Horizontalization, verticalization and longevity extension: Three dimensions of the transformations of the survival curve – the case of Switzerland

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ABSTRACT

From a long time, demographers and epidemiologists have studied human survival curve which shows a "rectangularization" associated with the health transition. However, the complexity of this transformation is rarely disentangled. We propose to distinguish and measure three dimensions which are (i) the horizontalization of the survival curve due to a fall in infant mortality, (ii) the verticalization corresponding to a higher concentration of the ages at death, and (iii) the longevity extension which corresponds to a possible increase in human longevity. In this work, longevity refers to the most common length of life rather than the life expectancy at birth. Accordingly, the indicators for each dimension are built on the late mode and standard deviations from it. Using Swiss life tables since 1876-1880 and afterward, this paper documents the changes in three dimensions of the transformation of the survival curve through the 20th century.

Keywords: Longevity, horizontalization, verticalization, Switzerland

INTRODUCTION

The rectangularization of the survival curve and its links to potential limits on increases in life expectancy has been debated over several decades in low mortality countries. According to Fries, the human survival curve tends to become ideally rectangular because an upper boundary to human life expectancy at 85 years is determined by fixed genetic limits (Fries 1980). His hypothesis has been supported by the well-known biologist Leonard Hayflick (1981).

Although heated debate about this proposition continued (Fries 1984; Myers and Manton 1984a, 1984b; Schneider and Brody 1983), there appear to have two camps about changes in the shape of the survival curve, which may have a bearing on the issue of limits. On the one hand, many demographers studying the transformation of survival curves in different countries have found evidence of rectangularization during the epidemiological transition (Cheung 2001; Eakin and Witten 1995; Go et al. 1995; Hill 1993; Levy 1996; Manton and Stallard 1996; Martel and Bourbeau 2003; Nagnur 1986; Nusselder and Mackenbach 1996, 1997; Paccaud et al. 1998; Pelletier et al. 1997; Robine 2001; Rothenberg et al. 1991; Wilmoth and Horiuchi 1999). On the other hand, the rectangularization trend observed in France, Japan, Sweden and the United States was gradually replaced by an almost parallel shift of the survival curve to the right, which may imply that a slight tendency to “derectangularization” of the survival curve is emerging (Yashin et al. 2001).

The links between the rectangularization of the survival curve and the limits to human life expectancy is still being strongly debated. Oeppen and Vaupel (2002) showed that if we consider the record-holding countries, life expectancy at birth for females has risen for the last 160 years at a steady pace of almost 3 months per year, from 45 years in Sweden in 1840 to 85 years today in Japan. If this trend goes on, life expectancy at birth will rise to 100 years in the developed nations by the year 2060. Some also showed that no evidence of clear limits to the human life span could be found in the best available data sets, for example French data (Barbi, Caselli, Vallin 2003). Research over the past decade suggests that ageing-related death is highly plastic. Survival can be substantially benefited from improvements in economic and social conditions and to ongoing medical advances (Carey 2003; Carey et al. 1998; Oeppen and Vaupel 2002; Riley 2001; Vaupel et al. 1998; Vaupel, Carey, Christensen 2003).

However, some have argued that potential life expectancy at birth could not become significantly greater than age 85 without major biomedical advances (Olshansky, Carnes, Cassel 1990; Olshansky, Carnes, Grahn 1998). These practical upper limits to life expectancy would be 88 years for women and 82 years for men (Olshansky, Carnes, Désesquelles 2001). Living organisms operate under warranty periods limiting the individual life duration and life expectancy of populations (Carnes, Olshansky, Grahn 2003; Olshansky 2003; Olshansky, Carnes, Butler 2001). A recent research suggested that the steady rise in life expectancy during the past two centuries may soon come to an

end which is mainly attributable to the obesity “epidemic”, for instance in the United States (Olshansky et al. 2005). According to Wilmoth and Horiuchi (1999), the limits to life expectancy and the rectangularization of the survival curve are two independent phenomena that need separate study. Human survival curves will never become totally rectangular, meaning zero variability in age at death.

One of the common visions shared by many demographers today analyzing mortality changes over time in low mortality countries is that most of the gain in life expectancy before the first half of the twentieth century was due to large reductions in mortality early in life. However, recent and future gains in human life durations are mainly due to mortality decline among the elderly. These two successive stages illustrate the transformations of the survival curve (Kannisto et al. 1994; Robine 2001; Wilmoth 1998, 2000, 2002).

The concept of “rectangularization of the survival curve” is poorly defined and visually judged on occasion. Although many indicators have been used to monitor the “rectangularization of the survival curve” and/or the “compression of mortality” and to study the links with the “limits to human longevity”, the indicators between “rectangularization”, “compression” and “human longevity” were barely differentiated. Not all these indicators are required to monitor the transformations of the survival curve and its links to the limits of human longevity. Using all of them will produce redundant

information. According to Kannisto (1999, 2000a, 2000b and 2001), indicators should be free from any fixed age and/or percentile determinations, which is not the case for most of them.

Cheung et al (2005) introduced three complementary and coherent measures, free from any fixed age or percentile determinations, to disentangle the complexity of the "rectangularization of the survival curve" that accompanies the epidemiological transition: (1) the "horizontalization" corresponds to how long a cohort can live, and how many cohort members survive, before aging-related deaths significantly decrease the proportion of survivors; (2) the "verticalization" corresponds to how concentrated aging-related deaths are around the modal age at death; and (3) the "longevity extension" corresponds to how far the right-hand tail, representing the highest normal life durations, can exceed the modal age at death. Their work is based on the concept of normal life durations, introduced by Lexis in 1878 (See Cheung et al 2005 for more details on the theoretical framework).

Cheung (2003) also developed associated indicators in the form of M-/+*k*SD(M+) for indicating the shortest and longest normal life durations. Early findings suggested that *k* value should be comprised between 3 and 5 (Cheung et al. 2005a and 2005b). A more recent study (Cheung et al. 2005) on the basis of a long empirical series on the maximum reported age at death (MRAD) in Switzerland suggests that *k* is 3.2, constant over time:

that is, the changes in the modal age at death (M) do not change the standard deviation of individual life durations above it (SD(M+).

Therefore, the aim of this paper is to analyse changes in the three dimensions of the survival curve and the associated indicators in Switzerland from 1876 to 2002 and to answer whether the transformations of the three dimensions of the survival curve in Switzerland have a divergent pattern in which the survival curve is more horizontal and vertical and where its tail moves relatively far from M, suggesting an acceleration in the increase in longevity.