EFFECT OF CHANGING AGE COMPOSITION ON MEASURES OF MORTALITY FROM MALIGNANT NEOPLASMS, FOR WHITE AND ALL OTHER RACES: UNITED STATES, 1950-75

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First I shall review a few statements made long ago by some illustrious statisticians about the selection of a standard population for computing age-adjusted death rates. Then I shall examine with you the effect of the selection of the total population in the United States in 1940 as the standard population for almost all age-adjusted death rates (based on the "direct method") published by the National Center for Health Statistics. We shall base our examination on the effect on the age-adjusted death rate for malignant neoplasms.

Mr. G. Udny Yule began his paper on the use of indices for measuring occupational mortality, read before the Royal Statistical Society, November, 1933, with the question, "What do we want to do by standardization?"¹ His answer to his question was in part as follows: "The problem is simply to obtain some satisfactory form of average... an average which will measure in summary form the general fall in mortality between two epochs, just as an index-number measures the general fall or rise in prices."

Professor M. Greenwood in his laudatory discussion of Mr. Yule's paper said: "In the first section of his paper Mr. Yule defines the limitations of processes of so-called standardization, and I think it is important to bear those limitations in mind, because some of the mistakes and ambiguities to which he has drawn attention do arise from neglect of the fact that a pint pot cannot contain more than a pint."

Professor Greenwood reminded his audience that: "It was not until the seventeenth century that it was realized that in seeking to grasp everything, one tended to grasp nothing. Then we had the introduction to a statistical tabulation in which our predecessors a hundred years ago were engaged, and we merged individuals into groups, deliberately sacrificing some valuable information for the sake of retaining a clearer view of other important facts. What has happened is that the groups themselves and the information relating to those groups have become more and more detailed, and so we reached the stage when it was necessary to summarize the summaries and that is at the base of these various methods."

Dr. Percy Stocks, who, at this same meeting of the Royal Statistical Society, followed Professor Greenwood with a discussion of Mr. Yule's paper, cautioned the audience that in using either the direct or indirect method of age-adjustment with the 1901 population of England as the standard "... we are now over-weighting our standard death-rates with the mortality of childhood, for whereas the 1931 Census population contained 24 percent of children under 15, we weight their mortality as though they formed 32 percent, as they did in 1901. Since the greatest decline in mortality has occurred at these ages, this fact is over-represented in the fall of standardized death-rates, and the lack of improvement at the older ages is not sufficiently represented."

Before any attempt to determine whether Dr. Stocks' cautionary remarks about over-weighting England's age-adjusted death rates with childhood mortality are also applicable to the age-adjusted death rates published by the National Center for Health Statistics and its predecessor agencies, let us look at the summary of standard populations used by England and Wales and the United States, as given to us by Linder and Grove² in their momentous work entitled Vital Statistics Rates in the United States 1900-1940.

These authors state: "When age-adjusted rates were first published regularly in the English official reports of vital statistics (in 1883), the standard population used was that of the entire country at the previous census. The changing of the standard at the end of each decade was later felt to be unsatisfactory, so the age and sex distribution of the population of England and Wales in 1901 was taken as a 'permanent' standard near the beginning of the century. Despite the fact that it is no longer at all typical of the existing population, this distribution is still used in the Registrar-General's reports for age-adjustment of death rates by the direct method."

In this same work Linder and Grove report that for the United States the direct method of age adjustment was adopted by the Bureau of the Census in 1911, and that at that time "the rates were based on the same standard million of England and Wales in 1901, since it was felt that the results 'would be of greater value for comparison'."

The study of Linder and Grove appeared in 1973. In this work the authors chose for their standard population that of the total United States in 1940. Since then NCHS and its predecessors have clung as tightly to this standard as England and Wales have clung to the population of 1901.

As the charts I shall now show you indicate, the effect of this choice of the 1940 population on the level of the curves for age-adjusted death rates is quite different for the white male and female populations than for the male and female populations of Negro and other minority races (hereinafter denoted by "all other" or "all other races").

To better assess what information is summarized by the age-adjusted death rate for malignant neoplasms, let us first review what is summarized by the total or unadjusted death rate. For any given year this rate may be defined as the total number of deaths from malignant neoplasms in that year per 100,000 exposed to the risk of death throughout the year. The number of persons thus exposed is taken to be the enumerated population for census years and the estimated mid-year population for inter-censal years. The total death rate is clearly upward (figure 1).

These total or unadjusted death rates are undoubtedly valuable rates. They tell us the total probability of death from malignant neoplasms from the combined influence of all factors affecting death from this cause.

The following two well-known trends inform us why for malignant neoplasms the most important of these factors is the age distribution of the population under study: (1) Death rates for malignant neoplasms rise steeply with advance in age until

MALIGNANT NEOPLASMS: DEATH RATES AND AGE-ADJUSTED DEATH RATES: 1930-75



the end of the life span; and (2) since 1940 the proportion of persons at ages 45 years and over in this country has increased appreciably.

The first question we must answer, therefore, is whether the long upturn in the total death rate for malignant neoplasms is attributable for the most part to the increased proportion of older people in the population, or to increases in age-specific death rates for this cause. The measure we will use to answer this question is, of course, the age-adjusted death rate. Inasmuch as the standard population is the population of 1940, for that year the age-adjusted rate is the same as the total or unadjusted death rate for malignant neoplasms.

A comparison of age-adjusted death rates for malignant neoplasms with the corresponding total or unadjusted death rates for the period 1930-75 shows only a moderate rise in the ageadjusted death rates. It would be wrong, however, to conclude from this, as one might easily be misled to do, that the steep rise in the total or unadjusted rate is attributable almost entirely to the increasing proportion of older persons in the population. As will be shown below, this relative stability of the age-adjusted rate for the total population results for the most part from the offsetting of the steep rise in the age-specific death rates for the male population with the fall in the age-specific death rates for the female population.

Before 1940 the curve for the age-adjusted death rate is higher than that for the total death rate; and after 1940, progressively lower than that for the total death rate. This change in position results from the fact that the proportion of persons at the high risk ages of 45 years and over was lower before 1940 and progressively higher after 1940 than the proportion at these ages in the population of 1940. It follows, therefore, that since 1940 we are to an increasing extent over-representing in our age-adjusted death rate for the total population the low mortality from malignant neoplasms for children and young adults and under-representing the rising mortality for older age groups.

For the male population the total or unadjusted death rate for malignant neoplasms increased 34.6 percent during 1950-75, an average annual increase of 1.4 percent (figure 2). The corresponding unadjusted death rate for the female population also increased, but only 11.2 percent, an average annual increase of about 0.4 percent.

A different pattern emerges when this mortality is measured by age-adjusted rates. For the male population the trend is still upward; but for the female population the trend for the age-adjusted death rate is downward.

The trends of the age-specific death rates for malignant neoplasms for the male population make clear that the steep rise in mortality from this cause as measured by both the total or unadjusted death rates and by the age-adjusted rates is attributable for the most part, not to the ageing of the population, but to an increase in the force of mortality from this cause. For every age group in the span 45 years and over the male death rates for malignant neoplasms are substantially higher for 1975 than for 1950.

The gap between the total or unadjusted death rate and the age-adjusted rate for the male population widened during 1950-75-from 12.1 to 30.9 deaths per 100,000. This gradual enlargement of the gap reflects the slowly increasing percentage during 1950-75 of men in the total male population at ages 45 and over-from 28.2 to 28.9 percent.

In contrast the trends of the age-specific death rates for malignant neoplasms for the female population indicate that the moderate rise in mortality from this cause as measured by the total or unadjusted death rate is attributable in great part, if not entirely, to the ageing of this population, and not to an increase in the force of mortality from this cause. For every age group in the entire life span the female death rates for malignant neoplasms are substantially lower for 1975 than for 1950.

Also in contrast to the pattern for the male population, as a result of the decline in the age-adjusted rate, the gap between the total or unadjusted death rate and the age-adjusted death rate widened rapidly during 1950-75-from 16.0 to 43.8 deaths per 100,000. This enlargement reflects the increasing percentage during 1950-75 of women at ages 45 years and over-from 28.7 to 32.9 percent.

The total death rate and the agc-adjusted death rate for malignant neoplasms rose during 1950-75 for both white males and for all other males (figure 3). But the increases were much greater for the latter group.

For white males the position of the curve for the age-adjusted death rate below that for the total rate beginning in 1940 reflects the fact that in their age-adjusted death rates we are under-representing mortality from malignant neoplasms at older ages. For example, whereas in 1975 white men at ages 45 years and over formed 29.8 percent of their population, we weight their mortality as though they formed only 26.7 percent as did persons at these ages in our standard population.

In contrast, for all other males the position of the age-adjusted death rate above the unadjusted death rate throughout 1914-75 (the longest period for which we have these rates by race) results from the fact that in their age-adjusted death rates we are over-representing mortality from malignant neoplasms at older ages. In 1975 men of races other than white at ages 45 years and over formed only 22.1 percent of their population. Yet we weight their mortality as though they formed 26.7 percent, as did persons at these ages in our standard population.

Before taking up our examination of age-adjusted death rates for the female population, let us pause briefly to recall the absolute number of men in the United States who lost their

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FIGURE 2 MALIGNANT NEOPLASMS: DEATH RATES AND AGE-ADJUSTED DEATH RATES, BY SEX: 1960-75

T FIGURE 3 MALIGNANT NEOPLASMS: DEATH RATES AND AGE-ADJUSTED DEATH RATES FOR THE MALE POPULATION, BY COLOR: 1960-75



lives at ages 45-64 and 65-74 years—as a result of increases in the death rates for malignant neoplasms between 1950 and 1975 (figure 4).

Also for white females the total death rate for malignant neoplasms rose during 1950-75, especially during 1965-75 (figure 5). But as indicated by the negligible decline (1.1 percent) in the age-adjusted death rate between 1965 and 1975 (from 108.1 to 106.9 deaths per 100,000 population) most of this upturn in the total death rate is attributable to the ageing of the population. It is likely that their curve for the age-adjusted death rate will soon turn upward—pushed up by the rapidly increasing death rate among women for malignant neoplasms of trachea, bronchus, and lung.

Again, as for white males, the position of the curve for the age-adjusted death rate for white females below that for their total rate beginning in 1940, reflects the fact that in their age-adjusted death rates, we are under-representing mortality from malignant neoplasms at older ages. In 1975 white women at ages 45 years and over formed 34.2 percent of their population. Nevertheless we weight their mortality as though they formed only 26.7 percent as did persons at these ages in 1940.

For all other females the total death rate rose slightly, but the age-adjusted death rate declined between 1950 and 1975. The position of their age-adjusted death rate above the unadjusted death rate throughout 1914-75 results from the fact that in their age-adjusted death rate we are over-representing mortality from malignant neoplasms at older ages. Illustrating again with data for 1975, whereas in that year women of races other than white at ages 45 years and over formed only 24.4 percent of their population, we weight their mortality as though they formed 26.7 percent, as did persons at these ages in our standard population.

FIGURE 5



Space does not allow us to show mortality trends for both total and age-adjusted death rates for all body sites in which malignant neoplasms occur. Therefore we shall limit our remaining charts to age-adjusted rates for some of these sites. As may be expected, however, from the discussion above for mortality from all malignant neoplasms combined, for most of these body sites, for the white population the position of the curve for the total death rate is above that for the age-adjusted rate; and for the population other than white, the position of the curve for the total death rate is below that for the age-adjusted rate. This is true for both males and females of the white and other races (figures 6-9).

FIGURE 6 AGE-ADJUSTED DEATH RATES FOR ALL OTHER MALES FOR LEADING SITES OF MALIGNANT NEOPLASMS: UNITED STATES, 1950-75



FIGURE 7 NUMBER OF MEN LOST AT AGES 45-44 AND 45-74 YEARS AS A RESULT OF INCREASES IN DEATH RATES FOR MALIGNANT NEOPLASMS BETWEEN



FIGURE 8 FIGURE 8 AGE-ADJUSTED DEATH RATES FOR WHITE FEMALES FOR LEADING SITES OF MALIGNANT NEOPLASMS: UNITED STATES, 1960-75



FIGURE 9 AGE-ADJUSTED DEATH RATES FOR ALL OTHER FEMALES FOR LEADING SITES OF MALIGNANT NEOPLASMS: UNITED STATES, 1960-75



Conclusion

Despite the fact that our standard population of 1940 is no longer typical of the existing total population, should we continue to use it? We have seen that the choice of the standard definitely influences the magnitude of the index. But why should we be concerned if the curve for the age-adjusted death rate is above or below the curve for the total or unadjustedrate?

This writer agrees with Greenwood who had this to say "... If we could only persuade people that the whole process of standardization was merely to facilitate comparison, the psychological difficulty created by a choice of a wholly fictitious standard population would vanish."

References

¹Yule G. U. On some Points relating to Vital Statistics, more especially Statistics of Occupational Mortality. Journal of the Royal Statistical Society, vol. 97, pp. 1-84. 1934. ²Linder, Forrest E. and Grove, Robert D., Vital Statistics Rates in the

² Linder, Forrest E. and Grove, Robert D., Vital Statistics Rates in the United States, 1900-1940 (Washington, D.C.: Bureau of the Census, U.S. Government Printing Office, 1943).