A Method for Constructing Life Table Bands for Paleodemographic Mortality Analysis

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EXTENDED ABSTRACT

DESCRIPTION OF THE TOPIC TO BE STUDIED

One of the main goals of paleodemographic analysis is the description of the survival conditions of the excavated population. Therefore paleodomgraphers try to gain information about the ages at death to reconstruct the mortality pattern of the analyzed skeletal population. However, the possibilities for analysis and interpretation in the field of paleodemography are basically restricted and of much weaker quality than for modern demography that is based on official population registers. By its very nature an anthropological site always describes a stationary population. Each person determined to have died at a given age x or an age range from x to x+a must have been alive from birth. Individuals, whose remains have not been found and whose ages have not been determined, can not become members of the studied population. Thus, the population under control may not be a representative sample of the living population at any time in the past. This potential bias is relevant and must always be taken into account for the interpretation, but can not be corrected for. However, if these restrictions are accepted it is in principle possible to do demographic mortality analysis.

Irrespective of the principal differences in the existing techniques of age determination there will certainly be some members of the observed population, where the ages at death can only be determined to lie within a relatively wide range, for example between age 20 and 50. With other skeletal remains of the same site the age determination might be much easier depending on the physical condition of the excavated material. Following up a former approach[1] we propose a new method to analyze mortality patterns of such skeletal populations taking into account the uncertainty produced by age estimation for skeletons and basing on modern demographic and statistical techniques, and we show that this method provides informative and interpretable results.

DATA AND METHODS

Since almost all archeological sites are characterized by an under-representation of infants and children, a paleodemographic life-table should not start at age zero or at least not be interpreted below ages 15 or 20. As already described, for each person there is an individual range of potential ages at death. Consequently, it is impossible to determine one special life table characterizing the mortality pattern according to the given information about ages at death of the observed skeletons. The correct way is to define an area containing the searched mortality pattern with a given probability, thus, to construct a life table band. Each of the single ages within the given age ranges has a certain probability to be the true but unknown age at death. If there are no better information each single age has to be assumed to have the

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[1] The idea of constructing life table bands as proposed in this paper is a further development of the basic idea using Monte Carlo simulations in order to describe the mortality condition of a skeletal site that was presented by the authors together with Reiner Dinkel at the Paleodemographic workshop held at the Max Planck Institute for Demographic Research in Rostock in the year 2000 and by Marc Luy at the workshop "Paleodemography – anthropological, demographic, and statistical aspects" organized by the German Demographic Association and the German Association for Anthropology in Rostock in the year 1999.

same probability. The approach we propose uses an random number generator to draw for each individual an exact age within the given age range. This procedure is then repeated again and again, for instance for 500 times. Consequently, each of these 500 trials determines an exact age-at-death-distribution, from which an exact set of five year probabilities of dying and based on this the corresponding age-at-death distributions can be calculated. To determine an age-at-death band with an assumed degree of certainty of 95 percent we have to cut 2.5 percent of the l(x)-values at both extremes of the whole observed l(x)-distribution. These two boundaries for the age-at-death distribution can be used for defining a life table band for the observed skeletal population. In the case of stationary conditions these boundaries directly represent the life table band. However, if it possible to assume a certain (stable) growth rate of the population the age-at-death band can be used to construct a life-table band for the observed population, applying the estimated growth rate for adjusting lived risk years underlying the determined age-at-death band.

One question arising with this procedure is the plausibility of the assumption, that each age in the whole interval is given the same probability to be selected. At the very first moment one might potentially assume that it would be more plausible to assume age 40 in case of a given interval 20 to 60 and age 50 in case of an interval 20 to 80 and so on. Doing so, however, an unrealistic small number of deaths would be allocated to low and high ages and a very high number to middle ages. The life table resulting from such an age-at-death distribution would thus become heavily deteriorated from all experiences. If the age determination does only succeed to give a wide interval then we should indeed assume that each exact age within the whole interval has the same probability to be selected. However, if there is a more precise information about the probability distribution inside the age ranges the proposed method can be adjusted without any problems.

The reliability of the proposed method of life table bands will be demonstrated on a bronze age skeletal population from Ikiztepe, Turkey, containing 673 skeletons. In additional tests, this data will be used to simulate different other situations regarding the individual age-ranges to test if the method provides logical and robust results.

FINDINGS

Figure 1 shows the life table band (stationary conditions) for the Ikiztepe skeletal population after 500 random trials in comparison to the survival functions derived from the given lower and upper limits of the age ranges of the 673 individuals (maximum range). The stationary life table band (age-at-death band) describes a considerably smaller area of uncertainty. The reason is that in each repetition of random number calculation the probabilities to die between ages x and x+4 differ, but in sum these values will be above average for some ages and below average for others, resulting in a relatively similar survivorship curve. Using several test simulations we can show that the width of the age-at-death band depends on the given average ranges of age intervals in the observed population. When a greater share of the skeletal population can only be determined with less precise age ranges the boundaries of the age-at-death band becomes larger, reflecting the increasing degree of uncertainty caused by the less precise age determination.

Furthermore, the stationary life table band for the Ikiztepe skeletal population describes a very specific age pattern with a relatively high mortality in the middle ages around age 50 that is untypical for present populations. This becomes clear in figure 2 where the stationary life table band is compared to the Coale/Demeny model life tables. All further simulations and comparisons to the traditional used paleodemographic methods show that the method yields reliable and very robust mortality patterns containing the typical characteristics of survival conditions of the analyzed skeletal population.

Fig. 1: (95%-) Life table band (stationary conditions) from age 20 for the Ikiztepe skeletal population using 500 random draws (solid lines) in comparison to the life tables using the upper and lower limits for the ages at death (dotted lines)

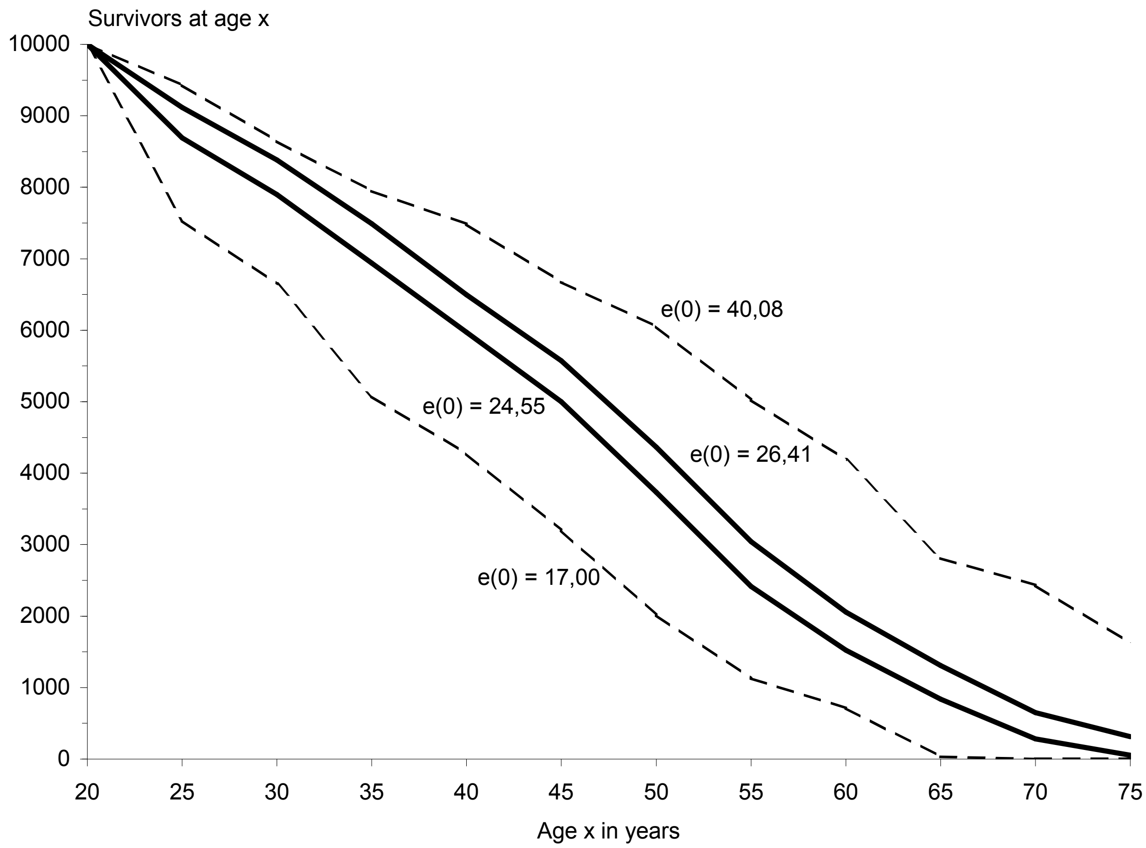

Fig. 2: (95%-) Life table band (stationary conditions) from age 20 for the Ikiztepe skeletal population using 500 random draws (bold solid lines) in comparison to the Coale/Demeny-life tables of highest mortality level