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Tempo effects may distort the interpretation of trends in life expectancy

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Abstract

Objectives: Recently, a new interpretation problem of trends in period life expectancy has been discussed in the demographic literature. The so-called tempo effects arise if large numbers of deaths are suddenly postponed. In such conditions, the life table inflates longevity gains in the population because it weights avoided deaths with the full remaining life expectancy. This article explains how such effects occur and indicates their relevance using an illustrative example.

Study Design and Setting: Data of East and West Germany from the Human Mortality Database for the years 1990−2009 were used. We simulated a scenario that contrasts the observed life expectancy in West and East Germany with an alternative one based on the assumption of short-term postponements of deaths.

Results: Our example demonstrates that if tempo effects have distorted changes in life expectancy, the pace of improvement in underlying mortality conditions could be over- and underestimated.

Conclusion: We recommend that the assumptions of the life table, in this case about the remaining life expectancy of avoided deaths, are carefully evaluated in all applications. Interdisciplinary efforts to develop models to detect and quantify tempo effects from life expectancy calculations should be put on the research agenda.

Keywords: Demography; Mortality; Health impact assessment; Health status; Public health policy; Life expectancy; Population health

1. Introduction

Period life expectancy (PLE) is one of the most used indicators of population health because it is based on data that are available in almost all countries in the world [1]. It is independent of the age structure of a population and has a clear and intuitive interpretation: the average number of years a newborn would live if current mortality rates would prevail throughout its life [2]. Population health researchers often use life expectancy to make comparisons between countries or over time and usually interpret life expectancy as an indicator of the prevailing mortality conditions in the respective year.

Recently, doubts on the reliability of PLE as an indicator of current mortality conditions have been formulated, in particular during periods of sudden and large changes in mortality, as for instance during the turmoil caused by the transition to market economies in Eastern Europe during the 1990s or the sudden improvement in living conditions in East Germany after its reunification with the Western part [3−6]. In these circumstances, the life table might give an overly optimistic or pessimistic impression of the change in mortality conditions. This problem has been discussed extensively in the demographic literature under the name of ''mortality tempo effects'' [7−20]. These effects are defined as distortions in death rates due to short-term shifts in deaths to either higher or lower ages during rapidly changing mortality conditions [21]. The aim of this article is to translate the main arguments of this discussion and their implications to a more general audience of population health researchers.

This new problem in the interpretation of life expectancy adds to some other more widely known problems. Population health researchers are well aware of the fact that PLE is not a prediction of the number of years those born at that time will live but merely a summary of prevailing age-specific mortality rates [22]. Also, it has been recognized that changes in PLE are also determined by positive or negative selection effects of past developments, which could either work in a period or cohort direction [23].

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What is new?

Key findings

- This paper introduces a new problem of interpretation of trends in period life expectancy, termed as "tempo effects" that is discussed in the demographic literature, but so far not acknowledged in public health.

What is the implication, what should change now?

- A rarely acknowledged feature of the life table is that when mortality is changing variations in death counts are weighted with the remaining life expectancy at each age.
- If during times of rapid progress a large fraction of deaths is merely delayed by a few months or years, an overestimation of the real improvement in underlying mortality conditions is likely.

What is the implication, what should change now?

- Those who apply life tables should be aware of the assumption it uses to assign remaining life-years to avoided deaths and the potential consequences for the interpretation of trends in period life expectancy.

The structure of this article is as follows. We first review the discussion on "tempo effects" in the recent demographic literature, then we provide an illustration based on the convergence of PLE between former West and East Germany after the German unification, and we end with a few general conclusions and suggestions for population health researchers.

2. Mortality tempo effects

Life expectancy is defined as the average age to which the members of a birth cohort are expected to survive over their life course [2]. Its computation requires about a century of data, and therefore, usually, a shortcut is to use observations of one calendar year only. Here, all age-specific death rates observed at a single point in time are combined to calculate the expected average length of survival of a hypothetical cohort. The advantage of PLE over other summary measures of mortality is that it standardizes for differences in the age–structure of populations and provides an up-to-date summary of the prevailing mortality conditions.

However, starting in 2002, a series of articles surprised the demographic community, claiming that life tables are distorted whenever mortality is changing because of so-called mortality tempo effects [7,16,24]. These effects belong to a larger class of distortions defined as "*an undesirable inflation or deflation of a period* […] *indicator of a life-cycle event*" [25]. The general idea is that any period measure is prone to timing shifts of the events it counts, which in the case of mortality refers to postponements of deaths. Consequently, the change in the indicator does not necessarily represent the actual change in underlying mortality conditions in the population.

The extent of a "tempo bias" depends on a rarely acknowledged feature of the life table. When mortality is changing, variations in death counts are weighted with the remaining life expectancy at each age [12,16,26]. Hence, the change in PLE over time is guided by hypothetical weights rather than the real improvement in survival time in the population. This might be reasonable if the additional survivors are as healthy as the average population, for example, people saved from dying in a traffic accident [19].

But this assumption is not reasonable in all situations. A simple example, given by Vaupel [27], is the case when every death in a population is suddenly postponed by 1 year. Although this delay by definition increases the average survival time of the population by 1 year too, the PLE would temporarily increase to infinite as no deaths are observed in the year in which the change happens. A less drastic case has been described by Bongaarts and Feeney, who show for a model population that a delay of all deaths by 0.3 years during a period translates into an overly optimistic change in PLE of about 3 years instead of the expected 0.3 years [7].

The mechanism underlying mortality tempo effects is schematically shown in Fig. 1, in which a theoretical population is shown in which annually 100 deaths occur to 1,000 person-years at risk. Its PLE is 10 years, calculated as one over the mortality rate of 0.1 [2]. At time $t = 2$, however, suddenly, half of the deaths are saved and shifted to the next period. This 50% reduction in the mortality rate will increase PLE to 20 years according to the conventional life table calculations, computed as one over 0.05. Implicitly, these calculations assume that the deaths avoided at time $t = 2$ will be gradually distributed over the next time periods according to the current mortality rate, thus on average 20 years as given by the remaining life expectancy. However, the deaths are in fact only postponed by 1 year. If this shorter delay would properly be accounted for in the life table calculations, life expectancy at time $t = 2$ would only be 10.5 years because, in fact, half of the population gains 1 year. The difference between 20 and 10.5 is the tempo effect, here 9.5 years. Similar distortions will occur in case of a sudden increase in the number of deaths.

The size of a tempo effect depends on the difference between the amount of time the death events were shifted at each age (short-term shift) and the remaining life expectancy at that age (life table assumption). The example given previously shows the consequence for the estimation of PLE if deaths were shifted by 1 year, and the remaining life