ANNOTATIONS

AGE DISTRIBUTIONS AS AFFECTED BY CHANGES IN FERTILITY AND MORTALITY—A FURTHER NOTE

THE note by Karpinos in the January issue of the *Quarterly* provides an opportunity to clarify what is and is not shown in recent analyses of the relation of mortality and fertility to age distributions.[1] I shall limit myself—as Karpinos does—to stable age distributions under various fertility and mortality schedules. Some of the recent discussion (notably Stolnitz's article and the latter part of my earlier piece) extends to other than stable distributions; but the points raised by Karpinos' note can conveniently be handled in the stable-distribution context.

The recent discussion can be divided into two major components: (a) an analytical part providing the means for determining the ultimate effect on a stable age distribution of *any* change in mortality, fertility, or both; and (b) an empirical part that, by applying techniques developed in the analytical portion, summarizes the age-distribution effects of *recorded* changes in fertility and mortality.

The main conclusions of the analytical part of the discussion are easily stated. Fertility changes have unambiguous effects

[1] Karpinos, Bernard D.: Age Distributions as Affected by Changes in Fertility and Mortality, Milbank Memorial Fund *Quarterly*, January, 1957, XXXV, No. 1, pp. 95–96; Coale, Ansley J.: The Effect of Declines in Mortality on Age Distributions. *In* TRENDS AND DIFFERENTIALS IN MORTALITY, Proceedings of a Round Table at the 1955 Annual Conference, Milbank Memorial Fund; Coale, Ansley J.: The Effects of Changes in Mortality and Fertility on Age Composition, Milbank Memorial Fund *Quarterly*, January, 1956, XXXIV, No. 1; Stolnitz, George J.: Mortality Declines and Age Distribution, Milbank Memorial Fund *Quarterly*, April, 1956, XXXIV, No. 2. *See also* the long list of citations in the Stolnitz article.

—a reduction in fertility *always* reduces the fraction at younger ages (below the mean age of a population, roughly speaking), and raises the fraction at older ages. The effect of changes in mortality, on the other hand, depends on the age composition of the changes. A uniform per cent improvement in the probability of surviving has no effect on the age distribution; above-average improvements in survivorship in infancy and early childhood have effects similar to a rise in fertility—yielding a larger fraction of young persons and a smaller fraction of older persons; while above-average improvements in survivorship at ages above 50 increase the fraction at those ages. The majority of substantial improvements can be closely represented by a uniform per cent increase in the probability of surviving at all ages, plus an excess improvement under age 5 and over age 50.[2] To ask whether an improvement in mortality of the usual form raises or lowers the fraction over 65 (with constant fertility) is to ask whether the excess improvement in survivorship under age 5 does or does not swamp any improvement over age 50. The analytical part of the discussion cannot provide an answer to this question. It can be answered only by looking at the age pattern of each mortality improvement.

A survey of 44 rather large changes in mortality risks shows that in a slight majority of cases the fraction over 65 would have been *decreased* had fertility remained at former high levels and mortality been subject to the recorded improvement. This statement would hold for Scotland 1865–1895, England and Wales 1846–1886, Berlin 1878–1901, Breslau 1883–1898, Italy 1881–1900, Switzerland 1878–1896, Germany 1905–1933, Sweden 1905–1925, Norway 1905–1925, France 1900–1935, Canada 1928–1941, United States (Death Registration Area, white population) 1900–1940, Iceland 1905–1935, Netherlands 1905–1925, Denmark 1903–1938, New Zealand 1903–1936, German Federal Republic 1946–1950, Union of South Africa (European population) 1921–1936 and 1936–1946, Japan 1923–1953, Jamaica 1921–1946, Portugal 1920–

[2] Even if the improvement in mortality departs from this pattern, its effect on the stable age distribution can be approximated by a graphical technique described in Coale, A. J.: The Effects of Changes in Mortality and Fertility on Age Composition.

1940, and Mexico 1930–1940 (a total of 23 instances).

In most other instances, a slight increase in the fraction over 65 is more than offset by a larger increase in the youngest fractions (both increases of course occurring at the expense of intervening ages) so that the median age of the stable population is lowered by the mortality improvement. Examples of this are Belgium 1846–1896, Sweden 1846–1896 and 1936–1943, Germany 1876–1896, Prussia 1856–1896, Netherlands 1846–1885, Switzerland 1905–1935, Australia 1905–1933, Scotland 1911–1931, England and Wales 1911–1931, Denmark 1938–1948, Canada 1941–1947, Trinidad and Tobago 1921–1946, British Guiana 1921–1946, Chile 1920–1940, Ceylon 1921–1952, and Taiwan 1905–1938 (a total of 17 instances).

Finally, there are a relatively few instances of large changes in mortality (for which a life-table record exists) where both the fraction over age 65 and the median age are increased. These are Norway 1936–1947, Netherlands 1936–1948, United States (white population) 1945–1952, and Republic of Ireland 1936–1946 (a total of 4 instances).

All instances of the last category of mortality improvement are found in the recent history of low-mortality areas; and this category is inevitably destined to become increasingly prominent if mortality reductions continue. There is simply no more room in the advanced countries for further substantial improvements except of the form that would produce disproportionately more old people, with only a minor offsetting effect at the young end of the age distribution.

To turn now to Karpinos' specific statements. As an analytic proposition, it is beyond dispute that an increasing proportion of aged persons can arise from decreases in mortality, fertility, or both. I would insist that a *decreasing* proportion *can* arise from decreases in mortality (but not in fertility). As an empirical generalization, it appears that the majority of the recorded large changes in mortality show a more prominent "youthening" than an "aging" effect. The most notable exceptions, however, are concentrated in the recent experience of low-mortality areas, as noted just above. I would disclaim any intention to explain the *current* aging of European and

North American stable age distributions entirely by fertility declines.[3]

I find little value in Karpinos' example (displayed in Table 1 in his note), either empirically or analytically. Its empirical value is limited by the fact that it compares mortality risks in life tables that do not represent the changing life-chances in a single real population, but rather the different life-chances in three quite different groups. One of the life tables is based on at least moderately reliable data—the table for United States white females in 1929–1931. Another—the table for United States Negro females—is based on a combination of registered deaths and enumerated population that is quite probably seriously deficient at both extremes of the age range. In other words, the detailed shape of this Negro life table is not reliable. But it is the shape that determines the age-distribution effects of shifting to another life table. The third life table in the comparison is a largely hypothetical table taken from Dublin and Lotka, LENGTH OF LIFE. It was derived by applying plausible reduction factors to the q_x values of the 1931 New Zealand life table in an effort to estimate as of 1936 what a very low mortality life table would look like. A more appropriate comparison with the 1929–1931 Negro life table is provided by a later United States nonwhite table. The table for 1949 has l_x values at ages one and 45 comparable to the 1929–1931 white life table. Moreover, the defects in an earlier table—such as the United States table for Negroes in 1929–1931—are likely to be repeated to some degree in a later table; hence the age pattern of changes is perhaps less influenced by erroneous data than when the standard of comparison is a life table with a different pattern of errors.

In shifting from the 1929–1931 United States Negro life table to the 1929–1931 white life table (with constant fertility), the fraction over 65 in the stable age distribution is substantially increased.[4] The fraction over 65 is also increased in a

[3] However, this is an example of the limitations of the stable age distribution as an analytical device. The major portions of recent *actual* increases in the proportion aged are often the result of rapid declines in fertility occurring thirty to sixty years in the past.

[4] If the shift is from the 1929–1931 Negro life table to the 1949 nonwhite table, the increase in the fraction over 65 would be reduced by more than 50 per cent.

change from the 1929–1931 white life table to Dublin and Lotka's hypothetical table. However, these facts are in no way proved (as I shall show below) in Karpinos' table or in his text.

The analytical defect in Karpinos' table is more fundamental. The columns show the rising fraction above age 65 as the intrinsic rate of increase declines with the same life table. This rising fraction is quite properly attributed to declining fertility. The rows in the table show a rising fraction above age 65 for the same r, as one proceeds to life tables with lower mortality. According to Karpinos, the increased fractions over 65 are "mainly changes due to declining mortality." Actually, when mortality improves and r is fixed, *fertility* necessarily declines. Whether the tabulated increase in the fraction over 65 is caused largely or even wholly by this change in fertility depends on the age structure of the change in mortality.

Consider the comparison shown in Table 1:

Table 1. Per cent over 65 in various stable age distributions.

	Life Table of Sweden 1891–1900	Life Table of Sweden 1946–1950
r = 0	11.83	15.43
Fertility Constant at 1896–1900 Levels	7.48	6.66
Fertility Constant at 1950 Levels	14.92	13.47

Following Karpinos' lead, we would say that the higher fractions over 65 with lower mortality and the same value of r are "mainly changes due to declining mortality." Actually, if fertility is held fixed, the later life table yields a *smaller* fraction over age 65. Hence the change shown in the table for the same value of r is caused wholly (and then some) by the *decline in fertility* required to yield a constant r with improved mortality. That the differences in his table are in fact "mainly changes due to declining mortality" is the fortuitous result of his choice of (rather non-comparable) life tables.

To summarize: Improvements in mortality *can* either in-

crease or decrease the fraction over 65, and increase or decrease the median age in stable (and actual) age distributions. Fertility reductions can *only* increase the fraction over 65 and raise the median age. Except for the last two decades of experience in relatively advanced countries, the recorded declines in mortality have tended mostly to *decrease* the fraction over 65, and in an overwhelming majority of instances to decrease the median age. Recent experience in areas with the lowest mortality risks indicates a relationship that will inevitably become the universal one (if mortality improvements continue)—a rising fraction over 65 and a rising median age caused by mortality improvement.

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VITAL TRENDS AND AGE DISTRIBUTION: AN ADDED NOTE

DR. Karpinos' recent note, "Age Distributions as Affected by Changes in Fertility and Mortality," invites further comment.[1] That stable-age distributions, "though theoretical, can be advantageously utilized in general discussions on the expected effects of mortality and fertility on age structures" is readily accepted, provided their limitations are also clearly in sight. Since such distributions are inherently long-run, they provide little information or even guidance on transitions. Yet our interest as often as not is focused on 15 or 30 year consequences; indeed, most problems which have led to the postwar reexamination of the relations between vital trends and age have had just such time spans in view.[2]

The more immediate reason for the present note is to correct an apparent misinterpretation by Karpinos of his data. The variations he shows in the stable-age proportion 65 and over for varying rates of increase and a fixed life table are, as he states, the results of fertility changes alone. It is not true,

[1] Milbank Memorial Fund *Quarterly*, January, 1957, 35, No. 1, pp. 95–96.

[2] See the sources cited in my "Mortality Declines and Age Distribution," Milbank Memorial Fund *Quarterly*, April, 1956, 34, No. 2, pp. 178–215.