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Item 4 – Constructing assumptions for mortality: data, methods and analysis

Increasing longevity and decreasing gender mortality differentials: new perspectives from a study on Italian cohorts

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1. MORE LONG-LIVED, LESS DIFFERENT: AN INTRODUCTION

The change of survival patterns at different periods of life has demonstrated that Italy finds itself in a relatively advantageous position among countries with low mortality. Information for 2007 indicates that men and women born in that year can count on an expected average life span of 78.7 and 84.0 respectively. The present values are the last stage of a long development in which the figures for life expectancy at birth have doubled in little more than a century. Figure 1 illustrates the development of this for Italy from 1886 to 2007. In this long period of time men and women have added to the original 35.5 years for each of them, 43.2. and 48.5 years respectively. All the years recouped up to the Second World War were essentially due to the marked decrease in infant and youth mortality (Caselli and Egidi, 1991). The figures improved in the next thirty years due to the decline in adult mortality, while it was only in the 1970s that a decline in the mortality of the elderly made itself felt. In effect, from 1886 to 1940 the years of life remaining on average at 65 and 80 years remained more or less the same for men and women, on average 11 years for 65-year-olds and 5 years for eighty-year-olds. In figure 1 we can also see that survival of the elderly began to increase noticeably in the years of the so-called cardiovascular revolution, which began in Italy more or less in the mid-1970s. Women anticipated men in this process by at least 10 years. Starting from the same value, 65-year-old women today can expect 4 more years of life than men of the same age (on average 22 against 18 years) and 80-year-old women 2 years more (on average 10 against 8 years).

In effect, the data illustrated in figure 1 show that from the 1970s the trend of the life-expectancy gap at birth between men and women has been reversed. At the end of the nineteenth century there was practically no difference, the two sexes having the same levels, while before the outbreak of the Second World War 3 years now divided men from women, to the latter's advantage. Forty years later this gap had reached 7 years (maximum value 6.9 years in 1979). The divergence was steadily widening up to the 1970s, but has slowly but inexorably changed direction in the last thirty years, reducing the female advantage to 5.3 years in 2007. The trend for the differences in life expectancy at 65 years has also modified, but in this case it has pretty well stopped, remaining at levels close to 4 years. By contrast, once the threshold of 80 years has been reached (about 2 years), the gap in the number of years of life expectancy continues to increase to women's advantage, indicating that elderly men find it difficult to keep pace with females of the same age.

These behaviours are the result of a profound change in the age profile of over male mortality, or a mortality disadvantage that affects men rather than women at different periods of life. The analysis of sex ratios at different ages (Figure 2) in 1970 and 2007 indicates important modifications in the profile of the probability of death in the two genders too. Comparison shows that in adult and pre-senile ages (roughly 40-68 years) the gap between men and women has reduced notably in the course of time, but not in senile ages, where it has increased. In the period the sex ratios also increase to the disadvantage of men of young and adult age, but at these ages mortality levels are low for both sexes and so do not influence the values for life expectancy at birth. Interpreting the reduction of the mortality gap in adult and pre-senile age as the effect of an entirely female problem is certainly not correct, as we refer to a ratio, and its reduction might be due to the recouping of a male disadvantage already indicated earlier. Certainly the highest levels

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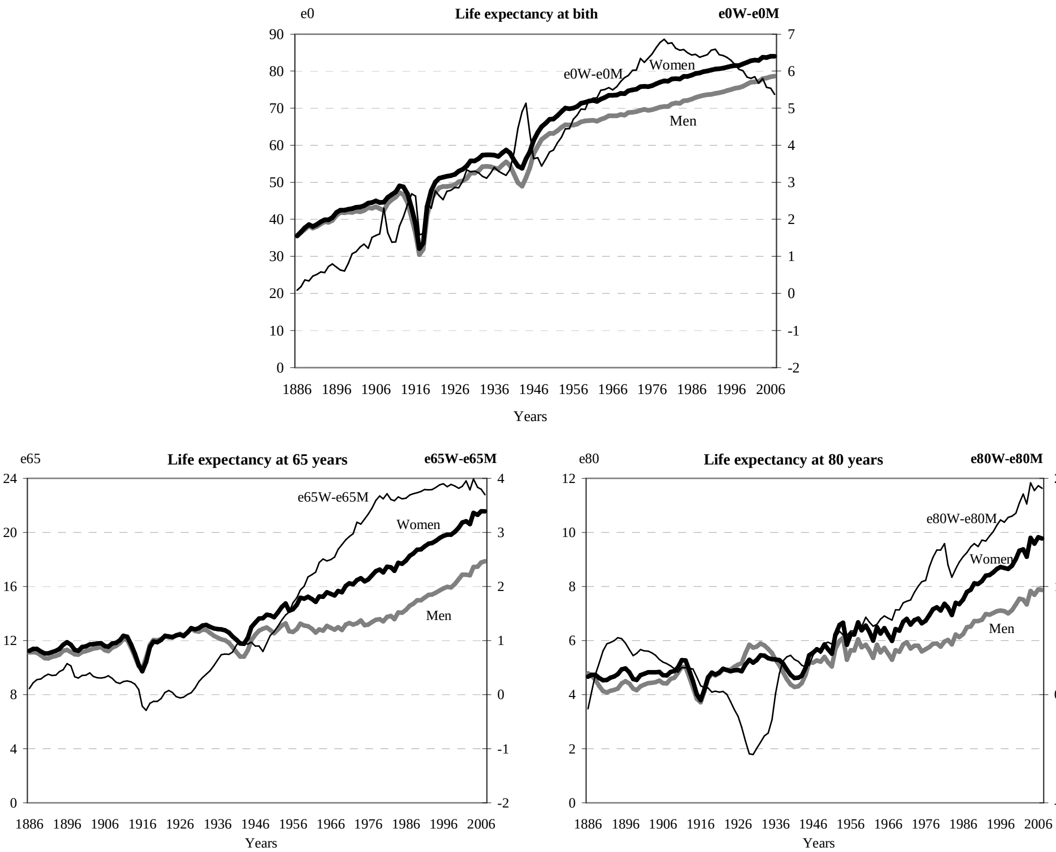
of the sex ratios between 40 and 70 years registered in 1979 involve the same cohorts that have the highest levels of sex ratios after 68 years of age in 2007, so the women who benefit after the age of 40 belong to the same group of cohorts.

Figure 1. Trends in life expectancy at birth, at age 65 and 80 year by sex and gender differences from 1886 to 2007

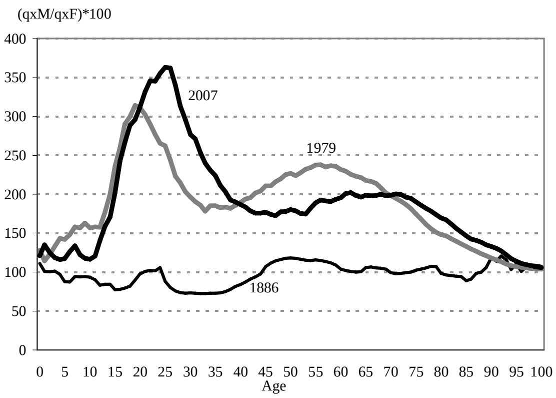


Sources: Dipartimento di Scienze Demografiche (graziella.caselli@uniroma1.it) Human Mortality Database, 2009, and Istat, 2010.

We may have a better understanding of the phenomenon if we study the mortality of the various cohorts. As we know, different life histories influence the final outcome, anticipating or postponing age at death. Studies of mortality that start from macro-data claim that the different mortality histories of the cohorts are the result of different life experiences. Introducing causes of death in this analysis contributes significantly to our understanding of the complex dynamics of survival and makes clearer the mechanisms that have determined these modifications. In effect, what is emerging in Italy today was already evident from the mortality models of Western European countries and the United States, and draws attention to modifications in behaviours and life-styles in advanced societies, and in their underlying risk factors.

The first aim of this study is to identify the reasons for the ongoing changes, with reference to the change in causes of mortality in men and women for the cohorts that are gradually entering adult and old age. The final aim is to use the information obtained to predict the mortality of future cohorts. The results may help us understand what the determinants are of future survival patterns, knowing which will be useful for identifying the possible spin-offs on the health and social security services in the future.

Figure 2. Sex ratios – over male mortality – in the years 1886, 1979 and 2007.



Sources: Human Mortality Database, 2009, and Istat, 2010.

2. DATA AND METHODS

2.1 Data

To achieve the aims of this study it was necessary to prepare a historical series of data on mortality by sex and age in Italy that both covered a fairly long period of time and was also reliable. In fact, one of the aims of the study is to examine the changing trend in survival following a longitudinal approach that takes into account the profile of mortality by cause. Information on the cohorts born before the XX century was obtained from the database of mortality by sex, age and cause of death prepared by the Department of Demography at the University of Rome "La Sapienza" (caselli.graziella@uniroma1.it). For the cohorts born between 1861 and 1970, our data are roughly what was included in the mortality archive for Italy of the Human Mortality Database of the MPIDR of Rostock. For the 1970s onwards – 1974 to 2007, to be precise – the mortality data of Istat (www.demo.istat.it) were used. The data were collected by single age (from 0 to 100 years) and causes of death. Mortality rates and/or probabilities refer to one age by a cohort in two calendar years. The causes of death studied were harmonized on the basis of the IX revision of the International Classification of Diseases-ICD (a major reclassification of death by causes in Italy from 1887 to 1952, based on VI revision was performed by the National Institute of Statistics – Istat, 1958 -; the harmonisation with IX revision until 1970 was performed by Caselli and Egidi, 1991-; until 2007 we referred to the Istat database) and collected in the following major groups: infectious diseases (1-139; 279.1), cancer (140-209), circulatory diseases (390-459), respiratory diseases (460-493), digestive diseases (520-579), violent causes (800-999), and other causes of death (for the remaining causes).

2.2 The APC model in mortality projections

In general a measure of mortality may be expressed as a function of the covariate Z and of certain parameters Θ (Caselli, Capocaccia, 1989):

$$m = f(Z, \Theta)$$

In order to project the risk of death, a model taking account of age, period and cohort components of mortality (APC model) was used. Referring to age-specific mortality, mortality by cause is represented by the logarithm of the rates. More specifically, the series of logarithms of mortality rates is a function of the age, period and cohort covariates:

$$\log(y^{*}_{t,x}) = a + a(x) + p(t) + c(t-x)$$

that is

$$\log(y^{*}_{t,x}) = a + \sum_i b_i \cdot (x)^i + \sum_j c_j \cdot (t)^j + \sum_k d_k \cdot (t-x)^k \qquad i = 1,..,h_1;\ j = 1,..,h_2;\ k = 1,..,h_3$$

The age, period and cohort parameters were estimated through the least squares method with a stepwise procedure. The model is not hierarchical (if an effect of degree "n" enters the model it doesn't necessarily mean that effects lower than "n" degree also enter) and the maximum degree admitted for each component is restricted to the third one.

As the pattern of mortality by cause may prove different when we move from infant to adult age, and from adult to old age, the APC model was applied separately for the following age groups: 0, 1-18, 14-39, 35-59, 55-79, 75-100. As can be seen, this sub-division in age groups was done so that some age classes were present in two immediately succeeding age groups (this is so for the age classes 14-18, 35-39, 55-59 and 75-79). The intentions was both to exploit as far as possible the information contained in the profile of mortality by cause of a given age group, and also to define the intersections between one group and the next. In fact, after applying the model APC to the different age groups, the estimate of mortality in the intersections was determined on the basis of this expression:

$$\log(y^*_{t,x}) = \left(\omega^L_x a^L + \omega^R_x a^R\right) + \left(\omega^L_x a^L(x) + \omega^R_x a^R(x)\right) + \left(\omega^L_x p^L(t) + \omega^R_x p^R(t)\right) + \left(\omega^L_x c^L(t-x) + \omega^R_x c^R(t-x)\right)$$

$$x = \ 14\text{-}18,\ \ 35\text{-}39,\ \ 55\text{-}59,\ \ 75\text{-}79$$

where the indices "*L*" and "*R*" represent, respectively, the age group to left and right of the intersection, while $\omega^L_x \;\; e \;\; \omega^R_x$ are distributions respectively decreasing and increasing of weights, so that $\omega^L_x + \omega^R_x = 1$

The APC model is valid if used to describe past mortality trends. Regarding the projection time horizon, however, the use of the period effect curve is inadequate and risky because of unpredictable short-term factors. Thus the period curve is sub-divided into two components: a) the trend underlying the period component given by the straight line uniting the first and last year of observation; b) the deviations from this average trend. Two additional hypotheses were to suppose that the underlying trend would hold for the future and to consider any fluctuations from this trend as equal to zero (Burgio, Frova; 1995). By these transformations it is possible both to identify the model and to control the period effects.

Projections were produced for each cause of death. The sum of the projected rates represents the overall mortality "*by cause*" approach. As a comparison projections were carried out also according an "*all cause"* approach.

Once these projections were produced it was possible to obtain a complete picture of mortality both by period and by cohort. The projections cover the period 2008-2065 and the complete *cohorts* (0-100 years) studied are therefore those appearing *between 1865 and 1965*. Obviously, for each of these cohorts part of their history, varying in length according to the age reached in 2007, has already been observed.

The projected mortality history presented in this paper refers to our projections "*by cause*".

2.3 The cohorts studied

The generally accepted definition of life expectancy at a given age *x* for a cohort expresses the years lived on average by each individual of that age. The correct calculation of life expectancy is therefore only possible if the cohort is completely extinct. In this work, for the non-extinct cohorts we shall refer to the mortality histories projected with the methodology illustrated above.

Following the schema in table 1 may be useful for understanding the philosophy behind this study. We started from a concrete result, which is that of the inversion of the trend of the gap in life expectancy at birth between men and women. It was observed both that this trend began at the end of the 1970s, and also that in that period there was the greatest gap in mortality between the two genders in adult age (particularly in the age class 45-64 years), i.e. between individuals in the cohorts born between World War I and the early 1930s. It was also noted that in 2007 these same cohorts show a similar behaviour, but this time in old age. In 2007, however, the male cohorts of adult age (those born more or less between 1943-1945 and 1962) saw a reduction in the mortality gap dividing them from the female cohorts. The idea was to examine if at later ages too these distances continued to reduce, and if the new behaviours were or were not displayed in the presence of a lengthening life-span for both men and women.

For a synthesis of the main results we will refer to the intermediate cohorts of the various groups indicated in table 1, and in particular, the cohorts born in the years 1912, 1922, 1932, 1942 and 1952, also considering the cohort of 1865 and 1890, now extinct, and the one born in 1965, whose history of mortality in adult and old age is projected from the age 42 years and beyond.

Table 1. Schema for identifying some interesting cohorts, from those of adult age (45-64) in 1967, now extinct, to those who were adult in 2007, who will be extinct in 2037-2047. The cohorts to be followed at the various ages are those aged 45-64 on the dates indicated, to the right of the diagonal identified by these ages

Cohorts	1947	1957	**1967**	**1977**	1987	1997	**2007**	2017	2027	2037	2047	2057
1903-1922	25-44	35-54	**45-64**	**55-74**	**65-84**	**75-94**						
1913-1932	15-34	25-44	35-54	**45-64**	**55-74**	**65-84**	**75-94**					
1923-1942	05-24	15-34	25-44	35-54	**45-64**	**55-74**	**65-84**	**75-94**				
1933-1952	00-14	05-24	15-34	25-44	35-54	**45-64**	**55-74**	**65-84**	**75-94**			
1943-1962		00-14	05-24	15-34	25-44	35-54	**45-64**	**55-74**	**65-84**	**75-94**		
1953-1972			00-14	05-24	15-34	25-44	35-54	**45-64**	**55-74**	**65-84**	**75-94**	
1963-1982				00-14	05-24	15-34	25-44	35-54	**45-64**	**55-74**	**65-84**	**75-94**

3. COHORT MORTALITY MODELS: WHY THE ELDERLY OF TODAY ARE DIFFERENT FROM ELDERLY IN THE PAST AND FUTURE?

3.1 Longevity

The transition from the cohorts born between the second half of the XIX century and those born in the first decade of the XX century is marked by the start of the great decline in mortality and so of the first notable increase in survival (Figures 3 and 4, and Table 2). The years gained at birth, for example, by the cohort of 1912 compared with that of 1890 were 13 for men and 14 for women. This is clearly due to the decrease in the risks of death in childhood and at adult age experienced by the XX-century cohorts. An important role also begins to be played by the decline in mortality in old age, considering that the years gained after the age of 65 for the cohorts of 1912 compared with that of 1890 were 0.8 out of a total of 13 for men and 1.8 out of a total of 14 for women. As we shall see later, these cohorts were the first to benefit in late age from the positive effects of the cardiovascular revolution of the 1970s (see figure 6 in section 4).

Table 2. Life expectancy at birth, at 65 and 80 years for some cohorts. Men, women and gender gap.

Cohorts	Men			Women			Gender gap		
Periods	e0	e65	e80	e0	e65	e80	e0	e65	e80
C 1865	35.1	11.7	5.3	36.5	12.8	5.7	1.4	1.1	0.4
C 1872	37.0	11.9	5.7	38.7	13.0	6.2	1.7	1.1	0.5
C 1882	37.5	13.0	5.6	39.7	14.5	6.3	2.2	1.5	0.7
C 1890	38.4	12.9	5.8	42.1	15.4	6.8	3.7	2.5	1.0
C 1892	40.0	13.1	5.8	44.3	15.6	6.9	4.3	2.5	1.1
C 1902	42.1	13.5	6.3	49.8	17.1	7.7	7.7	3.6	1.4
C 1912	51.4	14.8	7.3	56.2	18.9	9.0	4.8	4.1	1.7
C 1922	55.9	16.2	$\boxed{8.1}$	62.8	20.6	$\boxed{10.0}$	6.9	4.4	1.9
C 1932	61.8	$\boxed{17.9}$	8.9	69.2	$\boxed{22.5}$	11.2	7.4	4.6	2.3
C 1942	64.3	19.8	10.0	71.5	24.3	12.5	7.2	4.5	2.5
C 1952	74.9	21.7	11.1	81.7	26.1	13.8	6.8	4.4	2.7
C 1965	81.3	24.4	12.7	87.6	28.3	15.4	6.3	3.9	2.7
P 2007	78.7	$\boxed{17.9}$	$\boxed{7.9}$	84.0	$\boxed{21.6}$	$\boxed{9.8}$	5.3	3.7	1.9
P 2050	88.7	25.2	12.5	92.4	28.5	15.0	3.7	3.3	2.5

It is interesting to note (Figure 3) how all the cohorts that lived through the periods of the two wars, whatever their age, show an increase in mortality corresponding to those ages. Obviously these higher risks of death reduced not only the average of years lived, but also the number of those who reached the threshold of old age, with a consequent reduction in the number of those who reached extreme ages of life too. Of these, the cohorts most penalized in terms of average survival are without a doubt those born during the years of the Spanish flu epidemic and World War I. Their mortality levels in the first years of life were equal to the levels of those born in the second half of the XIX century. For example, for men born in 1915 average survival was 49 years against the 51 years of those born in 1912.

The cohorts born during World War II were also penalized compared with their neighbouring cohorts. Their high levels of mortality in early infancy compromised their overall history of survival, despite the ample gains registered in adult age and, above all, those that, according to our projections, might be achieved in old age (see figure 6 in section 4).

Despite the strong decline in mortality projected in old age for the cohorts born in the early 1930s, represented in the table 2 by the cohort born in 1932, men and women following observed and projected values could live respectively 62 and 69 years on average, which is very little if we consider that the average years lived after the age of 65 were estimated at around 18 years for the former, and a little more than 22 years for the latter. The estimates referring to cohorts born in the decade after World War II are particularly interesting as they refer to a part already known of their, more or less long, mortality history (see figure 4). In effect, according to our projections, the cohorts born at the end of the 1950s should be those reaching the survival levels observed in the life tables of 2007 (78.7 years for men, and 84 years for women), while the cohorts born in the mid 1960s, who are now in their forties, might reach 81 years for men and 88 years for women (cohort 1965 in Table 2).

Figure 3. Trends of life expectancy at birth by sex and cohort, and gender differences from the cohorts 1865 to 1965

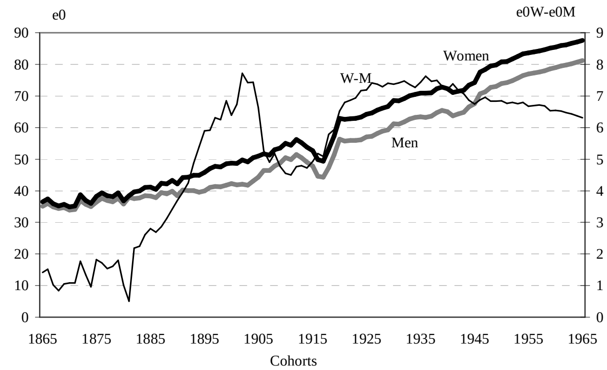
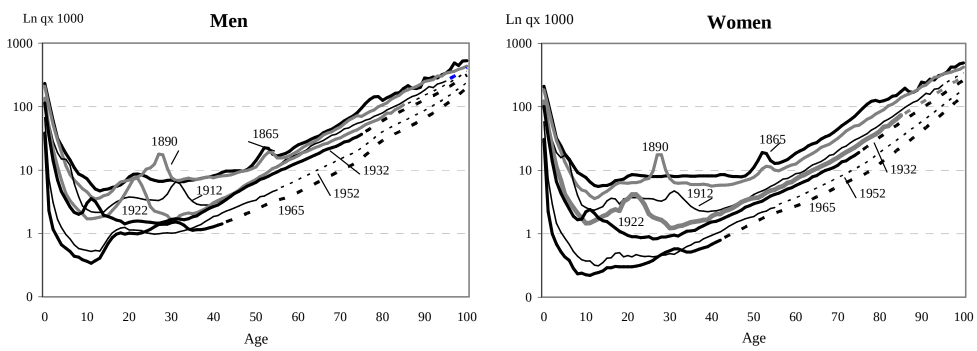


Figure 4. Mortality histories compared for the cohorts indicated: probability of death by age, observed and projected (dotted line), for men and women.



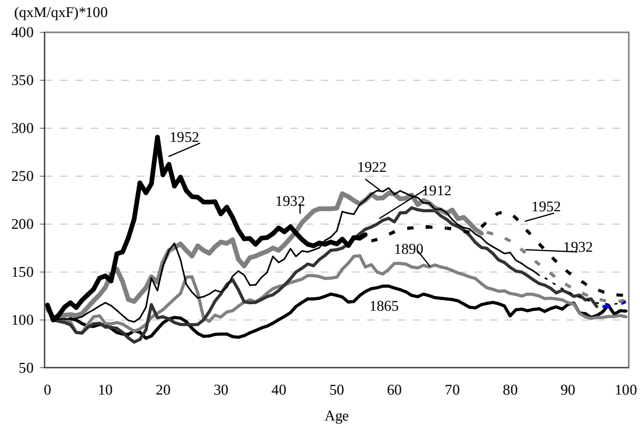
3.2 Gender differences

In our view, the development of survival differences between the two genders provides the most interesting results (Figure 3). Their trend for the various cohorts is, as one might expect, clearly different from that represented in figure 1. It is very clear that the most important increase in the differences begins with the male cohorts directly involved in World War I (1880-1899), these differences moving from little more than 1 year to around 7 years to the benefit of women. These differences reach almost 8 years for the immediately following cohorts (maximum of 7.7 years for the cohort of 1902), while from the cohort of 1905 to that of 1919 we find the lowest differences ever registered. Thus male children who were born or lived during the years of the Spanish Flu epidemic and World War I seem to have shared with the females the negative effects of the risks of disease experienced in those years more than those born in other cohorts. The same is true, as we shall see, for those born after World War II.

After the years of World War I, those born between 1920 and 1940 show once again an increase in the survival distance between the genders. The men of the 1920s were directly involved in World War II and, with those born in the 1930s were protagonists of the post-war rebuilding of the country. In all these cohorts the men were penalized compared with the women, with survival differences that reach a maximum of 7.6 years for those born in 1936, but with a gap that is almost always greater than 7 years. We might recall that analysis of the data for the period had shown in the year 1979 that these cohorts (Figure 2) had very high sex ratios corresponding to adult ages. We can now see more clearly how much the profile of their sex ratios in these ages is different from that of the preceding and succeeding cohorts.

It is for those born between 1940 and 1945 that the survival differences between the two genders start to come closer, and it is starting from the following cohorts that the trend reverses (Figure 3). For the last cohort of the study, that of 1965, the differences go down to 6.3. Even if we bear in mind that the survival values for these cohorts depend more on projections of mortality values, if we observe the progress of their sex ratios for those ages in which the mortality values are observed, it seems clear that the change begins with those cohorts born after World War II (Figure 5). The profile of their sex ratios has substantially modified. The maximum in youth has shifted forward and has increased. The maximum in adult age has shifted forward too, but has reduced. In conclusion, for the cohorts of the post-war period in the period of early infancy and, above all, between 40 and 64 years, the male disadvantage has reduced. We shall look at this in greater detail later, when we shall try to explain the development of survival differences between the genders on the basis of the development of mortality by cause at different ages of life.

Figure 5. Sex ratios actual and projected – over male mortality – by age an for some cohorts



4. FROM ADULT TO OLD AGE: WHAT CAUSES OF DEATH HAVE BEEN, OR COULD BE, RESPONSIBLE FOR THEIR INCREASING LONGEVITY?

To interpret the gain in survival between two succeeding cohorts, bringing out the role of mortality trends by ages and causes, we shall use Pollard's famous decomposition model (Pollard, 1988). We shall refer to the cohorts previously analysed to see what were the causes of death producing the extension in life expectancy thanks to the decline in their mortality in adult and old age (ages 45-64 and 65 and over).

Considering observed and projected survival for four cohorts, we can see that in the transition from a cohort involved in the first world war (1890) to one born immediately before the war (1912) - but involved in the second and reaching old age in a period very favourable for survival - a good 13 years were recouped for men and 14 for women. Of these, only 0.2 years were recouped thanks to a lower mortality of the 1912 cohort in the 45 and over years of life for men, and 0.4 for women (Figure 6). The reduction in mortality from circulatory diseases in adulthood and, above all, old age made a significant contribution to the increase in survival only for women, as a result of the fact that they benefited before men from the decline in mortality for these causes (Figure 6). Of course, for both men and women the increase in life expectancy between these two cohorts is due to a lower mortality of the 1912 cohort in the 15 years of life for infectious diseases and other diseases typical of early infancy and childhood (Caselli and Egidi, 1991).

Another 10 and 13 years of average survival for men and women respectively are gained in the transition from the cohort of 1912 to that of 1932, just as another 13.2 and 12.5 years are acquired in the transition from the cohort of 1932 to that of 1952. The contribution of the reduction in mortality in adult and old age (45 years and over) to the increase in survival between the cohorts of 1912 and 1932 reaches 2.6 years for men and 3.2 years for women and is about 2/3 due to the decline in mortality from circulatory diseases (Figure 6). However, the development of survival between these two cohorts is not yet marked by a decisive reduction in mortality from cancer, which actually makes a negative contribution among men in adult and old age. The cohorts born in the next twenty years (1932-1952) are those who benefited most from the positive effects of the "cardiovascular revolution". In effect, 1.9 of the 4.6 years overall gained in adult and old age by men of the cohort of 1952 compared with that of 1932 are due to the decline in mortality from circulatory diseases. The same proportions are 2.0 of the 3.8 years for women. In addition, in this period the reduction in mortality from cancer benefited men above all, allowing the cohort of 1952 to recoup 1.4 years of survival compared with that of 1932 (Table 3).

Table 3. Contributions of mortality from main causes of death to differences in life expectancy at birth between the cohorts 1890-1012, 1912-1932, 1932-1952 and 1952-1965. Men and women

Cohorts	All causes	Infectious diseases	Cancer	Circulatory diseases	Respiratory diseases	Digestive diseases	Violent causes	Others diseases
Men								
1890-1912	13.0	1.8	-0.3	1.0	1.8	2.7	1.2	4.7
1912-1932	10.3	1.2	-0.2	1.7	2.2	0.4	0.0	5.0
1932-1952	13.2	0.8	1.4	2.2	2.7	3.0	0.5	2.7
1952-1965	6.3	0.0	1.3	1.2	0.8	1.3	0.2	1.4
Women								
1890-1912	14.0	1.8	0.0	2.1	1.9	2.8	0.1	5.3
1912-1932	13.0	1.4	0.1	2.4	2.5	0.8	0.2	5.7
1932-1952	12.5	0.9	0.8	2.2	2.4	3.2	0.2	2.7
1952-1965	5.8	0.1	0.8	1.1	0.8	1.2	0.1	1.6

We compared four cohorts, each representative of the development of the mortality history of the forty cohorts that were involved in the most important changes in survival registered since the last war. There are both the adults of the 1970s, who are the old of today, and the adults of today, who will become the old of tomorrow, and whose future mortality has to be estimated by projection. Without entering into the description of the various results, we may note how contributions to the increase in survival modify their profile, when we move from the older to the younger cohorts and from men to women. The decline in childhood and youth mortality gradually becomes less important compared with the decline of mortality in youth and adulthood, followed by the significant decline in mortality among the old in the most recent cohorts. As regards the causes, the important contribution of the decrease in mortality from infectious, respiratory or intestinal diseases has given to that of the decrease in mortality from cardiovascular diseases and cancer.

Since circulatory diseases and cancer for the adult and elderly have long been the two main causes of death, it seems interesting to examine with care their mortality trend, comparing one cohort to another, and focusing on these ages, which are the periods that most favour the extension of life for the most recent cohorts (Figure 7). The mortality histories in adult age (45-64 years) are complete for the cohorts between 1865 and 1943. The estimates for the later cohorts start from our knowledge of part of the story. For example, for the cohort of 1952 the mortality is that actually observed up to 55 years old, while that between 56 and 64 years is projected.

The image provided by figure 7 for adults is enough to explain the two most important points about the aims of this study. In the first place the reasons for the changes in the mortality models of adults today compared with the immediate past appear absolutely clear. We should recall that, according to the illustrated schema in table 1, the adults of 1977 are those of the cohorts 1913-1932, while the adults of 1997 are those of the cohorts 1933-1952 and that the cohort of 1952 is regarded as the central one in the group of cohorts of adult age in 2007.

Figure 6. Contributions by age (30+ years) of the mortality by the main causes of death to differences in life expectancy at birth between two selected cohorts. Men and women

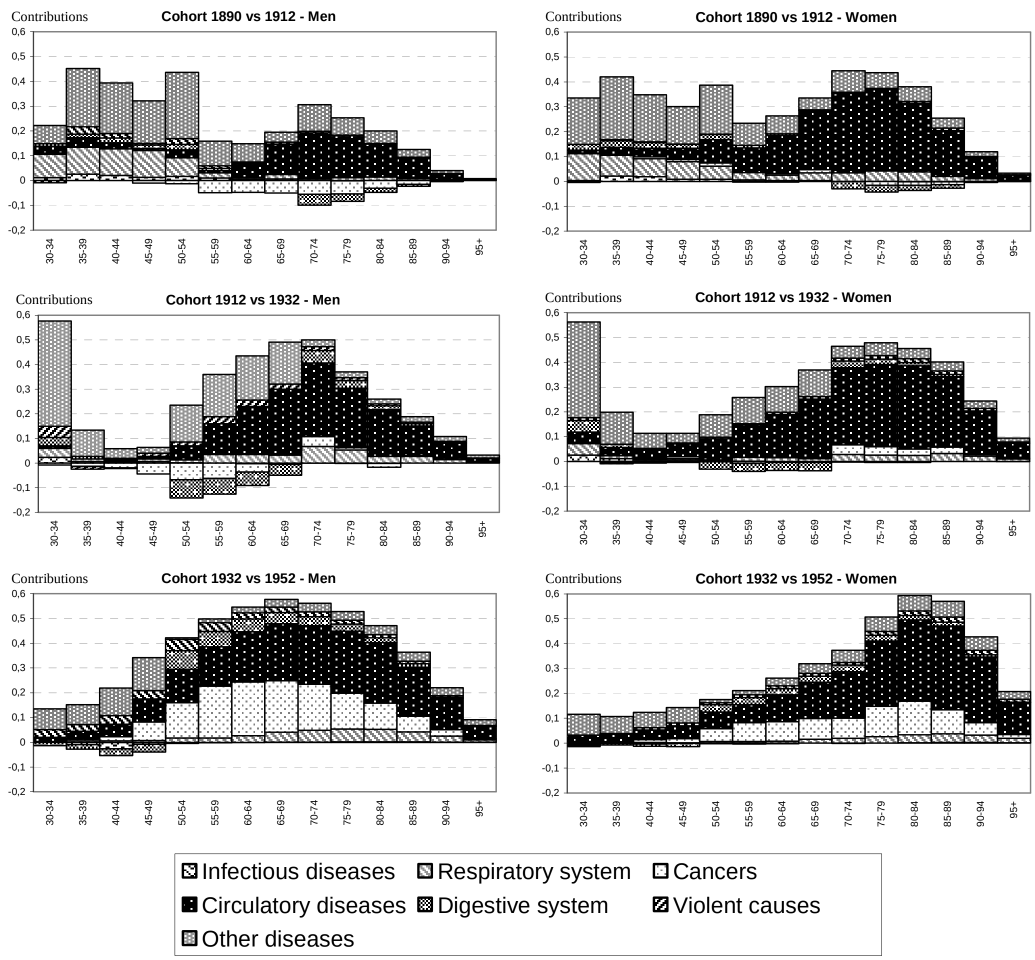
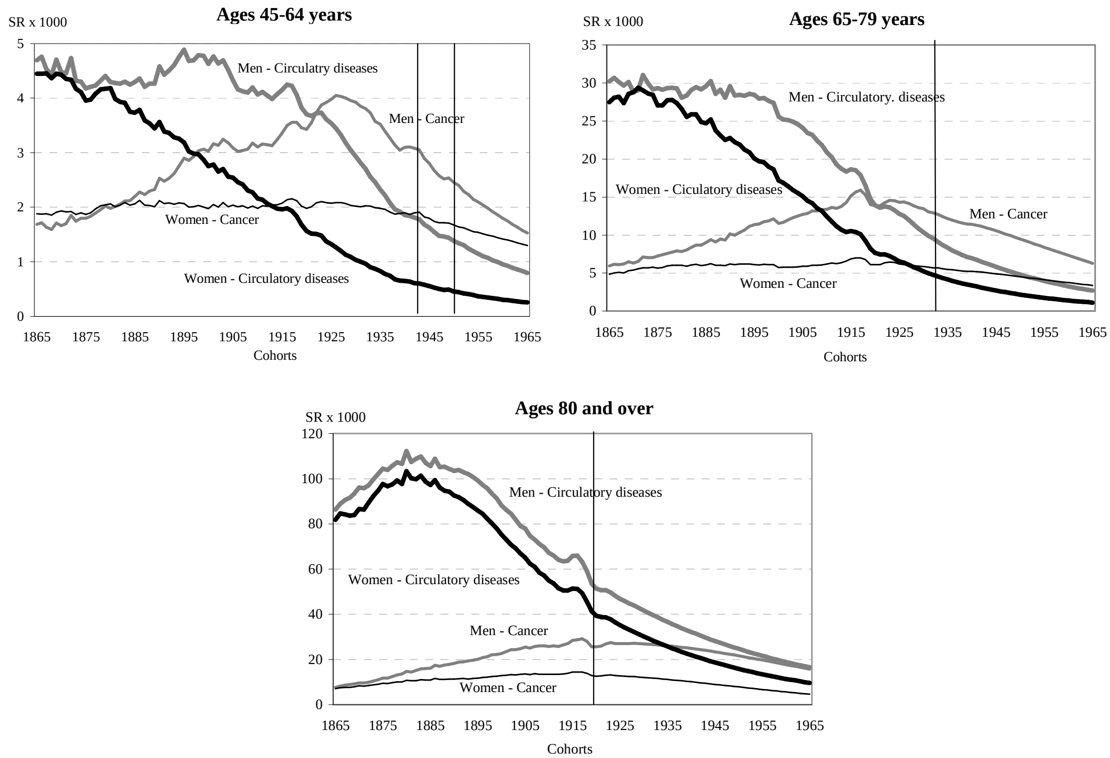


Figure 7. Trends of standard mortality rates by classes of age 45-64, 65-79, 80 and over, by two causes of death, observed (on the left) and projected (on the right). Men and Women. Standard Population: Italian both men and women as of January 1st 1952



For men, mortality due to circulatory diseases fluctuates frequently, but has a slightly decreasing trend until the cohorts born during World War I. The highest values are those for the cohorts involved in or born during the war. Mortality due to cancer, by contrast, shows a clearly growing trend up to those born in the 1920s. As is widely accepted, the increase in male cancer is largely the result of the increase in mortality from the cancer of the respiratory system, which is closely linked to cigarette smoking, a practice that was widespread among soldiers during the war, but also a life-style that was particularly cultivated among the cohorts of adult men in the 1890s. The increase in mortality due to cancer in the age class 45-64 does not involve only men in the cohorts that took part in the war, but also those born during the conflict (though to a lesser extent) and later those who took part in World War II. These three groups of cohorts, which we have seen were also penalized in their average survival values, actually lost years of life compared with the others because they were also struck down at these ages by higher mortality due to circulatory diseases. As a result, fewer of the individuals in these cohorts reached the threshold of 65 years, and despite the lower mortality levels they enjoyed in later ages, above all due to circulatory diseases, the number of them that might have hoped to reach extreme ages remained very limited.

It is interesting to note that it was around the cohorts born in the early 1920s that the crossover in adult age took place between the curve of circulatory disease and that of cancer. From then on, mortality due to cancer occupied first place in these ages and for all the following cohorts. The cardiovascular revolution and the start of the decline in mortality from cancer fully involved the men in the cohorts born towards the end of the 1920s down to the one born in 1935. In adulthood, but also at later ages, the men in these cohorts experienced a decline in mortality from these two causes not only in terms of male mortality but also compared with the decline experienced by women in the same cohorts of the same age.

For women, mortality at adult age from cardiovascular disease had already begun to decrease for the cohorts born in the second half of the XIX century, and this decrease had continued rapidly and more or less consistently for the later ones. Mortality from cancer remained more or less at the same levels for all cohorts, both at adult age and at later ages (65-79 years), showing a moderate increase only after the age of 80. There was a different gender behaviour in the development of mortality for these causes, which became particularly important for the cohorts born between the second half of the 1920s and the second half of the 1930s. Observing figure 7 we can see that the rhythm of decline for adult men, but also for old people at later ages, accelerates more than that for the women in the same cohorts and of the same age. This different behaviour probably plays a significant role in the bridging of the distances in survival observed in figure 3, but also in figure 1, and in the modifications of the sex ratios at adult age observed in figure 2. What we have noticed in the period mortality diagrams might then be explained by the various modifications in the mortality models of the cohorts of men and women. We shall deal with this aspect in the next section, but we can straightaway conjecture that the reduction in gender differences is due more to men recouping among the more recent cohorts than to a potential reduction in the rhythm of the increase in survival by women in the same cohorts, such as is visible in other countries.

The examination of figure 7 deserves a final comment on the part of the curve concerning the most recent cohorts, and hence the mortality values that are most a matter of projection. In particular, if we observe the values projected for the cohort of 1965, we see that the low mortality level for cancer in men, which might already be reached in adult age (45-64 years), would bring them very close to the women, although a decrease has been projected for them too. Another interesting result is that, for the cohort of 1965, cancer will become the main cause of death in old age too (65-79 years) both for men and women.

5. ARE WOMEN LOSING SOME OF THEIR ADVANTAGE OR MEN RECOUPING THEIR DISADVANTAGE?

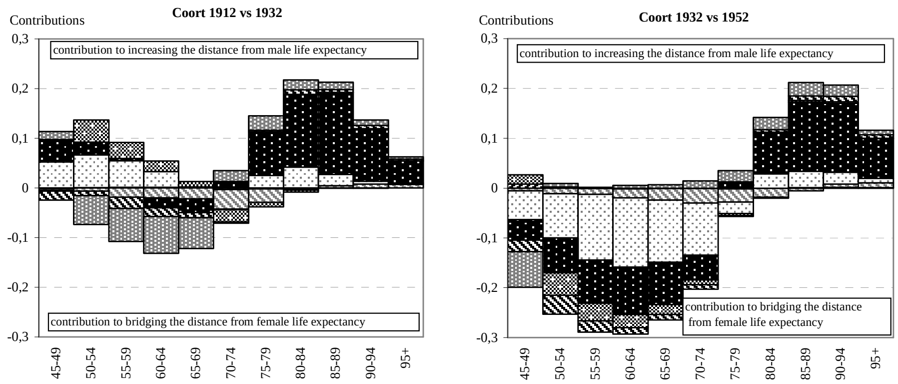
The survival of women for all the cohorts thus remains higher than that of men. Applying Pollard's decomposition model we can see which adult and old ages and which causes are responsible for the gender gap that can be seen in life expectancy at birth for the group of cohorts considered so far (Table 4). For the cohort of 1932 we can see that the ages most involved in producing the 7.4 years of gender difference observed are those over 45 years, while the causes determining these differences are mainly cancer and circulatory diseases, where the higher male mortality contributes to the gender gap with 2.2 years (30% of 7.4) for the former and 1.9 years (26%) for the latter cause of death. For the cohort of 1952 the gender difference in survival of 6.8 years is due to cancer for 2.2 years (32% of 6.8) and to circulatory diseases for 1.8 years (26%). With the cohort of 1965 the relative importance of the reduction in mortality from cardiovascular diseases and cancer remains significant. In fact, of the 6.3 years of differential between women and men it emerges that 1.7 (27% of 6.3) and 1.9 (30% of 6.3) respectively are due to these causes of death.

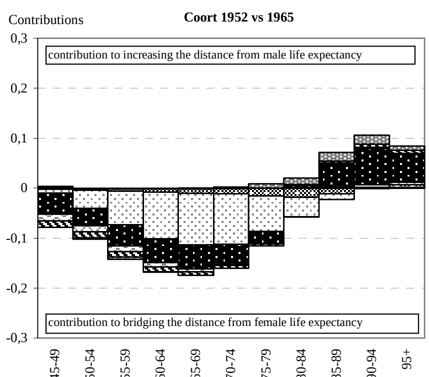
As has already been stated, starting from the cohorts born in the 1930s the decline of mortality in adult and pre-senile ages for the most important causes of death is more rapid for men. We have said that this has an impact in reducing the gender gap in life expectancy that can be seen when we move from the cohorts of the past to those more recent. The contribution of different ages and different causes to the reduction of the gender gap in life expectancy can be read estimating – once again with recourse to Pollard's model – the ages and causes responsible for these reductions. Figure 8 summarizes effectively the role of the action of age and cause of death dynamics in deciding the bridging (negative contributions) or increasing (positive contributions) of the distances between the two genders as we move from one cohort to the next.

Table 4. Contributions of mortality by two main causes of death to differences in life expectancy at birth between men and women: cohorts 1932, 1952, and 1965

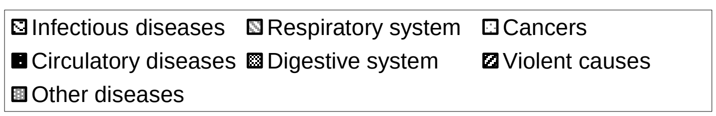
Cohorts	Total	45-64 years		65 and over years		Total ages	
	Differences	Circ. dis.	Cancer	Circ. dis.	Cancer	Circ. dis.	Cancer
1932	7.4	0.7	0.7	1.1	1.5	1.9	2.2
1952	6.8	0.5	0.4	1.2	1.9	1.8	2.2
1965	6.3	0.3	0.1	1.3	1.8	1.7	1.9

Figure 8. Contributions by age of the main causes of death to increasing or decreasing gender differences between two selected cohorts in life expectancy at birth (positive bar: contribution to increasing the distance from male life expectancy; negative bar: contribution to bridging the distance from female life expectancy)





Increasing or decreasing gender differences between two cohorts			
Cohorts	Cancer (all ages)	Circ. diseases (all ages)	All causes (all ages)
1912-1932	0.3	0.8	2.7
1932-1952	-0.6	0.1	-0.7
1952-1965	-0.5	-0.1	-0.5



We can say that for the most recent cohorts (1952-1965) almost all the causes have contributed to the gradual erosion of the female advantage between 45 and 70 years of age, but that the role of cancer was decisive. Beyond the age of 70, however, it was above all thanks to the particularly fortunate progress in mortality from circulatory diseases that women increased their advantage. The profile is very similar for the groups of cohorts 1932-1952 and 1952-1965, but if we turn from the cohort of 1952 to that of 1965 women's advantage seems to be more and more relegated to more advanced ages.

6. DISCUSSION AND CONCLUSION

Before commenting on the most interesting results, we think we should underline that making projections by cohort has the advantage of starting from a mortality history, more or less long and already observed, and so limiting projections to just one part of the whole story. The result is very clear in figure 4 of session 3. In our study we have presented the survival history of one hundred cohorts, from the one born almost immediately after the reunification of Italy (1865) to the one born in 1965. We could have extended our analysis further, but our aim was to analyse the mortality profile by age and cause for the cohorts that were adults in the first decade of this century and that will be old in the near future.

Life expectancy at birth and in old ages calculated by cohort allow us to see the final result of a whole history of survival and so to interpret some of the differences that can be seen between cohorts as the effects of having experienced different life histories (Cheung et al, 2008; Robine et al., 2006). The cohorts born during the years of the Spanish Flu epidemic and World War I, but also in part those born during World War II, are those that saw their years of survival reduced, inverting the positive trend that had been registered passing from one generation to the next. Many studies have brought out the devastating effects of high infant mortality and mortality in the early years of life on the average number of years lived by the men and women of these cohorts.

On the basis of the mortality histories observed and projected, the longevity of the cohorts received a clear boost when those born after World War II became adult. For men and women life expectancy at birth increased slightly more than 10 years, if we compare the cohort born in 1942 with the one born in 1952, while for the preceeding cohorts from 1912 onwards the growth in survival for each succeeding set of ten cohorts was on average 5-6 years for men and 6-7 years for women. There is no sign of the catastrophes experienced by those born earlier in the mortality histories in infancy, youth and adulthood for the cohorts born after World War II. Those born after World War II enjoyed the benefits of economic, social and health improvements, which reduced to the lowest levels recorded the risks of mortality from infectious diseases and used for the first time modern treatments for diseases that had previously been fatal In addition, in old age they will be able to benefit from the marked reduction in the risks of circulatory diseases, as a result of the so-called cardiovascular revolution. The longevity of these cohorts will benefit above all from the effects of prevention, due to the constant improvement in educational levels. For men in particular the reduction in cigarette smoking (Gallus et al., 2006) may have an impact on their survival, thanks to the decline in mortality from cancers, above all those of the respiratory system (Caselli and Egidi, 2010).

The cohort analysis has allowed us not only to observe the important modifications of the longevity between cohorts but also between genders. This analysis confirms and adds to the results of the period analyses, providing answers to some of the questions advanced in observing both the continual increase in the survival gaps between genders before 1979 and the reversal in the last thirty years.

In particular, the cohort analysis has shown how the increase in the gender gaps in survival are often the result of a life history that penalized the cohorts of men involved in World War I, but also in World War II, probably by the adoption of habits such as cigarette smoking that increased their risk of death, particularly from cancer (Waldron, 1986; Valkonen and Van Poppel, 1997). At the same time that men who had suffered the effects of a life history that had involved risks that endangered their health, Italian women in the same cohorts who had been marginalized from the world of work and protected by a traditional culture, were as a result also protected from more harmful life styles and so were able to recoup more years of life, gradually increasing the gap between them and men.

The most interesting result is that concerning the reduction in the gender gap for the most recent cohorts (1952-1965). In other countries this reduction was determined by a worsening in female survival due to the new life styles of women, which became more and more similar, negatively, to those of men (Pampel, 2003 and 2005; Preston et al, 2006). This is not true in Italy for the cohort involved in our study. Here women of the past and present cohort in adult and old ages did not increase their risks of death by imitating male behaviours (see figure 7). Italian women of adult age today seem to remain, all things considered, quite close to a traditional culture, and even if they experiment more frequently some of the typically male risks (smoking, for example), we may suppose that they quickly try to reduce the intensity and length of their exposure to these risks, and so their impact on their overall survival. In fact, if we examine the prevalence of smoking among women from some selected countries in the mid-1970s, by age (Forey et al.2002; Statsky, 2009), in Italy they had, at age 50-59 a value of 14% vs 48% in England an Wales and 18% in Japan (where the prevalence of female smoking is one of the lowest), while at age 40-49 this value was 16%, equal to Japanese women and lower than Danish women (49%). Among Italian women aged 30-39 years in 1976 (61-70 years in 2007) their smoking prevalence was 29% vs 46% of Danish women.

Men of the recent cohorts, by contrast, seem to imitate the female mortality models and even reduce some of the typically male risks of illness and death. This may be the result of a new culture of the body that seems more and more interesting to young males, who study and imitate some of the behaviours of women. Greater care for their bodies, for example, leads them directly or indirectly to follow the path of prevention and to detect in advance some illnesses that might otherwise become lethal. We would like to be able to interpret the gradual closening of male and female survival values (due to the reduction in male adult mortality as we move from the 1952 cohort to that of 1965) as the result of a feminizing of male behaviour. We might conclude that Italian males in the younger generations seem to have understood that they need to study women if they want to live longer, hoping that Italian women do not imitate the men of the previous generations!

This concern is not unfounded, if we consider that the young women of today are those that most frequently adopt habits and behaviours that are damaging to their health. Smoking prevalence is increasing rapidly among them (Ficolelli, 2009), reaching levels that approach those of women in countries where the smoking habit has been widespread for a long time. In the 2004 survey the Italian women that described themselves as current cigarette smokers were 22.5%, compared with 30% for men as the difference in smoking prevalence between gender was greater in the elderly (Gallus et al, 2006).

Obviously, the results of our projections can also be read in period terms. In this case we clearly have to bear in mind too mortality by age and cause for all the cohorts born between 2008 and 2050. According to the life tables for 2050 men will reach 88.7 years of survival at birth, against 92.4 years for women (Table 2). This means that instead of the 6.9 years of difference in 1979 and the 5.3 years in 2007 there will be a difference of 3.7 years in 2050 and the trend towards a gradual closening of male and female survival will continue. Indeed, for the young women of today we can see a long-term process of coming closer to the men of the same age, as, although they will maintain mortality levels for cancers that are much lower than men's, the projection of a slight increase in their mortality from these causes will combine with an increased reduction of men's.

Obviously, between now and 2050 there will also be a gradual increase in the survival of the elderly, with a life expectancy for sixty-year-olds of 25 years if male, and almost 29 years if female, and for eighty-year-olds of 12.5 and 15 years respectively (Table 2). The constant increase in survival will be accompanied by an inevitable increase in the population of old and very old people. In the coming decades the large cohorts of the post-war period will pass the threshold of seventy and then eighty years, immediately followed by those born during the years of the economic boom, to which in the course of time have been added increasing quotas of immigrants who arrive in Italy at a young or adult age, and who might remain there in old age. Graziella Caselli and Viviana Egidi (2010) have made some calculations, using the hypothesis that the proportion of those seriously disabled through old age remains constant and equal to the levels of 2004. Starting from the results of our projections they forecast that in 2030 there will be almost 4,000,000 disabled over the age of sixty, against the figure of slightly more than 2,000,000 in 2004. Although, according to a more favourable hypothesis, the numbers of the seriously disabled should reduce with the same rhythms registered in the last ten years, that would still mean around 2,900,000 seriously disabled, 2,300,000 of whom would be over the age of eighty. If we also take into account those with partially reduced functional autonomy the overall estimate would be over 8,000,000, of whom 4,000,000 would be over the age of eighty.

Faced with these possible scenarios, the country clearly needs to start considering health service policy in the light of its adequacy and sustainability, quite apart from the impact that this process of growth in the elderly population would have on social facilities and families.

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