more accurate results than those derived from prevalence-based methods (such as Sullivan's (1971)).

Nevertheless, the use of SILC also entails some drawbacks for the objectives of this research. First, the purpose of SILC is primarily to collect data on income, poverty, social exclusion and living conditions, while questions on health conditions remains marginal. Specifically, the SILC questionnaire only incorporates the three-question-set of the Minimum European Health Module (MEHM), which includes the GALI question. Despite having its own limitations, being a self-reported single-item question, GALI has been shown to be a good indicator of participation restriction because of health problems, also in terms of validity and reliability (Van Oyen et al., 2018).

The second limitation of the use of SILC for our objectives, and common to most survey data, is that it suffers from attrition, weak mortality follow-up and the target population are individuals living in households (thus excluding those living in institutions, probably in worst health conditions). For these reasons, mortality underestimation (and therefore life expectancy overestimation) when compared to population-level measure is inevitable. To overcome this issue, we propose a correction method that allows SILC mortality and life expectancy estimates to be comparable to those at the population level.

Third, SILC interviews are conducted annually, which means that, in estimating the transition probabilities of individuals followed longitudinally (for at least two survey occasions), it is assumed that they make a single transition (to the same state or to another state) within the year. This is a reasonable assumption given the small interval and that GALI refers to long-term limitations in activities ("...for at least the past six months…").

A fourth and crucial limitation concern the variations in SILC questionnaires and survey techniques over time, which prevent direct comparisons between estimates over the long time-span considered (2004-2019) and instead constrains our analysis to be broken into three distinct periods. As shown in Figure 2.2 from the results section, the DFLE trend has two breaks (represented by the dotted lines in 2010 and between 2015 and 2016) that are fully attributable to data issues.

Starting from the break of 2010, DFLE (and DLE) estimate for this year is not included in our trend, because the result is strongly influenced by reasons not attributable to health and mortality changes, turning the estimate to be unreliable. In particular, until 2010 interviews were conducted in a face-to-face setting with a paper-and-pencil (PAPI) survey technique, which was substituted by a computer-assisted (CAPI) technique. Moreover, before 2010 the recruitment, training and conduction of the survey were carried out through the municipal survey network, while from 2010 onwards the survey was outsourced to private survey networks managed by contracted companies. Finally, the 2010 SILC survey for Italy includes an ad-hoc module ("Health Conditions" in: Individual Questionnaire, Section 3) with several questions relating to disability and specifically to limitations in the Activities of Daily Living.

These three factors may have affected answers related to GALI and, for this reason, this data point was not validated, either by Istat or Eurostat's HLY. These issue are also explicitly noted in the country reports for Italy provided by the European Health and Life Expectancy Information System (EHLEIS Information System, 2018), within the EurOhex project, stating that the GALI prevalence from the 2010 SILC was not validated and it was estimated as the mean prevalence of 2009 and 2011.

The steep increase in DFLE (about 2 years) between 2015 and 2016 is mostly attributable to data issues and specifically to the fact that between 2015 and 2016 the survey technique switched from CAPI to a mixed one, in which most of the interviews were conducted by telephone (CATI). The whole questionnaire also changed accordingly (with the aim of making it more convenient in a telephone interview) and, together with the modified interview setting (being no longer face-to-face), may modified the attitude towards disability reporting.

Another limitation is that all ages above 79 are aggregated in a unique "80+" category. This is a relevant drawback for the analysis of health status, especially in an ageing country like Italy (where the age class 80+ may be very heterogeneous), forcing the analyses to be restricted up to age 79. This prevented us from making more general considerations as to whether poor health or disability are being compressed or expanded throughout the life course over age 50 and especially at older ages.

Finally, because of this of small numerosity in the strata, this study does not consider that DFLE is unequally distributed within the country and between social groups (Moretti & Strozza, 2022) and also its evolution may be different. For this reasons, the results shown here may be an average of what can be observed in the different regions and macro areas or between individuals with different levels of education. Moreover, we condensed the disability status in a dichotomous variable, irrespectively of its severity (GALI distinguished between mild or severe disability). The results, in fact, do not allow to capture whether the compression (expansion) experienced by the two genders over time is attributable to improvements (worsening) of mild and/or severe disabilities. The disability expansion, for example, can result from an increase in mild disability but a decrease in the severe ones.

Despite these limitations and the challenges arising from some of them, our study presents a number of advancements compare to the state of the literature, using various methodological and analytical strategies to minimise possible sources of bias. This is the first study on Italy that uses longitudinal data to estimate transition probabilities among disability states and to death (using discrete-time event history models) and, based on those, estimates DFLE (through Markov Chain multistate incidence-based life tables) and its long trend. Moreover, using a decomposition method that has been applied in a novel way to multistate models, we provide explanations of DFLE changes in terms of changes in underlying transition probabilities over time. We believe that providing these estimates is essential in an ageing country, that has experienced great improvement in mortality and health, both in the past and in recent decades, and where the evidence on the dynamics of morbidity and health deterioration from mid to old age are still very scarce, sparse and based on cross-sectional data.

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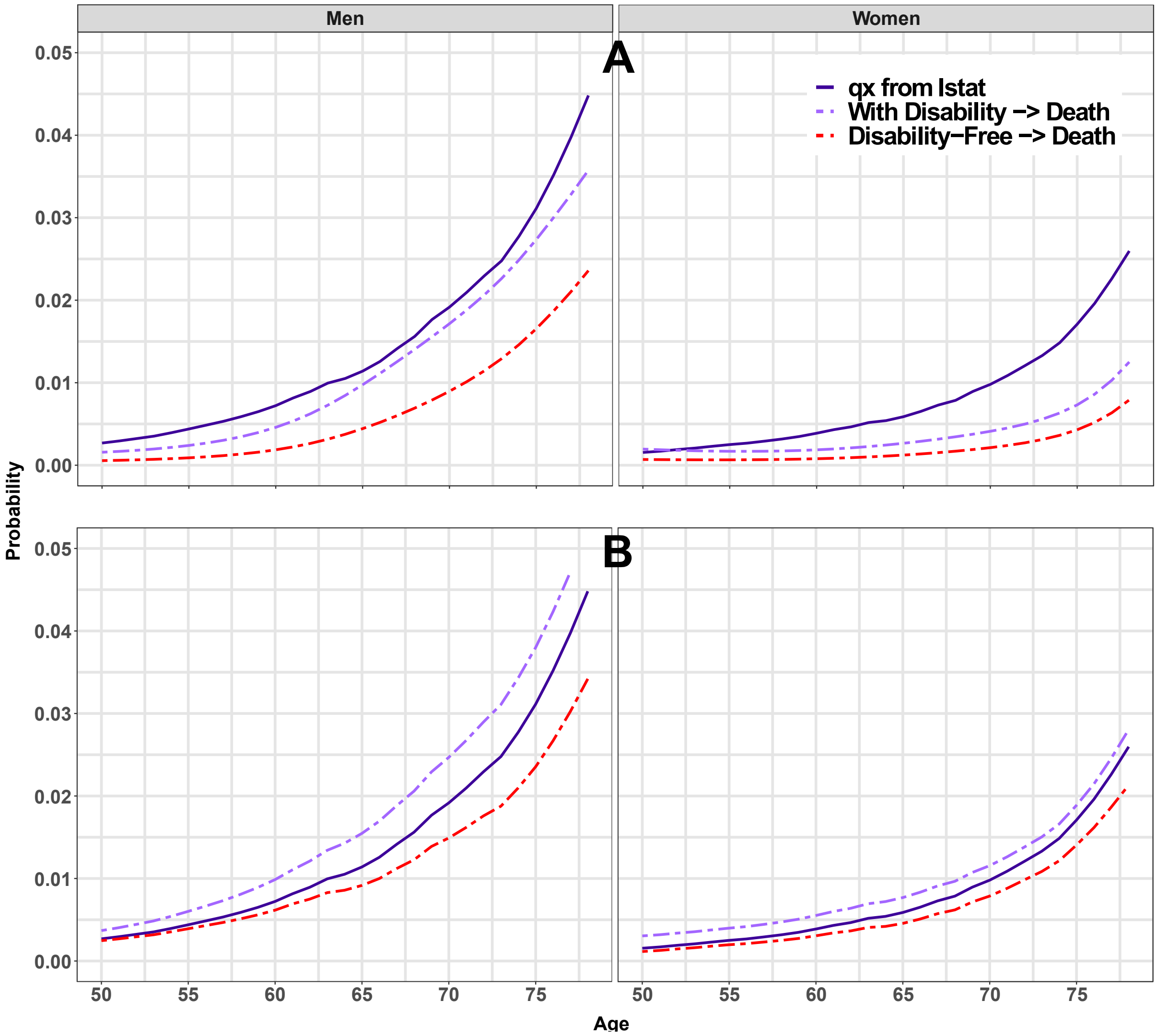
Supplementary materials

Correction Method

Figure 2.4 shows an example, for the year 2013, of the application of the correction method that has been explained in the methods section. In particular, the figure shows the age-specific progression of the probability of death by disability status (the transitions from being disability-free or with disability to death) from SILC, before (Panel A) and after (Panel B) the correction, in comparison with the population-level mortality rate provided by Istat (qx, from the life tables). To be noted that the correction procedure does not modify the relationship between the disability-specific risk of death, but it only scales the levels (and thus of all probability of transition among transient and the death state) to match the death probabilities from the life tables.

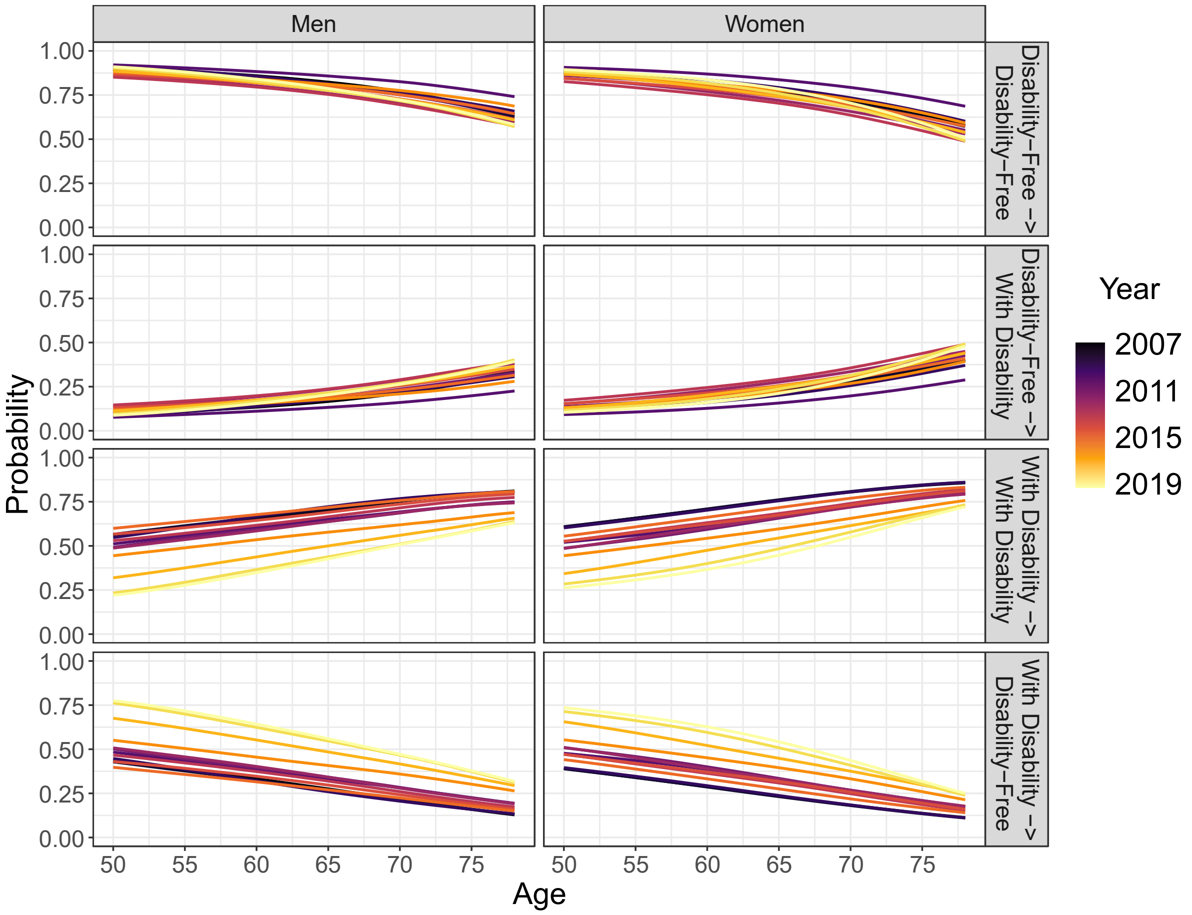
Figure 2.4: Age-specific probability of death at the population level from Istat compared to the probability of death by disability status from SILC in 2013 by gender



Evolution of transition probabilities among transient (disability) states over time

Figure 2.5 shows the yearly evolution over time (2007-2019) of the age-specific transition probabilities among transient states, namely the probability of staying disability-free, the onset probability (transition from being disability-free to being with disability), the probability of staying with disability and the recovery probability (transition from being with disability to being disability-free), by gender.

Figure 2.5: Transition probabilities among transient (disability) states, by gender, from 2007 to in 2019



3. Gender and educational inequalities in disability-free life expectancy among older adults living in Italian regions

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Abstract

BACKGROUND

Italy's life expectancy at age 65 is one of the highest in Europe, but its disability-free life expectancy (DFLE) is not so high. To understand this diverging pattern of longevity and health it is essential to consider indicators accounting for both mortality and morbidity, and to analyse the gender, social, and geographical inequities characterising them.

OBJECTIVE

The aim is to quantify the gender, social, and geographical inequalities in DFLE among Italian older adults and analyse the age-specific contribution of mortality and morbidity to those inequalities.

METHODS

This study draws on census-linked mortality data and disability prevalence for the years 2012–2014. DFLE at age 65 in Italian regions is computed by gender and educational attainment using the Sullivan method. Age-specific mortality–morbidity contributions to the gender and educational gaps in DFLE are calculated using the stepwise decomposition method.

RESULTS

Although at the national level older women and men share similar DFLE, these estimates hide important geographical and social inequalities. Women's health disadvantage completely outweighs their life expectancy advantage, resulting in lower DFLE. Educational inequalities in health are far more dramatic than those in mortality and the disadvantage in DFLE accumulates over education and region of residence.

CONCLUSIONS

In Italy notable differences in DFLE are found between genders and between educational groups, suggesting the need for better health policies aimed at reducing inequalities.

CONTRIBUTION

This study provides novel empirical findings on gender, educational, and geographical inequalities in DFLE for Italian older adults and explains how age-specific mortality and morbidity contribute to shaping these inequalities.

3.1 Introduction

Steady increases in life expectancy and longevity have been predominant features of the demographic change worldwide (Oeppen and Vaupel 2002). In this context, Italy ranks among the European countries with the highest life expectancy at both birth and at age 65. In 2019 Italian women placed fourth, behind Spain, France, and Switzerland, with a life expectancy of 22.9 years at age 65. Italian men ranked sixth, only a half-year gap from Switzerland, which ranked first (20.3 and 19.7 years of life expectancy at age 65 in 2019 respectively) (Eurostat 2022). There is an ongoing debate on the consequences of (population) ageing for population health (Fries 1980; Gruenberg 1977; Manton 1982). Understanding whether increased life expectancy is complemented by the improvement in the health conditions of those who reach older ages is crucial. Disability resulting from functional limitations is one of the most important dimensions of morbidity to consider in ageing populations such as the Italian one. It determines whether people at older ages can actively engage in daily activities within the family, society, and the economic context. In societies with an older population–age structure it is essential to go beyond life expectancy and consider indicators that simultaneously account for mortality and morbidity. For this reason, health expectancy indicators, such as disability-free life expectancy (DFLE), were introduced in the second half of the 20th century (Sanders 1964; Sullivan 1971). When considering DFLE, Italy loses its advantage in terms of life expectancy at age 65 (Eurostat 2022). Italian women rank thirteenth in Europe, 6.4 years behind the frontrunner, Sweden (10.2 and 16.6 years of DFLE at age 65 respectively). Italian men rank ninth, 5.3 years behind Swedish men (10.6 and 15.9 years of DFLE at age 65 respectively). Studies on inequalities in DFLE are essential to deepen knowledge on the diverging patterns of longevity and healthy longevity in Italy.

It is well known that longevity and health are characterised by gender inequalities: women outperform men in terms of survival, while men have better health at older ages than women, the so-called “health–survival paradox” (Case and Paxson 2005). This paradox can be explained by the different disease patterns of the two genders, by differences in health reporting, and also by the association between health and mortality: as women live longer they are more likely to be exposed to poor health conditions than men (Di Lego, Di Giulio, and Luy 2020). A study by Frova, Burgio, and Battisti (2010) shows that (until 2005) gender inequalities in DFLE at birth in Italy were declining, mainly due to mortality improvement among men, but still favoured women. However, focusing on older Italians (DFLE at age 65), nowadays men expect to live more healthy years than women (Caselli, Egidi, and Strozza 2021). Moreover, it is also well known that health (both in terms of both expected length of life and its quality) is not equally distributed within a country (Caselli, Egidi, and Strozza 2021; Zueras and Rentería 2020) or among social groups, regardless of which indicator of socioeconomic status is used (Cambois et al. 2020). It is important to consider the region of residence in Italy due to the high regional variation in, for instance, general health (Istat 2021) and socioeconomic status (Franzini and Giannoni 2010). This regional heterogeneity is also related to the decentralised national health system, possibly introducing local differences in healthcare provision and quality. As detailed in studies focusing on DFLE in Italy, it is important to go beyond the conventional north–south divide and investigate spatial health clusters at the regional level (Gruppo di Coordinamento per la Demografia 2009; Minicuci and Noale 2005). Also, inequalities in DFLE and in life expectancy have not been declining at the same pace, suggesting further investigation of gender and social inequalities is needed within regions (Caselli, Egidi, and Strozza 2021). This is relevant to health policymakers, since geographical inequalities in health reflect the need for policies aimed at reducing them to improve the health conditions in the whole country. Socioeconomic inequalities in DFLE have been investigated in Torino and Toscana, in the context of a European comparison. The study by Mäki et al. (2013) shows a gap of 2 years in DFLE at age 30 between low and high educated women, and 4 among men. The gap is 3.1 years and 2.7 years respectively when considering DFLE at age 65 in Italy (Caselli, Egidi, and Strozza 2021). Health inequalities constitute a major threat which deserves appropriate consideration, since ensuring long and healthy lives for everyone is a fundamental human goal, one of the pillars of the 2030 Agenda for Sustainable Development Goals (United Nations 2015), and one of the objectives of the Decade of Healthy Ageing (World Health Organization 2021). While some studies have investigated inequalities in DFLE separately by gender, education, and region of residence, no prior study has considered these three elements at the same time.

The aim of this study is twofold: first, to shed light on gender, social, and geographical inequalities in DFLE among older adults living in Italy, and second, to complement measures of inequality with an analysis of the age-specific morbidity and mortality contributions that explain them.

3.2 Data and methods

This study draws on census-linked mortality data for 2011 by 5-year age class, gender, educational attainment, and region of residence, including mortality records for the following three years (2012–2014). This represents the most recent available Italian data with this level of detail. At the same level of detail, disability prevalence is computed based on data from the Italian survey 'Aspects of Daily Living'. Robust prevalence estimates are obtained by averaging over the 3-year period 2012–2014 and applying sample weights. The study sample comprises 30,738 individuals aged 65 years and older and living in households, pooled over the 3 years. They each completed a paper-and- pencil-interview, providing information on their gender, region of residence, level of education, and disability status. The latter is based on the Global Activity Limitation Indicator (GALI), expressing self-reported long-term limitations on activities people usually do, and differentiates individuals without disability from those with mild or severe disability (Robine, Jagger, and Euro-REVES Group 2003).

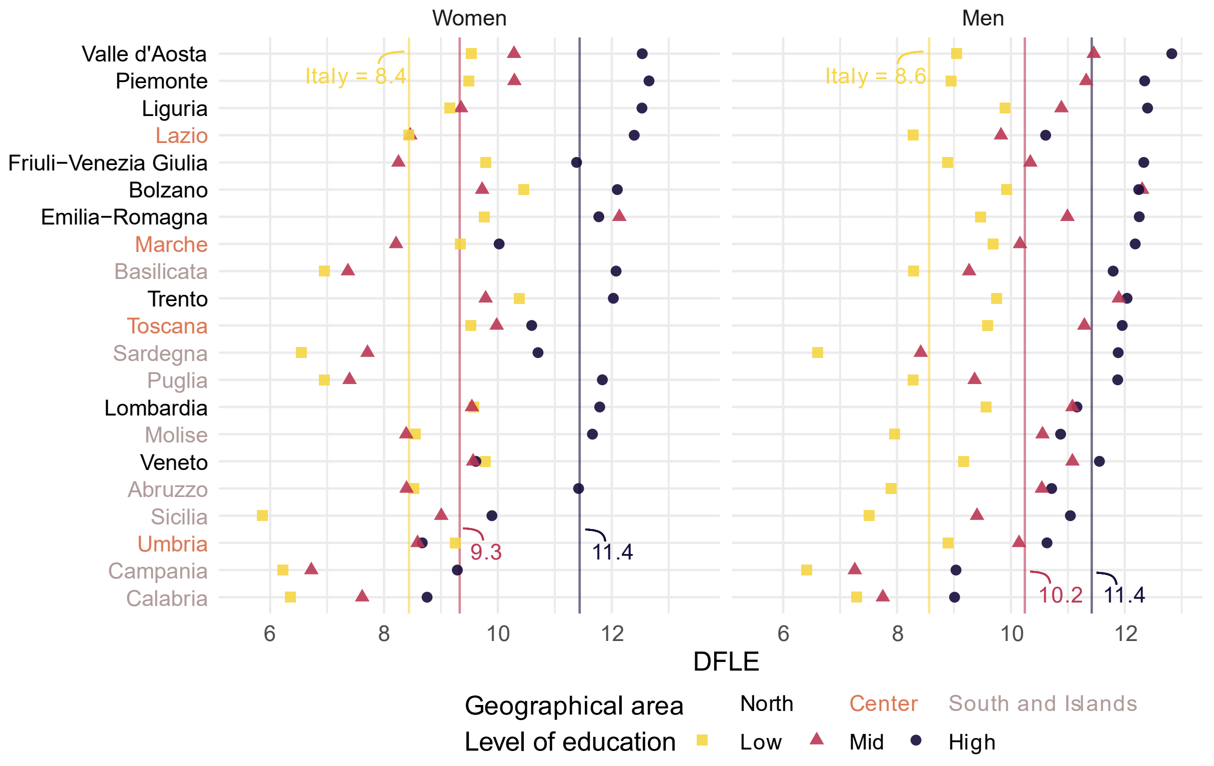
DFLE is calculated using the Sullivan method (Imai and Soneji 2007; Sullivan 1971), based on health prevalence data, and is computed at age 65 to focus on the health conditions of life years at older ages. Confidence intervals for DFLE are computed to acknowledge the variability in the health measure arising from the sample size used to compute disability prevalence (Villavicencio, Bergeron-Boucher, and Vaupel 2021). As this study focuses on inequalities in DFLE, gender and educational gaps in DFLE are computed for each Italian region. The step-wise decomposition method (Andreev, Shkolnikov, and Begun 2002) is used to understand the age-specific contribution of mortality and morbidity to the gaps in DFLE between genders or educational groups, allowing to quantify the effect of the observed differences between groups on the indicator as a non-linear function of its parameters (prevalence and rates). The analysis is performed in R version 4.1.3 (R Core Team 2022), and the decomposition is implemented with the Demodecomp R-package (Riffe 2018). An interactive online application (Shinyapp) was developed to provide supplementary figures (i.e., DFLE at age 65 with confidence intervals, life expectancy at age 65, and the ratio of DFLE to total life expectancy at age 65) and detailed information on data and methods [margmoretti.shinyapps.io/IneqDFLEItaly]. As an additional support, the code to replicate the analysis and to reproduce the Shinyapp is available in the GitHub repository [github.com/MMargherita/IneqDFLEItaly].

3.3 Results

Figure 3.1 shows DFLE at age 65 by gender and level of education for the Italian regions and autonomous provinces. At the national level, DFLE at age 65 is around 10 years for both women and men (total life expectancy at age 65 is 22.3 years and 18.8 respectively). This value varies between 11.4 and 8.4 (8.6 for men) for the high- and low-educated, respectively. When analysing regions individually the differences between them should be interpreted carefully, given the small size of some populations (for more details, DFLE with confidence intervals is provided in the Shinyapp [margmoretti.shinyapps.io/ IneqDFLEItaly]). In Figure 3.1, regions are ordered from the highest to the lowest DFLE and classified according to their geographical area. The high-educated living in some northern regions (i.e., men in Valle d'Aosta, women in Piemonte) have the highest DFLE in the country of almost 13 years, while the low-educated living in the south (i.e., women in Sicily and Campania) have the lowest of around 6 years; most of the regions with DFLE below the Italian average (vertical lines in the figure) are located in the south of the country. Lazio is a peculiar case, with highly educated women having one of the highest DFLE and highly educated men one of the lowest. The regions with the lowest DFLE are Campania and Calabria, regardless of the level of education and for both genders, with notable differences from all the other regions, even their neighbours.

The figure shows a gender-specific peculiarity in DFLE by educational attainment for all the regions: the higher the educational attainment the higher the DFLE. What changes between men and women is how mid-educated individuals perform: the DFLE for mid- educated men is close to that of high-educated men, but mid-educated women experience mortality–morbidity levels similar to those of low-educated women. This is more evident in northern and central regions, while in the south men and women present more similar values.

Figure 3.1: Disability-free life expectancy (DFLE) at age 65 by gender and level of education for the 21 Italian regions and autonomous provinces, 2012–2014

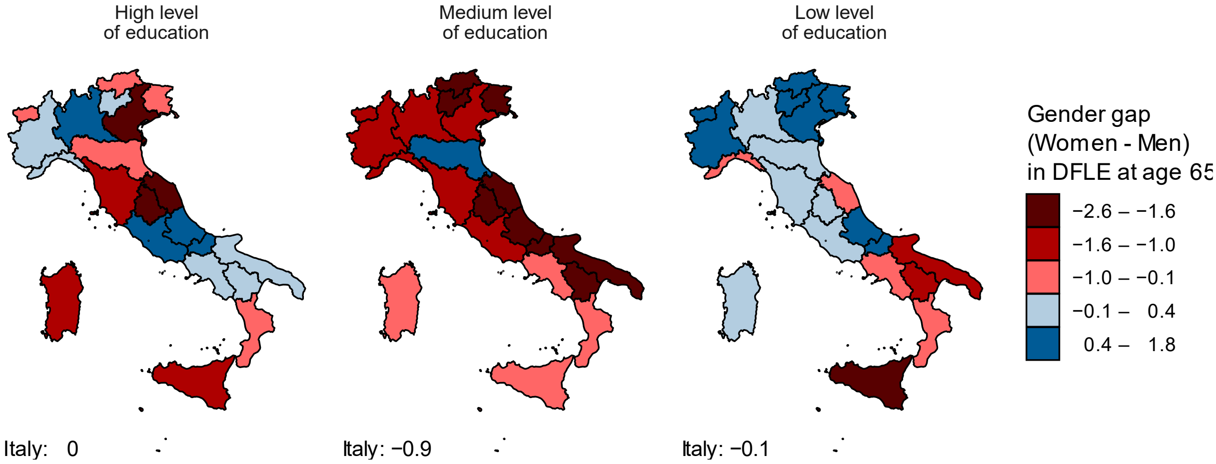


Note: Regions are classified by geographical area according to a grouping of NUTS-1: North (North-East and North-West), Centre, and South and Islands. Mortality data by level of education, used to compute DFLE, are released by the Italian National Institute of Statistics. Disability data come from the survey 'Aspects of Daily Living'. Disability status is defined according to the question in the Global Activity Limitation Indicator (GALI): "For at least the past 6 months, to what extent have you been limited because of health problems in activities people usually do? Would you say you have been: severely limited; limited but not severely; not limited at all". Level of education measures the highest educational attainment achieved: considering the age groups in the analysis, we defined low- educated as those with primary school diploma or less, mid-educated as those with lower secondary school diploma, and high-educated as those with upper secondary school diploma or higher.

Due to the high level of detail in our analysis, some assumptions to deal with missing strata are made: the Piemonte and Valle d'Aosta, Molise and Abruzzo, and Basilicata and Puglia regions, and Trento and Bolzano autonomous provinces, are assumed to have, in pairs, the same health prevalence.

Figure 3.2 illustrates the gender gap in DFLE at age 65 in Italian regions, namely the difference between women's and men's DFLE, for the three levels of education. At the national level, women and men show a similar life expectancy free from disability, although gender differences in DFLE assume a specific picture when stratifying the Italian population by educational attainment: low-educated women and men and high- educated women and men have similar DFLE, while the gap is largest for the mid- educated, where women have the greatest disadvantage, equal to more than one year at the national level. At the regional level, for the mid-educated the highest gaps are mainly found on the east coast and in the north-east of the country, with values ranging between 1.5 and 2.6 years of difference, favouring men. There are only a few regions where men are disadvantaged compared to women, mostly located in the centre-south and north or north-west for the high-educated and in the north for the low-educated.

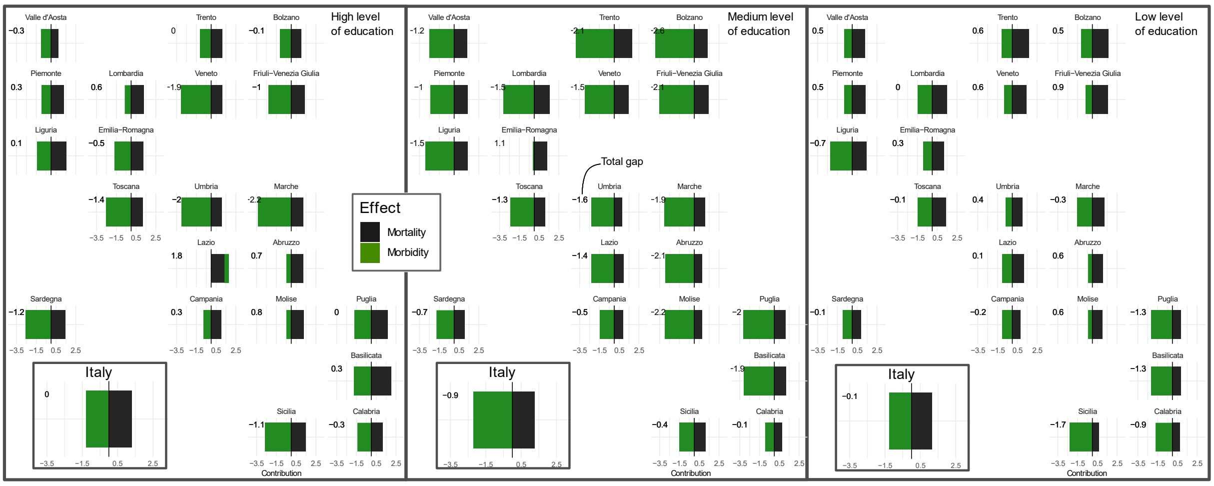
Figure 3.2: Gender gap (women – men) in disability-free life expectancy (DFLE) at age 65 by educational attainment for the 21 Italian regions and autonomous provinces, 2012–2014



Note: For each level of education, Italian regions are classified based on the quintile distribution of their gender gap in DFLE (calculated as the difference between DFLE for women and men).

Figure 3.3 shows mortality and morbidity contributions to the gender gap, resulting from the decomposition, for each region. The figure reveals that mortality contributions are always greater than zero, implying that mortality differences drive the gap toward positive values (the well-known female survival advantage) and this advantage is greater among the highly educated. Morbidity contributions are always greater than mortality contributions, and almost always negative, meaning that health disparities contribute to negative values of the gender gap, favouring men. We observe reduced health differences between low-educated men and women living in the north and centre, and between high- educated men and women in the central-southern regions, where mortality plays a more pronounced role in determining the gaps.

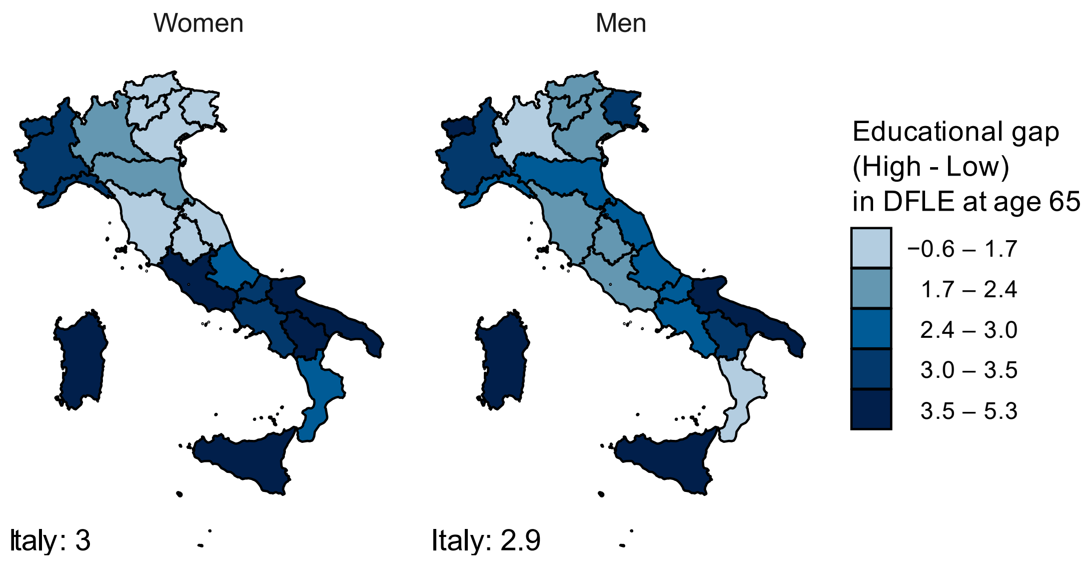
Figure 3.3: Mortality and morbidity contributions to the gender gap in disability-free life expectancy (DFLE) at age 65, by educational attainment, for the 21 Italian regions and autonomous provinces, 2012–2014



Note: The positioning of regions and autonomous provinces represents the geographical shape of Italy (Geofaceting, see Kashnitsky and Aburto 2019). The value of the gender gap, by level of education, is annotated for each region and autonomous province. The bars show the contributions, expressed in years, of the differences in mortality (rates) and morbidity (disability-free prevalence) between the two genders. Positive (negative) values of the contributions indicate women's advantage (disadvantage). Since there seems to be no clear age-specific pattern, this figure only shows the total contribution, i.e., the sum of the age-specific contributions for each region. The figure including the age-specific contributions is available in the Shinyapp: [margmoretti.shinyapps.io/IneqDFLEItaly].

Figure 3.4 shows the educational gap in DFLE at age 65 in the Italian regions, namely the difference in DFLE between the most- and least-educated. This difference is especially pronounced for both genders, with the gap for men reaching 2.8 disability-free years at the national level. At the regional level, almost all gaps for men are greater than 1.5 years, with most values above 2.5 years. The picture for women is more diverse, with an educational gap of 2.9 years at the national level. The largest gaps for women are found in the southern and central-southern regions, whilst the smallest are in some central-northern regions and the north-east.

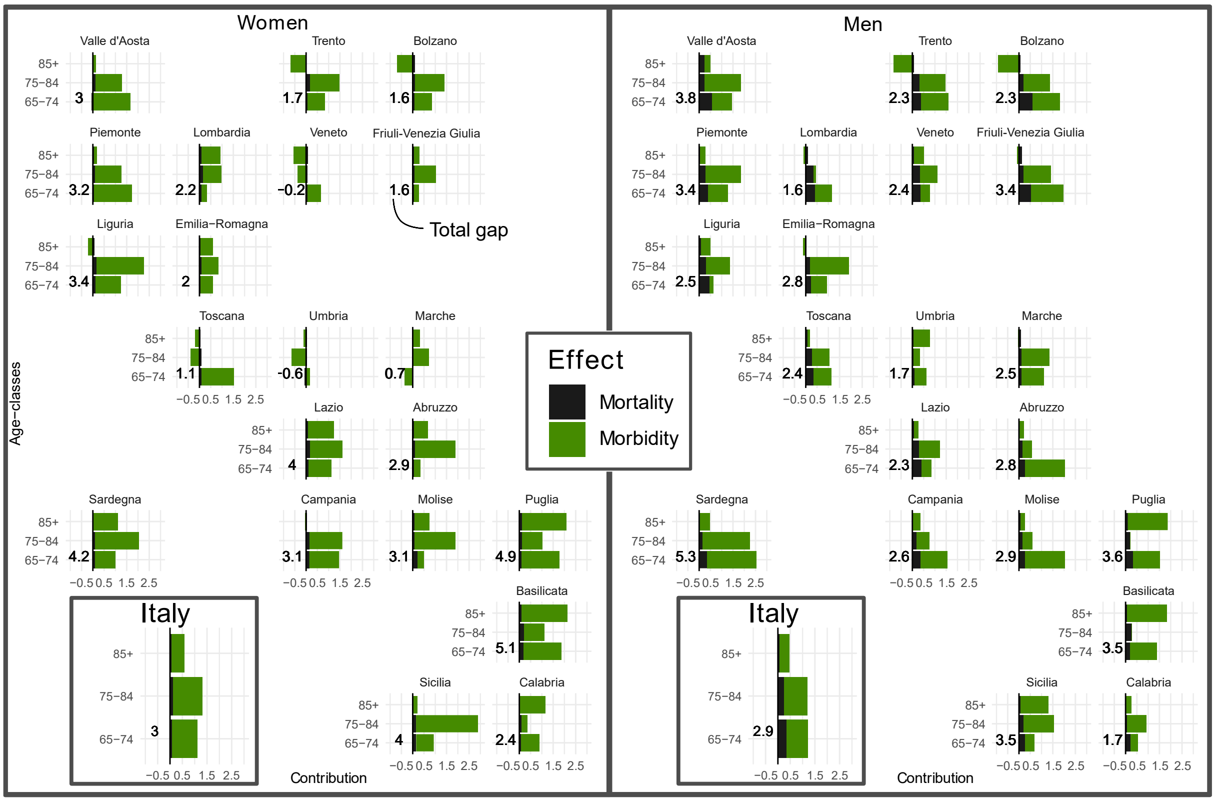
Figure 3.4: Educational gap (high – low) in disability-free life expectancy (DFLE) at age 65, by gender, for the 21 Italian regions and autonomous provinces, 2012–2014



Note: For both genders, Italian regions are classified based on the quintile distribution of their educational gap in DFLE (calculated as the difference in DFLE for those with high and low level of education).

Figure 3.5 displays the results of the decomposition of the educational gap into mortality and morbidity contributions, for each Italian region and age-class, by gender. Men's mortality contributions decline with age, nearly disappearing and giving way to health contributions, which are overall the most important factor in determining the educational gaps. This is especially true among women, for whom different levels of education do not necessarily reflect larger differences in mortality; however, inequalities in health and, as a result, in DFLE, are noticeable. The picture for morbidity contributions among women is quite diverse, making it difficult to find a general pattern. Among men, morbidity contributions also reduce at higher ages in most of the regions except the south- east, as was observed for mortality. However, even though morbidity contributions at older ages (85+) are limited, their intensity is higher than that of mortality contributions.

Figure 3.5: Mortality and morbidity contributions to the educational gap in disability-free life expectancy (DFLE) at age 65, by gender, for the 21 Italian regions and autonomous provinces, 2012–2014



Note: The positioning of regions and autonomous provinces represents the geographical shape of Italy (Geofaceting, see Kashnitsky and Aburto 2019). The value of the educational gap, by gender, is annotated for each region and autonomous province. The bars show the contributions, expressed in years, of the differences in mortality (rates) and morbidity (disability-free prevalence) between the high- and low-educated. Positive (negative) values of the contributions indicate high-educated advantage (disadvantage). Contributions are calculated by 5-year age groups but showed by 10 years for better visualization.

3.4 Discussion

In international comparisons, Italy has one of the highest life expectancies at age 65, but not-so-high DFLE. This makes Italy a very interesting case for understanding the diverging patterns of longevity and health by analysing inequalities within its population. A few studies focus on inequalities in DFLE in Italy by gender (Frova, Burgio, and Battisti 2010), socioeconomic status (Mäki et al. 2013), and region (Minicuci and Noale 2005). However, only two studies consider more than one dimension at the same time in this context (Caselli, Egidi, and Strozza 2021; Gruppo di coordinamento per la demografia 2009). To our knowledge, no prior study has investigated analytically gender, socioeconomic, and regional inequalities in DFLE in Italy simultaneously. This study presents novel evidence of gender and educational inequalities in DFLE at the regional level for Italian older adults, as well as investigating the contribution of mortality and morbidity to the exploration of gender and educational inequalities. In terms of gender gaps, this study shows that while older women and men share similar DFLE at the national level, these estimates hide important heterogeneities between regions and social groups. In fact, the highest gender gap (female disadvantage) among the mid-educated is more than 2.5 years in some eastern regions. Women's (functional) health disadvantage at older ages completely outweighs their advantage in mortality and life expectancy, which, however, has been declining in recent years (Frova, Burgio, and Battisti 2010). This results in a disadvantage in DFLE for women. In the context of the well-known excess mortality of men over women at all ages, it might be surprising that women do not experience a similar advantage in DFLE. Besides gender differences in health perception and reporting, this phenomenon has two explanations: women suffer from fewer fatal ill health conditions than men, which are less likely to lead to death but often lead to disability; and as women live longer than men, the excess years at older ages are more exposed to higher risk of poor health (Di Lego, Di Giulio, and Luy 2020).

Mäki et al. (2013) consider inequalities in DFLE in Italy to be relatively low when compared to other European countries. However, they analyse data from Toscana and Torino only, limiting the generalization of their results. We instead found important social differences in DFLE for both genders at age 65, similar to Caselli, Egidi, and Strozza (2021). Highly educated men's advantage is almost 3 years at the national level and almost always more than 1.5 years at the regional level. Women show a more diverse regional picture. The educational gaps in DFLE are mostly driven by differences in morbidity, which is the predominant factor explaining differences for older men and, most of all, for women. The literature on social inequalities at the regional level in Italy is limited to studies on mortality and life expectancy (e.g., Lallo and Raitano 2018, Caselli, Egidi, and Strozza 2021), while the present study shows that social inequalities in health indicators are far more dramatic than those found in mortality (as also highlighted in Cambois et al. 2020), resulting in large differences in the quality of older Italians' life expectancy. Moreover, the extent of the gap translates into a double disadvantage for the least educated and those living in southern regions of the country, as they can expect to live fewer years and in worse health than, respectively, the highly educated and those living in northern regions. The disadvantage in DFLE also cumulates over the different dimensions of education and region of residence, so that the difference between the highest DFLE at 65 (more than 12 years, for the highly educated in the north) is more than double that of the lowest (about 6 years, for the low-educated in the south).

There are some considerations that can be discussed regarding the different extent of the gender and educational gaps and the heterogeneity at the regional level. First, the structure of the Italian population in terms of educational attainment differs among regions and between genders. The share of low-educated individuals is higher in the south than in the north. The geographical distribution is more homogeneous among men than women, who show a higher prevalence of the low-educated. The highest educational attainment achieved may represent differing socioeconomic status (SES) for men and women. Educational attainment might be less accurate in capturing the SES of older Italian women, whose actual SES might be represented by that of their partner. Furthermore, educational background and health-related behaviours are strongly related, with low-educated individuals being more likely to engage in risky behaviours. This might explain the double disadvantage (mortality and health) experienced by those with a low level of education. However, there may be differences in the way men's and women's risky behaviour (e.g., smoking) relates to education (Luy, Di Giulio, and Caselli 2011). The underlying differences between areas within the country are key factors that explain regional health and mortality heterogeneity. Italy is characterized by strong regional, cultural, behavioural, and economic differences. In particular, the regionalisation of the national healthcare system strongly affects its quality, particularly disadvantaging the south. This aspect plays a fundamental role in determining the observed regional heterogeneity.

This study has limitations that need to be acknowledged. First, the data only include individuals living in households; excluding those living in institutions might bias the results as institutionalised individuals are also more likely to be in poor health. It is also reasonable to assume that those living in institutions might have a specific SES composition and be more prevalent in certain regions. However, in 2013, older adults living in institutions represented only 2% of the population over 65 in Italy (Istat 2015). Second, since DFLE estimates are based on observed prevalence of disability, all the limitations pertaining to prevalence-based measures are embedded. Specifically, the Sullivan method has some strong assumptions that need to be acknowledged: stationarity of the population and its age-specific disability prevalence. In particular, the assumption that the disability rates do not change – until the synthetic cohorts under analysis are extinct – is very strong. If the underlying disability rates change over time, this may result in biased estimates (lower/higher DFLE). Finally, in this study we use a self-reported indicator of disability (GALI) that is only a proxy for individuals' objective functional health status. This study shows the need for more years of detailed mortality data by level of education that provides evidence for years more recent than 2013, with a temporal trend to understand whether the country has been experiencing an expansion or compression of morbidity, with finer estimates than those at the national level.

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4. Trends over two decades of disability-free grandparenthood in Italy and its gender differences

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Abstract

Decreasing fertility rates and increasing lifespan have affected the time grandparents and grandchildren co-exist. Any changes in the time and length of grandparenthood could alter the quality and the direction of intergenerational exchange. In Italy, a country in which grandparents constitute a fundamental resource for the provision of informal childcare and families are the main sources of support for individuals, it has therefore become crucial to study grandparents' health evolution, as it is of importance for intergenerational transfers. In this research note, disability-free grandparenthood at age 65 (period life expectancy as a grandparent free from disability) by gender is estimated for Italy from 1998 to 2016. A decomposition analysis is implemented to assess the contribution of changes in mortality and in the prevalence of disability and grandparenthood on the evolution of disability-free grandparenthood over time. Between 1998 and 2016, Italian grandmothers and grandfathers gain disability-free years of life overlapping with their grandchildren. The extent of the increase of disability-free grandparenthood years is shown to be primarily led by the sharp improvement in health and survival conditions and slowed down by the postponement in the transition to grandparenthood for men.

Key words: Ageing, Disability, Grandparenthood, Life expectancy

4.1 Introduction

Increasing longevity and changes in fertility have been two key demographic features of European countries during the twentieth century. On one hand, the longer lives that we can expect to live today potentially translate into more years of intergenerational overlap than in the past. On the other hand, fertility delay and reduction can counterbalance the effect of the longevity revolution on kin networks, by postponing the age of transitioning in the different family roles. One of the intergenerational relationships most affected by these processes is grandparenthood (Di Gessa et al. 2020; Leopold and Skopek 2015a; Margolis 2016; Skopek 2021; Szinovacz 1998). Adults in Italy become grandparents rarer and later in life than before, although this delay is offset by gains in longevity, which still keep the grandchildren-grandparents' life time spent together stable (Cisotto et al. 2022). Italian grandparents are older today than in the past, and whether the years of life gained in later life are of good or bad quality is a major concern (Fries 1983; Gruenberg 1977; Kramer 1980; Manton 1982). Indeed, the health status of grandparents can strongly affect the generational overlap with grandchildren, both in terms of duration (Leopold and Skopek 2015b; Margolis 2016; Margolis and Verdery 2019) and of quality (Margolis and Wright 2017). In particular, grandparents' health is crucial in understanding the direction of intergenerational transfers, since it could impact whether grandparents are providers or recipients of care (Aassve et al. 2012; Grundy 2005; Hank and Buber 2009; Igel and Szydlik 2011). On the one hand, when grandparents are healthy, they can provide intergenerational transfers, such as caring for grandchildren, facilitating grandchildren's development, or supporting (financially, functionally, or emotionally) adult children; on the other hand, when grandparents are unhealthy, they are more likely to be recipients of care, turning intergenerational relations into a caring burden for adult children or grandchildren. Grandparents' health is particularly relevant if we also value the beneficial effect of the time spent together, for both grandparents (Di Gessa et al. 2016) and grandchildren (Fruhauf and Orel 2008), and how informal grandparental care impacts on adult children's outcomes, including labour force participation (Arpino and Bordone 2014; Moussa 2019; Tomassini et al. 2020), and fertility decisions (Rutigliano 2020).

Moreover, the dynamics of mortality, health and fertility differ between the genders in several regards: women generally marry at a younger age (with older men), have children (thus grandchildren) earlier, live longer but in poorer health (Case and Paxson 2005; Di Gessa et al. 2020; Leopold and Skopek 2015a). This implies that women can expect to live more grandparent years than men; at the same time, older women live with worse health conditions than men, and this may lead to equal or shorter periods as healthy grandparents.

Due to its family-focused welfare and social background and inadequate public care facilities for children and older individuals, Italy is clearly one of the countries in which grandparents constitute a fundamental resource for the provision of informal childcare (Glaser and Hank 2018; Zamberletti et al. 2018), and families remain the main sources of support for adult individuals (Kalmijn and Saraceno 2008; Tomassini et al. 2020). However, the health of grandparents has only been studied to a limited extend in Italy, and no evidence exists addressing healthy grandparenthood (Margolis and Wright 2017). Within this context, our study has three main objectives: first, to shed light on the evolution of disability-free grandparenthood (DFGP) (i.e. the length of life as a grandparent free from disability) at age 65 between 1998 and 2016 in Italy; second, to disentangle the DFGP progression according to changes due to the longevity revolution and due to grandparenthood-disability prevalence; third, to analyse gender differences in DFGP in Italy and their consistencies over time.

4.2 Data and methods

Data are drawn from two sources, the Family and Social Subjects (FSS) survey and the Italian life tables, carried out and provided by the Italian National Institute of Statistics (ISTAT) for 1998 and 2016. The analytical sample considers all FSS respondents aged 65 and over, living in Italy and reporting their grandparenthood and disability status (i.e., individuals reporting having severe disability or not, and either being a grandparent or grandchild-less). The final sample comprises 7972 and 6407 individuals in 1998 and 2016, respectively. In 1998, respondents were asked to report chronic diseases inducing permanent disability. In 2016, interviewees were asked about the presence of long-standing activity limitations because of a health problem (Global Activity Limitation Indicator) (Robine et al., 2003). Both variables were found to show similar patterns (Cisotto et al., 2022; Pasqualini et al., 2021), allowing to identify, in the two years, those respondents reporting severe functional limitation (disability) due to health problems or chronic diseases.

Our research builds on the healthy grandparenthood measure recently introduced by Margolis and Wright (Margolis and Wright 2017), as we apply the Sullivan method (Sullivan 1971) to calculate the disability-free grandparenthood (DFGP) for older women and men living in Italy in the two target years. We first compute the age-specific prevalence of individuals in each status π_x^i (i.e., disability-free grandparent, grandparent with disability, disability-free grandchild-less and grandchild-less with disability). Second, we apply the age-specific prevalence π_x^i of the four states of interest to the age-specific person-years lived from the life tables L_X.

$$L_X^i = \pi_x^i \cdot L_X$$

In this way, we specify the person-years lived in each status L_X^i. Finally, we sum these quantities for the ages above 65 and divide them by the lifetable survivors at the age of 65 l_{65}, resulting in residual life expectancy in each status e_x^i.

$$e_x^i = \frac{\sum_{x=65}^{\omega} L_x^i}{l_{65}}$$

The sum of life expectancy at the age of 65 in each of the four states equals the total life expectancy e_x at the same age. Thus, life expectancy is partitioned into years spent being (i) disability-free grandparent, (ii) grandparent with disability, (iii) disability-free grandchild-less and (iii) grandchild-less with disability.

$$e_x = \sum_i e_x^i$$

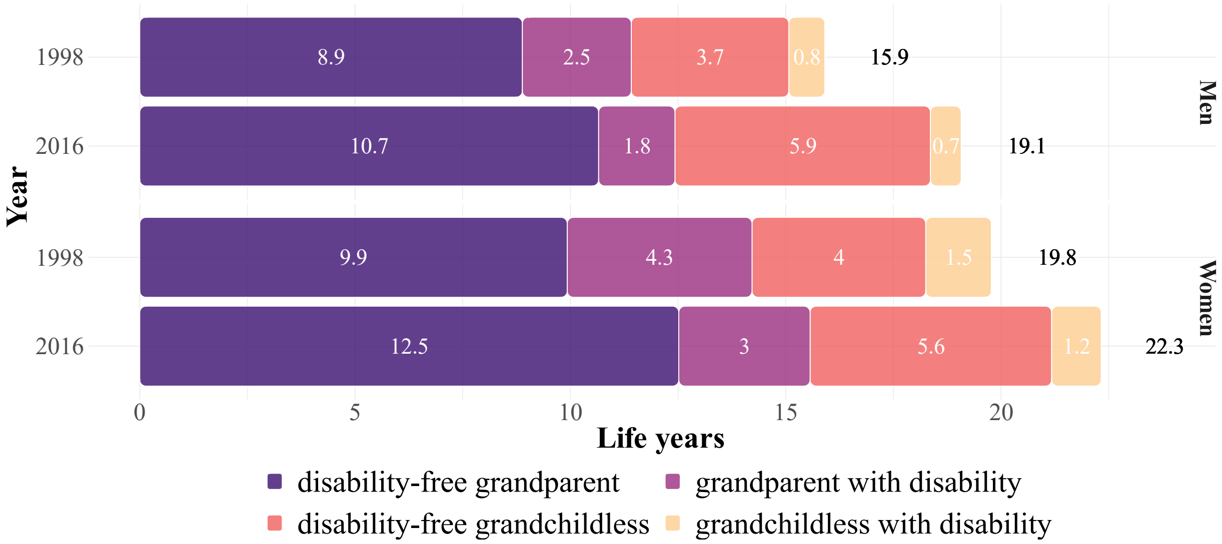
The key outcome is the DFGP estimate (i.e., the period life expectancy as a disability-free grandparent), which measures the average number of years that a hypothetical cohort of individuals can expect to live as grandparents free from disability, if they experience the mortality, disability and grandparenthood conditions observed in the studied years. Finally, by implementing the Horiuchi decomposition method (Horiuchi et al. 2008) we assess the age-specific contributions that the changes in mortality and grandparenthood-disability prevalence have on the evolution of DFGP from 1998 to 2016.

4.3 Results

Figure 4.1 shows the partition of overall life expectancy at the age of 65 into the different states of grandparenthood and disability by gender, for 1998 and 2016. In 1998, at the age of 65, Italian men have approximately a life expectancy of 16 years and women of almost 20. Of these, the years spent as a grandparent (11.4 for men and 14.2 for women) outweigh those as grandchild-less, and only half of life expectancy is of DFGP (almost 9 and 10 years for men and women, respectively). Women can expect to live more years as grandmothers than men as grandfathers, but the share of years lived as grandparents over the total life expectancy is similar for both genders (more than 70%). However, although women have one year more of DFGP than men, the share of DFGP on total life expectancy and on overall years as grandparents are higher for men (respectively 55% and 78%) than for women (50% and 70%). In fact, Italian women aged 65 in 1998 had more years with disability than men and, particularly, more years to live as grandmothers.

From 1998 to 2016, along with the increase in life expectancy at the age of 65 (by more than 3 years for men and 2.5 for women), the DFGP also increased, exceeding 10 years for grandfathers and 12 for grandmothers. Over the same period, the increase in men's DFGP (of around 2 years) was at a slower pace than that of life expectancy, while women's (more than 2.5 years) was faster. As a result, despite the male disadvantage in longevity decreased between 1998 and 2016, the DFGP gender gap increased and reached almost 2 years in 2016. Interestingly, in 2016 women and men shared the same portion of DFGP over the remaining life expectancy at the age of 65 (around 56%). However, compared to men, women displayed a higher portion of life expectancy as grandmothers (almost 70% vs 65% for men), and a lower share of DFGP over the total grandparent years (80% vs 85% for men), implying that the health quality of grandmothers is poorer than that of grandfathers.

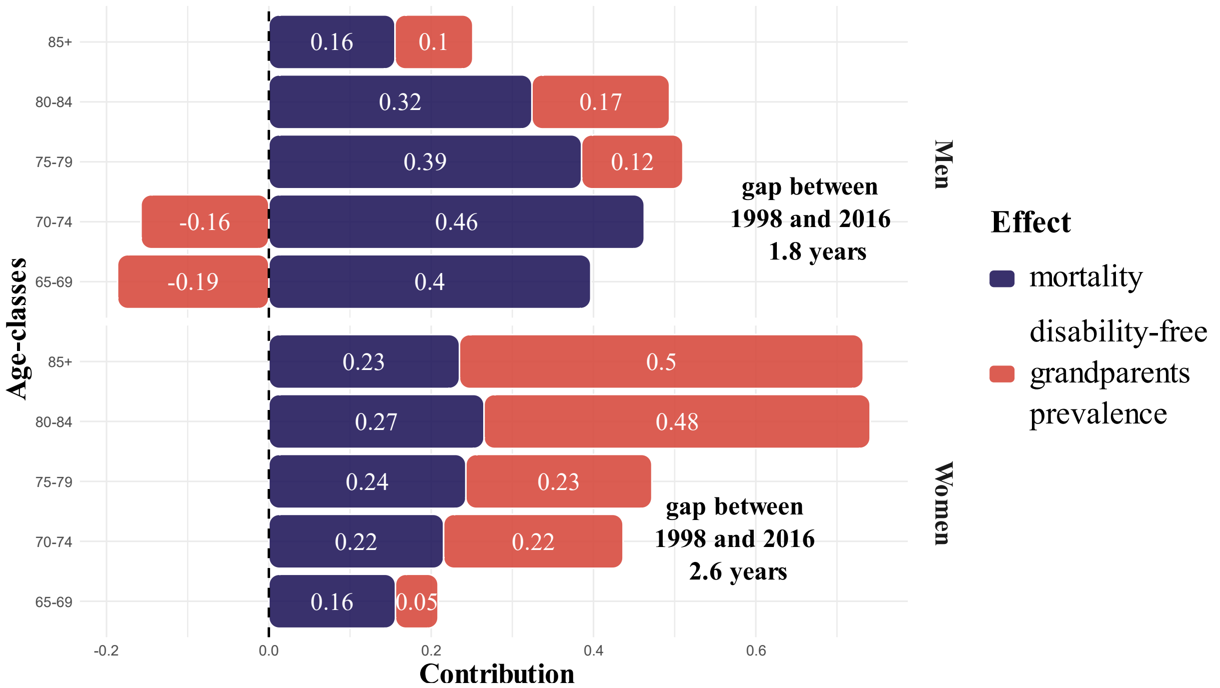
Figure 4.1: Life expectancy at age 65 by grandparent-disability status for Italian men and women in 1998 and 2016



Note: Life expectancy at age 65 is represented by the overall length of the bar (with a value noted in black next to them) and it is partitioned, by gender, into the years being: disability-free grandparent, grandparent with disability, disability-free grandchild-less and grandchild-less with disability. Being with disability include only having severe disability. The data used in this study are from the Family and Social Subjects survey of the Italian National Institute of Statistics (Istat). The data processing for the year 2016 were conducted at Istat Laboratory for the Analysis of Elementary Data (ADELE) and in compliance with the regulations on the protection of statistical confidentiality and personal data protection. The results and opinions expressed are the sole responsibility of the author and do not constitute official statistics. The analysis and graphic depiction of the results is performed in R software (R Core Team 2022).

Figure 4.2 displays the contribution of the evolution of mortality rates and disability-free grandparents' prevalence to the overall variation in DFGP between 1998 and 2016, by gender. For women, the impact of increased longevity and prevalence of disability-free grandparents rises with age (except for mortality contribution at age 85+). Up to the age 80, the contribution of improved survival is of greater relevance in determining the increase in DFGP, while for the oldest old women (aged 80+) the increased prevalence of disability-free grandmothers contributes most. Over time, there is a clear improvement in women's survival and an increase in the prevalence of healthy grandmothers at any age, which contributes to an overall increase of 2.6 years in DFGP. For men, the reduction in mortality rates always shows a positive impact on the increase in DFGP, which, however, decreases after the age of 70. Overall, in determining the evolution of men's DFGP, the prevalence of disability-free grandparents contributes less than mortality and, moreover, negatively between the ages of 65 and 74. Hence, from 1998 to 2016, there is a decrease in the prevalence of disability-free grandfathers, which leads to a 4-month reduction (0.19 + 0.16 years) in the average number of DFGP years. Knowing that overall disability-free prevalence has not diminished from 1998 to 2016 (Caselli et al., 2021) (and thus that of men), this indicates that there is a reduction (delay) in grandparent's prevalence in those ages during this period, resulting in a slowdown in the increase of DFGP and offsetting the positive effect of the reduction in disability and mortality during the observed period.

Figure 4.2: Mortality and disability-free grandparents prevalence contributions to the DFGP gap between 1998 and 2016 for Italian older men and women, by age classes



Note: The total DFGP gap between 1998 and 2016 for the two gender is partitioned in the different contribution of mortality and morbidity in each age-class. The data used in this study are from the Family and Social Subjects survey of the Italian National Institute of Statistics (Istat). Being with disability include only having severe disability. The data processing for the year 2016 were conducted at Istat Laboratory for the Analysis of Elementary Data (ADELE) and in compliance with the regulations on the protection of statistical confidentiality and personal data protection. The results and opinions expressed are the sole responsibility of the author and do not constitute official statistics. The analysis and graphic depiction of the results is performed in R (R Core Team, 2022), the decomposition is implemented using the Demodecomp R-package (Riffe, 2018).

4.4 Discussion and conclusions

Healthy grandparenthood is a central aspect of the demographic understanding of grandparenthood. Still, its determinants (grandparenthood timing, as well as mortality and morbidity) differ substantially between countries. The present study examines the healthy grandparenthood period of life in Italy, a country in which inter-family and intra-family reciprocal relations are based on a dense network of aid exchanges, where (non)economic and care support is distributed cooperatively among the members, making the family a true solidaristic institution.

Relating to the methodology involved in the study, the average number of years individuals spend in DFGP, and its evolution, is influenced by patterns of grandparenthood, disability, and mortality observed in the years under consideration. Because these rates and prevalence vary over time and across several dimensions, demographic methods such as Sullivan's can help to explain the effects of these changes on the duration and quality of intergenerational overlaps. In fact, expectancy indicators are essentials tools to correctly compare populations accurately (or the same population over time) and their risks (in this case: mortality, disability, and grandparenthood), net to the differences in their age-structures. In addition, the use of decomposition techniques allows researchers to disentangle the effect that the underlying changes in the parameters (i.e., mortality rates and grandparenthood-disability prevalence) have on the estimated indicator, as the DFGP is a non-linear function of these parameters.

This study has some limitations. Firstly, the DFPG indicator is based on cross-sectional data and the underlying hypothesis embedded from using the Sullivan method is that of stationarity of the reference population and of its age-specific risks (i.e., mortality rates and disability-free grandparenthood prevalence). For this reason, the proposed measures must be interpreted as summary indicators of mortality, disability, and grandparenthood of the reference years. Cohort estimates or multistate analysis based on longitudinal data would be more accurate and informative, but these sources are not available for Italy. Secondly, the age-specific disability status of the population relies on different measurements in the two FSS surveys: the 2016 survey includes the harmonized Global Activity Limitation Indicator question, which was not yet present in the 1998 survey, while referring, instead, to the presence of a permanent disability. The difference in disability measurement may affect the results. Another limitation of our study is that the presence of grandparents below the age of 60 is very low, and the assessment of grandparenthood is limited to older adults aged over 65. Hence, we do not observe younger grandparents, possibly underestimating the total length of (healthy) grandparent years. Moreover, the FSS survey includes only individuals living in households, thus excluding those living in institutions although they are estimated to represent only 2% of the older population (Istat, 2015). Finally, the average number of years individuals spend in DFGP, and its evolution, is influenced by patterns of grandparenthood, disability, and mortality observed in the years under consideration. However, these demographic changes are not equally distributed across the Italian population. As an example, fertility (and so, the timing of grandparenthood), mortality and health exhibit large variations according to education levels and area of residence (Impicciatore & Zuanna, 2016; Petrelli et al., 2018). Moreover, the overall disability-free life expectancy for older Italians has been shown to have a relevant gap according to educational level and region of residence (Moretti & Strozza, 2022), and so the DFPG would probably behave in a similar way. These differential patterns could lead to large differences in healthy grandparenthood, especially for some population subgroups. Nevertheless, the small dimension of the analysed sample does not allow for the inclusion of territorial or socioeconomic dimensions, while data on life expectancy differentiated by education level is available only for 2011 in Italy.

Despite these limitations, this study provides the first evidence on DFGP evolution and its gender differences in Italy, a country which deserves specific attention due to its remarkable decline in mortality and fertility, as well as having a lack of public support and assistance to the individual. Hence, the extent to which the healthy grandparenthood lifespan varies over time is crucial in the understanding of the consequences on intra and inter-family support and intergenerational transfers. Besides, the research also contributes to reflections on the roles of mortality, health, and family dynamics as measures to be considered simultaneously in a synthetic indicator, as life expectancy by disability and grandparenthood status. Indeed, future changes in healthy grandparenthood will be based on mortality and morbidity reduction, as a counterbalance to fertility and grandparenthood delay. Moreover, the COVID-19 pandemic strained the Italian system in protecting older people in times of crisis, a system already stressed by decades of linear cuts and exacerbated by the 2008 economic crisis. In this perspective, future research should broaden the study's application to other measures of health, such as self-rated and mental health, as well as, whenever possible, focusing on socioeconomic and territorial disparities to assess the within-country variance.

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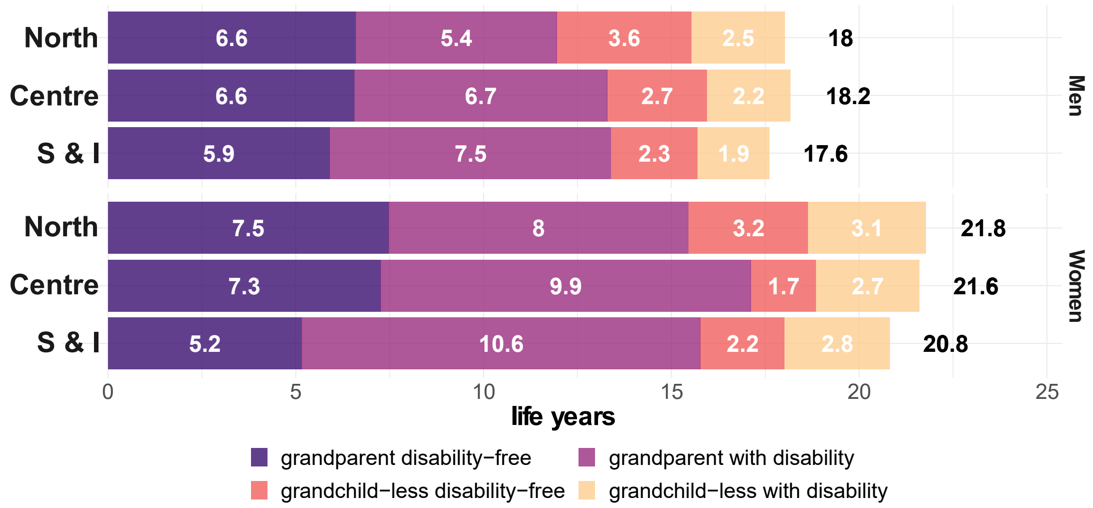
Supplementary results

Territorial differences in 2009 and 2016

The additional figures 4.3 and 4.4 represent the partition of overall life expectancy at age 65 into the different states of grandparenthood and health status, by gender and geographical macro areas (i.e., North, Centre, South & Islands – S&I) in 2009 and 2016. To be noted that these results are not directly comparable to the ones shown in the main text as, in this case for 2009 and 2016, the disability status "with disability" capture both mild and sever disability (instead of only the sever ones) from the Global Activity Limitations Indicator.

In 2009 (Figure 4.3), at the age of 65, Italian older adults can expect to live more years as grandparents (if we look at the purple and pink part of the bars) than as grandchild-less, and women can expect to live more grandparent years than men. In relation to total life expectancy at age 65, men have more disability-free remaining years (purple and orange part of the bars) than with disability, except for the South repartition, where only half of their remaining years are disability-free years. Women, in contrary to men, can expect to live more years with disability than disability-free. Regarding territorial inequalities in disability-free grandparenthood (only the purple part of the bars), the South and Islands macro area is the most disadvantaged for both genders, with a gap versus the North reaching more than 2 years for women.

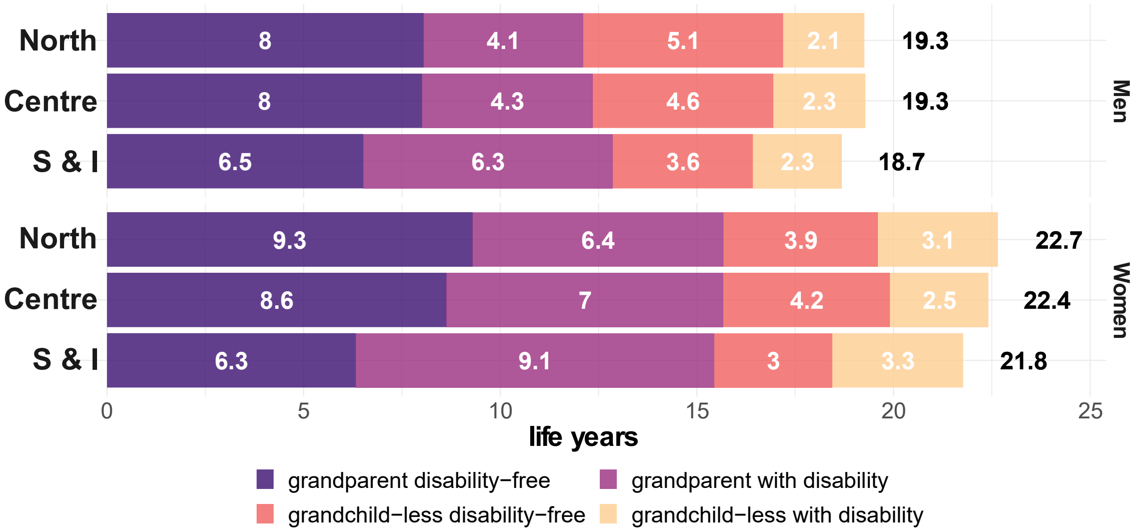
Figure 4.3: Life expectancy at age 65 by grandparent-disability status for Italian men and women in 2009, by gender and geographical macro areas



Note: Life expectancy at age 65 is represented by the overall length of the bar (with a value noted in black next to them) and it is partitioned, by gender and geographical macro areas (i.e., North, Centre, South & Islands – S&I), into the years being: disability-free grandparent, grandparent with disability, disability-free grandchild-less and grandchild-less with disability. Here, being with disability include either being with a mild than a severe disability. The analysis and graphic depiction of the results is performed in R software (R Core Team 2022).

From 2009 to 2016 (Figure 4.4), as life expectancy increases, disability-free grandparenthood years increase by more than one year at the national level. All macro areas and both genders experience an increase of at least 1 year, while a smaller increase for men living in the South and Islands. The years to live as a grandparent with a disability slightly decrease, while those as disability-free grandparent increase between the two points in time. Interestingly, in 2016, there are no remarkable territorial differences in the number of grandparent years for women, but differences are evident in the years of disability-free grandparenthood. Moreover, in the South and Islands, compared to the total life expectancy, the years with disability are predominant (pink and yellow), both for grandparent and grandchild-less years, despite the general improvement in health status from 2009 to 2016. Men living in the South and Islands in 2016, despite having a lower life expectancy at 65 than in other areas, can expect to live more years as grandparents; however, the number of years spent as disability-free grandparents are less than in the other macro areas of Italy and represent only half of the years as grandparents.

Figure 4.4: Life expectancy at age 65 by grandparent-disability status for Italian men and women in 2016, by gender and geographical macro areas



Note: Life expectancy at age 65 is represented by the overall length of the bar (with a value noted in black next to them) and it is partitioned, by gender, into the years being: disability-free grandparent, grandparent with disability, disability-free grandchild-less and grandchild-less with disability. Here, being with disability include either being with a mild than a severe disability. The data used in this study are from the Family and Social Subjects survey of the Italian National Institute of Statistics (Istat). The data processing for the year 2016 were conducted at Istat Laboratory for the Analysis of Elementary Data (ADELE) and in compliance with the regulations on the protection of statistical confidentiality and personal data protection. The results and opinions expressed are the sole responsibility of the author and do not constitute official statistics. The analysis and graphic depiction of the results is performed in R software (R Core Team 2022).

5. Discussion and conclusions

The area of research of this thesis, disability-free life expectancy (DFLE) at mid-to-older ages in Italy, is of major importance in a country where the population is rapidly ageing. The increasing life expectancy, declining fertility rates, and consequent population ageing, may have serious implications for the social and economic systems. The health-related quality of the ageing process plays a crucial role in determining whether population ageing undermines these systems or is instead an opportunity. In this regard, achieving healthy ageing for everyone is of primary importance, as emphasized by the United Nations' 2030 Agenda for Sustainable Development Goals and the World Health Organization's 2021-2030 Decade of Healthy Ageing. The demographic indicators and measures presented in this thesis offer new insights into the progress made towards achieving healthy ageing for all in Italy. They reveal how far the country has come in this direction, how healthy ageing is distributed among population subgroups, how it may be important also for families and intergenerational relationships, and how these phenomena are driven by the evolution and profiles of mortality and disability risks.

5.1 Summary of results

Chapter 1 presents an introductory and comprehensive framework of the most relevant aspects related to the lengthening of life and of the quality of the years gained in terms of health (functional health and disability), its inequalities, and its relationship with specific kinship dynamics, in general and in particular for Italy (section 1.1). This chapter also presented a review of the existing literature on health expectancy (section 1.2), the objectives (section 1.3), the data sources (section 1.4), and the methods (section 1.4) of this thesis. In the following chapters (Chapters 2, 3 and 4) three applications are included in scientific papers format, each one devoted to an in-depth exploration of specific issues highlighted in the introduction and in the objectives section of the thesis. Chapter 2 provides, for the first time in Italy, a long-term estimate of the DFLE, based on longitudinal data, up to the most recent years, also analysing the contributions to its evolution made by the underlying changes in the dynamics of disability onset, recovery, and disability-specific mortality (both from disability-free and with disability) using a novel application of a decomposition method to multi-state estimates. In this paper, it is found that, during the last two decades, DFLE between ages 50 and 79 has progressed, even if not always as favourably as life expectancy. In fact, women and men show DFLE trends resulting in disability compression in more recent years (2016-2019), whereas both experienced periods of disability expansion in earlier years (2007-2015 for men, 2011-2015 for women). Overall, the increase in DFLE is by no means negligible and, through the decomposition of its change, it is shown that the driving forces behind DFLE evolution are changes in the transitions in and out of disability (onset and recovery), while changes in the probabilities of death contribute to a smaller extent. The decrease (increase) in the probability of onset and, especially, the improvement (worsening) in the probability of recovery, have been the most important forces causing an increase (decrease) in DFLE around retirement age in recent (earlier) years. The trends observed in DFLE from mid-to-older ages exhibit a more favourable trend for women than for men, reducing the gender gap to almost zero in 2019. Women enjoy greater improvements over time in terms of the probability of disability onset, reducing to a greater extent the chances of getting a disability when compared to men.

Chapter 3 sheds new light on gender, socioeconomic and territorial inequalities in DFLE and their intersections in Italy, as cumulative factors potentially producing multiplicative disadvantages in healthy lifespan. Moreover, the chapter explores further the gender and educational gaps in DFLE through the analysis of the different age-specific contributions of the mortality and disability risk differentials. Inequalities in DFLE are a relevant issue for the country. In fact, while overall and at the national level there appear to be no gender differences in DFLE, this hides important peculiarities and inequalities by region of residence and level of education. For example, when compared to men, women are found to be particularly disadvantaged in terms of DFLE among the mid-educated and especially in some eastern regions. In Italy, educational inequalities in health are dramatically more accentuated than those in mortality. Differentials in disability risks are, in fact, the major drivers for the high educational inequalities in DFLE, throughout the country and for both genders (alongside the presence of significant territorial heterogeneity). These inequalities result in a double disadvantage for the least educated and those living in southern regions, as they can expect to live, even at older ages, shorter lives in worse health when compared to the highly educated and those living in northern regions. These findings also reveal an intersection between the level of education and the region of residence, resulting in the difference between the DFLE of the most advantages (highly educated in the northern regions) being more than double that of the most disadvantaged (low-educated in the southern regions).

Chapter 4 analyse the evolution over the last decades of the disability-free grandparenthood indicators, by gender, and explains its progression according to changes in survival (due to the longevity revolution) and changes in the prevalence of grandparenthood-disability (due to improvements in health and the postponement and reduction of fertility). In the context of increasing survival and improving health at older ages, Italian grandmothers and grandfathers gain years of life in coexistence with their grandchildren and more years of coexistence being in good functional health quality, meaning disability-free. In terms of gender differences, women can expect to live more years as grandmothers and as disability-free grandmothers when compared to men. The gender gap favouring women also increased over the last two decades. On the other side, the share of disability-free grandparent years on overall years as grandparents are lower for men than for women, as women have on average more years of life to be lived as grandmothers with disability (with crucial consequences on families). The extent of the increase of disability-free grandparenthood years for both genders is shown to be primarily led by the sharp improvement in health and survival conditions and, for men, also slowed down by the postponement of grandparenthood to older ages.

Overall, these findings highlight the importance of analysing the evolution, the gender, socioeconomic, and territorial inequalities in DFLE and the disability-free grandparenthood years in Italy, as well as their key drivers.

5.2 Limits

The studies presented in this thesis have some limitations that are worth to be discussed. The common limitation of the three studies can be summarised in the need for more extensive data sources to comprehensively understand the issue under study. In fact, major limitations come from the lack of longitudinal data that specifically focus on health, including functional health, its multidimensionality, and dynamics over time. Such data sources are crucial in understanding the health status of individuals, as well as the factors that contribute to the healthy ageing process. Longitudinal studies that follow individuals over time and collect their health histories can provide valuable insights into the determinants of health and how they evolve over the life course. Furthermore, territorial and social determinants as risk factors for health should be included to capture the eventual differential evolution, over the whole life course. Longitudinal studies that track health events and exposure factors over time can also help to understand how these factors influence the onset, timing, duration (eventually chronicisation), and possible increased mortality risks of the health status of interest. Indeed, through these data, it is also possible to better trace a sequence of events in order to establish causal relationships. Additionally, comprehensive data should include a range of sociodemographic information to also capture family dynamics and transitions in different family roles, such as the transition to grandparenthood (but also, for example, the transition to widowhood which has important health consequences for those who survive the death of their partner). This would enable researchers to understand the impact of social and family factors on health outcomes, as well as the role of social determinants in shaping health trajectories.

5.3 Implications

Italy, like many other developed countries, is experiencing an ageing population process, due to increasing life expectancies and declining birth rates. While this testifies the success in healthcare and medical advancements and in prevention, it may also present a number of challenges that threaten the sustainability of social, economic, and healthcare systems. One of the most significant challenges may be the increase of individuals in poor health and with disability, being a health states that often characterise last stages of life. This places a particular strain, from a collective perspective, on healthcare and social systems, and, from an individual perspective, in a decreased quality of life at mid-to-older ages.

Furthermore, the impact of unhealthy ageing can extend beyond the individual level to contribute also to existing socioeconomic inequalities. Individuals of disadvantaged subpopulations, such as those with lower levels of education, have higher risks of experiencing poor health outcomes and reduced health-related quality of life at older ages. This may also, in turn, exacerbate the already existing socioeconomic disadvantages they face. These inequalities can lead to both costs and challenges for society, and they provide insights into how policies addressed to disadvantaged subgroups can improve the overall well-being of the population. By addressing these disparities and promoting a more equitable distribution of education, resources and health, the average and overall conditions of the population can be improved. Addressing these social and economic inequalities through targeted interventions, such as improving education, more investment in the healthcare system and interventions for primary and secondary prevention (especially targeted to more disadvantaged groups), can help reduce the negative effects on vulnerable populations and promote a more equitable and sustainable society. This would lead to an improvement for the population as a whole, as reducing the differences would mean convergence towards better overall population health levels.

Various other dimensions of society can suffer from the consequences of an unhealthy ageing process, including family dynamics. As older individuals with disabilities may require specialised care and assistance, families may face increased caregiving duties. This can result in significant strain on family relationships, financial burden, and stress on caregivers who must balance caring for their loved ones (and even being sandwiched between caring for their parents and their children) with their own lives. Therefore, it is crucial for society to address the challenges faced by all those families caring for individuals with disabilities, and to provide adequate support and resources (which are currently really scarce if not actually lacking in Italy) to ensure the well-being and quality of life of all family members.

The years in which this thesis has been written have been marked by an unprecedented global health crisis of the COVID-19 pandemic, that hit Italy particularly hard. While this crisis is not a topic covered in this thesis, which only considers periods up to 2019, it is worth briefly discussing and acknowledging something that we may have understood of the Italian situation. The COVID-19 pandemic has exposed the weaknesses of the Italian healthcare system, particularly in the first period, in terms of its ability to care for older individuals and other vulnerable populations. With a large share of the older population aged 65 and older, Italy has been disproportionately affected by the pandemic, with older individuals at higher risk of severe health consequences and death from COVID-19. Years of economic cuts (especially after the Great Recession of 2008-2014) have left the healthcare system not enough equipped to keep up with the situation. It has underlined the need for Italy to prioritise and invest in the healthcare system, especially with the aim of ensuring adequate care and support for its older and more vulnerable individuals.

The health expectancy indicators presented in this thesis offer valuable information for policy making. These indicators can be used to monitor the evolution of healthy ageing, to compare the health and mortality risks of different populations and subgroups, and to estimate how alternative social and health policy strategies may be reflected in terms of risks and health conditions of the population, and thus in the indicators. These indicators are summary measures of health and mortality risks at the macro level. For this reason, they are not useful for identifying causal processes but rather for impact assessment. Since health expectancy measures are not affected by the confounding effect represented by the age structure of the populations to which they refer, they are particularly suitable for making comparisons between different populations, for evaluating, jointly, changes in mortality and health risks in the same population over time, or for making comparisons between different sub-groups of the same population (identified with respect to certain variables of interest such as, for example, gender, level of education, etc.). In this way, when analysing the changes in risks over time in the same population, these indicators make it possible to monitor health and mortality trends and correctly address the question of expansion, compression, and equilibrium of poor health. By monitoring changes in risks over time, policymakers can assess the consequences of past health and social policies and identify potential interventions to improve overall health outcomes. For instance, these indicators can be used to assess the medium-to-long-term consequences of periods of economic or health crises on the healthy ageing process. Then, when making comparisons between different (sub-)populations, it is possible to identify and highlight, in terms of equity, particularly fragile groups and (strata of) the population most in need of intervention. This may be useful for health and social policies in order to guarantee a long and healthy life for all, and thus also to improve overall DFLE. Given the limited and scarce resources with which health policy is confronted to maintain public health, these measures are useful tools in deciding how to allocate these resources more efficiently and how to choose between several potential and alternative interventions. By understanding the impact of different policies and interventions on health outcomes, policymakers can make more informed decisions to improve the overall DFLE of the population. In this way, health expectancy indicators can become an essential component of evidence-based policymaking in the healthcare sector.

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