SURVIVAL CONVERGENCE AND THE PRECEDING MORTALITY CROSSOVER FOR TWO POPULATION SUBGROUPS

(Abstract of a manuscript to be presented at Population Association of America 2005 Annual Meeting, Philadelphia, Pennsylvania, March 31 – April 2, 2005)

Xian Liu, Ph.D.[1,2]

Charles C. Engel, Jr., M.D., M.P.H.[1,2]

Han Kang, Dr.PH[3]

[1] Deployment Health Clinical Center
Walter Reed Army Medical Center
Washington, DC 20307-5001

[2] Department of Psychiatry
F. Edward Hebert School of Medicine
Uniformed Services University of the Health Sciences
Bethesda, Maryland 20814

[3] Environmental Epidemiology Service
Department of Veterans Affairs
Washington, DC 20420

Demographers and epidemiologists have long been concerned with assessing the impact of observable factors on the dynamics of human longevity, assuming mortality variability to be substantially reflected in a stratification of distinct population subgroups. The rationale of such stratification approaches follows as a natural consequence of the belief that environmentally advantaged persons live longer than do their counterparts who are disadvantaged.

More recently, there is an increasing skepticism concerning constant mortality differentials throughout the life course. Some human research studies have reported mortality crossover in later life using empirical data. These findings have prompted controversies on this crossover phenomenon, in turn leading to two schools of thought on the issue. Some researchers use the notion of "survival of the fittest" to explain the crossover of two mortality schedules. At younger ages, selection eliminates more relatively frail individuals from the environmentally disadvantaged population than from the relatively advantaged as its age increases, resulting in a greater death rate among them. Gradually, its mortality increases less rapidly with age because the surviving members of the disadvantaged population are those who are most fit. When such changes in the population composition get strong enough to offset the impact of environmental differences, mortality convergence and crossover occur between the environmentally advantaged and disadvantaged populations. Some other researchers cast doubts on the validity of the theoretical hypothesis of mortality crossover. They contend that there are substantial influences of age misreporting among the oldest old in datasets thus displaying a mortality crossover.

We are inclined to accept the demographic reality of mortality crossovers and the scientific value inherent in their occurrence. Mortality crossovers have been reported not only with socioeconomic status like race, but also by genetic population subgroups such as women versus men. It is unlikely that all these reports are in serious error. Most significantly, such crossovers have been observed in carefully controlled laboratory populations of non-human animals, among whom age misreporting is not relevant.

Further examination of this issue suggests mortality crossovers to be a frequently occurring demographic event, closely associated with the dynamic process of the highly observable survival convergence. From the biological standpoint, mortality among older survivors may depend more on the natural exhaustion of the organism through the life history and into age. Thus survival functions for two population subgroups, one environmentally advantaged and one disadvantaged, tend to converge in later life no matter how much they are departed in early life. Consequently, the group initially having the lower level of mortality would sooner or later experience faster mortality acceleration to complete the convergence of the survival functions. This acceleration would eventually lead to a higher schedule of mortality for the initially advantaged before the two curves converge at a certain age point. These relationships can be identified from distinct changes in the shapes of two group survival curves and will be mathematically proved in the paper.

It may be further inferred that mortality crossovers can also occur even if the two group survival curves do not meet in later life. As long as the two survival functions assume a trend of convergence, mortality for the advantaged group would have to accelerate faster than that for the disadvantaged, thereby fostering the possible occurrence of a mortality crossover.

These theoretical issues regarding the changing pattern of differential mortality lead to a number of important implications for future studies of human mortality and distribution of health status. First, the occurrence of mortality crossover calls for both a faster pace of mortality acceleration and, at a later life stage, a higher absolute increase in mortality rates for the advantaged group, as compared with the disadvantaged. The phenomenon of mortality crossover reflects a long-standing process of variation in differential mortality. Consequently, the pattern of differential mortality, at least at older ages, would be a function of life stage. Second, as survival convergence is a sufficient condition for mortality crossover, this relationship is independent of any other exogenous factors. For example, if survival curves for two different frailty subgroups converge, the two mortality schedules would still have to cross. Lastly, application of the basic survival function must be consistent with the underlying pattern that mortality differentials are convergent, rather than divergent, over age.

In this article, we describe demographic conditions leading to mortality crossover. We focus on the analysis of the convergence of the survival curves for two hypothetical population subgroups and the resultant changes in differential mortality. We then discuss the possibility of experiencing mortality crossover in the absence of survival convergence. Lastly, we examine two patterns of differential mortality:
(1) mortality crossover and its timing in conjunction with the convergence of two survival functions; and (2) mortality crossover and its timing without survival convergence.

Note: This research is supported by the National Institute on Aging (NIH/NIA Grant No.: R03AG20140-01). Address all correspondence to Dr. Xian Liu, Deployment Health Clinical Center, Building 2, Room 3G04, Walter Reed Army Medical Center, 6900 Georgia Avenue, NW, Washington, DC 20307-5001. Telephone: (202) 782-3652. Fax: (202) 356-1090. Email: xian.liu@na.amedd.army.mil.