Mortality Dynamics and Policy Changes: The Case of Germany

Elisabetta Barbi, Carlo G. Camarda and James W. Vaupel
Max Planck Institute for Demographic Research, Rostock - Germany

Long abstract prepared for the
XXV IUSSP International Population Conference
18 - 23 July 2005 Tours France

1 Introduction

An intriguing but still open question for demographers is how and at which age human longevity is determined. What are the main factors affecting adult and old mortality? Period circumstances or rather genetic and early-life factors[1]? The case of Germany - as remarked by several authors (Gjonca et al., 2000; Nolte et al., 2000; Scholz and Maier, 2003) - offers perhaps the best opportunity to study the impact of period circumstances influenced by political and socio-economic conditions on mortality dynamics. Since the mid 19th century, East and West Germany had been united under the same political and economic system for almost a century, sharing a common cultural and historical background. After the II World War, East Germany experienced a socialist economy whereas West Germany lived in a free-market democracy. With the collapse of the socialist regime in 1989 and German reunification one year later, the two regions were again merged into the same system under the West German political and economic model.

In the late 1940s life expectancy at birth was somewhat higher in West Germany than in East Germany. By the early 1950s East Germany mortality had fallen to and then below pre-war levels. For males, a slight East German mortality advantage compared with West Germany lasted from the early 1950s until 1977. For females, death rates at most ages were comparable in

[1]Many studies address this question. For reviews see e.g. Elo and Preston 1992; Doblhammer 2004.

East and West Germany from the early 1950s until 1975. Starting in the mid and late 1970s, East German life expectancy fell below West German levels, with a gap of well over one year for both males and females by the late 1980s. Since then, the gap has been cut by more than 50%, again for both males and females. Most of the improvements in East and West German life expectancy at birth and most of the more rapid improvements in East Germany are due to mortality reductions at older ages. Gjonca, Brockmann, and Maier (2000) report that more than 71% of the improvement in East German female life expectancy at birth from 1980 to 1996 came from ages 60 and over, and about 31% from ages 80 and over. Similar but somewhat smaller percentages hold for West Germany and for males. For both East and West Germany and for both males and females more than 60% of the improvement in life expectancy at birth was attributable to reductions in mortality after age 60. The higher the age, the bigger the mortality improvement. As a result, the number of East German centenarians per million population increased by 140% between 1990 and 1996 whereas the number for West Germany increased by 66%.

Scholars have focused on various hypotheses to explain age-specific patterns and differences between East and West Germany (for a more extensive discussion see Gjonca et al. 2000). Häusser, Hempel, and Reschke (1995) argue that when the Berlin Wall was built, many young adults and their families left East Germany and moved to West Germany while the elderly and unfit stayed. In contrast, Schott, Wiesner, Casper, and Bergmann (1994) argue that after the Second World War millions of debilitated refugees fled from Eastern Germany to West Germany. Other scholars (e.g. Hockerts, 1998) focus on differences in the welfare regimes of East and West Germany, with East Germany emphasizing health, medical, and social benefits for the working-age population whereas the West German system of monetary payments to the poor, the sick, and retired favored the elderly. Finally, various scholars have suggested life-style factors, and in particular healthy diet, as a major cause of East-West German differentials. In particular, after reunification the consumption of fresh fruits and vegetables dramatically increased (e.g. Winkler et al., 1992). It is still not clear how much of the credit for East German mortality reductions should be given to the effects of reunification.

The aim of this paper is to investigate the hypothesis that rapid improvements in East German mortality after 1990 are largely attributable to all those positive changes that came with the reunification in 1990 as opposed to the alternative hypothesis that the improvements are largely attributable to factors that predate reunification. As a first inspection of the data, we examine Lexis maps (Andreev, 1999; Vaupel et al., 1997) of age-specific death rate for East and West Germany, for both sexes, between 1956 and 1999, for the age range 0-99. In a second step, we adapt various bi-dimensional statistical models to these surfaces of data over age and time. If a mortality surface can be captured by some model, then insights can be gained into regularities of the surface over age and time. Furthermore, areas of deviation from expected patterns can be located and these areas can be studied to determine the reasons for the deviation.

2 Lexis Maps for East and West Germany

Graphic representations of mortality surfaces as Lexis maps over age and time are a powerful tool for a first inspection of the components that can affect mortality dynamics and for descriptive purposes.

Mortality data required for the construction of Lexis maps presented here were obtain from the Human Mortality Database (http:\\www.mortality.org).

Figure 1 depicts age-specific death rates for East and West Germany for both men and women, between 1956 and 1999, from birth to age 99. The same scale was used for both countries and both sexes to accommodate easy comparison. The maps offer a panoramic view of the evolution of mortality by age and over time. The shading goes from blue to red as the surfaces rise from low to high mortality.

As it is evident from the figure, until around 1975, women in East and West Germany shared more or less the same mortality levels. Starting from the mid 1970s, mortality trends of the two populations began to diverge. Women in West Germany enjoyed a more rapid mortality decline at all ages, although, from the late 1980s, this was somewhat slower at working ages. In East Germany - with the exception of infant and child mortality, that was gradually declining - women experienced a period of stagnation and very low improvements, especially for the elderly. Furthermore, during the period around reunification, eastern mortality even showed signs of an increase at adult ages. Only in the early 1990s, female mortality started to decline markedly, leading rapidly to a catching up of mortality at all ages, even at the oldest ones.

For men, the picture is roughly the same but with more emphasized negative trends for East Germany. By the mid 1950s, East Germany finds itself at a slight advantage. This situation was reversed by the late 1970s when men in West Germany enjoyed an increasing reduction in mortality at adult and old ages. As in the case of women, by the time of reunification, improvements in male mortality were slower at working ages or even slightly negative at certain adult ages. East Germany, on the contrary, shows evident signs of a decline only in the early 1990s, after a period of absolute stagna-

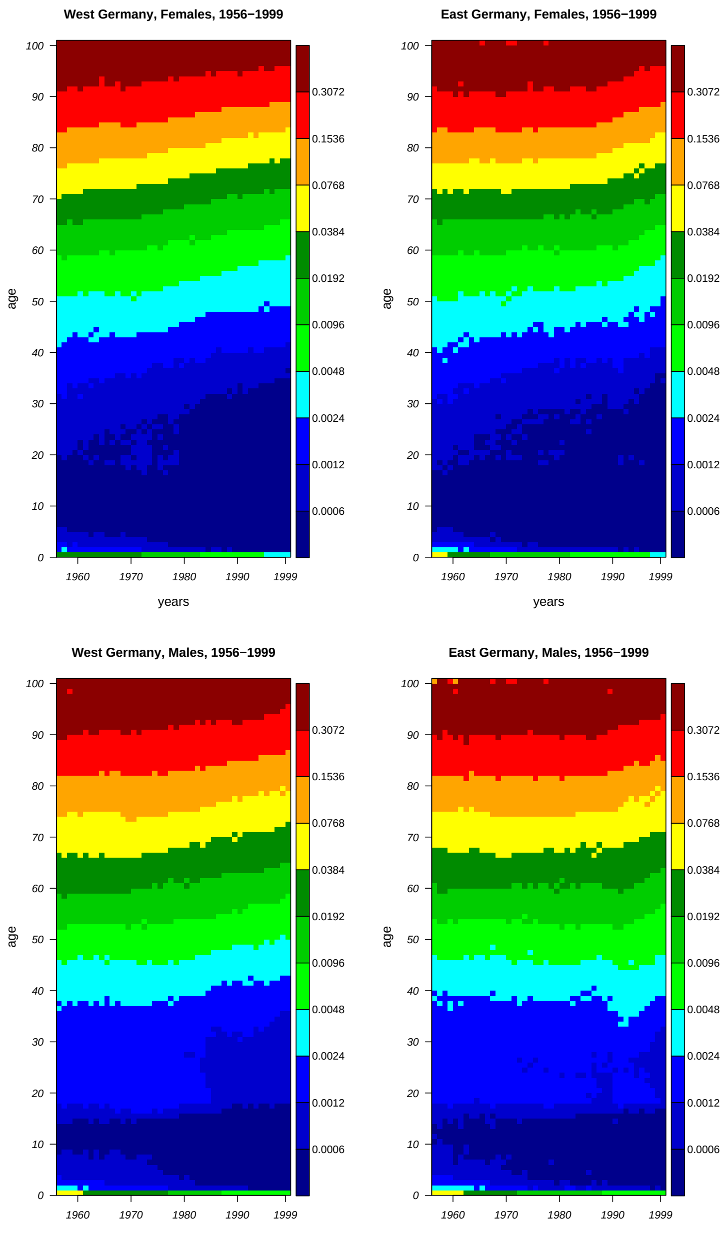

Figure 1: Age-Specific Death Rates for West and East Germany, 1956-1999

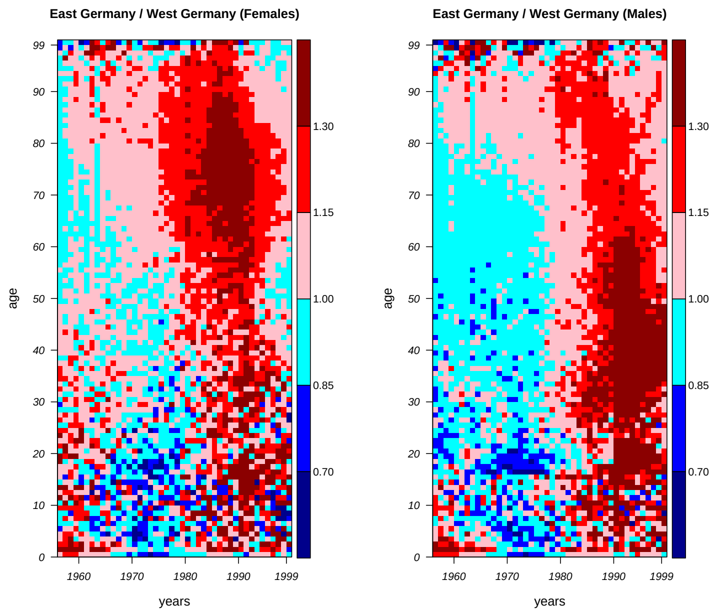

Figure 2: Age-Specific Death Rates of East Germany divided by Age-Specific Death Rates of West Germany, 1956-1999

tion and, around the reunification, even a mortality increase that was more pronounced as compared to women and involved adult and also young-old ages.

Figure 2 shows ratios between death rates of East Germany and West Germany, for both men and women. These maps allow to easily locate areas of deviations between the two country's parts. In particular, it appears immediately evident a time lag between male and female mortality improvements in West Germany, especially at old ages. Furthermore, two areas of maximum discrepancy between East and West Germany, which are differently located in the two sexes, clearly emerge. For women, the highest mortality disadvantage in East Germany (deaths rates equal or more than 30% higher than in West Germany) is concentrated after age 60 and during the 1980s whereas for men the highest disadvantage appears at working ages, between age 20 and 60, and persists to more recent years.

3 Models of Mortality Surfaces

A popular two-dimensional model for the analysis of mortality surfaces has been suggested by Lee and Carter (1992). Their model decomposes the mortality rate $m(x, y)$ at age x and in year y as

$$m(x, y) = exp[a(x) + b(x)k(y)], \tag{1}$$

where $a(x)$ is a fixed age-schedule of mortality, $k(y)$ is a function of time that determines how much mortality is affected by altered conditions, while $b(x)$ describes the relative impact of these altered conditions at different ages. This model is estimated using the singular value decomposition approach.

The Lee-Carter model is able to roughly capture the surfaces of death rates of several developed countries over the course of the 20th century. However observed mortality patterns may result from a more complex interaction of factors.

For truly capturing the structure of mortality surfaces, a third component, mortality selection, should also be incorporated in the model. Populations are heterogeneous. Individuals differ in their susceptibility to disease and death: frailer individuals age quicker and are eliminated earlier. A generalization that extends the model by an additional random variable to account for unobserved heterogeneity in individual frailty has been suggested by Vaupel (1999). Let

$$\mu(x, y, z) = z\mu_0(x)\exp[-\phi(y)r(x)] + c\exp[-\psi(y)]$$

be the force of mortality at age x and time y for individuals with unobserved frailty z, where $\mu_0(x)$ is the baseline function (the force of mortality for a standard individual with frailty 1), c is a positive constant, $r(x)$ is a function that determines the relative impact of altered conditions at different ages, and the two time-specific functions $\phi(y)$ and $\psi(y)$ denote the impact of altered conditions on mortality. If z follows a Gamma distribution with mean 1 at the starting age of observation x_0 then, the force of mortality at the population level, at age x and time y, is (Vaupel et al., 1979):

$$\bar{\mu}(x, y) = \mu_0(x)\exp[-\phi(y)r(x)]\bar{s}(x_0, x, y-x)^{\sigma^2(y-x)} + c\exp[-\psi(y)] \tag{2}$$

where $\bar{s}(x_0, x, y-x)$ is the proportion of the cohort born at time $y-x$ that survived from age x_0 to x and $\sigma^2(y-x)$ is the cohort-specific variance of the Gamma distribution at x_0 The underlying hypothesis is that individual's frailty is fixed at the starting age of observation x_0 – which can be either birth or higher ages – and can not change with age. The variance of the frailty distribution $\sigma^2(y-x)$,), hence, indicates the degree of cohort heterogeneity at age x_0 which may arise from both innate and acquired frailty, and reflects whichever unobserved influence of debilitation, compensation, as well as selection up to this age.

Since the survivorship function $\bar{s}(x_0, x, y-x)$ is computed on a cohort basis, a longer series of data are required to apply this model. In the case of Germany, where data are only available starting from 1956, it was not possible to apply the frailty-model generalization of the Lee-Carter model.

Another category of models, relational models, have proven useful in demography. Relational models of mortality are based on a standard mortality schedule capturing the complexity of age patterns of mortality, and on parameters capturing deviations from the standard. This concept can be generalized so that the standard mortality schedule is defined over time as well as age; i.e., as a surface. Generalizing the Lee-Carter approach, the standard mortality surface could be given by $\mu_0(x, y)$ and the relational model could be:

$$\mu(x, y) = \mu_0(x, y) \exp[b(x)k(y)], \tag{3}$$

An alternative model would be:

$$\mu(x, y) = \mu_0(x, y) \exp[b(x) + k(y)]. \tag{4}$$

The standard surface $\mu_0(x, y)$ could be estimated as the average surface for a number of populations for different countries. If the countries are grouped as one super-country, then all the deaths could be added together and all the population counts added together to calculate an overall values of $\mu_0(x, y)$. The maximum likelihood method is generally used for the parameters' estimate of mortality functions.

4 Modelling Mortality Surfaces for East and West Germany

To analyze the divergence and subsequent convergence of mortality in East Germany and West Germany we will adapt the Lee-Carter and the relational models presented in section 3 to male and female surfaces of age-specific death rates, for East and West Germany, between 1956 and 1999, from birth to age 99 (Figure 1). In addition, we will fit these models to male and female East German surfaces using data prior to reunification in 1990, predict the surfaces into the 1990s, and compare the predicted surfaces with the corresponding, observed surfaces to determine the extent to which the dynamics of Est Germany mortality was the result of trends that predated reunification.

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