Are gaps in disability free life expectancies diminishing in Italy?

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Abstract This paper studies gender differences in disability free life expectancy (DFLE), taking into account mortality and disability contributions. After analysing the types of disability that account for such differences, it goes on to examine temporal variability and age contributions to mortality and disability variation. The method used is an extension of Arriaga's model proposed by Nusselder. In 2005, disability free life expectancy at age 30 was 46.23 years for men and 48.74 years for women, with a gender difference of 2.51 years. Decomposing this difference we find that the mortality effect is 3.70 years, while the disability effect is negative and equal to -1.19 years. Ten years earlier, in 1994, DFLE at age 30 was 43.24 years for men and 46.55 years for women, with a difference between genders of 3.32 years. This broke down to a mortality effect of 4.33 years and a disability effect of -1.02 years. In conclusion, the gap in DFLE between men and women is narrowing, thanks to the more rapid drop in mortality rates in men. With respect to disabilities women are disadvantaged, although the difference (in both total disability and different types of disability) has been almost stable in recent years.

Keywords Life expectancies · Disability free life expectancies · Gender differences · Sullivan's method · Decomposition model

Introduction

The population in Europe is now continuously ageing. This is driven by three main factors: the first is related to the ageing of the baby-boom generation. Second, as fertility rates have fallen since 1965, the older population is growing at a proportionately faster rate than the younger generation. Finally, life expectancy at older ages is increasing (OECD 2005).

Western Europe has experienced a steady increase in life expectancy in the last 30 years and generally enjoys a long life expectancy compared to Central and Eastern Europe. The most dramatic increase has been in Portugal and Malta, where life expectancy has risen by approximately 10 years in this period. Italian and Spanish women, along with Italian and British men also experienced a significantly improved life expectancy, of 8–9 years. Despite this convergence, there is still some variation: the difference between countries with the longest longevity (Italy and Sweden) and those with the shortest (Ireland and Portugal) is approximately 3 years. In any case, these longevity gains are largely due to a significant fall in mortality rate at advanced ages, although a high degree of across-country heterogeneity can be observed (WHO—European Observatory on Health Systems and Policies 2009).

As noted by many authors there is a strong correlation between ageing and disability (Schmidt 2004; Gerlin 2005). At present, 30.7% of the population aged 60–64 has a longstanding health problem or disability, in comparison

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with only 6.9% of 16–24-year-olds (Eurostat 2003). This tendency can be observed in all European countries, although the rate of progression by age differs from country to country (Buhalis et al. 2006).

A frequently used measure for evaluating both the quantitative (years to live) and qualitative (years to live in good health) state of health of a population is disability-free life expectancy (DFLE). Its importance is demonstrated by the fact that in October 2004 it was included in the European Union's list of structural indicators. It has also been adopted internationally, and great attention has been paid to this subject, as demonstrated by the large number of research papers (Robine et al. 2003a, 2004, 2005a, b; Brønnum-Hansen 2005; Jagger et al. 2008). With respect to Italy, this indicator is available in the 'Health for All-Italy' information system and in the Disability Information System.

Disability-free life expectancy (DFLE)—calculated by combining mortality data with data on the prevalence of disabilities—provides a qualitative measure of the number of years lived. Calculated by gender, it provides a concise measure of how health conditions vary by gender within a given population (Matthews et al. 2006). However, in analysing the gender variability of DFLE, it is essential to take into account the separate contributions of the mortality and disability differentials. Only in this way can it become a tool capable of identifying public health priorities and objectives available to policy makers.

Various methods have been proposed for decomposing changes in life expectancy into cause-specific death rate (Arriaga 1984, 1989; Pressat 1985; Pollard 1988, 1990; Shkolnikov et al. 2001). Numerous publications have applied those methods (Robine et al. 2003b; Bongaarts 2006; Yoshinaga and Une 2005; Klenk et al. 2007; Gómez-Redondo and Boe 2005; Crimmins and Cambois 2003; Bebbington and Bajekal 2003; Robine et al. 1999; Bah 1998; Trovato and Lalu 1998; Kochanek et al. 1994; Velkova et al. 1997; Conti et al. 1999; Das Gupta 1994; Bellini et al. 1992; ISTAT 2003; Egidi et al. 2004; Frova and Prati 1999). However, just two main methodological publications have discussed the decomposition of life expectancy into good health or DFLE (Nusselder and Looman 2004; Andreev et al. 2002), while, to date, very few papers have reported the results of its application (Nusselder et al. 2005; Van Oyen et al. 2005).

This paper is the first attempt to study Italian gender differences in DFLE in Italy, taking account of the contributions of mortality and disability. After analysing the types of disability that account for such differences, it goes on to examine the temporal variability and age contributions to mortality and disability components.

Data and methods

Disability-free life expectancy (DFLE) for Italy is calculated using the Sullivan method (Sullivan 1971), which combines 5-year life tables with 5-years prevalence rate of disabilities.

The life tables were provided by the Italian National Institute of Statistics (Istat), while prevalence of disabilities was calculated using data from the Istat Health Interview Survey (HIS) for the years 1994, 1999–2000 and 2004–2005. This used a set of 20 questions, developed by an OECD working group and based on the International Classification of Impairment, Disability and Handicap (ICIDH), that enables specific dimensions of disability to be examined: the *communication dimension*, concerning sight, hearing and speech; the *physical dimension*, concerning mobility and locomotion, including confinement to the house or bed in the case of serious disabilities; and *autonomy in activities of daily living*, concerning personal care (see 'Appendix').

A person is defined as disabled when, excluding temporary situations, he or she reports the highest level of difficulty (incapable of or having severe difficulties in doing something) in at least one of the dimensions surveyed, despite any medical devices he or she may use (prosthesis, walking stick, glasses, etc.). In this study, disability is grouped in five clusters:

- (1) difficulties in the communication dimension only (DIS1);
- (2) difficulties in the physical dimension only (DIS2);
- (3) difficulties in performing activities of daily living only (DIS3);
- (4) difficulties in two of the dimensions (DIS4);
- (5) difficulties in all the dimensions (DIS5).

Prevalence rates per cluster were calculated by age, gender and year.

This method allows the difference between two disability-free life expectancies to be decomposed into the mortality-related and the disability-related contribution (Nusselder and Looman 2004). The decomposition method proposed by Nusselder et al. is an extension of Arriaga's model (Arriaga 1984, 1989) applied to DFLE.

As known, Sullivan's method enables the number of years lived in good health (or free from any disabilities) to be easily obtained by drawing upon the series of survivors from a life table and the prevalence data (or proportion of 'healthy people'). Considering the number of 'healthy' persons at age x (l_x), the number of person-years lived with a disability ($\pi_x L_x$) is simply the product of the proportion of disabled persons at age x (π_x) with the number of person-years lived L_x .

Thus, the change in the number of person-years lived with a disability can be expressed as follows:

$$\Delta_i \pi_x iL_x = [(i\pi_x + \Delta_i \pi_x) \cdot (iL_x + \Delta_i L_x)] - i\pi_x iL_x$$

where Δ is the change between time t and time $t + n$, x the age, i the width of the age class, iL_x the person-years lived in the age class, $i\pi_x$ the proportion of population with a disability and $i\pi_x iL_x$ the person-years lived with a disability.

The previous expression can be reformulated as follows:

$$\Delta_i \pi_x iL_x = (i\pi_x + 0.5\Delta_i \pi_x) \cdot \Delta_i L_x + (iL_x + 0.5\Delta_i L_x) \cdot \Delta_i \pi_x$$

In other words

$$\Delta_i \pi_x iL_x = \left[\frac{(i\pi_{x(t)} + i\pi_{x(t+n)})}{2} \right] \cdot \Delta_i L_x + \left[\frac{(iL_{x(t)} + iL_{x(t+n)})}{2} \right] \cdot \Delta_i \pi_x$$

By modifying the symbols ($t = W$ and $t + n = M$) in the previous equation, the gender differences for the number of person-years lived with a disability in age class x , $x + i$ ($\Delta_i \pi_x iL_x$) can be obtained by summing the mortality and disability contributions:

$$\Delta_i \pi_x iL_x = \text{MOR}_i + \text{DIS}_i$$

where $\text{MOR}_i = [(i\pi_{x(W)} + i\pi_{x(M)})/2] \cdot \Delta_i L_x$ and $\text{DIS}_i = [(iL_{x(W)} + iL_{x(M)})/2] \cdot \Delta_i \pi_x$

MOR_i expresses the change in the number of person-years lived with a disability due to gender differences in the mortality rates ($W - M$).

DIS_i indicates the change in the number of person-years lived with a disability due to gender differences in the disability prevalence rates ($W - M$).

At the same time, the gender differences for person-years lived without disability can be expressed through the 'non-disabled persons' part $1 - i\pi_x$.

We decided to include only people aged 30 and over in the analysis because the definition of disability contained in Istat's HIS survey includes all persons aged 6 and over, but the prevalence of disabilities is much lower in the early age classes. Hence, the results refer to the differences in DFLE at age 30.

Results

Gender differences

Women live longer and healthier than men (Table 1). However, gender gaps are decreasing. While in 1994 the life expectancy for women was 5.80 years longer than that for men, by 2005 this difference had dropped to 5.15 years. Gender gaps for DFLE also fell more rapidly than they did for life expectancy in the same period: the difference between women and men for DFLE was 3.32 years in 1994

and 2.51 years in 2005. The disadvantage for men thus has become ever smaller, especially for DFLE.

This is due to the effects of both mortality and disability. Considering the decomposition of the gender differences for DFLE, the mortality effects were always positive over time but decreased between 1994 and 2005 (from 4.33 to 3.70); this means that men still have a higher mortality rate than women but, in the last decade, the mortality rate decreased more rapidly for men than for women. In the same period the disability effects were worse for women; these effects on DFLE gender differences were always negative and slightly increased between 1994 and 2005 (from -1.02 to -1.19).

The combination of these two effects explains why DFLE gender gaps are decreasing slightly in Italy.

Figure 1 shows the contribution of age to the mortality and disability effects on gender differences in DFLE at age 30. About two-thirds of the total mortality effect is attributable to age groups 55–69 and 70–84 years in all three calendar years considered.

The main contribution to the total disability effect comes from the age groups 70–84 and 85 years and over. The increasing disadvantage observed for women in the period 1994–2005 is thus mainly due to the disability conditions of the oldest women.

The decomposition method was also applied to different types of disability, enabling analysis of the contribution of these components to the total disability effect (Table 2). In all 3 years considered the disability effect is largely explained by the physical disability dimension (DIS2), but this effect is decreasing slightly. At the same time, multiple disability (DIS4) is becoming ever more important, varying from -0.27 in 1994 to -0.62 in 2005.

Time differences

Between 1994 and 2005 life expectancy and DFLE increased for both men and women (Table 3). Nevertheless, the trend for men is more favourable.

There was a 3-year increase in DFLE for men aged 30 between 1994 and 2005. 82% (2.46 years) of this is

Table 1 Life expectancy (LE) and disability-free life expectancy (DFLE) at age 30, and number of years due to mortality and to disability effects on gender differences (females versus males)

	1994		2000		2005	
	LE	DFLE	LE	DFLE	LE	DFLE
M ₃₀	46.10	43.24	47.75	44.85	49.11	46.23
F ₃₀	51.90	46.55	53.11	47.52	54.26	48.74
F ₃₀ – M ₃₀	5.80	3.32	5.36	2.67	5.15	2.51
Mortality effect	5.80	4.33	5.36	3.94	5.15	3.70
Disability effect	0.00	–1.02	0.00	–1.27	0.00	–1.19

Italy, years 1994, 2000 and 2005

Fig. 1 Mortality and disability effects on disability-free life expectancy gender differences (Females-Males) at age 30, by age group in Italy. Years 1994, 2000 and 2005. Number of years gained/lost

Table 2 Disability effect on the disability-free life expectancy (DFLE) gender difference at age 30, by type of disability

Type of disability	Gender differences (females – males)		
	1994	2000	2005
Difficulties only in the dimension of communication (DIS1)	0.01	0.14	0.06
Difficulties only in the physical dimension (DIS2)	–0.59	–0.55	–0.43
Difficulties only in performing activities of daily living (DIS3)	–0.19	–0.16	–0.09
Difficulties in two of the dimensions (DIS4)	–0.27	–0.58	–0.62
Difficulties in all the dimensions (DIS5)	0.02	–0.13	–0.12
Total disability effect on DFLE gender difference at age 30	–1.02	–1.27	–1.19

Italy, Years 1994, 2000 and 2005. Number of years gained/lost

Table 3 Life expectancy (LE) and disability-free life expectancy (DFLE) at age 30, in Italy, by gender and year

	LE ₃₀	DFLE ₃₀
Males		
M ₁₉₉₄	46.10	43.24
M ₂₀₀₅	49.11	46.23
M ₂₀₀₅ – M ₁₉₉₄	3.01	3.00
Mortality effect	3.01	2.46
Disability effect	–	0.53
Females		
F ₁₉₉₄	51.90	46.55
F ₂₀₀₅	54.26	48.74
F ₂₀₀₅ – F ₁₉₉₄	2.36	2.19
Mortality effect	2.36	1.53
Disability effect	–	0.66

Mortality and disability effects on the variation from 1994 to 2005 of the DFLE and of the LE at age 30. Number of years gained

explained by the mortality effect. The remaining effect, due to disability (0.53 years), is mainly related to multiple disabilities (DIS4) and, to some extent, to ADL disabilities (DIS3) (Table 4).

In women, the increase in DFLE at age 30 is 2.19 years and the mortality effect accounts for 70% (1.5 years) of this increase. The disability effect is slightly more significant than for men (0.66 vs. 0.53): ADL disabilities (DIS3) account for 48% of the total effect and multiple disability (DIS4) for 38%.

Figure 2 shows the mortality and disability effects for DFLE variations for two periods (1994–2000 and 2000–2005) as well as for the total period (1994–2005) by age group and gender.

The mortality effect at age 30 between 1994 and 2005 is in the same for the two sub-periods (1994–2000 and 2000–2005) for both genders. However, the disability effect in these periods differs with gender: of a total of 0.53 years, men gained 0.26 years between 1994 and 2000

Table 4 Disability effect by type of disability on variation from 1994 to 2005 of the disability-free life expectancy (DFLE) at age 30, in Italy, by gender. Number of years gained/lost

Type of disability	Males	Females
	$M_{2005} - M_{1994}$	$F_{2005} - F_{1994}$
Difficulties only in the dimension of communication (DIS1)	0.00	0.03
Difficulties only in the physical dimension (DIS2)	-0.06	0.04
Difficulties only in performing activities of daily living (DIS3)	0.15	0.32
Difficulties in two of the dimensions (DIS4)	0.36	0.25
Difficulties in all the dimensions (DIS5)	0.08	0.02
Total disability effect on DFLE variation from 1994 to 2005 at age 30	0.53	0.66

and 0.27 years between 2000 and 2005, but for women the effect was more concentrated in 2000–2005 than 1994–2000. In other words, the prevalence of disability in women increased more rapidly between 2000 and 2005.

Slight gender differences are seen for the mortality effect in the various age groups. In men, the largest contribution is seen in the 70–84 age group, and to a lesser extent the 55–69 age group. In women, beyond the high contribution of the 70–84 age group, the oldest age group (85 and over) has the same contribution as the 55–69 age group.

The 55–69 and 70–84 age groups contribute most to the disability effect in both genders.

Discussion

The method used here to decompose the differences in DFLE has demonstrated its usefulness as a tool for identifying and analysing the factors that influence the time and gender heterogeneity of this indicator. On the basis of Italian data, the introduction of a quality of life dimension (disability) to the number of years to be lived greatly reduces the traditional advantage women have in mean duration of life. This is in common with many other European countries (Jagger et al. 2008; Burgio et al. 2009).

In this study, we found a gradual reduction over time in gender differences in DFLE, mainly attributable to the mortality effect. Women still live longer and still have a higher DFLE; however, gender gaps are diminishing. In the last decade, the mortality rate has fallen more rapidly for men than for women. The largest contribution is from the 70–84 age group, followed by the 55–69 age group. The greater disability effect observed for women in 1994–2005 is mainly due to the disability conditions of women aged 85 and over and to the physical (DIS2) and multiple (DIS4) disability dimensions. These are the two dimensions that require more investment in order to combat the disadvantage to women.

This slight reduction in gender differentials in LE and DFLE might be explained by the relatively recent adoption of unhealthy lifestyles by women together with the trend towards healthier behaviour in the younger generation of men (Conti et al. 2003). Time variations and gender differences could also be explained through possible changes in the social conditions (such as educational level, occupational position and income) of the analysed

Fig. 2 Mortality and disability effects of disability-free life expectancy time variations (1994–2000, 2000–2005, 1994–2005) at age 30, by age group and gender, in Italy. Number of years gained/lost

population (Crimmins and Saito 2001; Brønnum-Hansen and Baadsgaard 2008).

The contribution of each age group also reveals the population groups upon which public health measures should be focused. In addition, analysis by age permits the in-depth examination of those life stages in which gender differences in the prevalence of disabilities have the greatest weight in accounting for the overall differences.

Nevertheless, results obtained with the decomposition method should be interpreted cautiously, as there are limitations associated with both the data used and the assumptions upon which the model is based. The prevalence data, obtained through sample surveys, are based on self-reported data on health conditions and disability. This could have an influence on the gender differentials, especially as this is a subjective rather than objective definition of health. In fact, various factors could cause subjective perceptions of health—possibly attributable to different attitudes—to differ from people's 'real' health conditions.

For disability, as measured in this paper, the problem of self-reported disability is partially alleviated by using a standardised instrument like the 'functional activities of daily living' questionnaire that measures individual abilities regardless of the use of medical aids and/or prostheses.

Nevertheless this standardised instrument does not provide any measure of the effect of such aids in carrying out the activities surveyed. This is another limitation that could have an impact on the temporal differences.

The decomposition method also has some limitations. The particularly simple approach of Sullivan's method, which provides the basis for the method adopted here, measures DFLE with the assumption that a population is stationary. However, the prevalence data used in the model refer both to people who have recently been diagnosed as ill and to those who had been diagnosed at various periods in the past. Once the age and calendar year are set the number of disabled or ill people depends not only on the incidence observed during a given year but also on the numbers surveyed in past periods and at previous ages: these are a function of the population's history and its exposure to specific risks at different times. Thus, the number of years lived in good health calculated according to Sullivan's¹ method is obviously not exclusively a time-related indicator since the past incidence for each generation influences the prevalence levels observed in any given calendar year. Consequently Sullivan's method tends to either over- or under-estimate the real value, depending on whether the cohort effects on the probability of being ill at any given time are positive or negative. It is possible that gender differences are slightly over-estimated in our data,

due to a stronger positive cohort effect in the prevalence of disability for females. Incidence rates by age, gender and period are not available for Italy, but prevalence rates decreased from 1994 to 2005, suggesting that incidence also decreased. Moreover, in the same period the prevalence was higher for women than men. In fact, given that prevalence at a given age x depends on both the incidence at time t , age x and the number of people with disabilities at age $x-n$ at time $t-n$, the prevalence rates in 2004–2005 may be more overestimated for females than for males. Unfortunately this bias is not measurable with Italian data.

An additional limitation of the indicator proposed by Sullivan is that it suffers from the same disadvantages as the prevalence data; it overemphasises illnesses characterised by the sufferer's long-term survival in comparison with illnesses which are highly fatal (Sullivan 1971; Alho 1992; Freeman and Hutchison 1980; Keiding 1991; Preston 1987; Robine et al. 1993). In consequence, if the survival period is long, events that took place many years earlier can still be seen in the period prevalence data. Sullivan's indicator could thus be biased due to the 'demographic' inertia deriving from past events.

Nevertheless, the conventional Sullivan method does have some distinct advantages: first, its simplicity makes it easy to apply; second, the data necessary for its application tend to be readily available; and third, as it is widely applied in practice, it allows comparisons over both time and space to be performed, even if some authors (Brønnum-Hansen 2005; Brouard and Robine 1992; Mathers and Robine 1993) maintain that any international comparison must be done with great caution, given the indicator's insensitivity to sudden changes in morbidity levels. However, where mortality rate trends are stable, Sullivan's indicator can be a powerful instrument (Robine and Michel 1992). Imai and Soneji (2007) demonstrated that, under stationarity assumptions, Sullivan's estimator is unbiased and consistent.

In conclusion, this paper takes into account a quality of life dimension and at the same time a measure of the contributions of mortality and disability to gender differences by means of DFLE indicator and the application of the decomposition method of Nusselder to gender differences in DFLE. Moreover, the introduction of time and age dimensions allows to better understand both the trend of the phenomenon and the contributions of various age groups on the gender differences observed. The results of the analysis highlighted that gender gaps are diminishing because the mortality rate has fallen more rapidly for men than for women, mainly in the 70–84 age group. In contrast, the disability effect is greatly related to the disability conditions of women aged 85 and over. These evidences are a useful tool for policy makers to plan targeted public health interventions.

A further application of the method could include prevalence data for selected diseases closely related to mortality

¹ This, obviously, is also true for measurements obtained by the Sullivan-based decomposition model.

and disability (Nusselder and Looman 2004). In this way it could be possible to point out other determinants of gender differences in DFLE going beyond the disability dimensions and accounting for the diseases causing disability.

Appendix

Questions used to survey the disability

Difficulties in the physical dimension	
Is he/she forced to always stay at home without being able to go out for physical or psychological reasons ? (home includes the eventuality of space outside)	What is the longest distance he/she can walk by him/herself without stopping and without getting too tired?
YES	200 metres or more
NO	more than a few steps but less than 200 metres
	only a few steps
When he/she is standing up, is he/she able to bend down to pick up a shoe from the floor?	Can he/she go up and down a flight of stairs without stopping?
YES, without difficulty	YES, without difficulty
YES, with a little difficulty	YES, with a little difficulty
YES, with great difficulty	YES, with great difficulty
NO, he/she is not able to	NO, he/she is not able to
Can he/she go to bed and get out of bed without help?	Can he/she sit down in and get up from a chair without help?
without difficulty	without difficulty
with a little difficulty	with a little difficulty
can only go to bed and get out of bed with the help of someone	can only sit down in and get up from a chair with the help of someone

Difficulties in performing activities of daily living	
Can he/she get dressed and undressed without help?	Can he/she bathe or shower without help?
without difficulty	without difficulty
with a little difficulty	with a little difficulty
he/she can only do it with the help of someone	he/she can only do it with the help of someone
Can he/she wash his/her hands and face without help?	Can he/she eat without help, even cutting the food without help?
without difficulty	without difficulty
with a little difficulty	with a little difficulty
he/she can only do it with the help of someone	he/she can only do it with the help of someone

Difficulties in the dimension of communication	
Does he/she hear enough to be able to watch a television program at a volume that does not disturb other people, eventually using a hearing aid?	Does he/she see enough to recognise a friend 4 metres away (on the other side of the street), eventually using eye-glasses or contact lenses?
YES	YES
NO	NO
(If NO:) does he/she manage to hear a television program by raising the volume?	(If NO:) Does he/she see enough to recognise a friend 1 metre away (an arm's length away)?
YES	YES
NO	NO
Can he/she speak without difficulty?	
YES, without difficulty	
YES, with a little difficulty	
YES, with great difficulty	
NO, he/she is not able to	

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