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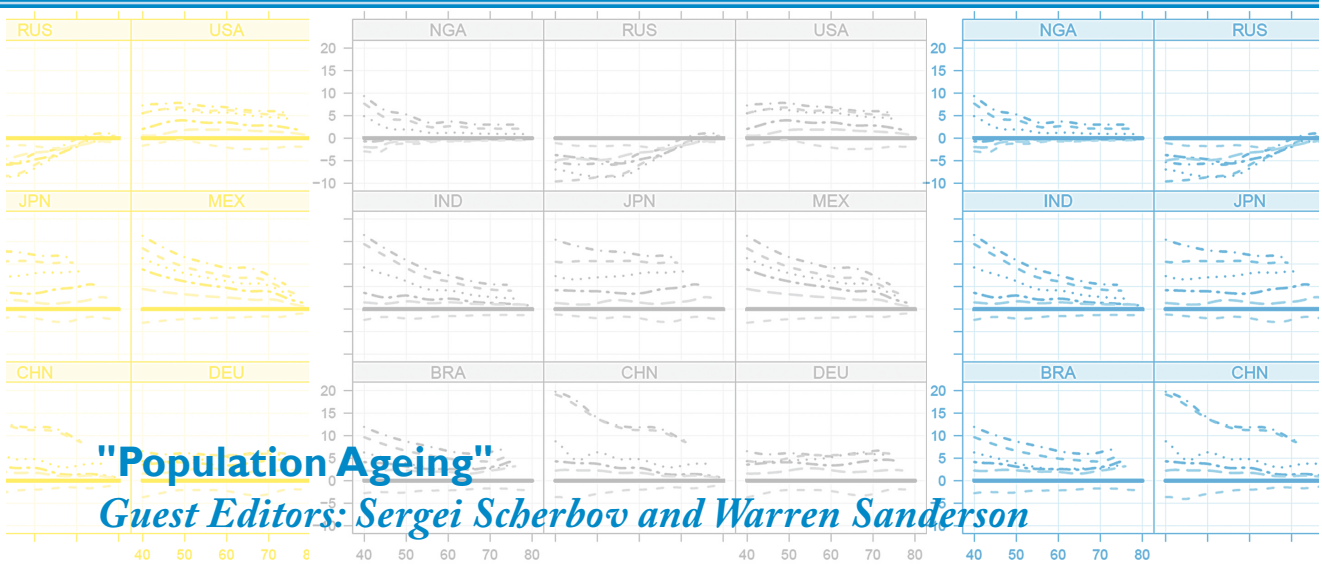
VIENNA YEARBOOK of Population Research 2016



"Population Ageing"

Guest Editors: Sergei Scherbov and Warren Sanderson

Vienna Yearbook of Population Research 2016
Austrian Academy of Sciences, Vienna

Special issue on "Population ageing"

Guest editors:
Sergei Scherbov and Warren Sanderson

Contents

Refereed Articles

Vienna Yearbook of Population Research 2016 (Vol. 14), pp. 1–3

INTRODUCTION

Warren Sanderson and Sergei Scherbov*

In the spring of 2017, a Google search of the phrase "60 is the new 50" yielded around 17,700 hits in English. When written as "sixty is the new fifty," there were around 9,880 hits; albeit with certainly many overlaps. People understand what "60 is the new 50" means, and some of them are even walking around wearing t-shirts and hoodies that reflect that idea. So far, however, an updated understanding of what it means to be "old" has yet to reach most scholars of population aging or public officials charged with making policies related to aging. If there were an aphorism that sums up the dominant academic and policy view of population aging, it would be something like: "The new 60 is the old 60."

It almost seems as though the ways in which population aging is conceptualized and measured have been frozen in time. In a UN analysis of population aging in the *Vienna International Plan on Aging, 1982*, people in all countries of the world were categorized as "old" upon reaching their 60th birthday. In a subsequent analysis of aging in *World Population Ageing 2015*, the point in the life course at which people were classified as "old" had not changed. Thus, implicitly, none of the changes in life expectancy and health that occurred between 1982 and 2015 were considered relevant to the study of population aging. The total dependency ratio – i.e., the ratio of people in the "dependent" age groups to people not in the "dependent" age groups, as defined by fixed chronological age boundaries – first appeared in 1913. While the new 60 may have been the old 60 in 1913, it certainly is not now.

There are some advantages to the approach to population aging based on the assumption that "the new 60 is the old 60." For example, it solves what could be called "the Segall problem." Segall is supposed to have said the following: "A man with a watch knows what time it is. A man with two watches is never sure." Thus, "the new 60 is the old 60" assumption is the equivalent of having only one watch. In the study of population aging, 60-year-olds are uniformly treated

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DOI: 10.1553/populationyearbook2016s001

as identical, regardless of whether they lived in Swaziland in 1950 or in Sweden in 2020. But considering the possibility that 60 may indeed be the new 50 leads us to think about the question of whether aging has to do with more than just chronological age. We are invited to wonder whether the watch that counts down to the end of our lives runs faster in some circumstances than in others.

It is important to have measures of age that depend on people's characteristics, such as their remaining life expectancy and their physical and cognitive health, because many behaviors are influenced by these characteristics. Moreover, changes in the behavioral patterns of age groups can have important economic and social implications. For example, older people are far more likely to engage in certain activities today than they were in the past, such as taking university classes, buying a house, or climbing a mountain.

In the last decade or so, new approaches to thinking about and measuring population aging have been developed. These approaches share the view that aging should be defined more by how people are living than by how long they have been alive. At each age, there are many aspects of people's lives that are relevant to the study of population aging, including how long they expect to live, how healthy they are, what activity limitations they have, how well they function physically and cognitively, and whether they receive a state-funded pension. These dimensions of people's lives differ across generations, across countries, and across subgroups of the population. The new 60 is not the old 60 when aging is viewed from a more holistic perspective. In recognition of this insight, the Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID, and WU) brought experts on aging together in November 2014 to discuss new ways of thinking about and measuring population aging. This volume is the result of that conference.

In our introductory essay, "A Unifying Framework for the Study of Population Aging," we provide a conceptual guide to the remaining papers in the volume, and show that the Segall problem need not arise in the multidimensional study of population aging. Three papers in this volume measure population aging using prospective age in addition to chronological age. Prospective age is based on remaining life expectancy. Emelyanova and Rautio examine aging in the Arctic region; while Gnajotovic and Devedzic analyze aging in Serbia; and Basten-Gietel, Sanderson, and Scherbov explore aging in emerging market economies. Two papers address the role of health in aging. Boissonnaeult and de Beer show that in 14 European countries, changes in measures of health and labor force participation among the elderly are only weakly related. Demuru and Egidi study aging in Italy by adjusting prospective ages for measures of health. Barslund et al. show how prospective ages can be used to make dependency ratios based on National Transfer Accounts data more dynamic. Novak and Palloni show that subjective survival expectations based on survey data are largely consistent with observed life expectancies. Riffe et al. add thanatological age to the mix. Thanatological age is defined as the exact number of years a person has left to live. Riffe et al. study the joint effects of prospective and thanatological age on markers of aging and

disability. Rehkopf et al. investigate the relationship between biomarkers and age in two populations of people aged 60+.

The papers in this volume exemplify the ongoing transformation of the study of population aging from having been a research area that was largely static, to becoming a field of inquiry that is exciting and dynamic.

Acknowledgements

This volume was partly supported by the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013) / ERC under Grant ERC2012-AdG 323947-Re-Ageing.

Vienna Yearbook of Population Research 2016 (Vol. 14), pp. 131–154

Adjusting prospective old-age thresholds by health status: empirical findings and implications. A case study of Italy

Elena Demuru and Viviana Egidi*

Abstract

While traditional measures of population ageing are bound to the concept of chronological age, new indicators have been proposed that take into account the dramatic changes that have occurred in later life due to increasing longevity. In this paper, we re-evaluate demographic ageing in Italy using prospective old-age thresholds based on both total remaining life expectancy and remaining life expectancy in good health. We show that the proportion of individuals above the prospective thresholds has been increasing much more slowly than the proportion of people aged 65 years and older, and that the increase in the proportion of individuals above the prospective thresholds adjusted for health status has been more or less large depending on trends in health status at older ages. Given these results and the ongoing improvements in health conditions among older people, we think the consequences of population ageing for Italian society could be less severe than expected.

1 Introduction

It is well known that all developed countries have been experiencing a marked decline in mortality driven by medical progress and improving living conditions over the whole life cycle (Amick et al. 2002; Ben-Shlomo and Kuh 2002; Demakakos et al. 2015), and especially in early life (Kermack et al. 2001;

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DOI: 10.1553/populationyearbook2016s131

Bengtsson et al. 2009; Beltràn-Sanchez et al. 2013). While the expansion of knowledge in the early 20th century about the treatment and the prevention of infectious and acute diseases led to important reductions in mortality at younger ages, death rates at adult and older ages did not start to decrease significantly until further scientific advancements in the treatment of chronic diseases were made after World War II (Meslé and Vallin, 2000; Caselli 2015). Since then, mortality has been continuously decreasing, especially at older ages (Kannisto 1994, 1996; Rau et al. 2008). People are now surviving to increasingly old ages, and it is no longer uncommon for individuals to live 100 years or more (Jeune and Kannisto 1997; Robine and Vaupel, 2002; Vaupel 2010).

As a result of mortality decline, the average life span has steadily lengthened over time, reaching very high levels in recent years. Thus, life expectancy at birth doubled in most developed countries during the 20th century (Human Mortality Database, 2015). Nonetheless, life expectancy is expected to continue to grow in the near future, and the most optimistic scholars even believe that a maximum human life expectancy does not exist (Caselli and Vallin, 2001; Oeppen and Vaupel, 2002). During the 1950s, life expectancy at older ages also began to increase. Thus, just as life expectancy at birth has been extended to ages once considered unreachable, the number of remaining years to live of people who have reached older ages has risen to such an extent that it is now usual (in the literature, as in life) to distinguish between the "old" and the "oldest-old"; with the latter group consisting of individuals aged 80 or 85 years and older (Suzman et al. 1992; Baltes and Smith 1999; Vaupel 2010).

As extending life must be considered one of humankind's greatest achievements, nobody who was present at the start of this process could have imagined that such a positive development in population dynamics would cause growing concern over time. Nonetheless, a potentially negative consequence of rising life expectancy is that, together with a simultaneous drop in fertility rates, this longevity revolution (Butler, 2008) is leading to a dramatic ageing of the populations of many countries, profoundly changing the balance between their young, adult, and older components (Cohen 2005). The problem is that many questions about the impact of this shift in the age structure of a population towards older ages on the sustainability of a country's health – as well as on its social and economic systems – still remain unanswered.

Pessimistic assumptions regarding our future ability to deal with the (potentially negative) effects of population ageing currently prevail; thus, the idea that it will gradually become impossible to satisfy the needs of the elderly for health and social care is widespread. These assumptions are, however, often based on observed trends in the numbers and the proportions of individuals who survive beyond a fixed age threshold – usually 65 years old. Such measures of population ageing do not take into account the possibility that many characteristics of the population at a given age could change over time. Yet some of these characteristics – in addition to life expectancy – are already changing; indeed, because people are living longer, the whole life course is being stretched. This expansion of the life course is modifying the meaning of particular ages, as well as the timing of transitions from one life

course stage to another (Lee and Goldstein 2003). People who are aged 65 years today can expect to enjoy longer and healthier lives than ever before. On average, they are more educated and live in better social and economic conditions than their peers born 50 to 100 years before. Even from a biological point of view, many studies have demonstrated that, although ageing is a universal process, a significant degree of plasticity exists both between individuals and between successive cohorts. This finding appears to hold regardless of the measure of biological ageing that is adopted (McDonald, 2014). For instance, the frailty index – i.e., the proportion of deficits present in an individual out of the total number of age-related health variables considered – depends on gender, education, marital status, and other socio-demographic characteristics; and thus changes from one cohort to another (Jones et al. 2005). The allostatic load – i.e., an indicator of individual ageing that links physiologic dysregulation to the risk of adverse health outcomes (Crimmins et al. 2003) – increases rapidly until age 65, and then stabilises, partially due to a selection effect among older people with respect to physiological status. It has indeed been demonstrated that biological risk and physiological dysregulation are strongly related to socioeconomic conditions over the life cycle, and that people in less favourable conditions die at younger ages. Thus, the physiological status differences between individuals are reduced at older ages (Crimmins et al. 2009). Finally, research on telomere length – which is frequently used as a biomarker of ageing – confirms that the rate of progression of individual ageing is strongly influenced by lifestyle. This explains the progress observed over time, and provides support for the claim that ageing can be further slowed through active health policies (Shammas 2012). It is thus clear that the ageing process has been changing at the individual level, and that we should rethink our assumptions about the relationship between age and different phases of life (Holstein and Gubrium 2000; Lee and Goldstein 2003). These developments should also be taken into account when evaluating the magnitude and the impact of ageing at the population level. New concepts and indicators are needed to correctly identify the individuals who should be truly classified as elderly, as being older than a fixed threshold is no longer a satisfactory measure of who is or is not "old". Studies on the economic impact of widespread longevity have also shown that forecasting future trends in health care expenditures based on the numbers and the proportions of people above the conventional old-age threshold (i.e., 65 years) would lead to unjustifiably alarming forecasts. Indeed, the bulk of health care expenditures are related to services administered to individuals during their last years of life (regardless of their chronological age); and to external factors, such as the cost of new technologies (Stearns and Norton 2004; Seshamany and Gray 2004; Shang and Goldman 2008).

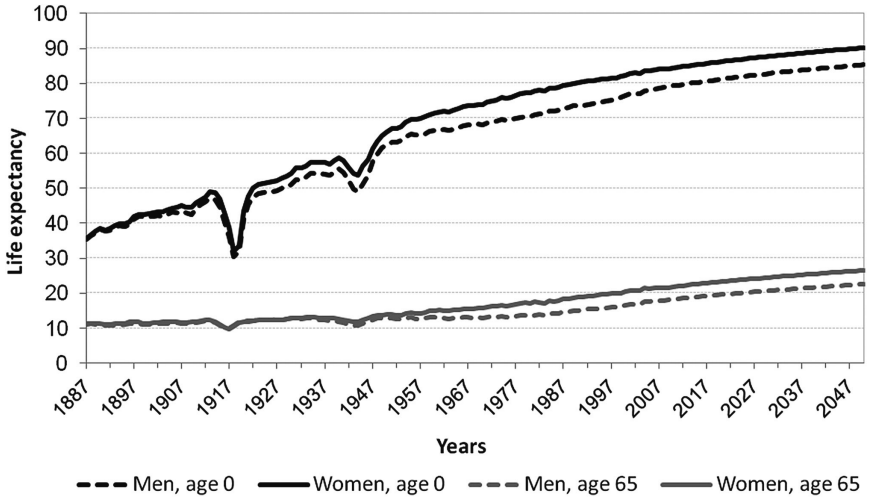
Different indicators may be used to represent the dramatic increase in longevity that occurred during the second half of the 20th century. The modal age at death is one of these indicators, and is an appropriate metric to use to describe increases in survival to very high ages (Kannisto 2000, 2001; Robine et al. 2007), as it is particularly sensitive to mortality dynamics at older ages (Horiuchi et al. 2013). Many studies have tried to link trends in the risk of death at older ages to the

process of ageing (Horiuchi and Wilmoth 1997; Barbi 2003; Vaupel 2010; Salinari and De Santis 2014; Zheng 2014). Other researchers have proposed new measures of population ageing based on remaining life expectancy. The most promising of these proposed measures introduces the concept of prospective age (Sanderson and Scherbov 2007, 2008, 2010, 2015; Lutz et al. 2008), thereby reactivating a line of pioneering research that was much discussed in the 1970s (Ryder 1975). Referring to prospective age instead of chronological age allows us to account for improvements in longevity. Prospective age is the age at which the number of years of remaining life expectancy equals the number of years observed at an age taken as a point of reference, such as a specific age in a past time period. We will use this concept to identify old-age thresholds that can be compared both between different years and between men and women, using the same value of remaining life expectancy as a point of reference.

While the prospective age concept can itself be seen as a breakthrough in the research into possible alternatives to traditional measures of population ageing, we think that this indicator could be further enhanced by incorporating information on the population's health status that accounts for the quality of the extra years of life gained through longevity improvements. The good news is that in countries where high-quality data on population health are available, prospective ages adjusted for health status can be easily computed by referring to remaining health expectancies – i.e., to the number of remaining years of good health – instead of the total remaining life expectancy.

In this paper, we apply the concept of prospective age (both with and without adjusting for health status) to an analysis of the past, present, and future magnitudes of population ageing in Italy. Our aim is to re-estimate population ageing using prospective measures that take into account not only increased longevity, but also the associated changes in the health conditions of older individuals in the population. In order to do so, we calculate the total number of prospective old-age thresholds between 1887 and 2050 (observed up to 2013 and then projected), and the prospective old-age thresholds without functional limitations and in good self-rated health for 1991, 1994, 2000, 2005, and 2013; i.e., for those years for which data from the national health interview survey conducted by the Italian National Institute of Statistics (Istat) are available. We show that the total prospective old-age thresholds have been rising steadily over the whole period, and that the increases in the shares of men and women above these thresholds have been much smaller than the increases in the shares of men and women aged 65 and older. After adjusting for health status, these results are even more encouraging, but they also confirm the existence of large gender differences. Indeed, the positive evidence that the old-age thresholds without functional limitations and in good self-rated health rose even more than the total prospective thresholds should be weighed against our finding that women made less progress than men, as women generally reported being in worse health (the well-known health-survival gender paradox, Oksuzyan et al. 2008), and the health status of women does not appear to be improving as rapidly as that of men.

Figure 1:
Observed and expected life expectancy of Italian men and women aged zero and 65 years between 1887 and 2050



Source: The observed data come from the Human Mortality Database for the years 1887–2013, and the predicted data come from Istat for the years 2014–2050.

2 How old is the Italian population? Traditional VS new measures of ageing

As in other developed countries, Italy has been experiencing a notable increase in life expectancy; a trend that is expected to continue into the foreseeable future. To better illustrate the evolution of life expectancy over time, the historical and the projected trends in life expectancy in Italy – at birth and at age 65 – are shown in Figure 1.

Between 1887 and 2013, life expectancy rose from about 36 years to 79.8 years among men and to 84.6 years among women. Furthermore, over the same period the remaining life expectancy at age 65 virtually doubled: it rose from approximately 10 years in 1887 to 18.3 years among men and to 21.8 years among women in 2013. Most of these improvements have, however, occurred over the last 60 years: in 1950, life expectancy at age 65 was 13.0 years among men and 13.9 years among women.

Apart from observing the rapid pace of these improvements, it is interesting to note that a significant gender gap in survival conditions has been gradually emerging. Whereas at the end of the 19th century Italian men and women had roughly the same life expectancy, today women can expect to live 4.8 years longer than men at all ages (down from a maximum gap of 6.7 years in 1980). According to forecasts made by Istat, by 2050 life expectancy will reach 85 years for men and 90 years for women;

Figure 2:
Prospective old-age thresholds, defined as the age at which the remaining life expectancy equals that of a person aged 65 living in 1887, for men and women between 1887 and 2050

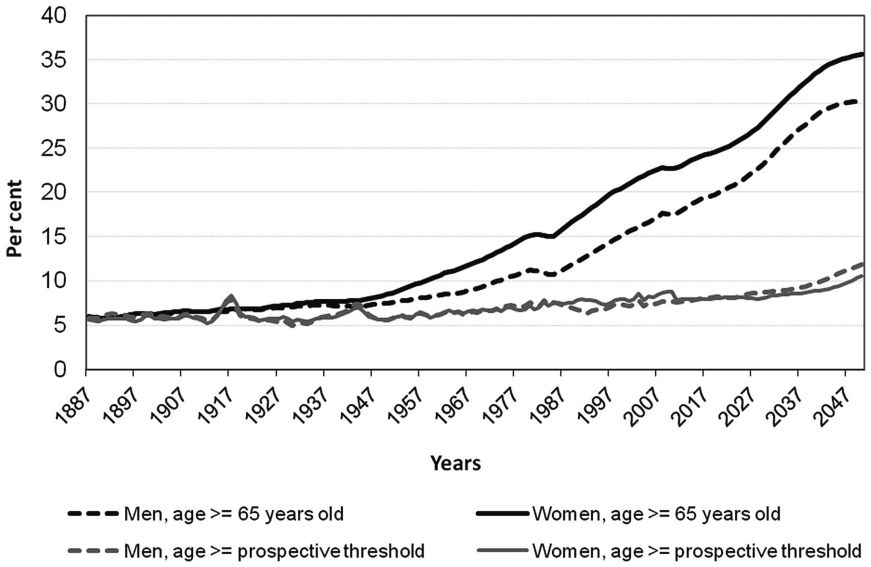
Source: Our calculations based on observed data from the Human Mortality Database for the years 1887–2013, and predicted data by Istat for the years 2014–2050.

thus, Italians are expected to gain another five years of life between 2013 and 2050. In addition, life expectancy at age 65 is projected to reach 22 years for men and 26.5 years for women by 2050; or four years more than in 2013.

The effects of such a dramatic increase in life expectancy are visible in the form of rising numbers and proportions in the population of individuals older than age 60 or age 65. However, the pace of this trend differs considerably depending on which measure of demographic ageing is used. If, as is generally the case today, we assume that age 65 is the old-age threshold, then we find that the proportion of elderly people in the Italian population has been growing at such a rapid pace that there may be doubts about society's ability to deal with the consequences. If, however, we use a prospective rather than a retrospective old-age threshold, a much less alarming demographic picture appears, as we show with the following example.

Based on the method suggested by Sanderson and Scherbov (2007), we first define the prospective old-age threshold for each year between 1887 and 2050 as the age at which the remaining life expectancy equals the remaining life expectancy observed at age 65 in the first year of the considered period; i.e., 1887. We then define as elderly those individuals who are older than the threshold. As can be seen in Figure 2, this measurement strategy allows us to compute a dynamic threshold that constantly changes to include any evidence of survival improvements at higher

Figure 3:
The proportion of individuals aged 65 and older and the proportion of individuals older than the prospective old-age thresholds, defined for each year as the age at which the remaining life expectancy equals that of a person aged 65 living in 1887, for men and women between 1887 and 2050



Source: Our calculations based on observed data from the Human Mortality Database for the years 1887–2013, and predicted data by Istat for the years 2014–2050.

ages. A significant increase in the threshold is indeed observed, especially since the beginning of the second half of the last century. Applying this strategy, we estimate that in 2013 the prospective old-age threshold was 76.5 for men and 80 for women, and will be 79.4 for men and 83.8 for women in 2050 (i.e., between 1887 and 2050, this threshold is expected to increase by 14 years for men and by 19 years for women). Yet in this scenario as well, we see that a gender gap has been gradually emerging over time.

In Figure 3, we can see the differences in the estimates of population ageing generated by the analysis based on the chronological old-age threshold (fixed at age 65), and by the analysis based on the new and dynamic prospective old-age threshold, which refers to remaining life expectancy.

The share of individuals older than the fixed threshold of 65 years increased from 6% of both men and women in 1887 to 18.3% of men and 23.3% of women in 2013. On the other hand, the share of individuals older than the prospective thresholds went from 6% to almost 8% of both men and women; a very limited increase relative to the increase observed when using traditional measures of ageing (2% among both men and women vs. 12% among men and 17% among women). Over the

next 50 years, the share of individuals in the population older than the prospective thresholds is expected to grow more consistently, but still at a much slower pace than the proportion of the population aged 65 years and older. While 35% of women and 30% of men are expected to be in the second group in 2050, just 12% of men and 11% of women are expected to be in the first group in 2050. It is important to note that the gender differences are much smaller when we analyse population ageing using the prospective rather than the chronological definition of the old-age threshold.

3 Changing health conditions among the elderly in Italy

A criticism that could be made about the use of the prospective measure of ageing is that it tracks progress in survival, without evaluating the conditions in which older people live their extra years of life. The prospective old-age thresholds defined in the previous paragraph do not include any information about the quality of the remaining life expectancy. This could lead to inaccurate estimates of the socioeconomic consequences of population ageing, as improved longevity would be a truly positive development if the years of life gained are spent in good health. Thus, the negative effects of ageing on socioeconomic sustainability might be overestimated if people are indeed living longer and healthier lives, as healthy agers could continue to have a role in society (Vaupel 2006), and would place a much smaller burden on the health system than is currently anticipated. Conversely, rising longevity could simply result in an increase in the number of years spent in poor health, and, consequently, in the proportion of individuals with high social and health care needs. In other words, individuals who survive to older ages could be a burden or a resource, depending on their health status. Based on this reasoning, we think that prospective old-age thresholds should account for changes in the health conditions of the elderly in order to provide more realistic information about the potential impact of population ageing in a specific country.

Here, we present a brief overview of the health status of the Italian elderly population. These results will be used in the next paragraph to adjust the prospective old-age thresholds for health status. Istat has been conducting nationally representative health interview surveys approximately every five years since 1991. Thus, high-quality, comparable health data are available for Italy for a period of about 20 years. We calculated health expectancies – i.e., the number of years of life to be lived in good health (Jagger and Robine 2011; Jagger et al. 2014) – of individuals aged 65, 70, and 75 in 1991, 1994, 2000, 2005, and 2013. We computed two different health expectancies: functional health expectancy, which refers to the number of years to be lived without severe functional limitations; and subjective health expectancy, which refers to the number of years to be lived in good self-rated health. Four different areas of functional limitation are included in the definition of functional health: limitations of the senses, limitations of movement, limitations in activities of daily living (ADL), and confinement. Self-rated health is assessed for

Table 1:
Total life expectancy (LE), functional limitation-free life expectancy (LFLE), life expectancy with functional limitations (LLE) and proportion of years to be lived without functional limitations (HR) among men and women of age 65, 70 and 75 in the years 1994, 2000, 2005 and 2013

	Men					Women				
	1991	**1994**	**2000**	**2005**	**2013**	**1991**	**1994**	**2000**	**2005**	**2013**
65 years										
LE	15.2	15.5	16.5	17.5	18.6	19.0	19.4	20.4	21.3	22.0
LFLE	12.1	12.7	13.7	14.6	15.6	13.8	14.1	14.9	15.6	16.1
LLE	3.0	2.8	2.8	2.8	2.9	5.1	5.2	5.4	5.6	5.9
*HR (*100)*	*80.1*	*81.9*	*83.1*	*83.7*	*84.2*	*72.9*	*73.0*	*73.3*	*73.5*	*73.3*
70 years										
LE	12.0	12.3	13.0	13.7	14.7	15.0	15.3	16.2	17.1	17.7
LFLE	9.0	9.5	10.3	10.9	11.8	10.0	10.3	10.9	11.5	11.9
LLE	3.0	2.8	2.8	2.9	2.9	5.0	5.1	5.3	5.5	5.8
*HR (*100)*	*75.2*	*77.2*	*78.8*	*79.2*	*80.2*	*66.7*	*66.9*	*67.3*	*67.5*	*67.3*
75 years										
LE	9.1	9.3	10.0	10.5	11.3	11.3	11.6	12.4	13.1	13.7
LFLE	6.1	6.6	7.2	7.6	8.3	6.6	6.8	7.3	7.7	8.1
LLE	3.0	2.8	2.7	2.9	2.9	4.7	4.8	5.1	5.4	5.6
*HR (*100)*	*67.4*	*70.5*	*72.5*	*72.4*	*74.2*	*58.5*	*58.5*	*59.0*	*59.1*	*59.2*

Source: Our calculations based on data from the Italian national health interview survey conducted by Istat in the years 1994, 2000, 2005, and 2013.

each individual using the question: "How is your health in general?". Respondents who answered "good" or "very good" are described as being in good health. It should be noted, however, that because this question had a different formulation in the 1991 Italian national health interview survey, it is not possible to compare the results obtained for this year with the other results. This shortens the observed interval from 1994 to 2013.

For all of the considered ages and calendar years, Table 1 reports the total life expectancy, the life expectancy free of functional limitations, the life expectancy with functional limitations, and the proportion of years to be lived without functional limitations relative to the total remaining life expectancy (*health ratio*). When we look at the table, we see immediately that the number of years to be lived without functional limitations has been rising continuously since 1991, at all ages and for both genders. At the same time, however, the increase in this figure has been much more pronounced among men than among women. In addition, over the past two decades, the number of years spent with functional limitations – which was already higher among women than among men in 1991 – increased slightly among women,

Table 2:
Total life expectancy (LE), life expectancy in good self-rated health (HLE), life expectancy in poor self-rated health (PHLE) and proportion of years to be lived in good self-rated health (HR) among men and women of age 65, 70 and 75 in the years 1994, 2000, 2005 and 2013

	Men				Women			
	1994	**2000**	**2005**	**2013**	**1994**	**2000**	**2005**	**2013**
65 years								
LE	15.5	16.5	17.5	18.6	19.4	20.4	21.3	22.0
HLE	11.0	12.3	14.4	15.5	12.9	14.8	15.9	16.6
PHLE	4.5	4.3	3.0	3.1	6.5	5.6	5.3	5.4
*HR (*100)*	*71.0*	*74.1*	*82.7*	*83.5*	*66.7*	*72.6*	*74.9*	*75.6*
70 years								
LE	12.3	13.0	13.7	14.7	15.3	16.2	17.1	17.7
HLE	8.1	9.1	10.9	11.9	9.9	11.2	12.2	12.8
PHLE	4.2	3.9	2.8	2.8	5.5	5.0	4.8	4.9
*HR (*100)*	*66.2*	*70.2*	*79.6*	*81.0*	*64.4*	*69.0*	*71.8*	*72.3*
75 years								
LE	9.3	10.0	10.5	11.3	11.6	12.4	13.1	13.7
HLE	5.7	6.6	8.0	8.8	7.2	8.1	8.9	9.4
PHLE	3.6	3.3	2.5	2.5	4.4	4.3	4.2	4.3
*HR (*100)*	*61.2*	*66.4*	*76.0*	*77.8*	*61.8*	*65.6*	*68.2*	*68.6*

Source: Our calculations based on data from the Italian national health interview survey conducted by Istat in the years 1994, 2000, 2005, and 2013.

but remained largely stable among men. Thus, the gender gap in health expectancy has been widening over the years, with men gaining more years of healthy life than women. This pattern is clearly demonstrated by the health ratio, which is not just higher among men than among women, but is also rising at a faster pace among men than among women. In 1991, 65-year-old men were expected to live 80.1% of their remaining life without functional limitations, compared to 72.9% for women. By 2013, the corresponding values had risen to 84.2% and 73.3%. Moreover, these gender differences tend to increase with age, especially in the most recent years: in 2013, 75-year-old women could expect to live only 59.2% of their remaining life without functional limitations, a much lower proportion than the 74.2% observed among men. Overall, Table 1 describes a relative compression of morbidity scenario, as it has been defined by Fries (1989): i.e., for both men and women, the number of years spent without functional limitations increased more than the number of years spent with functional limitations (Robine and Mathers 1993; Doblhammer and Kytir 2001).

Table 2 refers to self-rated health, and shows the healthy life expectancy (i.e., the life expectancy in good health), the life expectancy in poor health, the total life expectancy, and the health ratio for all ages and years starting from 1994. These indicators paint an even more favourable picture, as they show that since 1994, both men and women have experienced not only increases in the number of years lived in good health, but significant decreases in the number of years lived in poor health. Moreover, the health ratio for functional limitations has increased especially sharply. Notable gender differences are, however, still evident: women were already disadvantaged at the beginning of the study period, and especially at older ages, women did not make as much progress as men during the subsequent years. For instance, among 65-year-olds in 1994, the average share of life to be lived in good health was 71% for men and 66.7% for women; whereas among 65-year-olds in 2013, the corresponding proportions were 83.5% and 75.6%. Yet despite these differences, the trends described for both men and women show an absolute compression of the morbidity scenario, as the years spent in poor health decreased in both absolute and relative terms.

In sum, the health of the Italian older population has been evolving positively in recent decades, as major health problems are shifted towards older ages, and high-quality years are added to the total lifespan. Health has been improving among men in particular, while improvements seem to have been slowing down over time among women.

4 Prospective old-age thresholds: an adjustment for health status

To take into account the health conditions of older people in Italy, we substitute the functional limitation-free and healthy life expectancies for the total life expectancy in the calculation of prospective ages. Using this approach, we are able to define old-age thresholds based not only on progress made in survival, but on changes in the health-related quality of life.

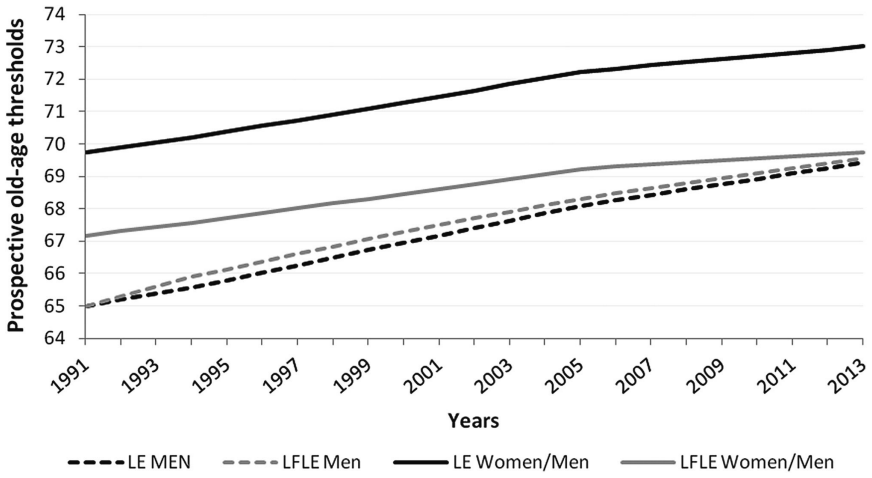
Focusing on the functional dimension of health, we compute the prospective old-age threshold without functional limitations as the age at which the functional limitation-free life expectancy equals that observed for an individual aged 65 in 1991, i.e., the first year of the reference period; we then compare this threshold with the total prospective ages (all health states considered), which is calculated by referring to the same year (Table 3). Among men, the functional limitation-free old-age threshold in 2013 was 69.6 years and the total prospective old-age threshold was 69.4 years; i.e., 4.6 and 4.4 years more than in 1991. Among women, the functional limitation-free old-age threshold in 2013 was 67.8 and the total prospective old-age threshold was 68.6 years; i.e., 2.8 and 3.6 years more than in 1991. Therefore, both prospective thresholds increased for both men and women over the last two decades. However, a difference emerges: the functional limitation-free prospective old-age

Table 3:
Total (LE) and functional limitation-free (LFLE) prospective old-age thresholds, respectively, defined as the ages at which the total and the functional limitation-free life expectancies equal those observed at age 65 in 1991 for men and women, and the prospective old-age thresholds of women relative to those of men in the years 1991, 1994, 2000, 2005, and 2013

Prospective	Men					Women					Women/Men				
age	1991	1994	2000	2005	2013	1991	1994	2000	2005	2013	1991	1994	2000	2005	2013
LE	65.0	65.6	67.0	68.1	69.4	65.0	65.5	66.7	67.8	68.6	69.7	70.2	71.3	72.2	73.0
LFLE	65.0	65.9	67.3	68.3	69.6	65.0	65.4	66.4	67.2	67.8	67.2	67.6	68.5	69.2	69.7

Source: Our calculations based on data from the Italian national health interview survey conducted by Istat in the years 1991, 1994, 2000, 2005, and 2013.

Figure 4:
Total (LE) and functional limitation-free (LFLE) prospective old-age thresholds, respectively, defined as the ages at which the total and the functional limitation-free life expectancies equal those observed at age 65 in 1991 for men, and the corresponding prospective old-age thresholds of women relative to those of men between 1991 and 2013



Note: The prospective old-age thresholds are calculated for 1991, 1994, 2000, 2005, and 2013; and were obtained by interpolation for all other years.
Source: Our calculations based on data from the Italian national health interview survey conducted by Istat in the years 1991, 1994, 2000, 2005, and 2013.

threshold increased slightly more than the total prospective old-age threshold among men, and less than the total threshold among women. Thus, in contrast to estimates of survival probabilities, these indicators suggest that elderly women have been doing much worse than their male counterparts, and that men have been ageing more successfully than women.

However, direct comparisons between men and women using the prospective old-age thresholds reported in Table 3 can be misleading, as men and women may be expected to live different numbers of years at the starting reference point, both in total and without functional limitations. Therefore, the remaining life expectancy used as a reference for computing the prospective age is not the same for men and women. To create comparable indicators, we calculated a gender-comparative prospective old-age threshold for women as the age at which the total and the health-specific remaining life expectancies equal those observed among men at age 65 in 1991. We called this new measure "the prospective comparative old-age threshold of women in respect to men".

The results, shown in Figure 4, confirm that including information on health has a large impact on prospective old-age thresholds. When we consider the total

Table 4:
Total (LE) and healthy (HLE) prospective old-age thresholds, respectively, defined as the age at which the total and the healthy life expectancies equal those observed at age 65 in 1994 for men and women, and the prospective old-age thresholds of women relative to those of men in the years 1994, 2000, 2005, and 2013

Prospective	Men				Women				Women/Men			
age	1994	2000	2005	2013	1994	2000	2005	2013	1994	2000	2005	2013
LE	65.0	66.4	67.6	69.1	65.0	66.2	67.3	68.1	69.7	70.8	71.8	72.6
HLE	65.0	68.3	69.9	71.6	65.0	67.6	69.1	69.9	68.1	70.2	71.6	72.3

Source: Our calculations based on data from the Italian national health interview survey conducted by Istat in the years 1994, 2000, 2005, and 2013.

prospective old-age thresholds, we see that a wide gender gap emerges, and that this gap has decreased only slightly over the period. These thresholds were indeed 4.7 and 3.6 years higher for women than for men in 1991 and 2013, respectively. The picture painted by the functional limitation-free prospective old-age thresholds is rather different. While it still appears that women aged later than men, the difference between the comparative prospective thresholds of the two sexes was much smaller. Moreover, because the gender gap had been decreasing so much over time, it was almost no longer visible by 2013: whereas the old-age threshold was two years higher among women than among men in 1991, the difference was just 0.1 years in 2013.

The results obtained for the subjective dimension of health are somewhat different. In this case, the prospective old-age thresholds in good self-rated health are defined as the ages at which the remaining healthy life expectancy equals that observed at age 65 in 1994. As Table 4 shows, in recent decades these thresholds increased more than the total prospective ages among both men and women. This result was expected given the more balanced distribution of improvements in self-rated health between older men and women. More specifically, the healthy prospective old-age threshold increased 6.6 years among men but just 4.9 years among women, while the total prospective old-age thresholds increased 4.1 years among men and 3.1 years among women.

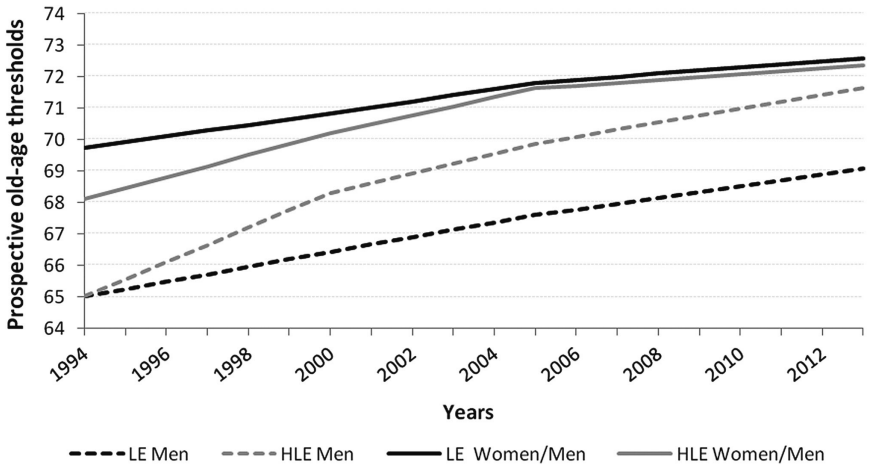
In addition, for the healthy prospective measures, we calculated gender-comparative thresholds in order to be able to make appropriate comparisons between men and women (see Figure 5). As in the case of functional limitations, we see a wide gender gap when we look at the total prospective ages, but a much narrower gender gap when we look at the prospective old-age threshold in good health: i.e., the gender differences for these two indicators were 4.7 and 3.1 years in 1991, and were 3.5 and 0.7 years in 2013. Once again, the gender differential observed at the beginning of the period has almost disappeared over time.

5 Ageing or rejuvenating? A re-evaluation of the impact of population ageing in Italy

We are now able to assess the impact of using prospective measures, both with and without correction for the health-related quality of life expectancy, when estimating population ageing. The results in Tables 5 and 6 are presented separately for each dimension of health because prospective old-age thresholds have different reference years, and, consequently, different remaining life expectancies that are assumed to be constant in time.

We first focus on the results obtained for functional health (Table 5). As has already been shown in Figure 3, the proportion of people over age 65 in the Italian population has been growing steadily since the 1950s. The rate of increase in this share has never slowed down, and is even expected to speed up in the near future,

Figure 5:
Total (LE) and healthy (HLE) prospective old-age thresholds, respectively, defined as the age at which the total and the healthy life expectancies equal those observed at age 65 in 1994 for men, and the corresponding prospective old-age thresholds of women relative to those of men between 1994 and 2013



Note: The prospective old-age thresholds are calculated for 1994, 2000, 2005, 2013 and obtained by interpolation for all other years.
Source: Our calculations based on data from the Italian national health interview survey conducted by Istat in the years 1994, 2000, 2005, and 2013.

fuelled by large generations of "baby boomers" progressing into later life. Yet if we change our perspective, we see that the percentage of individuals above the total prospective old-age threshold – calculated without adjusting for the health conditions at higher ages – is always substantially lower than the proportion of people aged 65 and older among both men and women. Furthermore, the growth in this percentage over the whole period has been limited: only 13.8% of men and 14.8% of women were above the total prospective thresholds in 2013. When correcting prospective ages to include only the years expected to be lived free of functional limitations, the situation changes only slightly for men, but worsens significantly for women: the proportion of women above the threshold rose from 15% in 1991 to 18.3% in 2013.

Some comments can be made about these results. First, a very discouraging picture emerges when traditional measures of population ageing are applied. Second, using prospective measures without taking into account the quality of the years of life gained with improving longevity – as is usually done in the literature – leads to an underestimation of ageing among women. This happens because the total prospective age does not take into account the increase in the number of years to be lived with functional limitations among women.

Table 5:
The proportion of individuals aged 65 years and older, the proportion of individuals above the total gender-comparative prospective old-age threshold, and the proportion of individuals above the gender-comparative prospective old-age threshold without functional limitations in the Italian male and female populations for the years 1991, 1994, 2000, 2005, and 2013

	% ≥ 65 years of age		% ≥ total gender-comparative prospective old-age threshold		% ≥ prospective gender-comparative old-age threshold without functional limitations	
Years	**Men**	**Women**	**Men**	**Women/Men**	**Men**	**Women/Men**
1991	12.6	17.5	12.6	12.2	12.6	15.0
1994	13.5	19.0	12.8	12.8	12.5	15.7
2000	15.3	20.8	13.2	13.7	12.9	16.8
2005	16.6	22.1	13.2	14.1	13.0	17.3
2013	18.6	23.6	13.8	14.8	13.6	18.3

Note: The references for the prospective ages are the total and the functional limitation-free remaining life expectancies of a man aged 65 in 1991.
Source: Our calculations based on population data from Istat.

Table 6:
The proportion of individuals aged 65 years and older, the proportion of individuals above the total gender-comparative prospective old-age threshold, and the proportion of individuals above the gender-comparative prospective old-age threshold without functional limitations in the Italian male and female populations for the years 1994, 2000, 2005, and 2013

	% ≥ 65 years of age		% ≥ total gender-comparative prospective old-age threshold		% ≥ prospective gender-comparative old-age threshold in good health	
Years	**Men**	**Women**	**Men**	**Women/Men**	**Men**	**Women/Men**
1994	13.5	19.0	13.5	13.4	13.5	15.1
2000	15.3	20.8	13.8	14.2	11.9	14.9
2005	16.6	22.1	13.7	14.5	11.4	14.7
2013	18.6	23.6	14.4	15.4	11.7	15.6

Note: The references for the prospective ages are the total and the healthy remaining life expectancies of a man aged 65 in 1994.

Source: Our calculations based on population data from Istat.

The results obtained when considering the subjective dimension of health and the year 1994 as a reference for calculating prospective ages are even more interesting (Table 6). The proportion of individuals above the total prospective old-age threshold rose among women, increasing from 13.4% to 15.4% between 1994 and 2013. However, the corresponding proportion among men fluctuated over the same period, between a minimum of 13.5% and a maximum of 14.4%. After adjusting the prospective thresholds for the perceived health status, it appears that from 1994 to 2005 the proportion of elderly individuals was declining. This was mainly the case among men, as the proportion of men above the old-age threshold in good health dropped from 13.5% to 11.4%; women experienced a smaller decrease, as the corresponding proportion of women declined from 15.1% to 14.7%. These figures tell us that, assuming an old-age threshold adjusted for perceived health, the Italian population was rejuvenating rather than ageing up to 2005. Even though the share of people older than the prospective threshold in good health subsequently rose, the picture created by the prospective measures of ageing is profoundly different from the one we are used to seeing. Finally, the proportion of men above the prospective old-age threshold adjusted for self-rated health was generally lower than the share of men above the total prospective threshold; whereas the situation among women did not change much.

It should be noted that, on the one hand, without adjusting for self-perceived health, the proportion of men above the prospective old-age threshold was higher than that of women; but that on the other, completely different trends appear for men and women when adjusting for self-perceived health. Using the total prospective ages in this case means overlooking the evidence that the number of years expected to be lived in poor health has been declining over time, and that this number has been falling faster among men than among women. Generally, it appears that using total prospective ages rather than prospective measures adjusted for self-rated health could lead to more pessimistic estimates of population ageing, as the first indicator could be disregarding possible improvements in the quality of life at older ages.

In sum, we assert that the impact of population ageing could be profoundly re-evaluated if prospective measures were commonly accepted. Such measures could prove especially useful when attempting to quantify the magnitude of population ageing in those countries in which the longevity of people aged 65+ has improved the most. Moreover, it appears that prospective old-age thresholds should be corrected by including indicators of the quality of life expectancy, as the failure to include such indicators could lead to the under- or the overestimation of population ageing when health worsens or improves over time.

6 Discussion and conclusions

In association with decreasing fertility, rising longevity has led to a dramatic increase in the proportion of elderly people in the population in recent decades. The elderly have traditionally been defined as individuals older than a fixed

chronological age threshold (usually 60 or 65). The growth in the older population can be seen as an extraordinarily positive development resulting from sharp declines in human mortality over the past century. However, as the share of older people in the population has expanded, concerns about the ability of society to adapt to this completely new age structure have been raised. Population ageing is indeed an epochal change that poses many challenges, and that requires a deep reorganisation of social, economic, and welfare systems in all affected countries (Christensen et al. 2009; Börsch-Supan et al. 2005; Soede et al. 2004).

At an individual level, increasing longevity has stretched the whole life course (Lee and Goldstein 2003): childhood and adulthood have lengthened considerably over the years, and adolescence and the so-called "fourth age" have even emerged as new stages of life (Higgs and Gilleard 2015; Perls 2015). Young-old people, and especially the baby boomers born after World War II, spent most or all of their lives in conditions of unprecedented prosperity and of expanding educational opportunities. Thus, these generations have different psychophysical profiles, behaviours, and expectations than previous cohorts (Baltes and Smith 2003; Crimmins 2004; Fuller-Iglesias and Smith 2009; Rice et al. 2010; Sabbath et al. 2015; Pinheiro Melo Borges Tiago 2016; Hülür et al. 2016).

Despite these changes, the definition of old age most commonly used to measure population ageing has not evolved over time, and is now obsolete. The concept of old age should be broader than the simple crossing of a fixed age threshold that does not refer to an individual's life history, health, and vitality (Ryder, 1975; Legaré and Desjardins, 1987; Egidi, 1992; Sanderson and Scherbov, 2007). Health conditions are especially relevant when assessing the impact of population ageing on society: indeed, the true borderline between adult and older ages could be drawn at the point at which a person's health status deteriorates to the extent that he/she is no longer able to live successfully and independently, and has thus become an economic and social burden on society (Preston and Wang, 2006; Caselli and Egidi, 2011). A healthy ageing process is essential for successful ageing, as remaining healthy allows older people to continue to be active participants in society.

Our analysis of the most recent evolution of population ageing in Italy takes into account advancements in both survival and health at older ages, and confirms the need to adjust prospective measures of ageing by considering the quality of the extra years of life gained. In particular, our results show that the estimates of the share of people above the prospective old-age threshold in the Italian population can be distorted if no reference to individual health status is included. Indeed, when using total prospective thresholds, the impact of population ageing could be either underestimated or overestimated depending on how specific health dimensions have evolved in conjunction with increasing longevity. When assessing population ageing among women, using total prospective old-age thresholds can lead to unduly optimistic estimates, whereas applying prospective old-age thresholds adjusted for functional limitations can generate more realistic estimates. Meanwhile, when assessing population ageing among men, using total prospective old-age thresholds can lead to more pessimistic estimates than using prospective old-age thresholds

adjusted for self-rated health. It is, in any case, clear that traditional measures based on fixed thresholds greatly overestimate the levels of population ageing and the pace of its increase, and thus arouse undue levels of concern. These measures completely fail to recognise that people older than a certain chronological old-age threshold can still be healthy and dynamic enough to face other challenges in life.

Our results are extremely encouraging, as they show that health in later stages of life has improved among Italians over the last two decades, with positive consequences for the magnitude of population ageing. In particular, the trends in health conditions we observed among the elderly are consistent with the most optimistic hypothesis regarding the possible evolution of health in old age: i.e., the hypothesis of the compression of morbidity (relative or absolute, depending on the health dimension considered) into a shorter period of time before death (Fries, 1980). At the same time, however, our results raise concerns about two specific problems. First, it seems that women are finding it more difficult than men to improve their health status, and are thus often unable to take full advantage of their longer lives. Second, improvements in health conditions at older ages, and especially in self-rated health, have been slowing in the most recent years; i.e., between 2005 and 2013. This slowdown may reflect the impact of the 2008 economic crisis on the health of the Italian population. Other negative effects could become visible in the future: 11% of survey respondents in 2013 reported that they had given up at least one health care service, even if they needed it (Istat, 2013). If Italians cut back on their use of preventive and other health care services, improvements in the health status of the population could decline further in the coming years.

To conclude, the most important result of our analysis is that if the evolution of population health is positive enough, and a measure of population ageing able to take into account longevity and health improvement is used, we may observe a rejuvenation of the population. Italian men have indeed been ageing in relatively good health over the past two decades, and when we look at the old-age thresholds adjusted for self-perceived health, we see that the male population was rejuvenating until the mid-2000s. Nevertheless, the two negative pieces of evidence discussed above should not be ignored, but should instead be seen as a warning that we cannot rely on the natural course of events. A range of actions aimed at supporting positive trends are needed. For example, improvements in health education could help to promote healthier behaviours throughout the lifespan, as together with working and living conditions, health-related behaviours at young and adult ages are predictive of health in later life (Börsch-Supan et al. 2011). Action should also be taken by citizens at the individual and societal levels, and by governments at a policy level to advance two main goals: challenging the stereotype that elderly people are a burden on society by emphasising the potential contributions they can make as the population ages (Blum et al. 2015; Higgs and Gilleard 2015); and promoting healthy ageing as the only means of assuring the future sustainability of our health, social, and economic systems.

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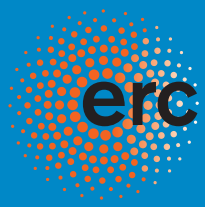
With financial support from



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