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THE USE OF THE CENSUS TO ESTIMATE CHILDHOOD MORTALITY: COMPARISONS FROM THE 1900 AND 1910 UNITED STATES CENSUS PUBLIC USE SAMPLES

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ABSTRACT

This paper presents estimates of child mortality by race and nativity for the United States as a whole and the Death Registration Area based on the public use microsamples of the 1900 and 1910 censuses. The estimates from the 1910 census are new. The paper compares the indirect estimates to mortality rates and parameters based on published census and vital statistics data. The federal censuses of 1900 and 1910 both asked questions of adult women on children ever born and children surviving which, when tabulated by age or marriage duration of women, can be used to estimate the probabilities of their children dying at various ages up to 25. Although the data on children ever born for 1910 were partially tabulated and published in conjunction with the 1940 federal census, the information on children surviving was never tabulated and published by the Census Bureau. None of the information from 1900 was ever published. The public use micro samples of the 1900 census (100,438 individuals in 27,069 households) and the 1910 census (366,239 individuals in 88,814 households) make possible the application of these well-established indirect methods. This paper applies the basic indirect age and marriage duration methods, as well as a method involving the backward projection of the age distribution of surviving own-children of younger adult women. The results match reasonably well to life tables calculated from aggregated census and vital statistics for the total white, native white and foreign-born white populations. The results are less definite for the African-American population, but it does appear that mortality in the black population was substantially better than that indicated but the widely cited Glover life tables for 1900/02, 1901/10, and 1909/11 for the original Death Registration Area of 1900. Overall, however, it appears that calculated life tables from published vital statistics and census populations for the Death Registration Areas of 1900 and 1910 do describe the remainder of the population relatively well. An appendix to the paper provides examples of the application of the basic indirect techniques of mortality estimation as well as the calculation of a mortality index which can be used with both individual-level and grouped data.

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INTRODUCTION

It is frequently the case that important events are described and understood by incomplete or partial information. This is certainly true for the period prior to the 1930s for the long-term mortality transition in the United States, arguably one of the most important occurrences in American history. We have evidence that the final phase of the transition, the sustained improvement in period death rates, did not begin until about the 1870s [Kunitz, 1984; Preston and Haines, 1991, ch. 2; Higgs, 1973; Haines, 1979]. From that period, dramatic changes took place in both levels and differentials of mortality. It appears that overall expectation of life at birth (e_0) improved from about 38.5 years in 1880 to about 47 years around 1900 to 51.5 years in 1910. Similarly, the infant mortality rate (infant deaths per 1000 livebirths) fell from about 225 in 1880 to about 114 in 1910 [Preston and Haines, 1991, Table 2.2]. The improvement was most rapid in large urban areas, where mortality had been the worst. The substantial urban mortality "penalty" of the late 19th century was rapidly disappearing by the early 20th century. Public health improvements, better nutrition and shelter, and some advances in medical science all played a role. Mortality improved for virtually all groups and regions between about 1880 and World War I, but relative differentials shifted.

Unfortunately, this important series of events is only imperfectly documented. Vital registration data did not cover the entire United States until the Death Registration Area (DRA) was complete in 1933. The DRA itself was not created until 1900 and then only included the six New England states, New York, New Jersey, Indiana, Michigan, and the District of Columbia. For the period of the early twentieth century, commonly reported data are the Glover [1921] life tables for 1900/02, 1901/10, and 1909/11, based on the DRA of 1900 (see e.g., DHHS [1992]; Linder and Grove [1947]). As is apparent in Table 1, the DRA of 1900 constituted only a portion of the American population, about 26% in both 1900 and 1910. It was more urban (66% in 1900 and 72% in 1910) than the nation as a whole (40% and 46% at the two censuses) and contained more immigrants (22% in 1900 and 25% in 1910) compared to the national average (13.6% and 14.5% respectively). Finally, the DRA of 1900 had less than 5% of the nation's African American population, and, of that, 82-83% was urban. The national average percentage urban of the black population was 20% in 1900 and 27% in 1910. There is thus some reason to suspect that biases might affect the representativeness of the Glover life tables vis-a-vis the national picture.

Earlier work by Preston and Haines [1991, ch. 2] has indicated that the Glover life table for 1900/02 provided a slight overestimate of the child mortality experience of the white population at the turn of the century, whereas the child mortality of the national black population was considerably more favorable than that in the small and highly urbanized population in the DRA. (Some of these results are presented below in Tables 2 and 3.) The black disparity was principally due to the much higher mortality of urban black children relative to those in the rural South, where most blacks lived. For the white population, the higher proportion urban was offset by greater progress in reducing urban mortality for them in the northeastern states of the DRA. So, for example, the implied e_0 for the white population was 51.8 years based on indirect estimates using the 1900 public use microsample, contrasted to an e_0 of 49.6 years for the DRA in 1900/02. But, for the black population, the estimates were 41.8 for the nation as a whole, in contrast to an e_0 of 33.8 for the DRA. (See Tables 2 and 3.)

The same factors affect comparisons in the period around 1910. The Glover life tables only report mortality for 1901/10 and 1909/11 for the original registration area of 1900, presumably to maintain comparable geographic coverage and/or data quality in the 1900/02, 1901/10, and 1909/11 life tables. The DRA was being augmented rapidly after 1905, reaching 20 states and the District of Columbia by 1910, 53.8% of total national population at that date (see Table 1). Only by 1920 did the reported full life tables reflect the actual composition of the DRA [DHHS, 1992].[1]

This paper presents estimates of childhood mortality for the whole United States calculated by indirect methods [United Nations, 1983, ch. III] in conjunction with data from the 1900 and 1910 public use microsamples [Graham, 1980; Strong, et.al., 1989]. The estimates are for the entire nation and relate to the period just prior to the censuses of 1900 and 1910. The estimates for 1910 are new. For purposes of comparison to other mortality data, estimates are also made for the DRA of 1900 in 1900 and 1910 and for the DRA states of 1910, as well as for the state of Massachusetts. These latter allow comparisons to the published Glover life tables for 1900/02, 1901/10, and 1909/11 for the original 1900 registration area and to life tables specially constructed from published census and vital statistics data for the DRA of 1910 (20 states and the District of Columbia) in 1910 and for Massachusetts. These latter life table for the DRA of 1910 in 1910 are also new. The present 1910 indirect mortality estimates are made for the total population as well as for the white, black, native white, and foreign-born white populations.

Previous studies have been done using the 1900 and 1910 public use microsamples to examine childhood mortality [Preston and Haines, 1991; Preston, Ewbank, and Hereward, 1994; Condran and Kramerow, 1991], but the results were usually reported in the form of a mortality index first developed by Preston and Haines [1991, ch. 2]. A similar type of study for six Texas counties in 1900 and 1910 has been conducted by Gutmann and Fliess [1992]. The results here are presented entirely as probabilities of child death between birth and given ages (q(x)'s) along with the implied expectations of life at birth and approximate dates to which the estimates applied.

METHODS[2]

There exists a set of indirect estimation techniques originally developed by Brass, Sullivan, and Trussell [United Nations, 1983, ch. III] which use data on children ever born and children surviving tabulated by five year age or marriage duration groups of adult women. These data and methods can generate mortality probabilities of children between birth and some exact age x (i.e., q(x)). The procedures begin with the idea that the proportion dead among children ever born to a group of women is the joint outcome of a set of age-specific death rates and the distribution of exposure times to the risk of death that were experienced by offspring of those women. For instance, if the probability of dying before age 5 is .30 and if all of the women's births occurred exactly 5 years earlier, then the proportion dead among their children should be .30. However, if all of their births had occurred exactly 2 years earlier, then the proportion dead among their children would be less than .30, since some child deaths occur between ages 2 and 5. The aim of indirect estimation techniques is to provide an adjustment for children's exposure to the risk of death that allows the underlying probabilities of death to emerge. In particular, the procedures are based on the following identity:

$$D/B = \int_0^{\alpha} c(a)q(a)da \qquad (1)$$

where B is the cumulative number of children born to reporting women; D is the cumulative number of deaths among those children; c(a)da is the proportion of children born to reporting women who were born within period a to $a + da$ years before the census; q(a) is the probability of death before age a for a child born to reporting women a years before the census; and α is the number of years since the birth of the first child born to reporting women.

From the theorem of mean value, there must be some age A between 0 and α such that

$$D/B = q(A) \int_0^{\alpha} c(a)da = q(A);$$

that is, the proportion dead among children ever born to the women must equal the probability of dying prior to some age A in the life table pertaining to those children. A briefer period of a child's exposure to the risk of death will result in a lower A. Short exposure periods can be constructed, for example, by limiting data to women aged 15-19 or to women who have been married fewer than 5 years. Numerous simulations of mortality and fertility histories [Sullivan, 1972; Trussell, 1975] have established that q(1) (the probability of dying before exact age 1 (q(1)) is best identified by proportions dead among children born to women aged 15-19, q(2) is best identified by reports of women aged 20-24 or in marriage duration category 0-4 years, q(3) by women aged 25-29 or married 5-9 years, and so on.[3] The correspondences are not exact and conventional estimation procedures provide adjustment factors tailored to a particular application. These adjustment factors correct the estimates according to the shape of the age-specific fertility function prevailing in the population under study, a shape that determines the time distribution of children's exposure to the risk of mortality. This shape is indexed by the ratio of cumulative average numbers of children ever born in successive age or marriage-duration intervals. Clearly, the ratio involves comparisons of cumulative childbearing across cohorts; to apply the methods, it is necessary to assume that the ratios also pertained in the course of childbearing to an actual cohort, which amounts to assuming that fertility has been constant.

An alternative approach to the indirect estimation of child mortality is the surviving-children method [Preston and Palloni, 1978; Haines, 1977]. This method involves the backward projection of the age distribution of surviving "own children" using various levels of mortality within a model life table system to the point where the back-projected number of births equals the number of children reported as ever born by the group of women. A model life table is simply an empirical representation of a "typical" life table for populations at a particular level of mortality. Various systems of model life tables have been constructed that vary in their input data and in their methods of estimation. Most frequently used, by virtue of their broad data base and careful construction, are the four regional systems of Coale and Demeny [1966, 1983]. Coale and Demeny observed four different types of relationships among age-specific death rates that prevailed historically in (mainly) European populations and assigned labels to these relationships that correspond roughly to the region of Europe supplying input data for a particular system.

The surviving children procedure is based on a rearrangement of equation

(1):

$$B/(B - D) = \int_0^{\alpha} [C_s(a)/(1 - q(a))]da, \qquad (2)$$

where $C_s(a)da$ is the proportion of surviving children who were aged a to a+da at the time of the census. Women can be grouped into broad age, duration, or other categories to implement this approach. The census sample provides direct reports on B and D, and $C_s(a)$ can be estimated directly from the age distribution of surviving own-children enumerated with the mother. An "own child" is not simply any child in the household but one who is identified as, or is surmised to be, the natural offspring of the mother. The matching of mothers and children is done through an examination of information on relationship to head of household, age, surname, place of birth, mother's parity and order of enumeration in the original census manuscripts for both mother and child. The availability of the age distribution of these own children is one of the advantages of a sample of original census returns. Given B, D, and $C_s(a)$, one then finds the set of q(a)'s within a model life table system that will satisfy equation (2). In order that the own-children estimates of $C_s(a)$ not be biased by children having left the home, it is necessary to confine the analysis to younger women. The Coale and Demeny (1966) "West" model life table system is used here to provide values of q(a); and the solution is derived by an iterative procedure built into a model life table generation program [Avery, 1981].[4]

The surviving-children method has some advantages over the more conventional estimation procedures based on equation (1). Most important, it is insensitive to recent fertility declines or to irregular patterns of fertility behavior in the past. The history of fertility is explicitly represented in the age distribution of surviving children, whereas fertility must be assumed constant in the conventional approach. Second, the method is flexible with respect to the age or duration groups of women that can be included in the analysis, a feature of particular advantage in dealing with some of the small-sample problems that are encountered here. The procedure is more sensitive than the others, however, to age-selective omissions and age misreporting of children (and their mothers). The 1910 U.S. census had a magnitude of age misreporting similar to that in 1880 and 1890 but greater than that in 1900 [Coale and Zelnik, 1963]. This has implications for the estimates discussed below.

Each of the procedures uses a set of model life tables. Under the conventional age and marital duration procedures, these model life tables are embodied in the multipliers that take account of the shape of the fertility history in a particular application. Different sets of multipliers exist for different model life table systems [United Nations, 1983, Tables 47 and 56]. In the surviving-children technique, the model life table is imposed directly. However, in neither case are results necessarily very sensitive to the model life table system chosen. Alternative model life table systems applied to the same set of data will produce identical values of q(a) at some age A^*. The age of child at which this identity pertains for a particular age or marital duration group of reporting women is usually close to the age shown in Tables 2 and 4. That is, it is around age 1 for women aged 15-19, around age 2 for women aged 20-24 or married 0-4 years, around age three for women aged 25-29 or married 5-9 years, etc. The reason that this identity applies is that any pair of solutions to equation (2) that are drawn from different model mortality systems must intersect somewhere in the range of ages 0 to α [Preston and Palloni, 1978]. If they did not intersect -- that is, if one q(a) function lay above the other at all ages -- then they could not both be solutions. The result is that two q(a) solutions drawn from different model life table systems for the ages are usually within 1 to 4 percent of one another. For the same reason, there is also an intersection between two solutions, one that is drawn from a model life table system and the other that has an arbitrary time trend in q(a) built into the system. Results of simulations of various types of mortality decline enable the assignment of a "date" to each estimate. The date is the approximate point at which plausible time trends intersect. Here we use the dating equations developed in the

United Nations' Manual X [United Nations, 1983, ch. III] and in the package "Mortpak-Lite", also developed at the United Nations [United Nations, 1988].

IMPLEMENTING THE ESTIMATING EQUATIONS

A number of filters were applied to the census data, particularly for the marital duration model, to increase the accuracy of estimation: (1) For the surviving-children approach, analysis was confined to women aged 14-34 because of the potential bias resulting from migration of children away from home. This would be more likely for older women with older children. We also excluded women whose oldest "own child" was implied to have been born before the women reached age 14. (2) When a woman's age is used as the index of her children's exposure to the risk of mortality (the "age model"), all women in the relevant age groups were used in the estimations, with the exception of those for whom an illegible or missing response was given either for children ever born or for children surviving. These women were also excluded from the other estimation approaches. Mean parity estimates by age, required for adjustment factors, are based on all women with a legible response on children ever born. (3) When a woman's marriage duration was used as the index of her children's exposure to the risk of mortality (the "marriage duration model"), we excluded women not in their first marriage, for whom the duration in their current marriage would be a very imperfect indicator of their children's exposure to mortality. In 1910, the census asked a question on number of times married. We chose only currently married, once-married women for whom children ever born and children surviving were known.[5] For 1900, we selected only women currently married with husband present who reported no surviving children other than own children present in their household; whose implied age at marriage (current age minus duration of marriage) was between 10 and 34 years; whose oldest own child's age was not more than two years greater than the duration of current marriage; and whose reported number of children ever born was not more than two greater than the duration of current marriage in years.

Despite the efforts to exclude from the marital duration model women who had borne children prior to their current marriage, it appears that the effort was not entirely successful. It is particularly a problem for the black population. There is some evidence in 1910 of significant misreporting of marital status such that there were too many reported first marriages of short duration [Preston, Lim, and Morgan, 1992]. Prior unions were often omitted and marital turnover was more rapid than suggested by the census itself. The 1910 census reported 16.9% of black women widowed at ages 35-44 in contrast to 6.5% among white women [U.S. Bureau of the Census, 1913, Table 23]. The 1900 census gave 19.6% widowed among black women and 8.1% among white women [U.S. Bureau of the Census, 1902, Table 29]. The extent of marital disruption was obviously greater in the black population, and it appears to have been considerably more serious than indicated in the census. Preston, Lim and Morgan [1992, Table 1] estimate for 1910 that about 27-28% of black women aged 35-44 were widowed and that some of these were reporting themselves as currently married. Also, the less formal nature of African-American marriage probably also caused some women (or other family member) to report to a census enumerator that she was currently married when she was not.

Since differences among the results using the Coale and Demeny models (i.e., Models North, South, East, and West) were not too great, particularly for q(5), only the estimates using Model West are reported. West Model indeed fits the experience of the total and white populations very well. The published Glover [1921] 1901/10 DRA life tables for whites and blacks were fitted to all four Coale and Demeny families, as well as to the newer five United Nations families of model life tables (i.e., Latin American, Chilean, South Asian, Far Eastern, and General) [United Nations, 1982]. For the white population, the fit was best using West Model.[6] Interestingly, the U.N. Latin American Model did relatively well for the American white population. It has been suggested that Coale and Demeny's Model West does not do especially well for the black population [Zelnik, 1969; Condran, 1984]. Ewbank [1987] believes that the United Nations Far Eastern Model describes historical black mortality better. Consequently, for the black population in 1910, both the

West Model and the Far Eastern model were used and the results reported.[7] On the other hand, when the Glover DRA tables for whites and blacks for the period 1901/10 were fitted to the various models, the West Model was either the best or close to it in all four cases (white males and females, black males and females).

For the surviving-children approach, equation (2) was solved to provide estimates for all women aged 14-34. It should be recognized that what constitutes a mortality level in the surviving-children approach is simply a complete model life table. Although detail by age of child is presented for this method, the estimates for any particular solution are not independent of one another but are constrained to correspond to the same model life table. Depending on the model life table family chosen, different q(a) sequences may result. All of the model life table systems, when applied to women aged 14-34, however, yield very similar results at age 5 because of the tendency for solutions produced by different model life table systems -- or by a model life table arbitrarily deformed by different time trends in mortality -- to intersect at some age of child [Preston and Haines, 1984]. Using a formula presented in Preston and Palloni [1978, p. 84], we estimate that the year to which this surviving-children estimate of q(5) pertains is about 1896 for the 1900 census and about 1905 or 1906 for the 1910 census.

DATA

The basic data for the study come from the public use microsamples of the 1900 and 1910 U.S. censuses. For 1900, a 1-in-760 sample of the original manuscripts produced a file of 100,438 individuals in 27,069 households. For 1910, a 1-in-250 sample of the original manuscripts produced 366,239 individuals in 88,814 households. There were a significant number of blacks and mulattoes in the data sets (11,377 in 1900 and 39,200 in 1910). A detailed description of the censuses and the samples can be found in Graham [1980], Preston and Haines [1991, ch. 2], Watkins [1994], Strong, et.al. [1989], and in Strong, Preston and Hereward [1994]. To conduct the analysis, files of all women aged 14 and over were created (32,866 in 1900 and 123,001 in 1910). The women were linked to their household and locational characteristics as well as characteristics of their spouses and selected characteristics of their children (if present). The information on children was used to obtain the age distribution of surviving own children and the proportion of children ever born who had survived for the surviving children model. The published life tables used for comparisons in Tables 3 and 5 are taken from Glover [1921]. Life tables constructed for the DRA states of 1910 (20 states and the District of Columbia)[8] in 1910 and for Massachusetts for 1904/06 and 1909/11 were based on published federal and Massachusetts census materials and vital statistics.

RESULTS

The principal estimates of individual q(x)'s for both the age and duration models are given in Tables 2 and 4 for 1900 and 1910, respectively. Also given are the dates to which the estimates apply and the e_0's or level implied by each q(x) within that model system. Only the estimates made with the West Model life table system are presented, with the addition of the United Nations Far Eastern model for the black population in 1910. Tables 2 and 5 give equivalent results for the surviving children method, along with an implied e_0 for each vector of q(x)'s (which all must come from the same model life table). The surviving children estimates all apply to the periods 1896 (for the 1900 census) and 1905/06 (for the 1910 census). Within each model, separate estimates are provided for the nation, for the original DRA states of 1900 (in 1900 and 1910), for the DRA of 1910, and for the state of Massachusetts in 1910. Massachusetts was chosen because of its long history of good and quite complete demographic statistics [Gutman, 1956] and the fact that it had a state census in 1905 which permits a life table for 1904/06. Tables 2 and 3 give separate results for whites and blacks. Tables 4 and 5 tabulate estimates for the total, white, native-white, foreign-born white, and black populations. Finally, Figures 1 and 2 graphically depict the estimates of q(a) from the three different estimation procedures.

One feature emerges immediately. The infant mortality rates (q(1)'s) as well as mortality to age 2 (q(2)) derived from the age model, based on women aged 15-19 and 20-24, are in a reasonable range for 1900 but are far too low for 1910. This is in relation to published life tables and to the other indirect estimates (the marriage duration and surviving children models). It may be due to age misstatement of some women and underreporting of events. The 1900 census asked two questions on age (age at last birthday and date of birth) while the 1910 census asked only one (age at last birthday). Coale and Zelnik [1963, p. 93] found that the degree of age misstatement in the 1900 census was significantly lower than in the 1890 and 1910 censuses, and that the level of accuracy in age reporting achieved in 1900 was not attained again until 1930 or 1940. If women aged 18 and 19 might round up to 20 and those aged 23 and 24 might round up to 25, these women would have been likely to have had more child deaths than those remaining in the age group. This misreporting would bias the results downward for the groups losing these women. This was less true in 1900 because of the greater chance that women would not misstate age. Selective omission of more disadvantaged persons would bias the estimates downward as well. Otherwise, at least for the white population, the estimates of q(3) through q(20) are in a reasonable range in comparison to constructed life tables for the United States for this period (see Table 3, lower panel, for 1900 and Tables 4 and 5 for 1910). There is also a notable tendency for the level of mortality (indexed by the implied e_0) to rise for dates further back in the past. Since mortality was declining in this period, such a trend is expected.[9] The q(x)'s at older ages from these methods reflect mortality regimes, on average, that pertain further back in the past.

For 1910, the native white population generally had more favorable mortality than did foreign-born whites, and the white population overall did better than did blacks. This pattern is consistent with results from the 1900 census and is strongly confirmed by work with the 1910 sample by Preston, Ewbank, and Hereward [1994, Table 3.2].[10] The results for the black population exhibit some irregularities in the mortality level for both age and marriage duration cohorts going to older or longer duration cohorts. Erratic results are especially evident for the marriage duration model where, as already mentioned, there appear to be too many once-married black women at short marriage durations. Significant numbers of these women had apparently been in a previous conjugal union or had been in some form of conjugal union for a longer duration than stated. They would thus have had children with a longer risk of exposure to mortality than would be proxied by reported marriage duration. For these and other reason, perhaps the best single index of childhood mortality is thus q(5), based on women aged 30-34 or women married for 10-14 years.

The most appropriate comparison to these q(5)'s and their implied e_0's from the age and marriage duration models are the Glover [1921] life tables for both whites and blacks. For the 1900 estimates (centered on 1894/95), we have only the 1900/02 DRA tables as reference points. But for the 1910 estimates, we have the life tables for the DRA of 1900 for the period 1901/10, centered close to the date to which the different q(5)'s apply (about 1904). They are also close to the approximate date (1905/06) to which the surviving children estimates apply.[11]

For the white population of the original 1900 DRA states in 1900, the implied e_0 using the age model was 49.8 at a q(5) of .179. This compared to an e_0 of 48.1 and a q(5) of .195 for the marriage duration model. The surviving children model gave a q(5) of .182 and an e_0 of 49.5. The Glover DRA life table for 1900/02 for both sexes combined) yielded an e_0 of 49.6 and a q(5) of .179. (See Table 3.) These were a good match. They also generalized well to the whole white population. The estimates of q(5) from the age and duration models (.167 and .173, implying e_0's of 51.1 and 50.5) are close to the Glover results for the DRA. The surviving children method produced a q(5) of .161 (implying an e_0 of 51.8) somewhat more favorable but not far off.

For 1910, similar results hold for the white population. For the DRA states of 1900, the implied e_0 using the age model was 51.3 at q(5)=.167

(Table 4). Using the marriage duration model, the equivalent figures are 52.1 and q(5)=.160. However, the surviving children model (Table 5) yields a lower q(5) (=.142) and a higher e_0 of 54.1. These figures are close to the q(5) of .166 and an actual e_0 of 50.9 for whites (both sexes combined) in the 1901/10 Glover table. (See Tables 4 and 5).

For the 1900 census, all three methods agree well for the DRA compared with published life tables based on vital statistics and census data. The results also generalize to the white population of the whole United States. For 1910, however, the fit is clearly better for the estimates based on individual age and duration cohorts than on the surviving children method which uses the experience of all women aged 14-34. Three potentially important sources of bias may be present. One is the tendency to overstate the ages of children, especially at the youngest ages (0 and 1) [see Rosenwaike and Hill, 1995]. This tendency would then bias the survival of children upward. Second, differential underenumeration of the very young (as opposed to age misstatement) would also operate in the same direction, leading to an age distribution of children that would be, on average, older and reflective of lower mortality. Finally, there may be a selectivity bias caused by the strong positive correlation of the deaths of children and their mothers. It is reasonable that the death of the mother, most often the primary care giver, would have a negative impact on child survival, especially among the youngest. Also, the same fatal infection might well kill multiple members of households at about the same time. This positive covariance in maternal and infant death was reported by Woodbury [1926, ch. IV] in his summary of matched death certificate-family studies in eight American cities during 1911-15. The same bias would also apply to the age and marriage duration models, and the upward bias in child survival from indirect estimation has been noticed for the 1911 Census of England and Wales, which had published tabulations of children ever born and children surviving by marriage duration [Woods, Watterson, and Woodward, 1989; Haines, 1994].

On this basis, and on the basis of the indirect estimates and their comparison to the Glover tables for 1900/02 and 1901/10, there is reason to believe that the national estimates of child mortality by indirect methods and their extension to adult mortality using West Model are reasonable for the white population based on the 1900 and 1910 censuses. Some of these results are summarized in Table 6. For 1900, the estimates of q(5) (.167 for the age model; .173 for the marriage duration model; and .161 for the surviving children model) and the implied e_0's (51.1, 50.5, and 51.8 respectively) can be taken as a reasonable range. Similarly, for 1910, the q(5)'s (.156 for the age model; .155 for the marriage duration model; and .138 for the surviving children model) along with the implied e_0's (52.6, 52.7, and 54.6 respectively) are plausible. In the latter case, the surviving children estimates are, however, at the more favorable end of the range.

Overall, it seems reasonable to believe that the white population had an e_0 of 50-52 years in the mid-1890s and around 52-54 years around 1905. This implied infant mortality rates of about 110-125 and 95-115 infant deaths per 1,000 livebirths, respectively. It would also indicate that the DRA states of 1900 were reasonably representative of the national white population. These results are also consistent with computed life tables for the white and native white populations of the 1910 DRA in 1910 (Table 5, lower panel). Finally, comparing the Glover tables for the DRA of 1900 for the years 1909/11 with a constructed life table for the DRA of 1910 in 1910 (Table 5, lower panel), it also appears that the original and augmented DRA's gave similar results for the white population (with a q(5) of .166 and an e_0 of 51.5)

BLACK MORTALITY

The estimates for the black population are less consistent. The Glover tables for blacks in 1900/02 give a q(5) of .338 and an actual e_0 of 33.8 for the 1900 DRA. (See Table 3.) The same information for the 1901/10 DRA life tables yields a q(5) of .324 and an actual e_0 of 34.1 for both sexes combined (Table 5). These published results are consonant with the estimates for 1900 for the 1900 DRA for blacks using the surviving children model (Table 3). Finally, the calculated life tables for 1910 using the 1910 DRA composition

(20 states and the District of Columbia less North Carolina) are similarly in this range with a q(5) of .325 and an actual e_0 of 35.6 years.

The outcomes are less satisfactory for 1910. The age model gives q(5)'s of .225 (West Model) and .260 (Far Eastern Model); and the marriage duration model yields q(5)'s of .244 (West) and .253 (Far East) for the original DRA states tabulated from the 1910 sample. These compare to a q(5) of .324 estimated by Glover for the period 1901-1910 in the original death registrations states of 1900. The 1910 census reports imply a much lower level of child mortality. The results for the surviving children method suggest a still more favorable mortality experience. The implied e_0 is closer to the Glover results for 1901/10 using the Far Eastern Model (33.8 years for the age model and 35.3 for the marriage duration model) than the West Model. The Far Eastern pattern is characterized by high older-age death rates relative to younger-age death rates, compared with the West Model [United Nations, 1982, p.15]. Interestingly enough, however, tests comparing the goodness of fit of the 1901/10 Glover tables for blacks to the nine different families of model life tables considered here (four from Coale and Demeny and five from the United Nations) gave the best fit to West Model at ages 0 to 10 for both males and females.[12] The constructed life tables for the DRA of 1910 using its actual composition but excluding North Carolina (lower panel, Table 5) exhibits similarly high black childhood mortality and an expectation of life at birth of around 35 years.

In general the Glover tables provide too high an estimate of national black childhood mortality rates in the late 19th and early 20th centuries. The test for 1900 is clear (see Table 6, upper panels). The q(5) for blacks was about 33% higher in the Glover life table for 1900/02 than for the various indirect estimates based on national sample census data. For 1910, the Glover results for the original DRA states for 1901/10 and 1909/11 and newly constructed life tables for the DRA states of 1910 for 1910 (Table 6, lower panels) all give higher values of q(5) than are found in the national estimates for blacks. The surviving children method gives an estimate of q(5)

(.213) which is probably too low relative to the age (.266) and marriage duration (.244) models.

The representativeness of the DRA for blacks is, of course, a major issue. But there is also the issue of the quality of Glover's estimate for the population of the DRA itself. A comparison of Glover's DRA tables with the results from our census samples restricted to the DRA provides one check on the quality of his estimates and our own. The comparison to the 1900 sample shows close agreement for both the black and white populations (see Table 3). But it did not work as well in 1910 (see Tables 4 and 5). The match is good for the age and duration models for whites, though the surviving children method yields low estimates. But the match for blacks is less convincing. The Glover results of q(5) (.324 for 1901/10 and .294 for 1909/11) are quite high relative to the indirect estimates (.251 for the age model, .214 for the duration model, and .212 for the surviving children method -- all with the Model West life table assumption). It is possible that there are some problems with the underlying data for the Glover tables themselves. Glover did not have adequate birth statistics, and those he did have he deemed partly defective. He needed births to provide the denominators for the calculation of q(1), the infant mortality rate, to start the life table. He therefore estimated births from populations of young children (above age 2) and deaths by age [Glover, 1921, pp. 338-342]. Although the work was careful, there appears to have been no effort to make adjustments for the differential underregistration of black deaths relative and underenumeration of black children. The procedure seems to have worked well for whites but is likely to have underestimated black births relative to infant deaths. Thus Glover's q(1) values would have been too high because the denominators (births) would have been differentially underestimated relative to the numerators (infant deaths).

Although Ewbank [1987] believed that the United Nations Far Eastern pattern best described the historical pattern of black mortality in the period 1880-1910, it does not seem that the Far Eastern pattern "fits" better than the West Model. If so, and if the West Model is more appropriate, then the extension from q(5) to adult mortality (and backwards to infant mortality) would yield e_0's in the range 40-44 and infant mortality rates in the range 150-180 per 1,000 livebirths for the American black population in the early 20th century. This would make the Glover tables (and the DRA) less likely to be representative of the experience of the whole black population, 83% of which was in lower mortality rural areas in 1910.

Tables 4 and 5 also give some comparisons of indirect estimates made for Massachusetts from the 1910 sample with two life tables for 1904/06 and 1909/11 calculated in the standard way with census populations, births, and deaths by age. This comparison was done because Massachusetts had the longest history of reliable birth and death registration [Gutman, 1956]. Reliable birth data allow for a better life table since q(1) may be estimated directly as the infant mortality rate. For the indirect estimates for Massachusetts, the age model gives a q(5) of .207 and an implied e_0 of 46.9 applying to about the year 1903. The marriage duration model produces a more favorable result: q(5)=.175 and an implied e_0 of 50.3 relevant to about 1904. The more favorable surviving children method yields q(5) and e_0 and .156 and 52.4 respectively. The age model is closest to the life table q(5) of .203 in 1904/06 and an actual e_0 of 48.5. Statistical analysis of the variances of the estimates provides confidence that the match was reasonable.[13] Massachusetts was experiencing significant mortality decline over this period: the crude death rate fell from 18.4 in 1900 to 16.1 in 1910, with the infant mortality rate decreasing from 148 in 1899/1901 to 126 in 1909/11. This can influence the indirect estimates. But it should also be noted that there is also here some tendency for the indirect procedures to produce "low-end" estimates of mortality, probably because of some selectivity of the women reporting.

Another test of the reliability of the indirect mortality estimates is based on a comparison of census-reported death rates for infants and young children with those derived from the public use sample for individual states and territories.[14] For each state or territory, a summary mortality index, based on indirect estimation procedures, was prepared using the information in the 1900 census sample on children ever born and children surviving for each geographic unit. The index is a ratio of actual to expected child deaths, and is described in detail in Preston and Haines [1991, pp. 88-90 and Appendix C]. In addition, a death rate for children aged 0-4 was calculated from data in the census of 1900 on mortality in the year prior to the census (June 1, 1899 to May 31, 1900). It is known that the census of 1900 included registration mortality data for the states of the Death Registration Area and for cities in states outside the Death Registration Area whenever such data were available. These data were then supplemented by the census question on deaths in the household in the year prior to the census [Condran and Crimmins, 1979]. The registration data are known to have been more accurate. The correlation between the mortality index and the census death rate for children 0-4 would not be perfect, since they covered different time periods and age groups. But the index was most influenced by young children and many of those deaths had taken place in the 1890s. The zero-order correlation between the index and the census death rate was, in fact, .689, which was statistically significantly different from zero at a one percent level. The correlation was much higher for the Death Registration Area states (.808).

A simple ordinary least squares regression was run with the mortality index as the dependent variable and the 1900 census death rate for children aged 0-4 as the independent variable. This simple regression fitted to <u>all</u> states and territories should produce positive residuals (i.e., predicted values of the mortality index exceeding actual values) for the Death Registration Area states and negative residuals (i.e., predicted values of the mortality index less than actual values) for non-Death Registration Area states and territories, <u>if</u> the mortality index was more accurate than the census death rates. This is indeed the result. For the ten Death Registration Area states plus the District of Columbia, the mean residual was +11.30 and only <u>one</u> state (Maine) had a small negative residual (-1.15). For the other 34 states and territories (or groupings), the mean residual was -3.36, and 23 of the 34 had negative residuals. Further, of the states and territories in this group with positive residuals, most had substantial registration coverage which was used in the census death reports.[15] Thus the results here strongly support the superiority of the indirect mortality estimates over direct census mortality data and also support their general reliability.

CONCLUSIONS

The chief value of this exercise lies in permitting comparisons between mortality in the Death Registration Area and that for the entire nation. A summary of these results and the comparisons can be seen in Table 6 and in Figures 1 and 2. The figures cover the total population only. On the whole, indirect estimation provides a reasonably accurate way to extend mortality analysis to areas not covered by vital statistics registration. In 1900, life tables for the DRA overestimated national mortality for both blacks and whites, though much less so for whites. But the racial composition of the DRA (with far fewer blacks than the national share) offset this bias for the total. Figure 1 provides an accurate picture of this, showing the close fit between the three different indirect methods and the vital statistics-based Glover life table of 1900/02. All the methods produce q(5)'s which match closely for whites. The divergence at the oldest ages (q(20) and q(25)) reflects the time trend in mortality, i.e. the mortality decline from the 1880s.

By 1910, differences between the mortality experience of the United States and the DRA were small for whites but continued to be substantial for blacks, largely because the black population of the DRA continued to be more urban.[16] Improvements in public health were urban-led in this period [Preston and Haines, 1991, chs. 1 & 3], and this advantaged the DRA states, but it did not yet seem efficacious for the black population. The results for the total population are encouraging but show a slightly wider dispersion in 1910 than in 1900 among the different methods of estimation and in comparison to the newly constructed life table for the DRA of 1910 (less North Carolina). This is exhibited in Figure 2. The q(x)'s for the three methods bracket the DRA life table for 1910 by age 5, with the age and duration models providing higher estimates by age 10 and the surviving children method lower estimates. But the match of the age and duration results with those from the DRA life tables is very close. It should also be noted that the indirect estimates apply to a slightly earlier point in time than 1910 during a period of rapid mortality decline.

In addition, indirect estimates provide detailed differentials by ethnicity, race, social class, and residence. In the case of ethnic differences, the young children of the foreign born are often native born and hence would be placed in a separate life table from their parents. Occupation of parents is rarely reported in conjunction with child deaths. In the case of incomplete geographic coverage as in the United States in 1900 and again in 1910, indirect estimates provide a way to extend mortality estimation to the portions of the nation (and the subgroups therein) not covered by adequate vital statistics. The results for both the black and the white populations fit into the picture of historical mortality decline in the United States after about the 1870s. It is also very important, however, to evaluate and calibrate the mortality rates derived by indirect techniques to other sources so that possible biases can be taken into account. That is part of what has been done here.

FOOTNOTES

1. There was some effort by the Public Health Service to estimate expectations of life at birth by gender and race from 1900 onwards. But these were estimated indirectly, and full life tables do not appear to have been generated annually. They appear to be interpolations (for the DRA only prior to 1929) adjusted for annual fluctuations in overall mortality. (See U.S. Bureau of the Census [1975], Series B107-115 and p. 47.)

2. This section borrows heavily from Preston and Haines [1991], pp. 60-67.

3. The correspondences are:

AGE GROUP	MARRIAGE DURATION	q(x)
15-19		q(1)
20-24	0-4	q(2)
25-29	5-9	q(3)
30-34	10-14	q(5)
35-39	15-19	q(10)
40-44	20-24	q(15)
45-49	25-29	q(20)
	30-34	q(25)

4. One exception is for the black population in 1910 for which the United Nations Far Eastern Model was used [United Nations, 1982].

5. In order to check the sensitivity of the model to additional assumptions, we selected also currently married, once-married women with husband present with implied age at marriage not younger than 10 years. The additional filters made little difference in the results.

6. The fitting was done using the program COMPAR in the United Nations microcomputer package Mortpak-Lite.

7. In the case of fitting the U.N. Far Eastern model by the surviving children method, it was necessary first to create a Brass logit model. The standard chosen was the Far Eastern model life table with the same q(5) as West Model level 13.5 (e_0 = 49.65 for both sexes combined). The latter is just about average for child mortality for the entire American population from the 1910 census sample. This was the procedure followed by Preston, Ewbank, and Hereward [1994, p. 77] in selecting a standard life table. This gave Far Eastern model life tables with male e_0 = 41.82 and female e_0 = 44.58. The reverse survival of the age distribution of surviving own children was then done using that Far East standard and allowing level (α) to vary but holding

"tilt" (β) fixed.

8. The DRA of 1910 included the six New England states, New York, New Jersey, Pennsylvania, Ohio, Indiana, Michigan, Wisconsin, Minnesota, Maryland, North Carolina, Colorado, Utah, Washington, California, and the District of Columbia. Unfortunately, the data for North Carolina (which contained about 40% of the black population for the entire set of states) reported only deaths for "municipalities having a population of 1,000 or over in 1900". (This practice continued up to 1916.) Although it comprised less than 5% of the whole DRA, it had many of the blacks. It was thus decided to exclude North Carolina from the mortality estimates presented in Table 5. As an alternative, the proportion of the population living in places of 1,000 and over in 1910 by age, gender, race, and nativity was estimated from the public use sample and assumed to approximate the base population (although some places in 1900 might have grown to over 1,000 between 1900 and 1910). This turned out to be largely the urban population of North Carolina and most of the black population was excluded (about 82%). The results with this alternative inclusion of larger places in North Carolina produced mortality results similar to that with North Carolina wholly excluded.

9. The crude death rate in the original DRA of 1900 declined from 17.2 per 1,000 in 1900 to 15.6 in 1910. [Linder and Grove, 1947, Table 2.]

10. Preston, Ewbank and Hereward [1994] provide the following mortality indices: total population, 1.000; white population, .922; native-white population, .867; foreign-born white population, 1.069; black population, 1.486.

11. Glover provides only tables for males and females separately. These were combined assuming a sex ratio at birth (males/females) of 1.05.

12. The program COMPAR in Mortpak-Lite was used for this procedure.

13. Because of its size, the 1910 census sample did not yield cell sizes for the Massachusetts estimates which were too small to provided statistically reliable estimates. The N's (children ever born) for the total population estimates were:

	AGE MODEL	DURATION MODEL
q(1)	20	--
q(2)	363	390
q(3)	601	744
q(5)	955	1,036
q(10)	1,246	1,051
q(15)	1,348	1,018
q(20)	1,302	902
q(25)	---	538

The surviving children method was based on 5,052 total births for the population of women aged 14 to 34. Assuming a binomial distribution for a proportion for the q(x)'s, the variance would be q(x)*(1-q(x))*N. They showed that the age model had a q(5) statistically insignificantly different from the 1904/06 life table but significantly higher than the q(5) in the 1909/11 Massachusetts life table. For the duration model, the indirect estimate of q(5) was significantly lower than that in 1904/06 but statistically insignificantly different for that in 1909/11.

14. Because of the small number of children ever born in the census sample for several states and territories, some had to be combined together. Thus Arizona, Nevada, and New Mexico were combined into one unit, as were Idaho, Montana, and Wyoming. Oklahoma and Indian Territory were taken as one unit. The District of Columbia was used as a unit of observation. Alaska and Hawaii were excluded. The result was 45 observations.

15. Among the states with positive residuals:

State	Residual	Percent Registration Coverage in the 1900 Census
Pennsylvania	5.35	41.1%
Ohio	4.09	31.9%
Maryland	4.05	44.3%
Delaware	13.13	41.4%
California	1.63	41.1%
Wisconsin	2.40	20.9%

Registration coverage is from Condran and Crimmins [1979], Table 2. [Preston and Haines, 1991, p. 230.]

16. This latter was true especially since the data for rural blacks in North Carolina was not available until 1916.

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TABLE 1. COMPARISON OF SELECTED CHARACTERISTICS OF THE DEATH REGISTRATION AREA OF 1900 AND OF 1910 WITH THE UNITED STATES AS A WHOLE.

	1900		1910		
	United States	DRA of1900 in 1900	United States	DRA of1900 in 1910	DRA of 1910
Total Population	75,994,575	19,960,742	91,972,266	24,045,580	49,456,979
% of total	100.0%	26.3%	100.0%	26.1%	53.8%
% Black	11.6%	2.0%	10.7%	1.9%	3.5%
% Urban	40.5%	66.1%	46.3%	72.2%	61.2%
% Foreign Born White	13.4%	22.3%	14.5%	24.9%	20.7%
% of U.S. Blacks	100.0%	4.5%	100.0%	4.7%	17.8%
% of Blacks Urban	20.5%	82.0%	27.3%	83.3%	48.8%

SOURCE: U.S. Bureau of the Census [1913].

TABLE 2. CHILD MORTALITY. CENSUS ESTIMATES. UNITED STATES, 1900.

AGE MODEL	15-19 q(1)	20-24 q(2)	25-29 q(3)	30-34 q(5)	35-39 q(10)	40-44 q(15)	45-49 q(20)
				AGE GROUPS			
UNITED STATES				q(i)			
TOTAL	0.15332	0.17664	0.16438	0.17736	0.20662	0.21983	0.26076
WHITE	0.16168	0.15176	0.15109	0.16705	0.19512	0.20920	0.24755
BLACK: West	0.13090	0.26216	0.21502	0.25164	0.27776	0.29367	0.34327
				N			
TOTAL	382	3378	6886	9123	11212	10861	9760
WHITE	288	2620	5740	7995	9681	9534	8421
BLACK: West	93	732	1079	1099	1488	1275	1315
				REFERENCE DATE			
TOTAL	1899.7	1898.5	1896.7	1894.6	1892.1	1889.4	1886.4
WHITE	1899.7	1898.6	1896.9	1894.8	1892.5	1889.8	1886.8
BLACK: West	1899.9	1898.5	1896.2	1893.4	1890.4	1887.3	1884.3
				IMPLIED e(0)			
TOTAL	44.46	46.46	49.81	50.00	48.67	48.60	46.46
WHITE	43.16	49.76	51.45	51.14	49.83	49.61	47.66
BLACK: West	48.22	36.43	43.84	42.17	41.71	41.71	39.30

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DURATION MODEL	0-4 q(2)	5-9 q(3)	10-14 q(5)	15-19 q(10)	20-24 q(15)	25-29 q(20)	30-34 q(25)
				DURATION OF MARRIAGE			
UNITED STATES				q(i)			
TOTAL	0.14722	0.15514	0.18234	0.19496	0.21885	0.25267	0.27768
WHITE	0.12926	0.13949	0.17267	0.19234	0.21101	0.24398	0.26915
BLACK: West	0.28021	0.26441	0.25096	0.22168	0.27879	0.32477	0.35960
				N			
TOTAL	2592	6716	9088	9034	8746	7222	6326
WHITE	2261	5868	8120	8224	7796	6462	5744
BLACK: West	322	811	916	791	924	733	564
				REFERENCE DATE			
TOTAL	1899.3	1897.2	1894.8	1892.4	1889.6	1886.5	1883.5
WHITE	1899.2	1897.1	1894.8	1892.4	1889.8	1886.6	1883.6
BLACK: West	1899.3	1897.4	1894.8	1891.8	1888.8	1885.8	1883.1
				IMPLIED e(0)			
TOTAL	50.35	50.92	49.46	49.39	48.70	47.20	47.07
WHITE	52.88	52.95	50.52	50.10	49.44	47.99	47.81
BLACK: West	34.59	38.52	42.25	47.17	43.03	40.82	40.28

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SURVIVING CHILDREN METHOD	q(1)	q(2)	q(3)	q(5)	q(10)	q(15)	q(20)	q(25)	Level	Implied e(0)
UNITED STATES										
Women 14-34										
TOTAL	0.12025	0.14906	0.16183	0.17636	0.19218	0.20381	0.22040	0.24234	13.65	50.08
WHITE	0.11076	0.13658	0.14802	0.16104	0.17561	0.18638	0.20187	0.22255	14.36	51.83
BLACK: West	0.17034	0.21380	0.23304	0.25496	0.27640	0.29209	0.31304	0.34026	10.32	41.83
Women 14-24										
TOTAL	0.13255	0.16566	0.18033	0.19703	0.21441	0.22718	0.24482	0.26802	12.75	47.92
WHITE	0.11775	0.14576	0.15818	0.17231	0.18780	0.19921	0.21551	0.23718	13.82	50.54
BLACK: West	0.18525	0.23237	0.25325	0.27701	0.29983	0.31647	0.33853	0.36706	9.44	39.68
Women 25-34										
TOTAL	0.11806	0.14617	0.15863	0.17281	0.18834	0.19978	0.21611	0.23782	13.80	50.48
WHITE	0.10970	0.13518	0.14647	0.15932	0.17375	0.18441	0.19978	0.22030	14.44	52.03
BLACK: West	0.16612	0.20851	0.22728	0.24866	0.26969	0.28509	0.30571	0.33253	10.57	42.46

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SOURCE: Indirect estimates based on the public use micro sample of the 1900 U.S. Census of Population. Coale & Demeny [1966] Model West is used in all cases.

TABLE 3. CHILD MORTALITY. VARIOUS ESTIMATES. BY RACE. U.S. DEATH REGISTRATION AREA OF 1900.(a)

PROBABILITY OF DEATH BEFORE EXACT AGE a (q(a)).

	q(1)	q(2)	q(3)	q(5)	q(10)	q(15)	q(20)	q(25)
AGE MODEL	1900 CENSUS SAMPLE USING WEST MODEL							
Total	0.13010	0.17495	0.16259	0.18398	0.22284	0.24371	0.27520	--
(N)	(56)	(675)	(1408)	(2156)	(2490)	(2729)	(2575)	--
White	0.13145	0.17403	0.16436	0.17947	0.21932	0.24585	0.27521	--
(N)	(55)	(655)	(1399)	(2107)	(2448)	(2706)	(2513)	--
	IMPLIED e(0)							
Total	48.34	46.69	50.03	49.29	47.04	46.33	45.17	--
White	48.11	46.82	49.81	49.78	47.40	46.13	45.17	--
DURATION MODEL								
Total	--	0.13855	0.14707	0.19962	0.23267	0.23796	0.28059	0.30224
(N)	--	(609)	(1620)	(2174)	(2062)	(2026)	(1810)	(1561)
White	--	0.13576	0.14724	0.19472	0.23133	0.23848	0.27854	0.30215
(N)	--	(597)	(1599)	(2139)	(2037)	(2022)	(1784)	(1542)
	IMPLIED e(0)							
Total	--	51.57	51.95	47.63	46.08	46.87	44.68	44.99
White	--	51.95	51.95	48.14	46.20	46.82	44.87	44.99

SURVIVING CHILDREN MODEL	q(1)	q(2)	q(3)	q(5)	q(10)	q(15)	q(20)	q(25)	Level	Implied e(0)
Women aged 14-34										
Total	0.12532	0.15577	0.16926	0.18462	0.20110	0.21318	0.23019	0.25264	13.29	49.24
White	0.12358	0.15347	0.16671	0.18179	0.19804	0.20997	0.22684	0.24912	13.41	49.54
Black	0.25814	0.32084	0.34862	0.38024	0.40824	0.42834	0.45426	0.48717	5.77	30.69

GLOVER'S 1900-02 LIFE TABLES FOR THE DEATH REGISTRATION AREA

	q(1)	q(2)	q(3)	q(5)	q(10)	q(15)	q(20)	q(25)	e(0)
Total	0.12448	0.15383	0.16708	0.18196	0.19948	0.21037	0.22761	0.25232	49.24
White	0.12231	0.15112	0.16414	0.17886	0.19616	0.20674	0.22355	0.24785	49.62
Black	0.23447	0.29094	0.31561	0.33824	0.36621	0.39008	0.42135	0.45491	33.76

a. The value of N for the age and duration models is the number of children ever born. For the surviving children model, the relevant N's are:

	Children Ever Born	Children Surviving	Children Present
Total	4261	3533	3344
White	4182	3478	3303
Black	70	46	34

SOURCE: Sample of census enumerator's manuscripts. See text for estimation procedures. 1900-02 Death Registration Area Life Tables are found in Glover (1921). Values of q(a) for both sexes combined are derived by combining life tables for males and females assuming a sex ratio at birth of 105 males per 100 females.

TABLE 4. CHILD MORTALITY. CENSUS ESTIMATES. UNITED STATES, 1910.

AGE MODEL	15-19 q(1)	20-24 q(2)	25-29 q(3)	30-34 q(5)	35-39 q(10)	40-44 q(15)	45-49 q(20)
			AGE GROUPS				
UNITED STATES				q(i)			
TOTAL	0.02795	0.10727	0.13950	0.17215	0.19298	0.21983	0.24128
WHITE	0.02740	0.09415	0.12361	0.15606	0.17785	0.20379	0.22559
NATIVE WHITE	0.03041	0.09297	0.11832	0.14867	0.16838	0.18469	0.21213
FOREIGN WHITE	0.00688	0.09766	0.14281	0.18144	0.20972	0.25646	0.26238
BLACK: West	0.03172	0.16472	0.22150	0.26631	0.28831	0.33625	0.34450
BLACK: Far East	0.08300	0.18300	0.22400	0.25900	0.27500	0.31700	0.33000
				REFERENCE DATE			
TOTAL	1907.6	1905.9	1904.2	1902.7	1901.2	1899.5	1896.9
WHITE	1907.7	1905.9	1904.2	1902.7	1901.1	1899.4	1896.8
NATIVE WHITE	1907.7	1906.0	1904.2	1902.5	1900.8	1898.9	1896.4
FOREIGN WHITE	1907.2	1905.6	1904.4	1903.4	1902.6	1901.4	1898.9
BLACK: West	1907.6	1906.0	1904.4	1902.9	1901.6	1899.9	1897.3
BLACK: Far East	1907.6	1905.9	1904.3	1902.9	1901.5	1899.9	1897.3
				IMPLIED e(0)			
TOTAL	70.2	56.1	53.0	50.9	50.1	48.6	48.2
WHITE	70.4	58.1	55.1	52.6	51.7	50.2	49.7
NATIVE WHITE	69.5	58.3	55.9	53.5	52.8	52.1	51.0
FOREIGN WHITE	75.0	57.5	52.6	49.6	48.4	45.1	46.3
BLACK: West	69.2	47.7	43.1	40.7	40.8	38.0	39.2
BLACK: Far East	51.7	37.2	34.7	33.9	35.2	35.5	35.4
DEATH REGISTRATION STATES OF 1900				q(i)			
TOTAL	0.01740	0.09899	0.12669	0.16870	0.19176	0.23301	0.25086
WHITE	0.01612	0.09529	0.12881	0.16691	0.18843	0.23318	0.24742
NATIVE WHITE	0.01572	0.08859	0.11346	0.15444	0.16130	0.19243	0.22494
FOREIGN WHITE	0.01640	0.10552	0.14191	0.18335	0.22373	0.28064	0.27523
BLACK: West	0.08204	0.22534	0.19013	0.25119	0.35284	0.30379	0.41880
BLACK: Far East	0.22700	0.26300	0.20200	0.26000	0.36200	0.30900	0.43200
				REFERENCE DATE			
TOTAL	1907.5	1905.7	1904.1	1902.6	1901.3	1899.6	1897.1
WHITE	1907.5	1905.7	1904.1	1902.7	1901.3	1899.7	1897.2
NATIVE WHITE	1907.5	1905.7	1903.9	1902.4	1900.9	1899.2	1896.7
FOREIGN WHITE	1907.4	1905.8	1904.3	1903.1	1902.0	1900.5	1898.0
BLACK: West	1907.7	1905.5	1903.0	1900.6	1898.2	1895.9	1893.4
BLACK: Far East	1907.7	1905.5	1902.9	1900.5	1898.2	1895.9	1893.4
				IMPLIED e(0)			
TOTAL	73.5	57.4	54.7	51.1	50.2	47.2	47.4
WHITE	73.9	57.9	54.9	51.3	50.6	47.3	47.7
NATIVE WHITE	74.5	59.1	56.5	52.7	53.6	51.4	49.8
FOREIGN WHITE	73.8	56.3	52.7	49.4	47.0	42.9	45.2
BLACK: West	57.6	40.2	46.6	42.2	35.1	40.8	33.3
BLACK: Far East	25.0	26.7	37.6	33.8	27.8	34.1	28.1

DEATH REGISTRATION STATES OF 1910

				q(i)			
TOTAL	0.02559	0.09788	0.12795	0.16384	0.18682	0.21928	0.24020
WHITE	0.02368	0.09399	0.12544	0.15958	0.18129	0.21654	0.23470
NATIVE WHITE	0.02596	0.08877	0.11173	0.14618	0.16352	0.18822	0.21266
FOREIGN WHITE	0.00822	0.10414	0.15395	0.18625	0.21697	0.26685	0.27529
BLACK: West	0.03240	0.14376	0.19653	0.26169	0.30953	0.29626	0.36748
BLACK: Far East	0.08600	0.16100	0.20000	0.25700	0.29800	0.28100	0.35400

				REFERENCE DATE			
TOTAL	1907.6	1905.9	1904.1	1902.6	1901.0	1899.3	1896.7
WHITE	1907.6	1905.9	1904.2	1902.6	1901.1	1899.4	1896.8
NATIVE WHITE	1907.7	1905.9	1904.0	1902.3	1900.6	1898.7	1896.1
FOREIGN WHITE	1907.2	1905.6	1904.3	1903.3	1902.4	1901.1	1898.6
BLACK: West	1907.6	1905.9	1904.1	1902.5	1901.0	1899.2	1896.6
BLACK: Far East	1907.6	1905.8	1904.1	1902.4	1900.9	1899.2	1896.6

				IMPLIED e(0)			
TOTAL	71.1	57.5	54.4	52.0	50.8	48.7	48.4
WHITE	71.5	58.2	54.9	52.2	51.4	49.0	48.9
NATIVE WHITE	70.8	59.0	56.8	53.7	53.3	51.8	50.9
FOREIGN WHITE	75.0	56.5	51.1	49.1	47.6	44.2	45.2
BLACK: West	69.0	50.6	45.9	41.2	38.8	41.5	37.4
BLACK: Far East	50.9	40.6	37.7	34.1	33.1	36.6	33.6

MASSACHUSETTS

				q(i)			
TOTAL	0.02810	0.11121	0.14575	0.20649	0.18391	0.26026	0.26100
WHITE	0.02269	0.11304	0.14733	0.20702	0.18052	0.25653	0.24619
NATIVE WHITE	0.06742	0.10783	0.12186	0.20562	0.13546	0.19243	0.19064
FOREIGN WHITE	0.00000	0.11304	0.16762	0.21009	0.20963	0.30207	0.28977

				REFERENCE DATE			
TOTAL	1907.4	1905.7	1904.2	1902.9	1901.8	1900.3	1897.8
WHITE	1907.5	1905.9	1904.3	1902.9	1901.6	1900.0	1897.4
NATIVE WHITE	1907.9	1906.1	1904.0	1902.0	1900.1	1898.0	1895.4
FOREIGN WHITE	1906.8	1905.3	1904.2	1903.6	1903.2	1902.3	1899.9

				IMPLIED e(0)			
TOTAL	70.1	55.4	52.1	46.9	51.1	44.8	46.4
WHITE	71.7	55.1	52.0	46.8	51.4	45.1	47.8
NATIVE WHITE	60.6	55.9	55.4	46.9	56.5	51.4	53.0
FOREIGN WHITE	----	55.1	49.4	46.5	48.4	41.0	53.9

DURATION MODEL	0-4 q(2)	5-9 q(3)	10-14 q(5)	15-19 q(10)	20-24 q(15)	25-29 q(20)	30-34 q(25)
			DURATION OF MARRIAGE				
UNITED STATES				q(i)			
TOTAL	0.12882	0.14615	0.16490	0.18479	0.20981	0.22518	0.24815
WHITE	0.11107	0.13386	0.15473	0.17635	0.20170	0.21660	0.23353
NATIVE WHITE	0.10639	0.13042	0.14621	0.16240	0.18200	0.19906	0.21687
FOREIGN WHITE	0.12636	0.14447	0.17840	0.21427	0.24727	0.25304	0.27752
BLACK: West	0.24088	0.23237	0.24353	0.26359	0.28037	0.32328	0.36964
BLACK: Far East	0.24100	0.23600	0.24500	0.27100	0.29300	0.34900	0.40700
				REFERENCE DATE			
TOTAL	1908.9	1906.6	1904.2	1901.8	1899.0	1895.6	1892.5
WHITE	1908.9	1906.6	1904.2	1901.8	1899.0	1895.6	1892.5
NATIVE WHITE	1908.9	1906.6	1904.2	1901.7	1898.8	1895.4	1892.4
FOREIGN WHITE	1908.9	1906.6	1904.2	1901.9	1899.2	1895.8	1892.7
BLACK: West	1908.9	1906.7	1904.3	1902.0	1899.4	1896.0	1892.9
BLACK: Far East	1908.8	1906.7	1904.3	1902.0	1899.3	1895.9	1892.8
				IMPLIED e(0)			
TOTAL	52.8	52.1	51.5	51.0	49.6	49.7	49.7
WHITE	55.5	53.7	52.7	51.9	50.4	50.6	51.0
NATIVE WHITE	56.1	54.2	53.7	53.4	52.4	52.2	52.4
FOREIGN WHITE	53.2	52.3	50.0	47.9	46.0	47.2	47.1
BLACK: West	38.4	41.9	43.1	43.1	42.9	41.0	39.6
BLACK: Far East	29.3	33.3	35.3	35.6	35.5	34.0	33.4
DEATH REGISTRATION STATES OF 1900				q(i)			
TOTAL	0.11378	0.14151	0.16299	0.19476	0.22619	0.23362	0.26861
WHITE	0.10577	0.13932	0.16029	0.19392	0.22470	0.23113	0.26376
NATIVE WHITE	0.09272	0.13136	0.14302	0.16423	0.17235	0.20734	0.22442
FOREIGN WHITE	0.12763	0.14961	0.18070	0.22820	0.27972	0.25704	0.30713
BLACK: West	0.36494	0.25170	0.21457	0.24409	0.34808	0.39674	0.51055
BLACK: Far East	0.36600	0.25600	0.21800	0.25300	0.37000	0.43700	0.57400
				REFERENCE DATE			
TOTAL	1908.9	1906.6	1904.2	1901.7	1898.9	1895.5	1892.4
WHITE	1908.9	1906.6	1904.2	1901.8	1898.9	1895.5	1892.4
NATIVE WHITE	1908.9	1906.6	1904.1	1901.6	1898.7	1895.2	1892.2
FOREIGN WHITE	1908.9	1906.6	1904.2	1901.9	1899.1	1895.7	1892.5
BLACK: West	1908.8	1906.2	1903.6	1901.0	1897.9	1893.9	1890.8
BLACK: Far East	1908.8	1906.2	1903.6	1901.0	1897.9	1893.9	1890.8
				IMPLIED e(0)			
TOTAL	55.0	52.8	52.0	49.0	48.0	49.0	47.9
WHITE	56.0	53.0	52.1	50.0	48.1	49.2	48.3
NATIVE WHITE	58.4	54.0	54.1	53.2	53.4	51.4	51.8
FOREIGN WHITE	52.9	51.6	49.7	46.5	43.0	46.8	44.6
BLACK: West	26.6	39.8	46.0	44.9	37.0	35.0	29.0
BLACK: Far East	25.0	31.0	38.4	37.3	29.3	27.8	25.0

DEATH REGISTRATION STATES OF 1910				q(i)			
TOTAL	0.11726	0.14126	0.16088	0.18676	0.21543	0.22592	0.25390
WHITE	0.11147	0.13737	0.15703	0.18366	0.21303	0.22134	0.24586
NATIVE WHITE	0.10513	0.12839	0.14165	0.15831	0.18339	0.19438	0.21480
FOREIGN WHITE	0.12513	0.15434	0.18301	0.22714	0.25898	0.26355	0.29908
BLACK: West	0.24064	0.22381	0.24178	0.26996	0.29361	0.34676	0.46436
BLACK: Far East	0.24000	0.22700	0.24500	0.27800	0.30800	0.37600	0.51600
				REFERENCE DATE			
TOTAL	1908.9	1906.6	1904.1	1901.6	1898.7	1895.3	1892.2
WHITE	1908.9	1906.6	1904.1	1901.6	1898.6	1895.2	1892.2
NATIVE WHITE	1908.9	1906.6	1904.0	1901.3	1898.2	1894.7	1891.7
FOREIGN WHITE	1908.9	1906.6	1904.2	1902.0	1899.3	1895.8	1892.7
BLACK: West	1908.9	1906.7	1904.5	1902.5	1900.0	1896.8	1893.6
BLACK: Far East	1908.8	1906.7	1904.5	1902.4	1900.0	1896.8	1893.6
				IMPLIED e(0)			
TOTAL	54.5	52.7	52.0	50.8	49.1	49.7	49.2
WHITE	55.4	53.2	52.5	51.1	49.3	50.1	49.9
NATIVE WHITE	56.4	54.4	54.3	53.9	52.3	52.7	52.6
FOREIGN WHITE	53.5	51.1	49.5	46.6	44.9	46.2	45.3
BLACK: West	38.5	42.8	43.2	42.5	41.7	39.0	32.3
BLACK: Far East	29.4	34.4	35.4	34.9	34.2	31.9	26.7
MASSACHUSETTS				q(i)			
TOTAL	0.12002	0.17715	0.17501	0.22341	0.24102	0.23902	0.28683
WHITE	0.11398	0.17846	0.17595	0.22204	0.23787	0.22401	0.27677
NATIVE WHITE	0.08860	0.18365	0.15857	0.23271	0.16057	0.16206	0.18431
FOREIGN WHITE	0.13950	0.17363	0.18744	0.21689	0.28562	0.26047	0.34317
				REFERENCE DATE			
TOTAL	1908.9	1906.7	1904.1	1901.3	1898.2	1894.9	1892.0
WHITE	1908.9	1906.7	1904.1	1901.3	1898.1	1894.8	1891.9
NATIVE WHITE	1908.9	1906.7	1903.8	1900.7	1897.2	1893.7	1890.9
FOREIGN WHITE	1908.9	1906.7	1904.2	1901.6	1898.7	1895.4	1892.4
				IMPLIED e(0)			
TOTAL	54.1	48.2	50.3	47.0	46.6	48.5	46.3
WHITE	55.0	48.1	50.3	47.1	46.9	49.9	47.2
NATIVE WHITE	59.0	47.4	52.3	46.1	54.7	55.9	55.5
FOREIGN WHITE	51.3	48.7	49.0	47.6	42.4	46.5	41.7

SOURCE: Indirect estimates based on the public use micro sample of the 1910 U.S. Census of Population. Coale & Demeny [1966] Model West is used in all cases except for the black population, where both Model West and the United Nations [1982] Far Eastern Model are used.

TABLE 5. CHILD MORTALITY. VARIOUS ESTIMATES. BY RACE & NATIVITY. UNITED STATES, 1901/11.

	MORTALITY PARAMETER								
	q(1)	q(2)	q(3)	q(5)	q(10)	q(15)	q(20)	q(25)	e(0)
INDIRECT CENSUS ESTIMATES: SURVIVING CHILDREN METHOD									
UNITED STATES									
TOTAL	0.10416	0.12786	0.13839	0.15045	0.16413	0.17428	0.18899	0.20867	53.08
WHITE	0.09648	0.11775	0.12726	0.13822	0.15085	0.16027	0.17403	0.19251	54.56
NATIVE WHITE	0.09279	0.11292	0.12193	0.13236	0.14488	0.15354	0.16684	0.18473	55.29
FOREIGN WHITE	0.10953	0.13497	0.14624	0.15906	0.17347	0.18412	0.19947	0.21997	52.06
BLACK: West	0.14255	0.17874	0.19477	0.21302	0.23159	0.24526	0.26384	0.28819	46.18
BLACK: Far East	0.14064	0.17338	0.19118	0.21131	0.23441	0.25004	0.27836	0.31671	40.18
DEATH REGISTRATION STATES OF 1900									
TOTAL	0.09994	0.12229	0.13226	0.14371	0.15682	0.16656	0.18076	0.19978	53.89
WHITE	0.09893	0.12096	0.13079	0.14210	0.15507	0.16472	0.17879	0.19766	54.09
NATIVE WHITE	0.09019	0.10947	0.11815	0.12824	0.14001	0.14881	0.16178	0.17923	55.82
FOREIGN WHITE	0.11103	0.13693	0.14841	0.16147	0.17607	0.18687	0.20239	0.22311	51.78
BLACK: West	0.14214	0.17822	0.19420	0.21239	0.23091	0.24455	0.26310	0.28740	46.26
BLACK: Far East	0.13959	0.17214	0.18985	0.20987	0.23186	0.24842	0.27662	0.31483	40.31
DEATH REGISTRATION STATES OF 1910									
TOTAL	0.09948	0.12169	0.13159	0.14298	0.15602	0.16573	0.17986	0.19881	53.98
WHITE	0.09773	0.11939	0.12906	0.14020	0.15301	0.16254	0.17646	0.19514	54.32
NATIVE WHITE	0.08910	0.10801	0.11656	0.12652	0.13813	0.14682	0.15965	0.17693	56.04
FOREIGN WHITE	0.11472	0.14177	0.15376	0.16741	0.18250	0.19363	0.20959	0.23085	51.09
BLACK: West	0.13144	0.16415	0.17865	0.19515	0.21237	0.22503	0.24258	0.26565	48.12
BLACK: Far East	0.12798	0.15832	0.17490	0.19372	0.21448	0.23017	0.25701	0.29361	41.86
MASSACHUSETTS									
TOTAL	0.10747	0.13224	0.14322	0.15575	0.16988	0.18034	0.19545	0.21563	52.45
WHITE	0.10860	0.13373	0.14486	0.15756	0.17184	0.18240	0.19764	0.21800	52.23
NATIVE WHITE	0.11295	0.13945	0.15119	0.16456	0.17942	0.19039	0.20614	0.22714	51.42
FOREIGN WHITE	0.10567	0.12985	0.14059	0.15287	0.16675	0.17705	0.19194	0.21185	52.79
FROM VITAL STATISTICS AND CENSUS DATA.									
GLOVER TABLES: ORIGINAL REGISTRATION STATES OF 1900 IN 1910									
TOTAL	0.11462	0.13908	0.14970	0.16113	0.17542	0.18494	0.19926	0.21954	51.49
WHITE	0.11302	0.13699	0.14742	0.15868	0.17281	0.18210	0.19599	0.21578	51.89
NATIVE WHITE	0.11557	0.13969	0.15006	0.16108	0.17551	0.18431	0.19807	0.21846	52.35
BLACK	0.20263	0.25274	0.27389	0.29372	0.31608	0.33698	0.36946	0.40462	35.83
GLOVER TABLES: ORIGINAL REGISTRATION STATES OF 1900 FOR 1901/10									
WHITE	0.11671	0.14217	0.15348	0.16599	0.18157	0.19195	0.20763	0.22976	50.90
BLACK	0.22425	0.27843	0.30179	0.32362	0.34930	0.37176	0.40459	0.44058	34.08
CONSTRUCTED LIFE TABLES: DEATH REGISTRATION STATES OF 1910 IN 1910(a)									
TOTAL	0.12087	0.14772	0.15837	0.16956	0.18417	0.19376	0.20862	0.22948	51.12
WHITE	0.11872	0.14493	0.15538	0.16641	0.18086	0.19019	0.20455	0.22486	51.46
NATIVE WHITE	0.11871	0.14463	0.15495	0.16581	0.18017	0.18946	0.20351	0.22357	52.21
BLACK	0.23201	0.28916	0.30791	0.32487	0.34493	0.36319	0.39451	0.42915	34.57
CONSTRUCTED LIFE TABLES: MASSACHUSETTS									
TOTAL, 1904/06	0.13738	0.18040	0.19082	0.20294	0.21780	0.22776	0.24334	0.26448	48.48
TOTAL, 1909/11	0.12650	0.15374	0.16366	0.17498	0.18904	0.19818	0.21153	0.22957	50.81

(a) Excluding North Carolina.

SOURCE: See text.

TABLE 6. SELECTED SUMMARY ESTIMATES OF CHILD MORTALITY AND IMPLIED EXPECTATION OF LIFE AT BIRTH. UNITED STATES. 1900 & 1910.

	CHILD MORTALITY: q(5)			EXPECTATION OF LIFE AT BIRTH		
MODEL/PERIOD	TOTAL	WHITE	BLACK(a)	TOTAL	WHITE	BLACK(a)
UNITED STATES, 1900						
AGE MODEL	0.177	0.167	0.252	50.0	51.1	42.2
MARRIAGE DURATION MODEL	0.182	0.173	0.251	49.5	50.5	42.2
SURVIVING CHILDREN MODEL	0.176	0.161	0.255	50.1	51.8	41.8
DEATH REGISTRATION AREA OF 1900						
VITAL STATISTICS/CENSUS	0.182	0.179	0.338	49.2	49.6	33.8
UNITED STATES, 1910						
AGE MODEL	0.172	0.156	0.266	50.9	52.6	40.7
			(.257)			(33.9)
MARRIAGE DURATION MODEL	0.165	0.155	0.244	51.5	52.7	43.1
			(.245)			(35.3)
SURVIVING CHILDREN MODEL	0.150	0.138	0.213	53.1	54.6	46.3
			(.211)			(40.2)
DEATH REGISTRATION AREA OF 1900 for 1901/10						
VITAL STATISTICS/CENSUS	0.161	0.159	0.294	51.5	51.9	35.8
DEATH REGISTRATION AREA OF 1900 for 1909/11						
VITAL STATISTICS/CENSUS		0.166	0.324		50.9	34.1
DEATH REGISTRATION AREA OF 1910 for 1910						
VITAL STATISTICS/CENSUS	0.169	0.166	0.325	51.1	51.5	34.6

(a) For the black population in 1910, the first number is based on West Model and the second number in parentheses is based on the U.N. Far Eastern Model.

SOURCE: Tables 2-4.

FIGURE 1.
CHILD MORTALITY. U.S. TOTAL POP. 1900.

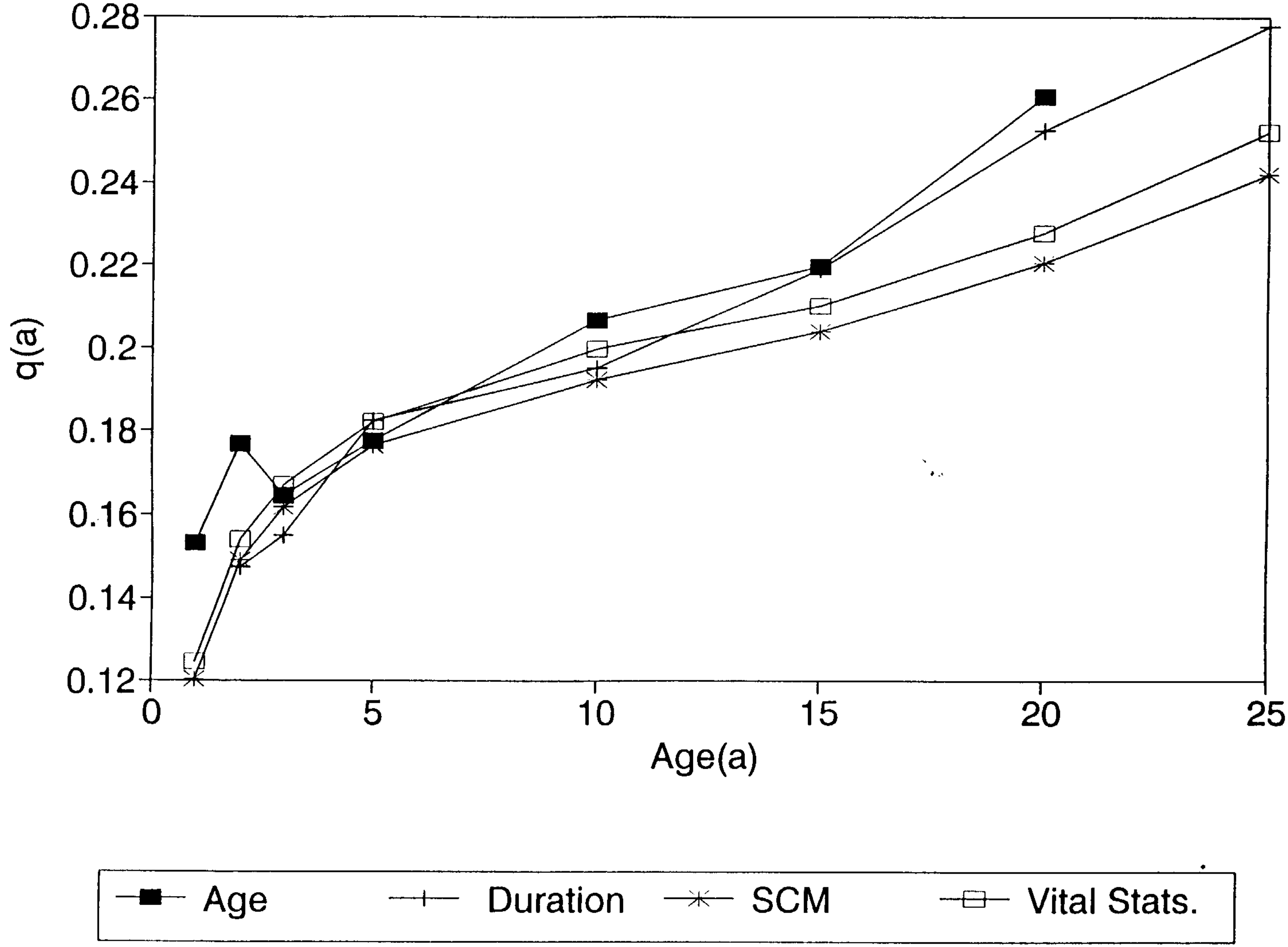
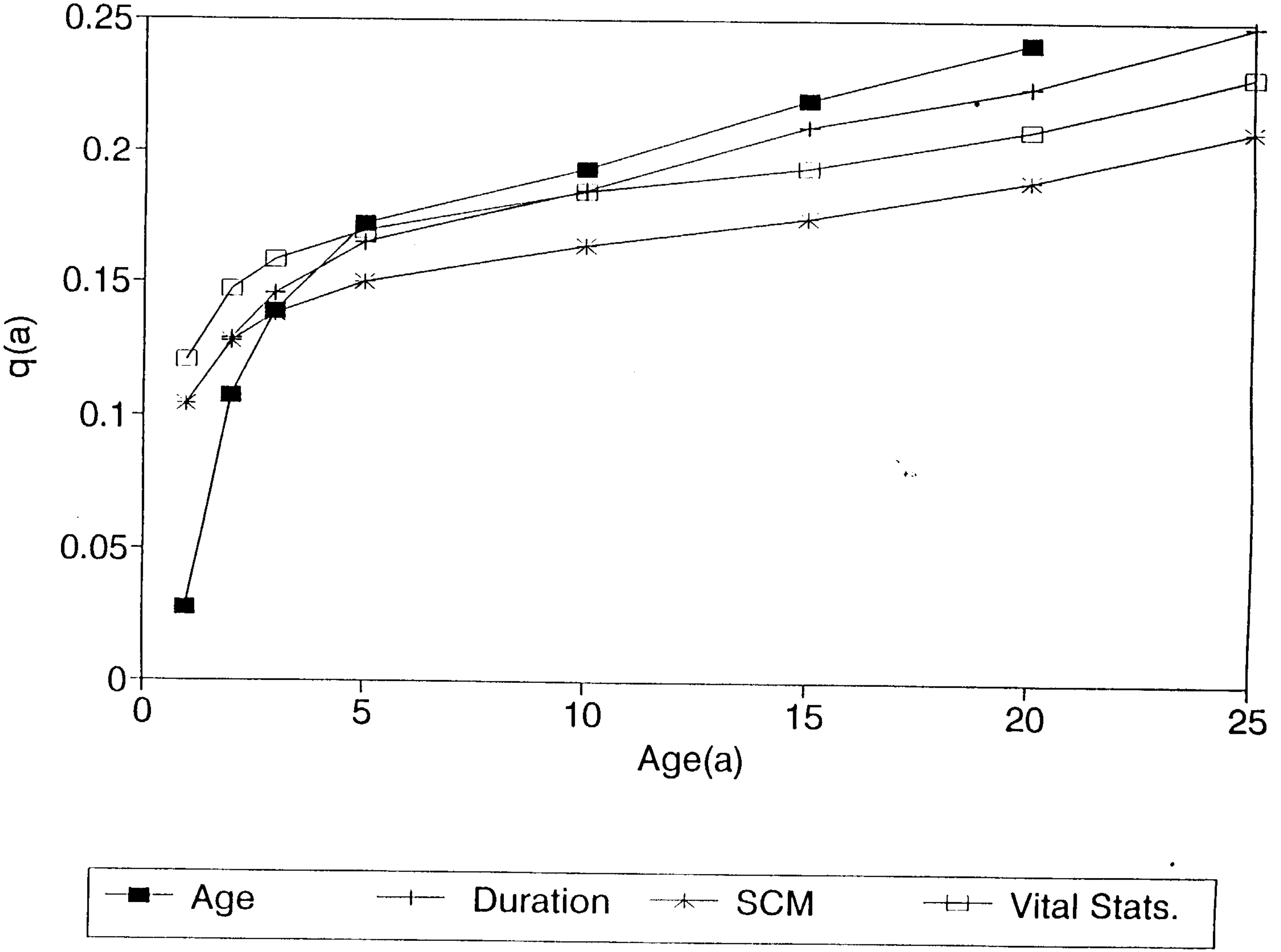


FIGURE 2.
CHILD MORTALITY. U.S. TOTAL POP. 1910.



APPENDIX

"Applying Indirect Methods of Child Mortality Estimation"

This paper has presented examples of the application of three methods of indirect estimation of child mortality using data on children ever born and children surviving by age and/or marriage duration of mother. The data in this case were tabulated from samples of individuals in census manuscripts, but there may be cases where published data provide the necessary input information (e.g., the 1911 Census of Marriage and Fertility of England and Wales). A third method was also presented, the surviving children method, which requires data on the age distribution of surviving own children as well as children ever born and children surviving for groups of women (e.g., by age, residence, ethnicity, etc.). The first two methods are described in detail in United Nation, Manual X [United Nations, 1983, ch. III] and the surviving children method in Preston and Palloni [1979]. Explicit examples are given in the United Nations manual, but the procedures can easily be programmed into various spreadsheets (e.g., Lotus 123, Quattro Pro, Excel). The surviving children method currently requires special-purpose software for the estimation [Avery, 1981].

What follows are some guidelines for estimating the age and marriage duration models in a spreadsheet. Initially, you will need tabulations of numbers of women, numbers of children ever born, and numbers of children surviving by age or marriage duration of woman. These may be published. If they arise from a micro data source like the PUMS (Public Use Micro Samples) of the United States Census, you will need to be careful about applying the correct filters to the data. For instance, you need to exclude missing values and illegible cases. For the marriage duration model, it is important to have only once married women. You will need to tabulate by standard five year age groups (i.e., for the age model, ages 15-19, 20-24,...45-49; for the marriage duration model, durations 0-4, 5-9,...30-34). Here is a description of the spreadsheet:

Columns A and B and C.. List the group (i) to which the child mortality estimates apply; then the age or duration group which provides the estimate of child mortality; and then the relevant x for the q(x) for that group:

(i)	Age Group	q(x)	Duration Group	q(x)
1	15-19	q(1)	0-4	q(2)
2	20-24	q(2)	5-9	q(3)
3	25-29	q(3)	10-14	q(5)
4	30-34	q(5)	15-19	q(10)
5	35-39	q(10)	20-24	q(15)
6	40-44	q(15)	25-29	q(20)
7	45-49	q(20)	30-34	q(25)

There will be seven rows for each model. Note that the q(x)'s vary between the models.

Column D. Enter the number of women in each group (W(i))

Column E. Enter the number of children ever born for each group (CEB(i)).

Column F. Enter the number of children surviving for each group (CSURV(i)).

Column G. Children Dead (CDEAD(i)) = CEB(i) - CSURV(i)

or +d5-e5 in e.g. row 5.

Column H. Average Parity = P(i) = CEB(i)/W(i) or +d5/c5 in e.g. row 5.

Column I. Average Proportion Dead = D(i) = CDEAD(i)/CEB(i)

or +f5/d5 in e.g. row 5.

We now estimate the models from the relationship q(x) = D(i)*[a(i) + b(i)*P(1)/P(2) + c(i)*P(2)/P(3)] where q(x) is the probability of dying between birth and the age corresponding to group "i" (shown above). Columns J, K, L, and M would contain the calculation of the q(x)'s for the four Coale and Demeny North, South, East, and West. Organize the spreadsheet as follows:

COLUMN

ROW	A	B	C	D	E	F	G	H	I	J	K	L	M
1	(i)	Age	x	W(i)	CEB	CSURV	CDEAD	P(i)	D(i)	q(x)	q(x)	q(x)	q(x)
2										North	South	East	West
3	1	15-19	1										
4	2	20-24	2										
5	3	25-29	3										
6	4	30-34	5										
7	5	35-39	10										
8	6	40-44	15										
9	7	45-49	20										
10													
11		Duration											
12	1	0-4	2										
13	2	5-9	3										
14	3	10-14	5										
15	4	15-19	10										
16	5	20-24	15										
17	6	25-29	20										
18	7	30-34	25										

Here are some examples of formulas which would be placed in the cells M3 to M9 (for the age model) and M12 to M18 (for the duration model) for Model West. Similar formulas would be placed in the cells for the other models with the coefficients changed according to Tables 47 and 56 in <u>Manual X</u>. Similar calculations can be made to estimate the number of years in the past to which the estimates apply based on Tables 48 and 57 in <u>Manual X</u> and on the data in the spreadsheet. The relevant formula is: t(x) = a(i) + b(i)*P(1)/P(2) + c(i)*P(2)/P(3).

```
CELL    Model West: Age
M3      +$I3*(1.1415-2.7070*($H$3/$H$4)+2.7070*($H$4/$H$5))
M4      +$I4*(1.2563-.5381*($H$3/$H$4)-.2637*($H$4/$H$5))
M5      +$I5*(1.1851+.0633*($H$3/$H$4)-.4177*($H$4/$H$5))
M6      +$I6*(1.1720+.2341*($H$3/$H$4)-.4272*($H$4/$H$5))
M7      +$I7*(1.1865+.3080*($H$3/$H$4)-.4452*($H$4/$H$5))
M8      +$I8*(1.1746+.3314*($H$3/$H$4)-.4537*($H$4/$H$5))
M9      +$I9*(1.1639+.3190*($H$3/$H$4)-.4435*($H$4/$H$5))
        Model West: Marriage duration
M12     +$I12*(1.2584-.4683*($H$12/$H$13)+.1080*($H$13/$H$14))
M13     +$I13*(1.1841-.3006*($H$12/$H$13)-.0892*($H$13/$H$14))
M14     +$I14*(1.2446+.0131*($H$12/$H$13)-.3555*($H$13/$H$14))
M15     +$I15*(1.3353+.1157*($H$12/$H$13)-.5245*($H$13/$H$14))
M16     +$I16*(1.3875-.0193*($H$12/$H$13)-.5472*($H$13/$H$14))
M17     +$I17*(1.4227-.1954*($H$12/$H$13)-.5127*($H$13/$H$14))
M18     +$I18*(1.4432-.1977*($H$12/$H$13)-.5339*($H$13/$H$14))
```

For the purposes of analysis it is not always convenient to use these estimates of child mortality. Further, these methods cannot be used with individual level data. To overcome these obstacles, a mortality index was created which is a ratio of actual to expected child deaths [Preston and Haines, 1991, pp. 88-90]. This has an intuitive interpretation: a ratio close to unity indicates that a particular woman or group of women (e.g., native white northern rural women) were doing about average. A ratio below unity indicates a better than average experience and a ratio above unity points to a worse than average mortality pattern. Appendix Table 1 provides the calculation of the index for the United States for 1900 and 1910. Expected child deaths are obtained by multiplying the children ever born for a particular marriage duration group of women or for the marriage duration group of a particular woman (i.e., 0-4, 5-9, 10-14, 15-19, 20-24). It is done only for the first five duration groups. The result of this calculation (i.e., CEB*(q(x)s/k(i)) in Appendix Table 1) yields expected child deaths for the denominator of the index. The numerator (actual child deaths) is directly available as children ever born minus children surviving. The multipliers are found in thee last columns of the upper and lower panels of Appendix Table 1. The upper panel is for 1900 and the lower panel is for 1910. The mortality standard used to obtain expected child deaths for 1900 was West Model mortality level 13 (both sexes combined). It was West Model level 13.5 for 1910. The additional multipliers using the United Nations Far Eastern Model is included for 1910 because of its potential relevance to the black population.

APPENDIX TABLE 1. CALCULATION OF THE MORTALITY INDEX. UNITED STATES. 1900 & 1910.

MORTALITY INDEX = (ACTUAL DEATHS)/(EXPECTED DEATHS)

EXPECTED DEATHS = [(q(x)s)/k(i)]*CEB

where CEB = children ever born
q(x)s = probability of dying between birth and exact age (x) in a standard life table
k(i) = multipliers from United Nations, MANUAL X (1983), ch. III.

k(i) = a(i) + b(i)*[P(1)/P(2)] + c(i)*[P(2)/P(3)]

where P(i) are average parities in marriage duration group (i).

For 1900, the mortality index may be calculated as follows:

(i)	Marriage Duration	(x)	P(i)	WEST MODEL a(i)	b(i)	c(i)	k(i)	WEST LEVEL 13 q(x)s	q(x)s/k(i)
1	0-4	2	0.9471	1.2584	-0.4683	0.1080	1.13042	0.16100	0.14242
2	5-9	3	2.2166	1.1841	-0.3006	-0.0892	0.99610	0.17511	0.17580
3	10-14	5	3.3195	1.2446	0.0131	-0.3555	1.01281	0.19119	0.18877
4	15-19	10	---	1.3353	0.1157	-0.5245	1.03449	0.20815	0.20121
5	20-24	15	---	1.3875	-0.0193	-0.5472	1.01385	0.22061	0.21760

For 1910, the mortality index may be calculated as follows:

(i)	Marriage Duration	(x)	P(i)	WEST MODEL a(i)	b(i)	c(i)	k(i)	WEST LEVEL 13.5 q(x)s	q(x)s/k(i)	FAR EAST e(0)=43.11 q(x)s	q(x)s/k(i)
1	0-4	2	0.7974	1.2584	-0.4683	0.1080	1.14985	0.15174	0.13196	0.14625	0.12719
2	5-9	3	2.0784	1.1841	-0.3006	-0.0892	1.01003	0.16482	0.16318	0.16189	0.16029
3	10-14	5	3.1563	1.2446	0.0131	-0.3555	1.01553	0.17972	0.17698	0.17973	0.17698
4	15-19	10	---	1.3353	0.1157	-0.5245	1.03431	0.19579	0.18929	0.19941	0.19280
5	20-24	15	---	1.3875	-0.0193	-0.5472	1.01977	0.20760	0.20358	0.21438	0.21022