

**VITAL and HEALTH STATISTICS**  
ANALYTICAL STUDIES

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the change in  
**Mortality Trend in the  
United States**

An analytical study of mortality trends by age, color, and sex to identify the diseases with a course of mortality causing the recent change in general mortality trend, and discussion of future prospects for further declines in mortality.

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Washington, D.C.

March 1964

U.S. DEPARTMENT OF  
HEALTH, EDUCATION, AND WELFARE  
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Public Health Service  
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# THE CHANGE IN MORTALITY TREND IN THE UNITED STATES

## INTRODUCTION

In a preliminary report,<sup>1</sup> attention was called to the recent change in the mortality trend for the United States and for a number of other countries. After a long period of decline, the trend of the crude death rate now appears to have leveled off. In the United States, the crude death rate has been more or less stationary during the period 1950-60.

The failure to experience a decline in mortality during this period is unexpected in view of the intensified attack on medical problems in the postwar years. As Spiegelman<sup>2</sup> pointed out, there has been a growth in the volume and scope of health services in prevention, diagnosis, medical and surgical therapy, and rehabilitation, and also an improvement in their quality. The rapid growth of health insurance plans has made high quality medical care readily accessible to ever increasing numbers of people. The rising level of living has resulted in improvement of work and home environment, quality and variety of food, educational attainment, and facilities for recreation. Developments in medicine arising from the exigencies of a global war have become readily available for application to civilian health problems. At no time in the history of the country have conditions appeared so favorable for health progress.

In this setting, it would seem reasonable to expect further reductions in mortality. On the other hand, the possible adverse effects on mortality of radioactive fall-out, air pollution, and other manmade hazards cannot be completely ignored.

Another consideration is the nature of mortality trends. It is obviously impossible for the death rate to decline indefinitely. At some point in time, the mortality rate must level off as it reaches the irreducible minimum. Also, with an aging population, the crude death rate may be expected to increase even if no change in age-specific death rates occurs. However, the nature of the recent changes in mortality trend does not appear to be consistent with either of these possibilities.

It is estimated that if the downward trend experienced between 1937 and 1953 had continued, over 300,000 fewer deaths would have occurred in the 5-year period, 1956-60. The estimated excess deaths (deaths in excess of the normally expected number) is about 85,000 deaths for 1961 and 131,000 deaths for 1962. The consequences of the failure of the general death rate to decline will increase with time and will have social and economic significance in terms of population growth and life expectancy.

In addition to the demographic implications, the change in mortality trend is of interest because of its possible public health significance. Mortality data have long been used as an indication of health and medical progress. They have reflected epidemic outbreaks as well as reduction in mortality from many diseases, particularly those of infectious origin. Also, the increasing

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death toll from the major chronic diseases has been made evident. If the leveling off of the death rate has resulted from failure to prevent deaths that are preventable, this is of public health significance. On the other hand, if the death rate has reached its minimum point, this is important in terms of future mortality.

In the examination of the recent change in mortality trend, several questions such as the following need to be answered.

1. Is the change in mortality trend real or due to some artifact such as change in completeness of death registration or errors in population estimation?

2. If the death rate has leveled off, what was the cause of this change?

3. Is the present stationary level of the crude death rate a transitory phase in the course of mortality, or does it mark the beginning of a new trend with the prospect of eventual upturn in mortality?

4. What implications does this change in mortality have for the future?

## GENERAL MORTALITY TREND: UNITED STATES

In the period 1900-1960, the crude death rate dropped from 17.2 to 9.5 per 1,000 population, a decrease of 45 percent. Although it is clear that

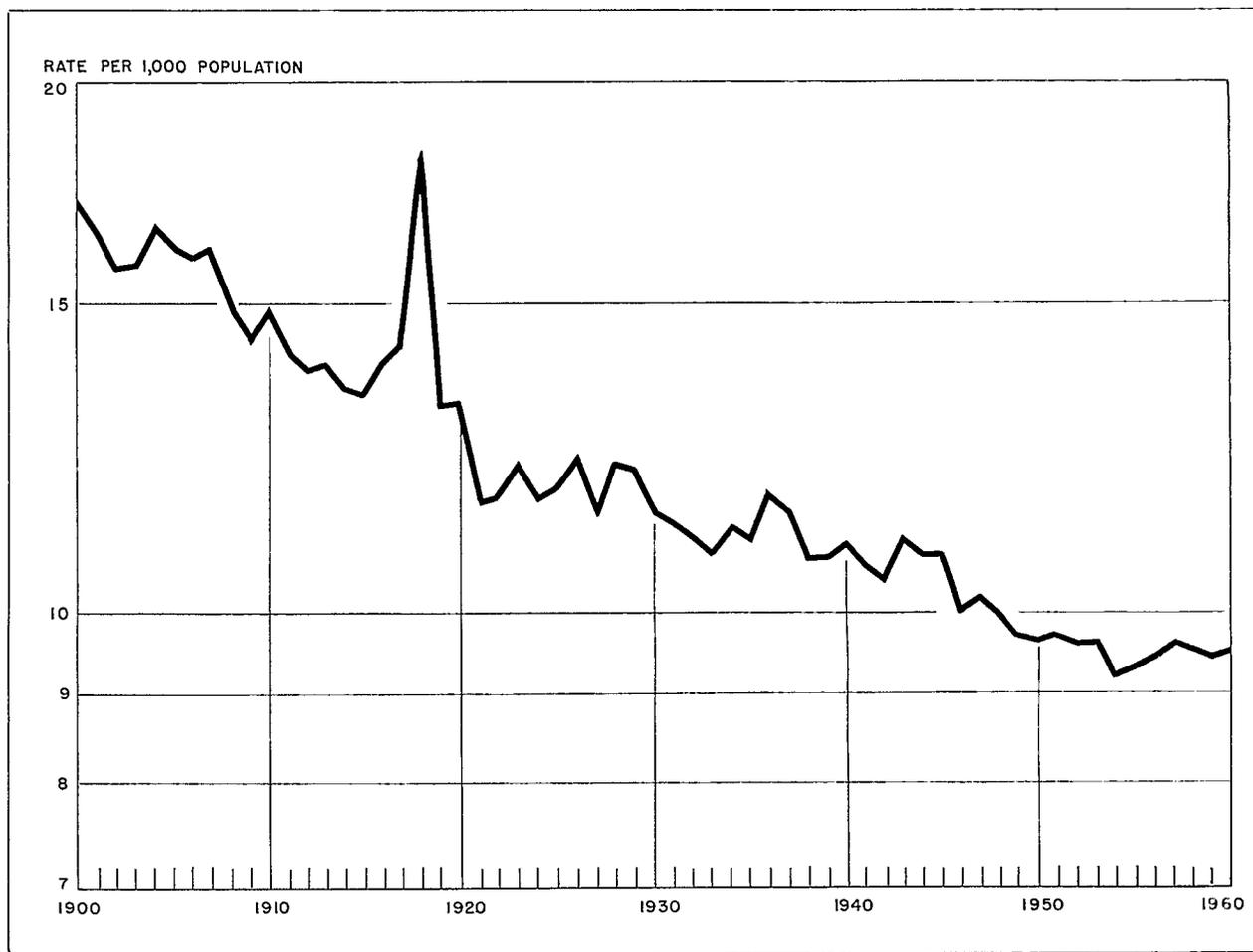


Figure 1. Crude death rates: United States, 1900-1960.

the rate of decline has not been uniform over this period (fig. 1), it is difficult to discern any well-defined series of linear trends. Part of the problem is that there is a great deal of annual variation in the crude death rate; superimposed on that is the effect of the changing age composition of the population.

A large part of the variability in the death rate is due to the frequent outbreaks of influenza occurring during this time. Collins and Lehmann<sup>3</sup> described influenza epidemics which occurred in 26 of the 33 years between 1918 and 1951. In the years 1954-60, there were two influenza outbreaks.

The excess in total mortality varied with the severity of the influenza epidemics. Also, Collins and Lehmann's study indicated a gradual diminution of the excess. Because these respiratory disease outbreaks have affected chronic disease mortality as well as influenza and pneumonia deaths, it is difficult to eliminate from the total death rate the variations due to these epidemics.

However, it is possible to adjust the annual death rates for the changing age composition of the population. This factor is significant because the crude death rate for an aging population will increase even though there is no change in basic mortality. In the period 1900-1940, the median

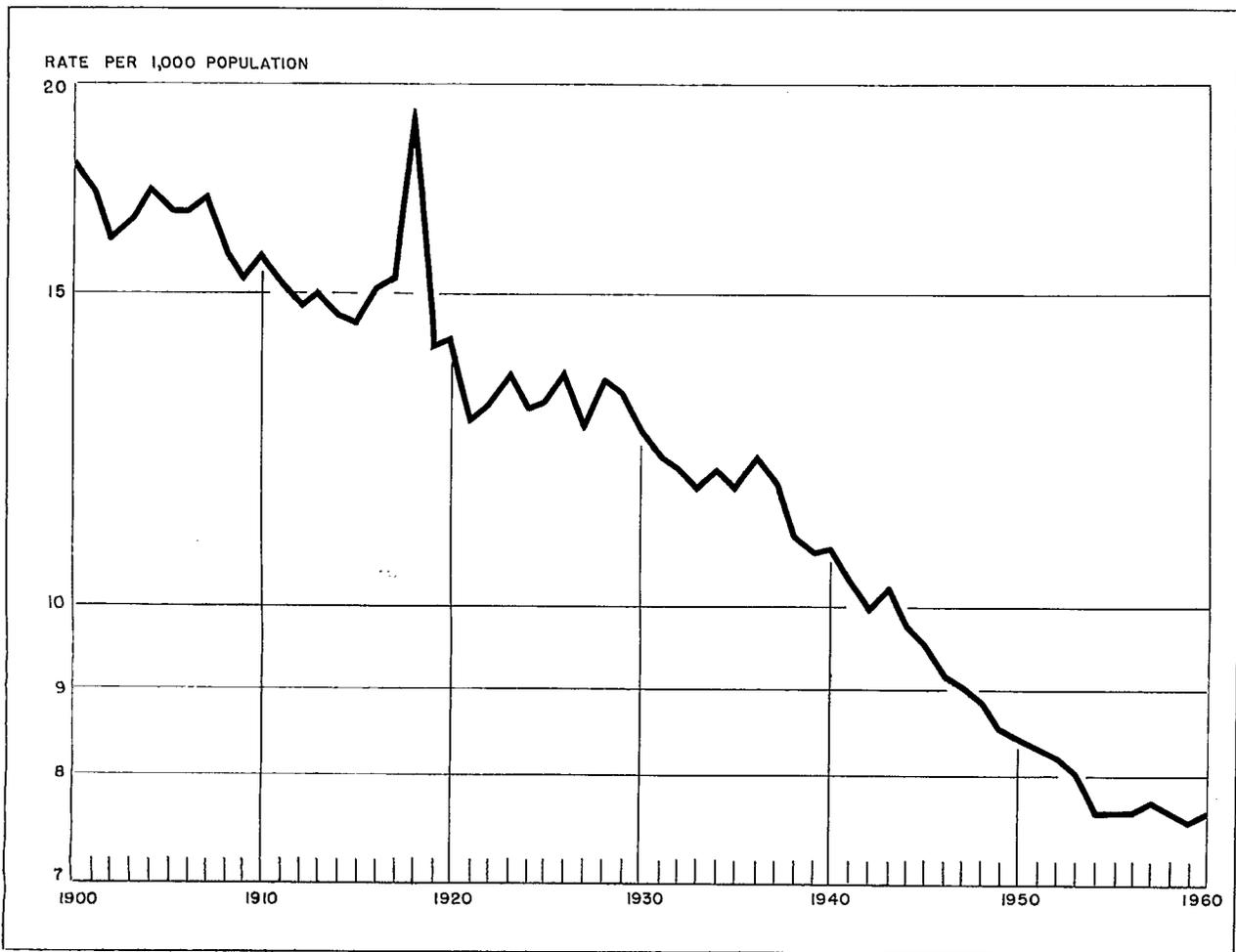


Figure 2. Age-adjusted death rates: United States, 1900-1960.

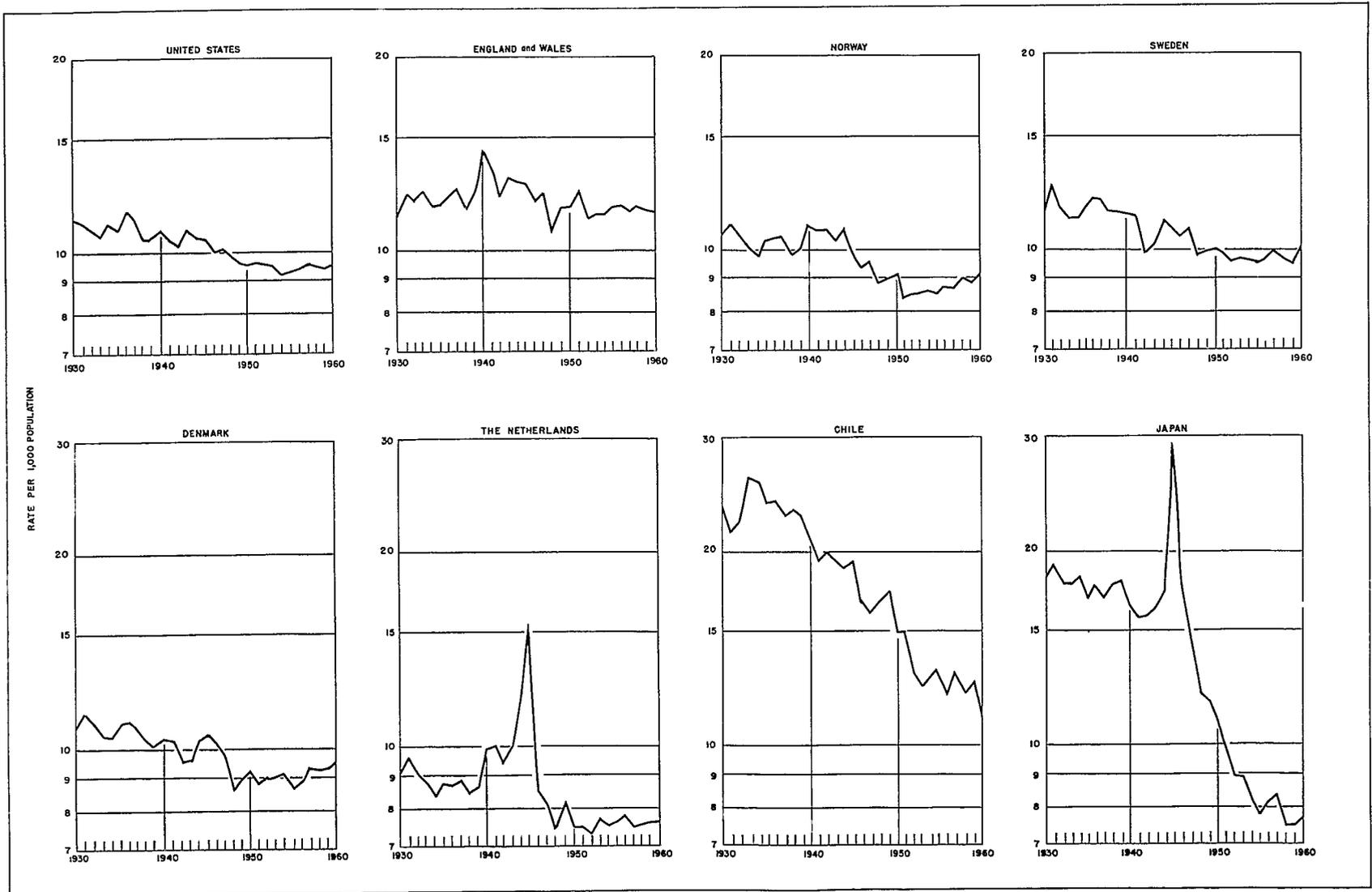


Figure 3. Crude death rates: specified countries, 1930-60.

age of the U.S. population increased continuously with the declining birth and death rates. With the change in fertility pattern with the onset of World War II, the median age of the total population has declined.

When the effects of the changing age composition are removed, the mortality trends become clearer. The age-adjusted rates show three major trends (fig. 2). The first of these is from 1900 to 1937. Starting about 1938, there was an acceleration in the downward trend which has been attributed to the introduction of the sulfonamides and antibiotic therapy. Since 1954, the death rate has leveled off.

The point of principal interest is the rapidly declining trend from 1938 to 1953 and the leveling off of the death rate after 1954 or 1955. Although there were a number of influenza outbreaks during 1938-53, Collins and Lehmann reported that the occurrences after 1940 have been small in terms of excess mortality. The years 1954 through 1960 were relatively free of influenza except for 1957-58 and 1960. It is possible that the type A<sub>2</sub> influenza virus outbreaks in these years may be responsible for the upturn in general mortality. However, according to estimates made by Eickhoff, et al.,<sup>4</sup> the excess mortality from the recent influenza outbreaks ranged between 20,000 and 39,300 per year. Annual excesses of this magnitude would not account for the observed leveling off of the general death rate.

## INTERNATIONAL MORTALITY TRENDS

Examination of mortality trends for a number of countries shows that the United States is not alone in exhibiting a change in trend in recent years (fig. 3). Several countries experienced excess mortality during the war years, but in the postwar years there was a resumption of the downward trend of the prewar period. During the last decade, however, there has been a marked slowing down in the rate of decline. In some countries, such as Norway, the Netherlands, and Denmark, the movement of the death rate in recent years has been distinctly upward. In others, such as Canada (not included in chart), the crude

death rates do not show any clear tendency. However, the age-adjusted death rates have leveled off for both sexes since 1954.<sup>5</sup>

The mortality figures that were examined for the different countries are crude death rates. Therefore, some of the recent changes could be attributed to changing age composition of the population. However, the age-specific death rates for England and Wales, for example, show that the death rates for the ages under 45 years are leveling off in much the same way as the rates for the United States. Also, the age-specific rates for Norway, Sweden, Denmark, Finland, and the Netherlands have changed in recent years. Even countries with a relatively high mortality such as Chile show the same kind of mortality experience.

## MORTALITY TRENDS BY STATE

Analysis of mortality trends for individual States is limited to the examination of crude death rates because population estimates by age, sex, or color are not available annually on a consistent basis. Nevertheless, it will be useful to look at the crude death rates to determine the geographic pattern, if any, of mortality trends.

Because of the unusual variations in the crude death rates for a number of States, it is difficult to make a satisfactory determination of the trend for all of the States. It is particularly difficult to categorize in a satisfactory and consistent manner the character of the trend shown in table 1. Yet, it seems clear that the crude death rate has leveled off in virtually all of the States. Even for New Jersey, Pennsylvania, Nebraska, and Hawaii—the States where there is no clear-cut trend over a long-time period—the crude death rate in the past 10 years has been relatively flat.

In 43 of the States and the District of Columbia, the crude death rates have leveled off or are increasing after a period of decline. In the majority of these States (31) the movement of the death rates in recent years has been level or only slightly upward. The trend for Indiana is more or less typical of this large group of States (fig. 4). In 12 States and the District of Columbia there appears to be a marked rise in the crude death rate during the past 5 to 10 years, as represented by the trend for North Carolina. These are mostly southern States, but the West North

Table 1. States showing changes in trend of death rates: 1935-60

A. Relatively rapid increase after period of decline

Alabama	Nevada
Arkansas	North Carolina
Colorado	South Carolina
District of Columbia	South Dakota
Louisiana	Tennessee
Missouri	West Virginia
	Wyoming

B. Leveled off or slight rise after period of decline

Alaska	Maine	Ohio
Arizona	Maryland	Oregon
Connecticut	Massachusetts	Rhode Island
Delaware	Michigan	Texas
Florida	Minnesota	Utah
Georgia	Mississippi	Vermont
Idaho	Montana	Virginia
Indiana	New Hampshire	Washington
Iowa	New Mexico	Wisconsin
Kansas	New York	
Kentucky	North Dakota	

Central and the Mountain States are also represented in this group.

In only two States, California and Illinois, does it appear that the crude death rates are still declining. The crude death rate for California dropped rapidly during the period 1935-54, but since then the downward movement of the death rate has slowed down. Oklahoma is the only State which has exhibited a long-term upward trend.

Some of the increase in mortality may be associated with the population change which occurred during the decade 1950-60. In some States there has been a significant increase in the proportion of elderly persons in the population; in others, the proportion of Negroes has increased. In both situations, the crude death rate will tend to increase. However, the demographic changes that have taken place during the past decade do not offer a clear and consistent explanation of the course of the crude death rate in the individual States. Also, it seems apparent that the recent change in mortality trend is not limited to any particular geographic subdivision. Unless the change in the

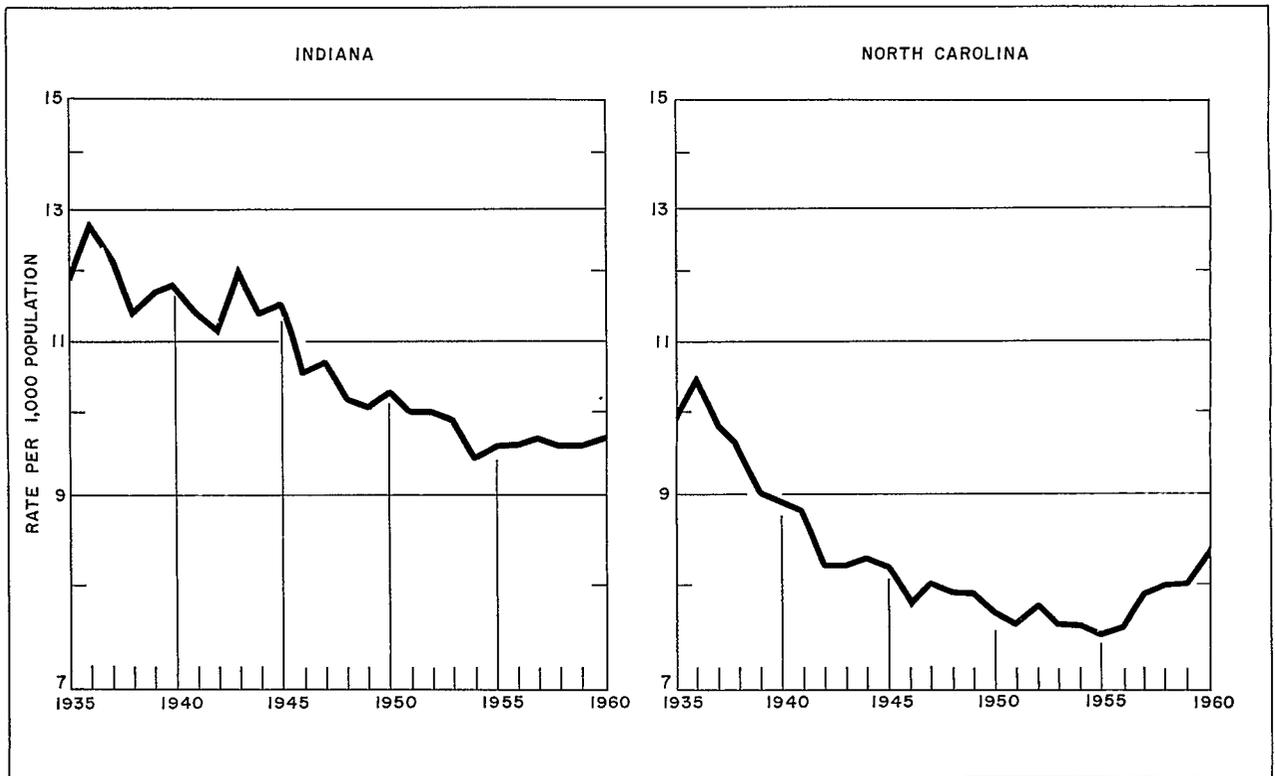


Figure 4. Crude death rates: specified States, 1935-60.

crude death rate can be attributed to aging of the population or some other demographic factor, it would seem that the reason or reasons for the change in trend lie in some condition operating across the country. Another significant point is that the change in trend appears to have taken place regardless of the level of the crude death rate for the individual State.

## TREND OF DEATH RATES BY AGE

Both the crude death rate and the age-adjusted death rate are composite measures weighted heavily by the population in the older age groups. Age-specific death rates are not subject to the same kind of problem and are more informative in tracing the course of mortality.

In an earlier report, it was observed that there was a marked deceleration in the rate of decline of the infant mortality rate (fig. 5). Be-

ginning about 1950, the rate of decrease in infant mortality dropped to about one-third of the rate of decline experienced in the preceding 17-year period. The mortality experience of white infants followed the trend for all infants, whereas the deceleration in the trend for nonwhite infants was even more marked. Between 1950 and 1960 the infant mortality trend was virtually flat. For white infants the neonatal mortality trend changed significantly, and the postneonatal trend was affected only slightly. For the nonwhite infants, both the postneonatal and the neonatal mortality trends showed a marked decrease in the rate of decline, with the latter leveling off.<sup>6</sup>

Since the change in the infant mortality trend has been a subject of special study, the examination of the age-specific death rates will be limited to those of other ages. As may be seen in figure 6, the same kind of change in trend observed for infants appears to be taking place in the death rates for other ages.

In order to gain a better understanding of the nature of the mortality trends by age, the logarithms of the death rates for the various age-color-sex groups were fitted with a straight line by the method of least squares taking 1937 as the starting point. This was the year when the downward trend in the death rate began to accelerate. The end point of the trend for this period of rapid decline was determined by eye. A second trend line was fitted for the remainder of the period up to 1960. This represents the period when deceleration in the downward trend of the death rates occurred.

Presented in table 2 are the slopes of the trend lines for the two periods (designated as periods I and II) expressed in terms of average percent change per year, and the results of tests of significance between the slopes for the two periods. These measures indicate generally the rapid rate of decline in the death rate, especially for the younger ages, starting in 1937, and the deceleration of the downward trend in the 1950 decade for most age groups.

The downward trend for every age group has slowed down for the white population. For white males, there are signs of a reversal in the trend of the death rates for the age groups between 45-74 years and 85 years and over with the rates rising in the period 1954-60. The mortality trend

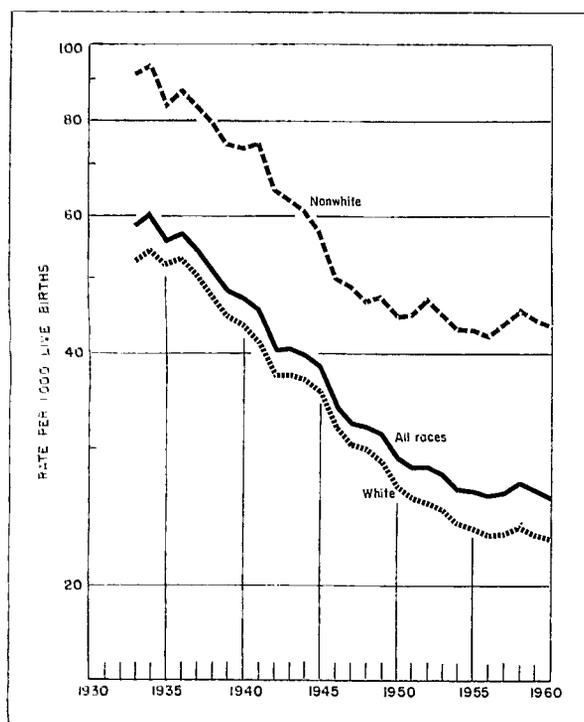


Figure 5. Infant mortality rates by color: United States, 1933-60.

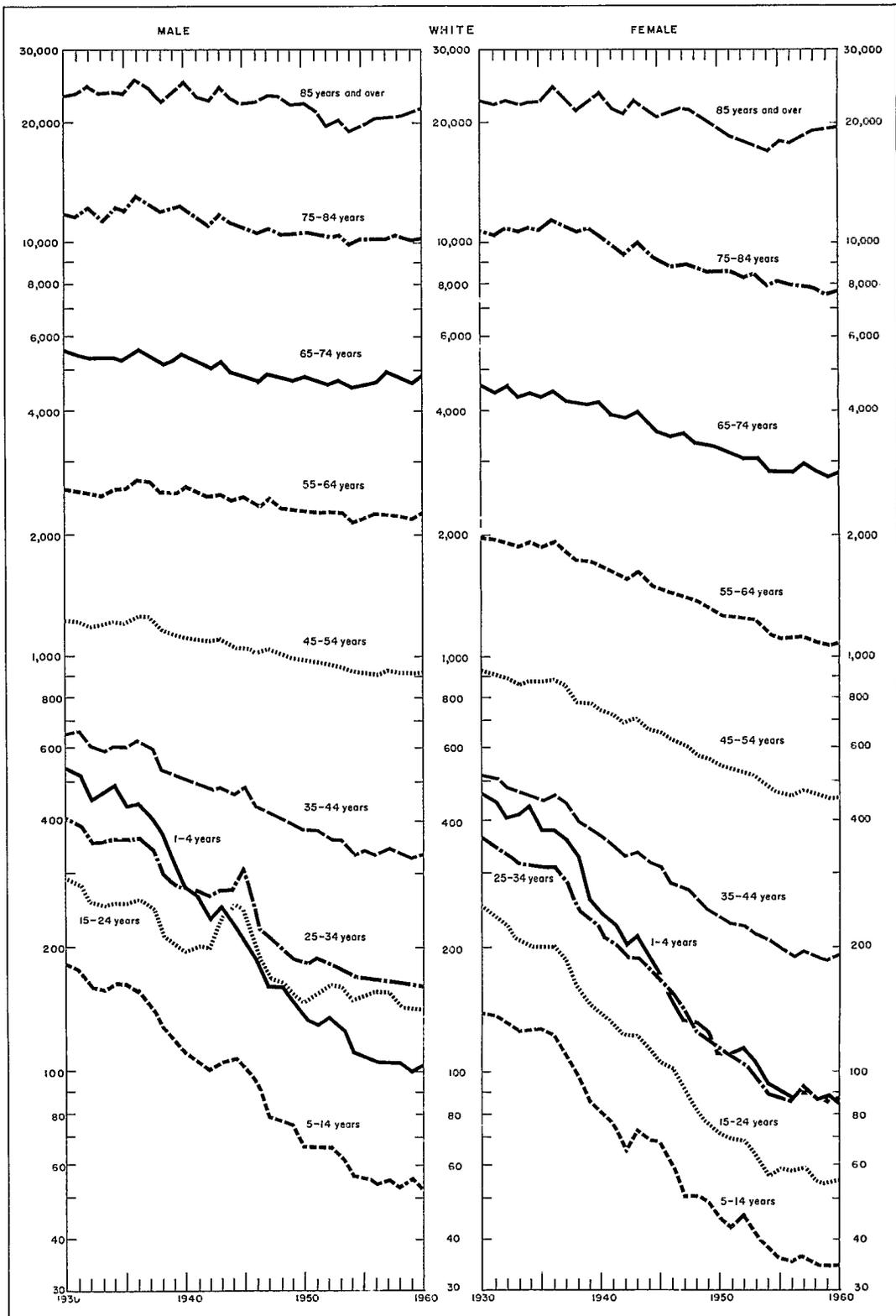


Figure 6A. Death rates per 100,000 population, by age and sex for the white population: United States, 1930-60.

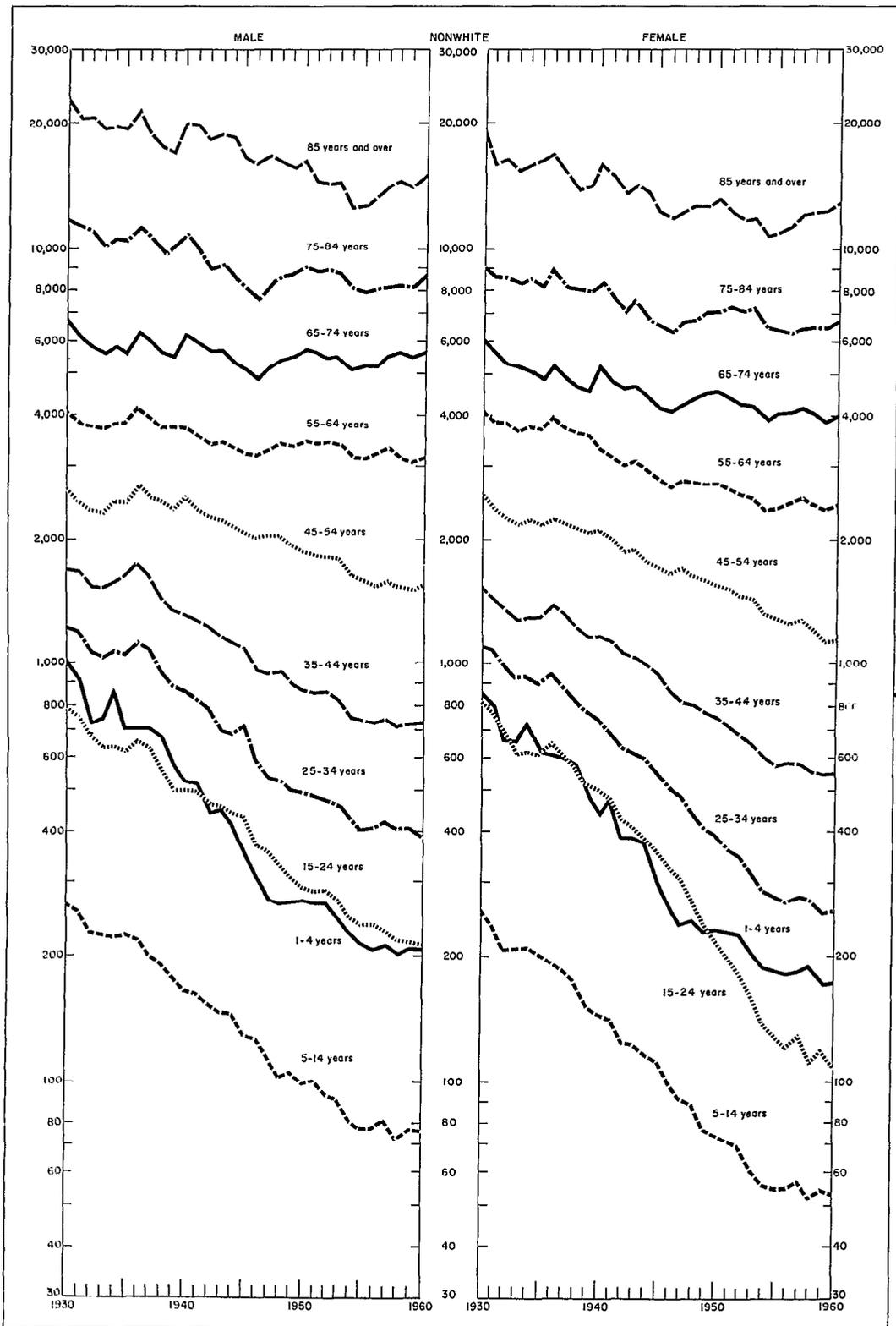


Figure 6B. Death rates per 100,000 population, by age and sex for the nonwhite population: United States, 1930-60.

Table 2. Change in mortality trend by age, color, and sex: United States, 1937-60

Age	White					Nonwhite				
	Period I		Period II		Significance level of difference in slopes	Period I		Period II		Significance level of difference in slopes
	Years	Rate of decline in percent	Years	Rate of decline in percent		Years	Rate of decline in percent	Years	Rate of decline in percent	
<b>Male</b>										
1-4-----	1937-50	-7.7	1954-60	-1.5	.001	1937-49	-8.3	1954-60	-0.8	.001
5-14-----	1937-54	-4.9	1955-60	-1.1	.05	1937-55	-5.0	1956-60	-1.2	.05
15-24-----	(a)	(a)	(a)	(a)		1937-53	-5.0	1954-60	-2.2	.05
25-34-----	1937-54	-3.9	1955-60	-0.6	.05	1937-53	-5.1	1954-60	-1.0	.001
35-44-----	1937-54	-2.9	1955-60	-0.3	.05	1937-54	-4.0	1955-60	-0.4	.001
45-54-----	1937-55	-1.5	1956-60	+0.5	.05	1937-53	-2.3	1954-60	-0.8	.001
55-64-----	1937-53	-0.6	1954-60	+0.3	.05	1937-46	-2.4	1947-60	-0.7	.001
65-74-----	1937-53	-0.9	1954-60	+0.8	.001	(a)	(a)	(a)	(a)	
75-84-----	1937-49	-1.5	1950-60	-0.3	.001	(a)	(a)	(a)	(a)	
85+-----	1947-54	-2.9	1955-60	+1.8	.001	1940-52	-2.6	1955-60	+2.9	.001
<b>Female</b>										
1-4-----	1937-51	-8.0	1955-60	-1.3	.001	1937-49	-8.3	1954-60	-1.4	.001
5-14-----	1937-54	-5.6	1955-60	-0.8	.05	1937-55	-6.4	1956-60	-1.0	.001
15-24-----	1937-54	-6.3	1955-60	-1.8	.001	1937-53	-7.9	1954-60	-3.6	.001
25-34-----	1937-54	-6.3	1955-60	-0.6	.001	1937-53	-6.2	1954-60	-1.5	.001
35-44-----	1937-54	-4.3	1955-60	-0.8	.001	1937-55	-4.4	1956-60	-2.1	.05
45-54-----	1937-55	-3.1	1956-60	-0.4	.001	(b)	(b)	(b)	(b)	
55-64-----	1937-53	-2.5	1954-60	-1.0	.001	1937-46	-3.6	1947-60	-1.3	.001
65-74-----	1937-53	-2.2	1954-60	-0.7	.001	(a)	(a)	(a)	(a)	
75-84-----	1937-49	-2.1	1950-60	-1.1	.001	(a)	(a)	(a)	(a)	
85+-----	1947-54	-3.4	1955-60	+2.0	.001	(a)	(a)	(a)	(a)	

(a) Trend lines not fitted. (b) No change in slope.

for the age group 75-84 years does not fit the pattern of rates for the adjoining age groups in that the death rates are still decreasing, although at a slower pace. Also, the decrease in the rate of decline began 4 or 5 years earlier.

The mortality trends for the nonwhite population have also changed. The only exception to this is the trend for females 45-54 years of age which shows a constant rate of decline through the whole period. The death rates for nonwhite males have leveled off during this past decade in every age group up to 55 years of age. At the older ages, and this applies also to the trends for nonwhite females, clear-cut trends are not discernible because the death rates exhibit a pronounced cyclical type of variation. Trend lines were not fitted to these data. However, generally speaking, the death rates in the older ages decreased rather rapidly from 1937 to about 1946 or 1947 after which the general trend has been declining more slowly or remaining relatively flat. An exception to this is the trend for white males 85 years and over, which declined fairly regularly from 1946 to 1954 and now appears to be rising.

The point at which the rate of decline started to change cannot be determined with precision, but generally speaking the trend for period II began about 1954 or 1955. This is true even of the death rates for the age group 1-4 years despite the fact that the observed death rates started to

deviate from the trend for period I about 1950 or 1951. The assumption of the second trend (period II) did not begin until several years later—in 1954 or 1955.

There are exceptions to this general rule. Period II trends for infants and white persons in the 75-84 year age group started about 1950. Period II trends for nonwhite males and females in the age group 55-64 years began earlier still, about 1947.

## TREND OF DEATH RATES BY CAUSE

There has been a notable shift in the pattern of mortality trends over the years. The death rate for many diseases of infectious origin which were once major public health problems has dropped to a low level. Improved sanitation, immunization, and new therapeutic procedures have all but eliminated a number of these diseases as causes of death. With the decline in mortality from the infective and parasitic diseases, the relative importance of accidental injuries and the chronic diseases as causes of death has increased.

The general mortality trend is the resultant of trends for various diseases, and the degree to which a particular disease influences the general trend depends upon the relative frequency of deaths involved. Although there are certain problems in interpretation of trends for various disease cat-

egories, the study of these trends may provide some clues to the problem of change in the general mortality trend.

## METHOD OF ANALYSIS

In examining mortality trends for various diseases and conditions, it did not appear practicable to study each disease category since rates based on small frequencies would not contribute much to the total death rate. Therefore, the examination was limited chiefly to trends of five principal causes of death. In addition, the trend for the infective and parasitic diseases (International Classification of Diseases Numbers 001-138) as a group was selected for study; another group selected was diseases of the respiratory system, excluding influenza and pneumonia (ICD Nos. 470-475, 500-527). In grouping diseases, it is recognized that significant changes in the trends for specific diseases will be obscured.

There does not appear to be a clear-cut method of evaluating, in an objective manner, effects of trends for specific diseases on the trend of the overall death rate. One approach considered was the exclusion of death rates for certain causes of death from the death rate for all causes. This would have eliminated any variation in the trend for specific diseases excluded from the total death rate. On the other hand, this procedure would have introduced an artificiality through the assumption of zero mortality from certain diseases. Also, the successive exclusion of death rates for various diseases would reach a point of absurdity when the trend for "all remaining causes" included only a fraction of the total deaths.

The approach used was to examine the declining trends of mortality from specific diseases. When the downward trend is linear, it may be assumed that the trend for that particular disease had no direct bearing on the leveling off of the total mortality trend. On the other hand, when there has been a significant change in the rate of decline in recent years, this would have contributed to the leveling off of the total mortality trend. The amount of contribution is the difference between the expected death rate (assuming a continuous downward trend) and the observed death rate. This difference represents the amount the general mortality trend would have declined if the trend for a particular disease had not changed.

Conceptually, there does not appear to be any serious objection to this approach. However, because of the variations in the death rates, there are some practical problems in determining precisely the endpoints of the linear portion of the trend. Some subjectivity is involved in making this determination from the graphic representation of the death rates. In most cases, the differences resulting from fitting one trend line or another would not be very great because the death rates for these problem cases are relatively low. However, when significantly large discontinuities appeared in the mortality trend for certain population subgroups, the projection of the earlier trend sometimes resulted in expected death rates which were consistently higher than the observed rates for a series of years. This method of analysis was abandoned when this occurred.

Because the causes of death differ by age and color, the course of mortality for the principal causes of death in each age and color group was examined. Of particular interest were those trends that contributed materially to the downward trend of the overall mortality between the late 1930's and 1960, especially if these trends leveled off in recent years. Also of interest was the mortality experience in the same period where the trends for the principal causes of death are flat or rising. The significance of the contribution of deaths from the various diseases or conditions to the total mortality will depend upon the frequency of deaths involved.

Figures 7 through 12 show the mortality trends for the causes of death to which frequent references will be made.

### Age Group 1-4 Years

In 1940, pneumonia and influenza, accidents, the major cardiovascular diseases, and diarrhea and enteritis accounted for about one-half of the deaths in the 1-4 year age group. Tuberculosis, diphtheria, whooping cough, and dysentery contributed an additional 13 percent.

The death rate for all of these causes of death, with the possible exception of accidents among nonwhites, declined substantially in the 20-year period following 1940. The drop in the tuberculosis death rate has been rapid, with a marked

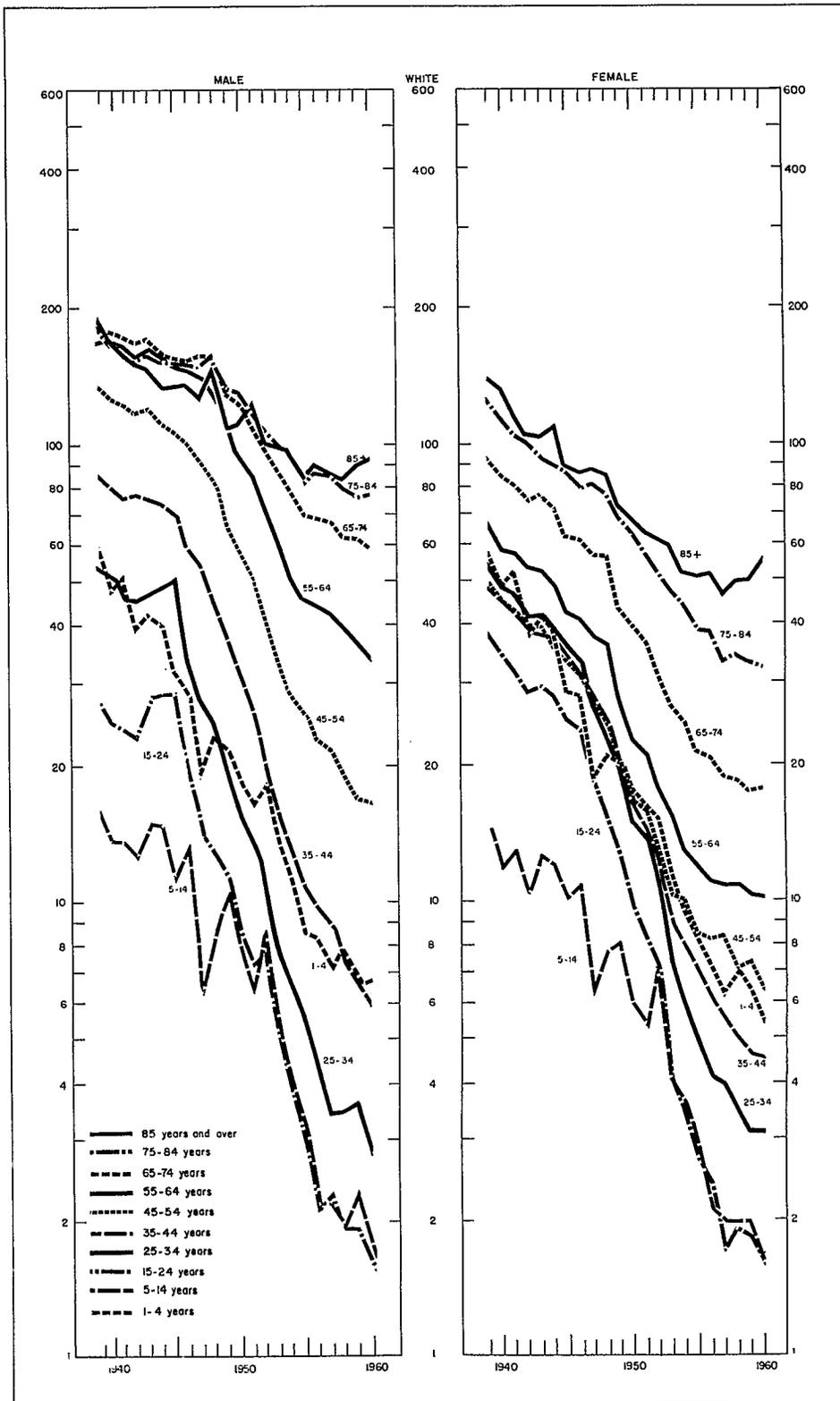


Figure 7A. Death rates per 100,000 population for infective and parasitic diseases, by age and sex for the white population: United States, 1939-60.

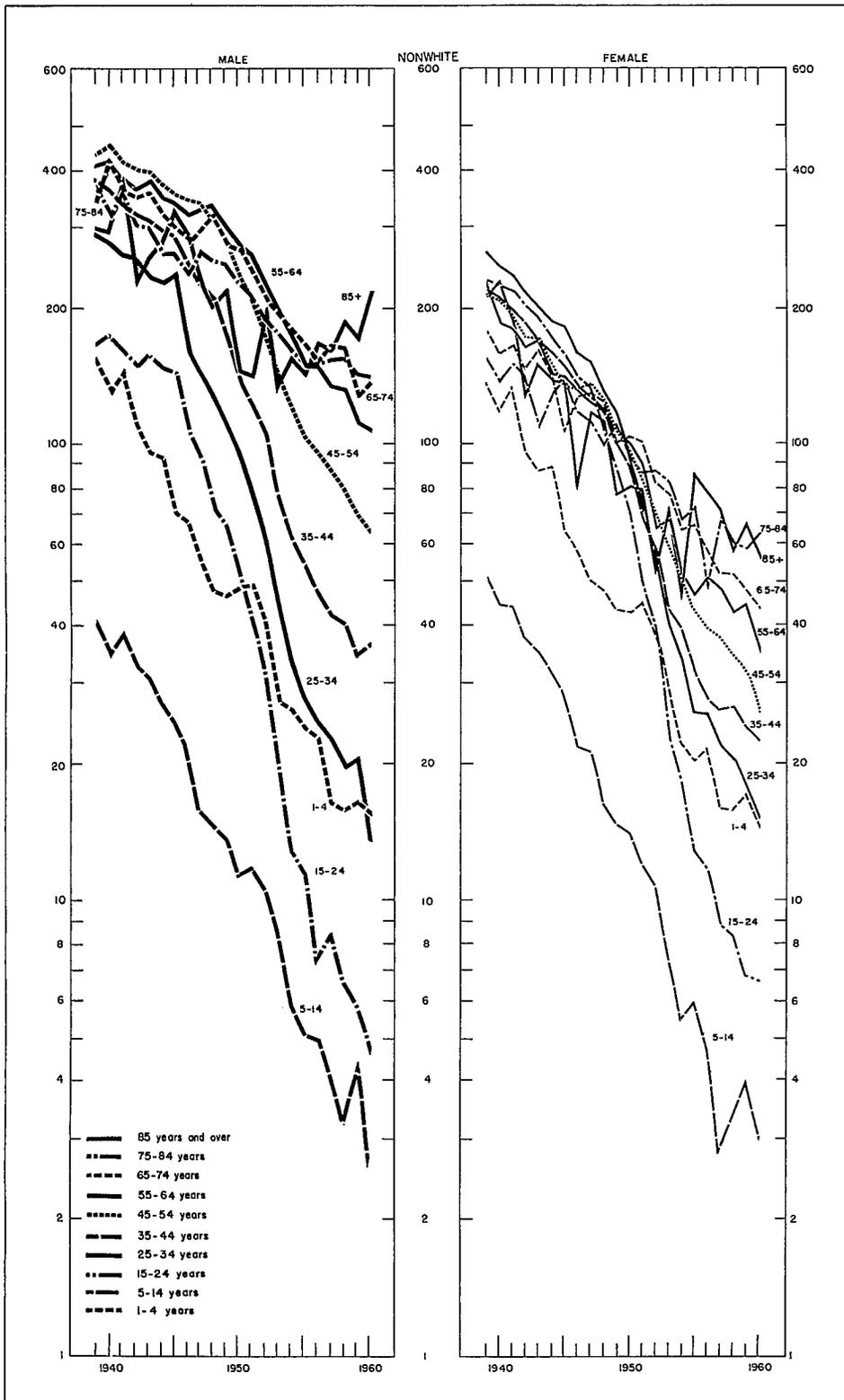


Figure 7B. Death rates per 100,000 population for infective and parasitic diseases, by age and sex for the nonwhite population: United States, 1939-60.

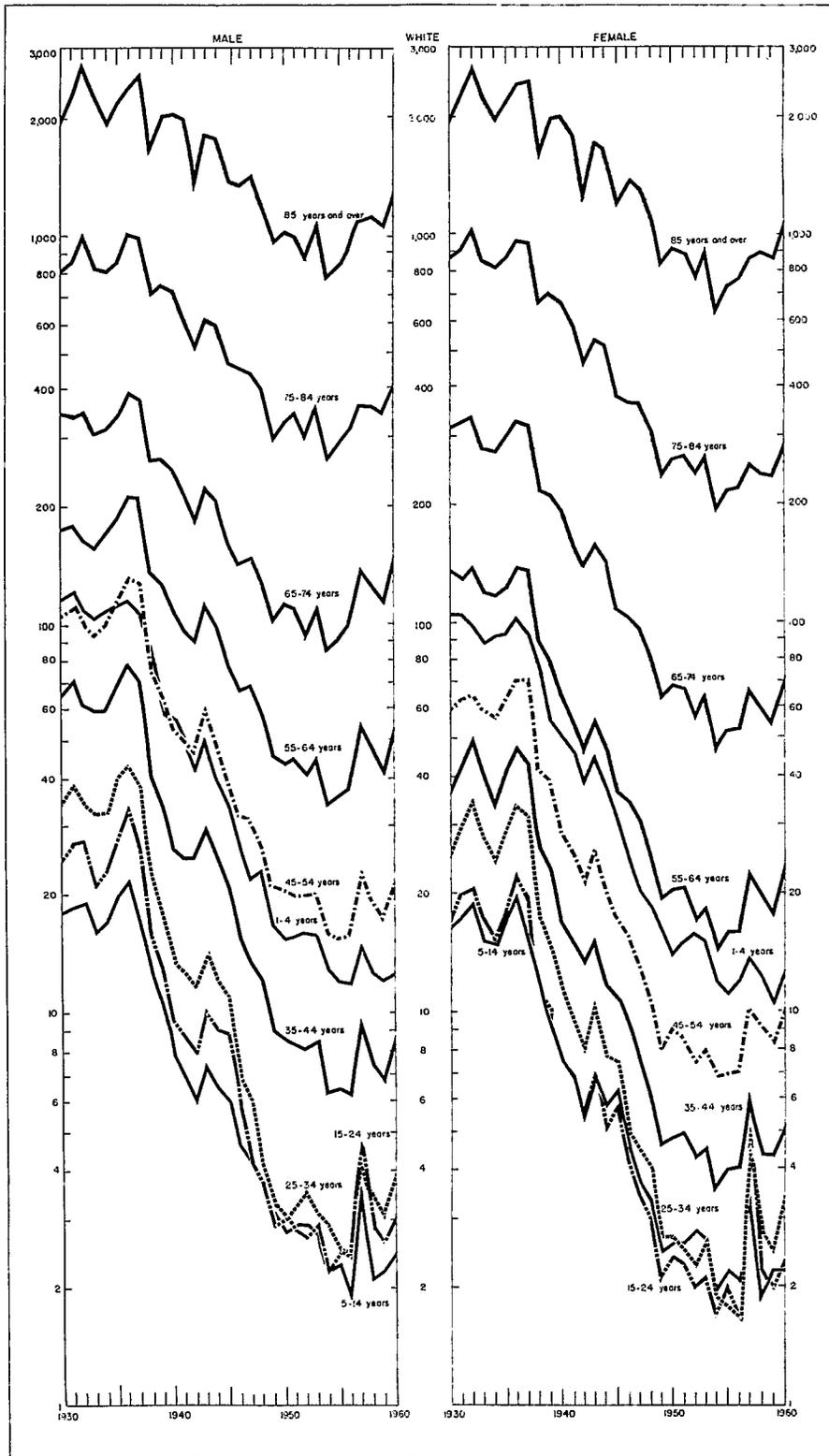


Figure 8A. Death rates per 100,000 population for influenza and pneumonia, by age and sex for the white population: United States, 1930-60.

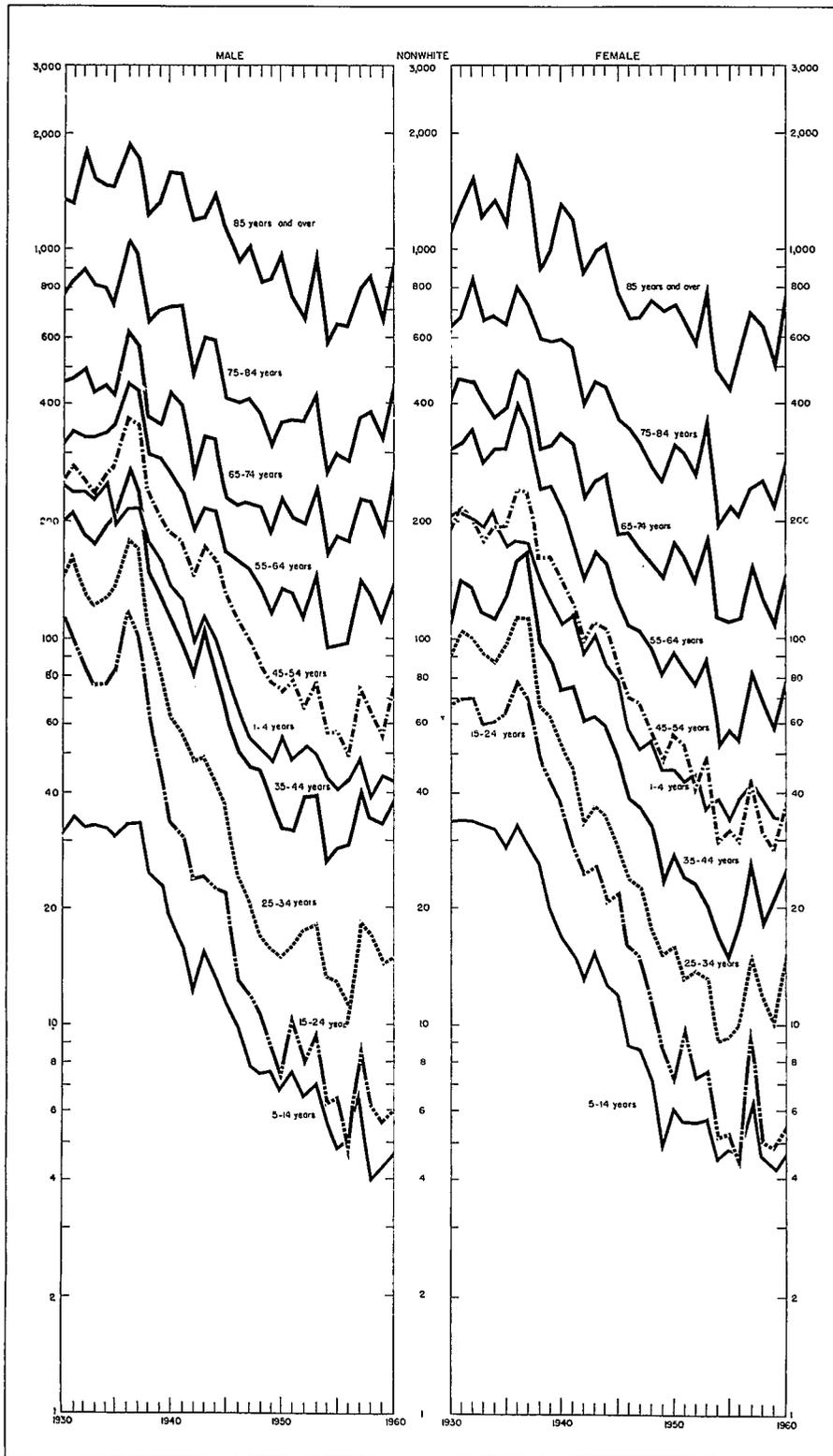


Figure 8B. Death rates per 100,000 population for influenza and pneumonia, by age and sex for the nonwhite population: United States, 1930-60.

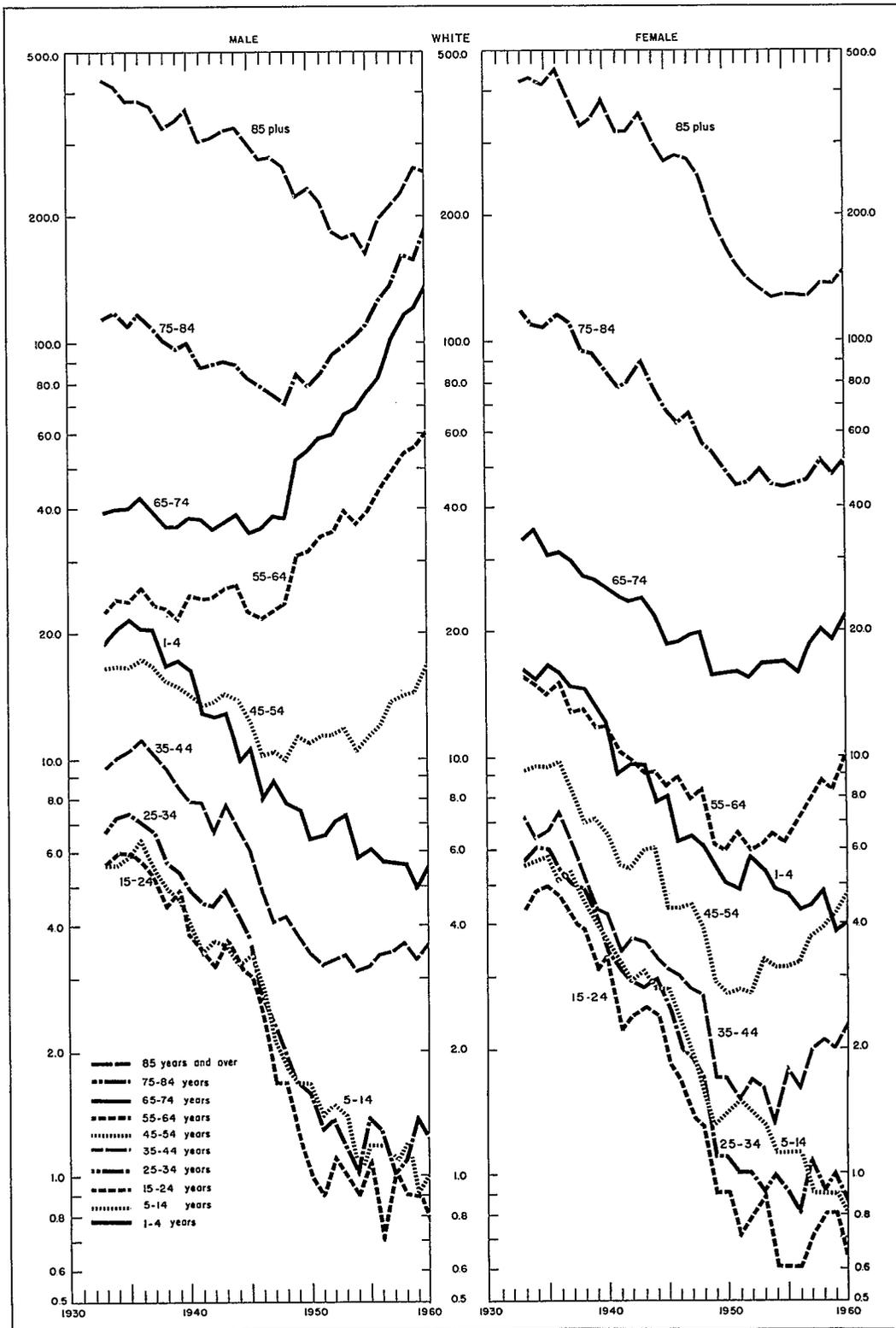


Figure 9A. Death rates per 100,000 population for diseases of the respiratory system excluding influenza and pneumonia, by age and sex, for the white population: United States, 1933-60.

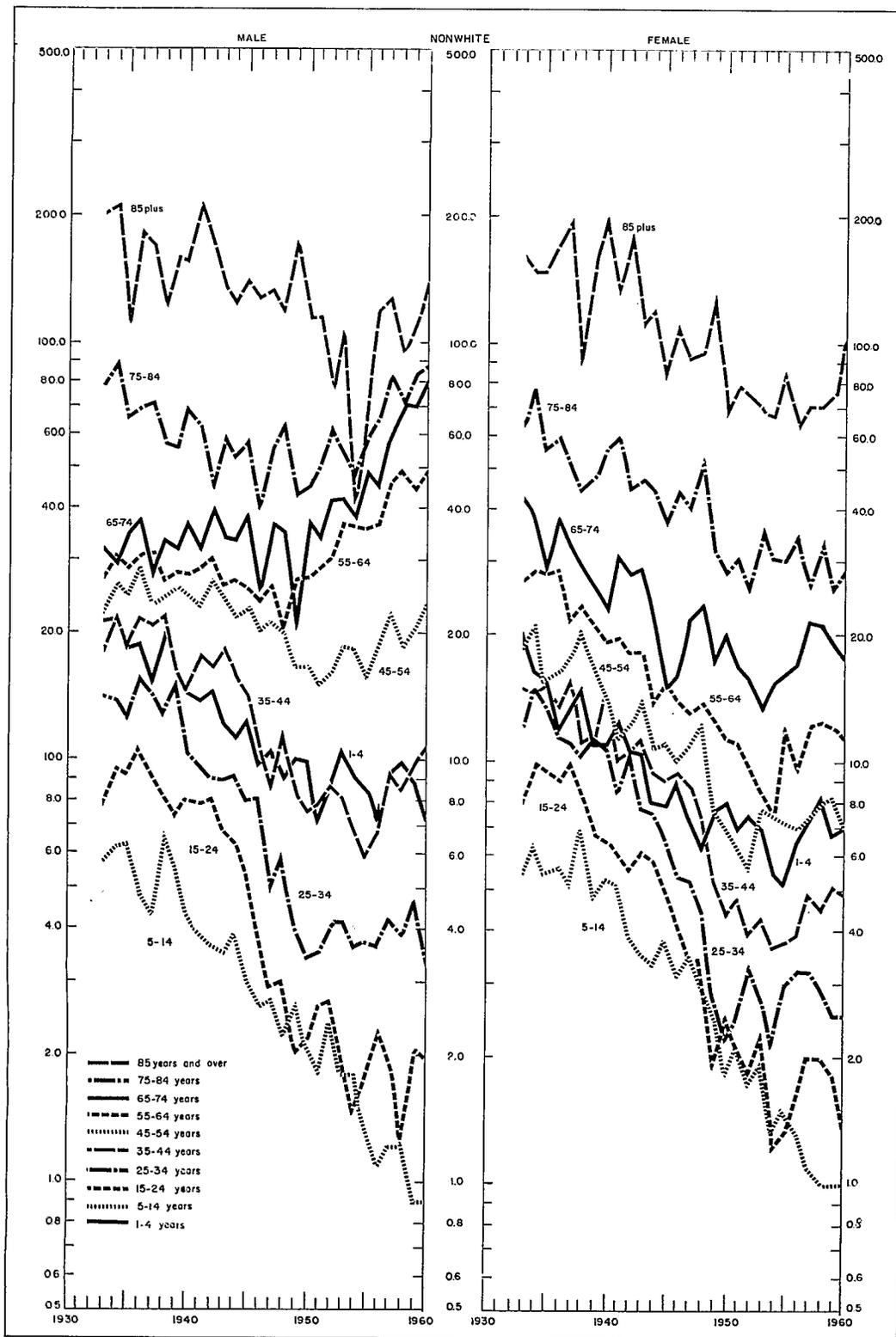


Figure 9B. Death rates per 100,000 population for diseases of the respiratory system excluding influenza and pneumonia, by age and sex, for the nonwhite population: United States, 1933-60.

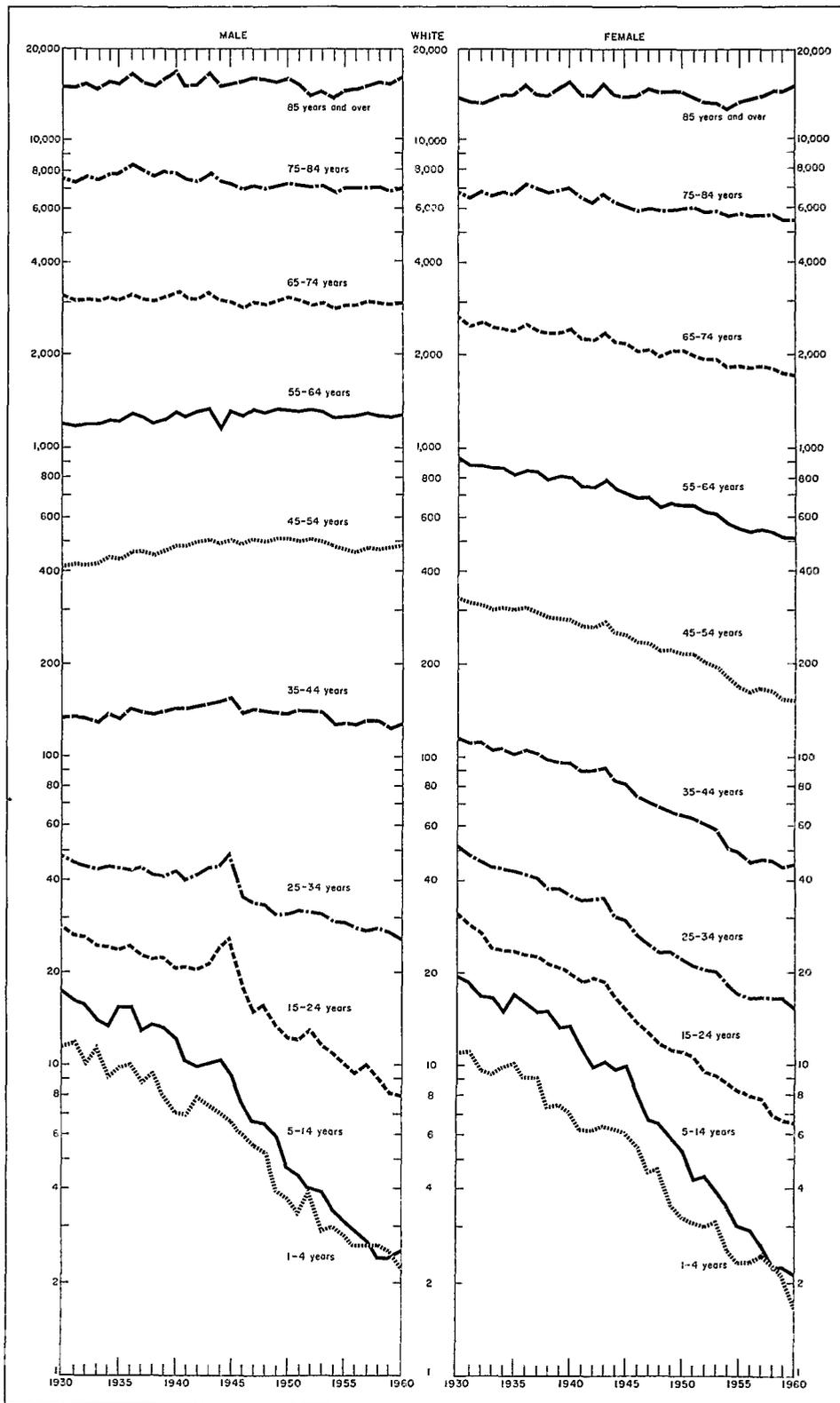


Figure 10A. Death rates per 100,000 population for major cardiovascular-renal diseases, by age and sex for the white population: United States, 1930-60.

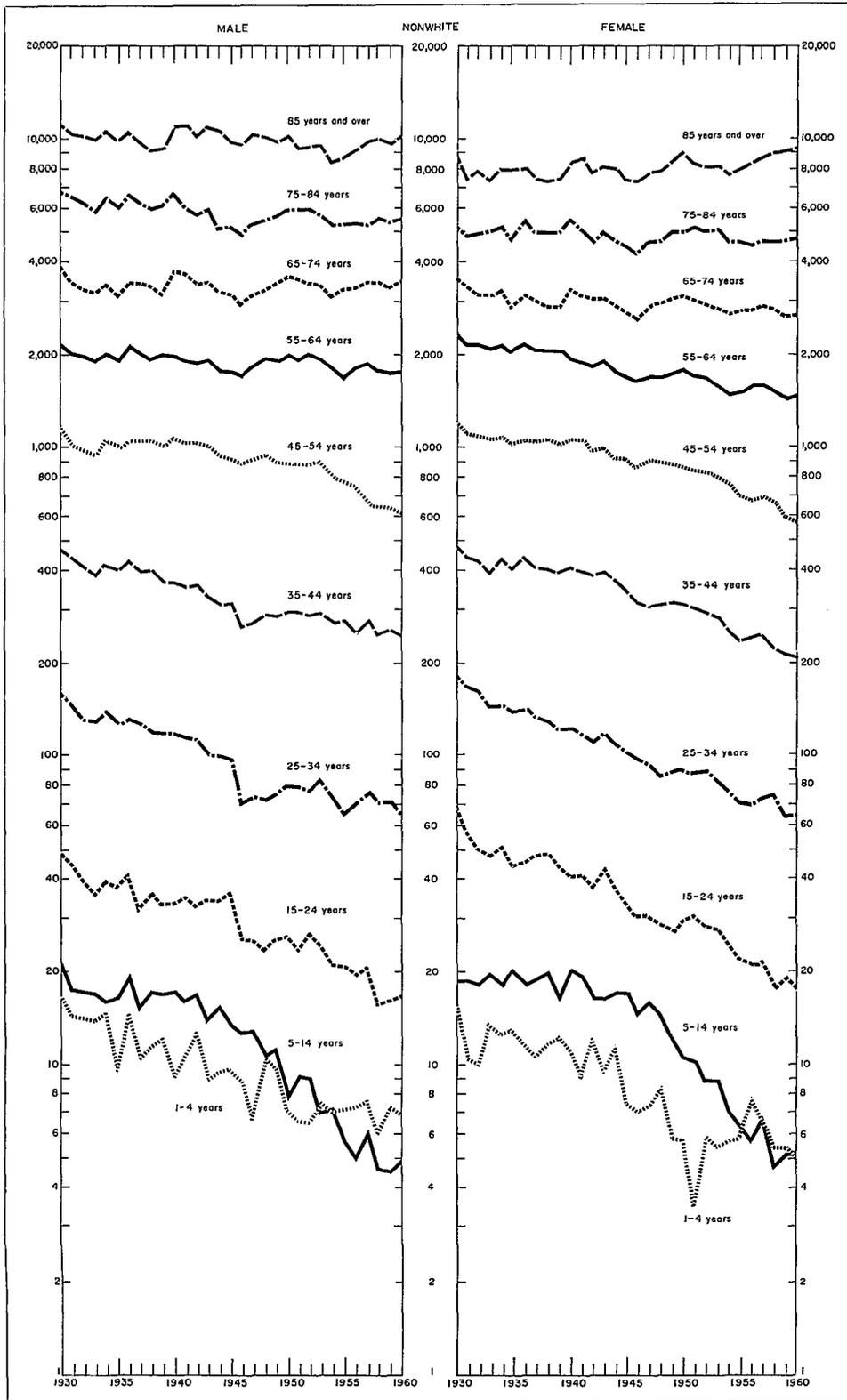


Figure 10B. Death rates per 100,000 population for major cardiovascular-renal diseases, by age and sex for the nonwhite population: United States, 1930-60.

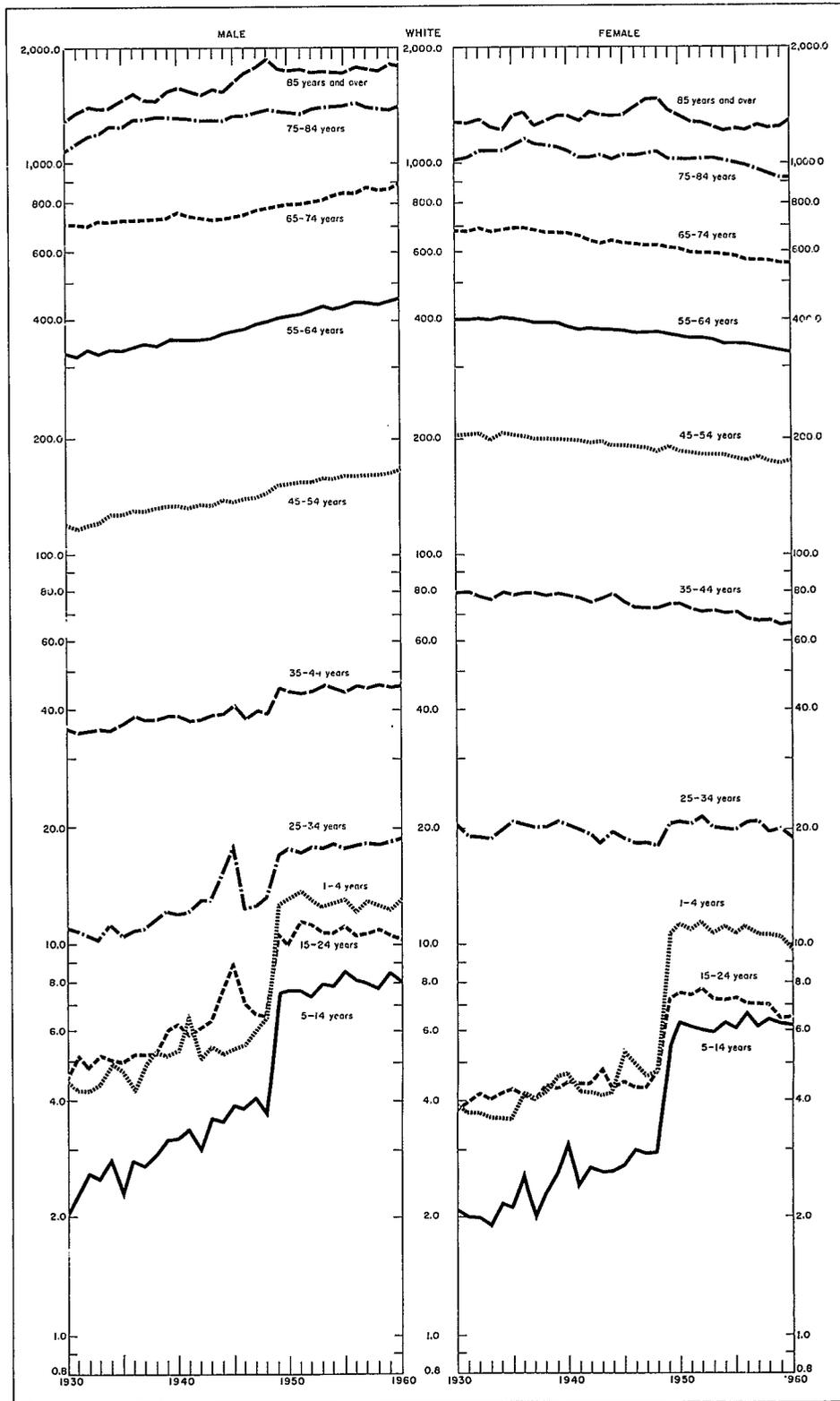


Figure 11A. Death rates per 100,000 population for malignant neoplasms, by age and sex for the white population: United States, 1930-60.

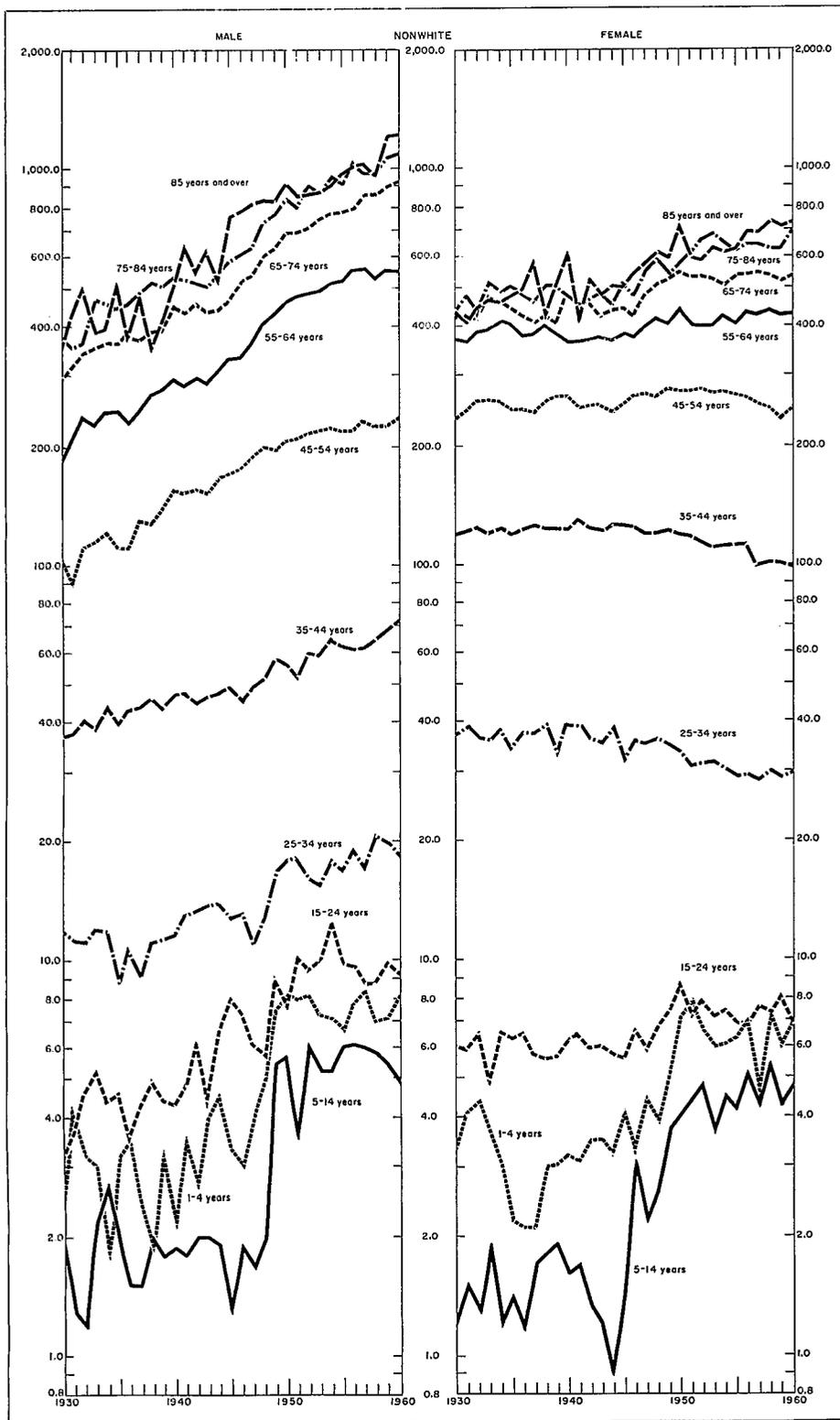


Figure 11B. Death rates per 100,000 population for malignant neoplasms, by age and sex for the nonwhite population: United States, 1930-60.

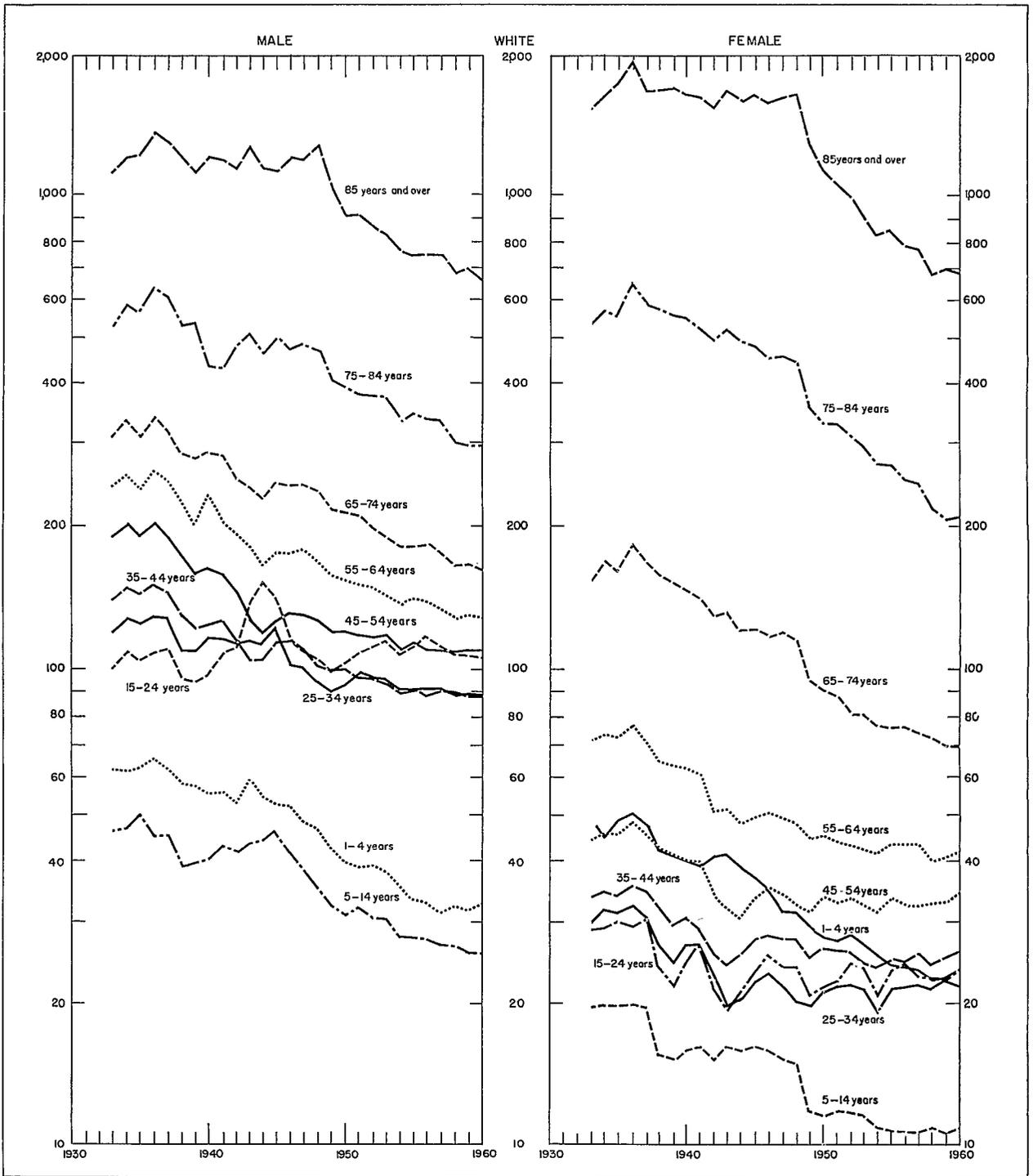


Figure 12A. Death rates per 100,000 population for accidents and other violence, by age and sex for the white population: United States, 1933-60.

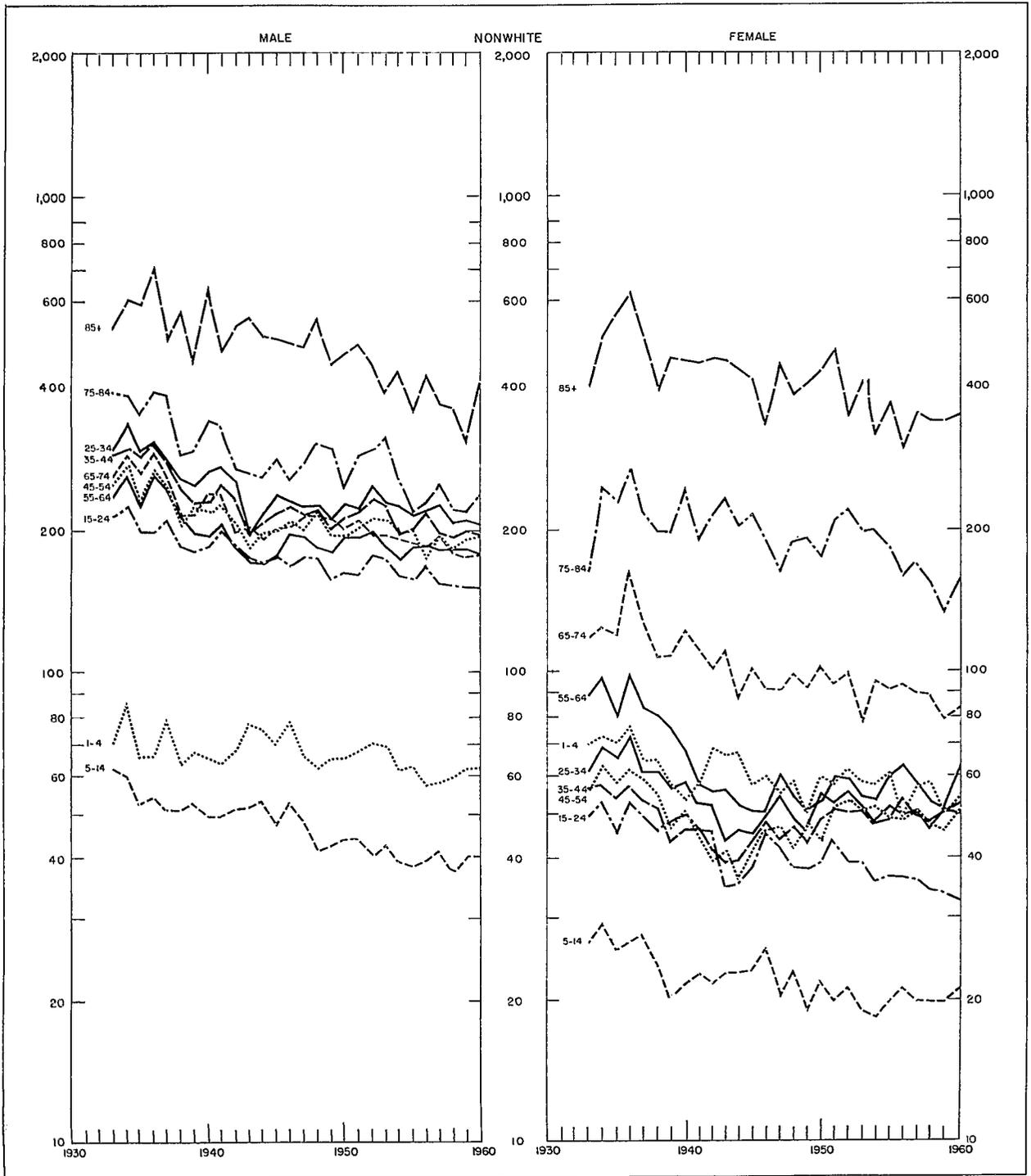


Figure 12B. Death rates per 100,000 population for accidents and other violence, by age and sex for the nonwhite population: United States, 1933-60.

acceleration in the rate of decline after 1950. However, the trend for the group of total infective and parasitic diseases is declining essentially in a straight line on a logarithmic scale. On the other hand, there has been a slowing down in the decline in the death rates for pneumonia and influenza, as well as other diseases of the respiratory system, diarrhea and enteritis, duodenitis, the major cardiovascular-renal diseases, and accidents and other violence. Although there has been a large reduction in the death rates for pneumonia and influenza and for diarrhea and enteritis, these diseases still ranked among the five principal causes of death in 1960.

If the mortality trends for pneumonia and influenza, other diseases of the respiratory system, diarrhea and enteritis, the major cardiovascular diseases, and injury from violence (for whites) had continued from 1938 to 1960 at the same relative rate of decrease, the general mortality trend would have declined at a greater rate than was actually experienced after 1950. However, except in the case of nonwhite males, the failure of the trends involving these cause-of-death categories to continue in a straight line does not appear to account for much more than 40 percent of the difference between the expected and the observed death rates for all causes in this age group subsequent to 1950. For nonwhite males, the corresponding figure may be as much as 45 percent.

The change in the pneumonia and influenza mortality trend starting about 1950 had the greatest effect on the course of the general mortality trend. However, this did not account for much more than one-fifth to one-third of the deviations from a straight-line trend of the total death rate for this age group. The change in the diarrhea and enteritis trend also appears to have played a relatively important role in affecting the total mortality trend.

What seems significant about the trends for children of preschool age is that much of the change in trend in the general death rate appears to be associated with the change in mortality trends involving diseases of infectious origin. The death rates for all of the diseases mentioned here, including the cardiovascular diseases which are mainly rheumatic infections in this age group, have undergone rapid decline with the introduction of chemotherapy and antibiotic therapy. The re-

cent leveling off of these rates raises an interesting question as to the reason or reasons for the change.

Even if the mortality trends for influenza and pneumonia, diarrhea and enteritis, diseases of the heart, and accidents had continued downward, a similar trend for all causes of death would not necessarily have resulted. For example, a straight line was fitted to the logarithms of the death rates from 1938 to about 1950 for each of the above-mentioned causes of death, infective and parasitic diseases, and diseases of the respiratory system excluding influenza and pneumonia, for white females 1-4 years of age. Each of these trends was extrapolated to 1960 on the assumption of a uniform rate of decline. The summation of these trends is shown in figure 13 as "A," which is substantially a straight line until 1956 when it starts to deviate from the trend line. The plotted points "B" represent the observed death rates for malignant neoplasms and congenital malformations which show a gradual rise from 1938 to 1948. (The discontinuity in the death rates between 1948 and 1949 are due to changes in the classification of malignant neoplasms.) Since 1949, these rates have been essentially level. When rates for trend "B" are added to the rates for trend "A," trend "C" is obtained. The points along this trend show much more marked deviations from the trend line and simulate the leveling off observed in the trend of the death rate for all causes. Thus, it seems that a combination of forces is operating in shaping the pattern of the death rate for all causes.

In 1960, pneumonia and influenza constituted about 13 percent of all deaths among white children 1-4 years of age and about 20 percent of the deaths among nonwhite children. Diarrhea and enteritis contributed from 3 to 4 percent of the total deaths. In addition, the group of other infective and parasitic diseases accounted for 6 to 8 percent of all deaths. If it were possible to completely eliminate these diseases as causes of death, the death rate for white children would be about 20 percent lower than the recorded rate of 95.2 per 100,000 population in 1960. Similarly, the death rate for nonwhite children in this age group would be about 30 percent lower than the death rate of 190.8 per 100,000 population for 1960.

The future course of mortality in this age group is also highly dependent upon what happens to the death rate for injuries from accidents and other violence, and the rising mortality rates for malignant neoplasms and congenital malformations. The death rate for violence for white children had been declining fairly rapidly but in recent

years has shown a tendency to level off. For non-white children, the rates did not decrease nearly so fast as for the white, but the general trend is still downward. Accidents and other violence accounted for about 30 percent of all deaths in this age group.

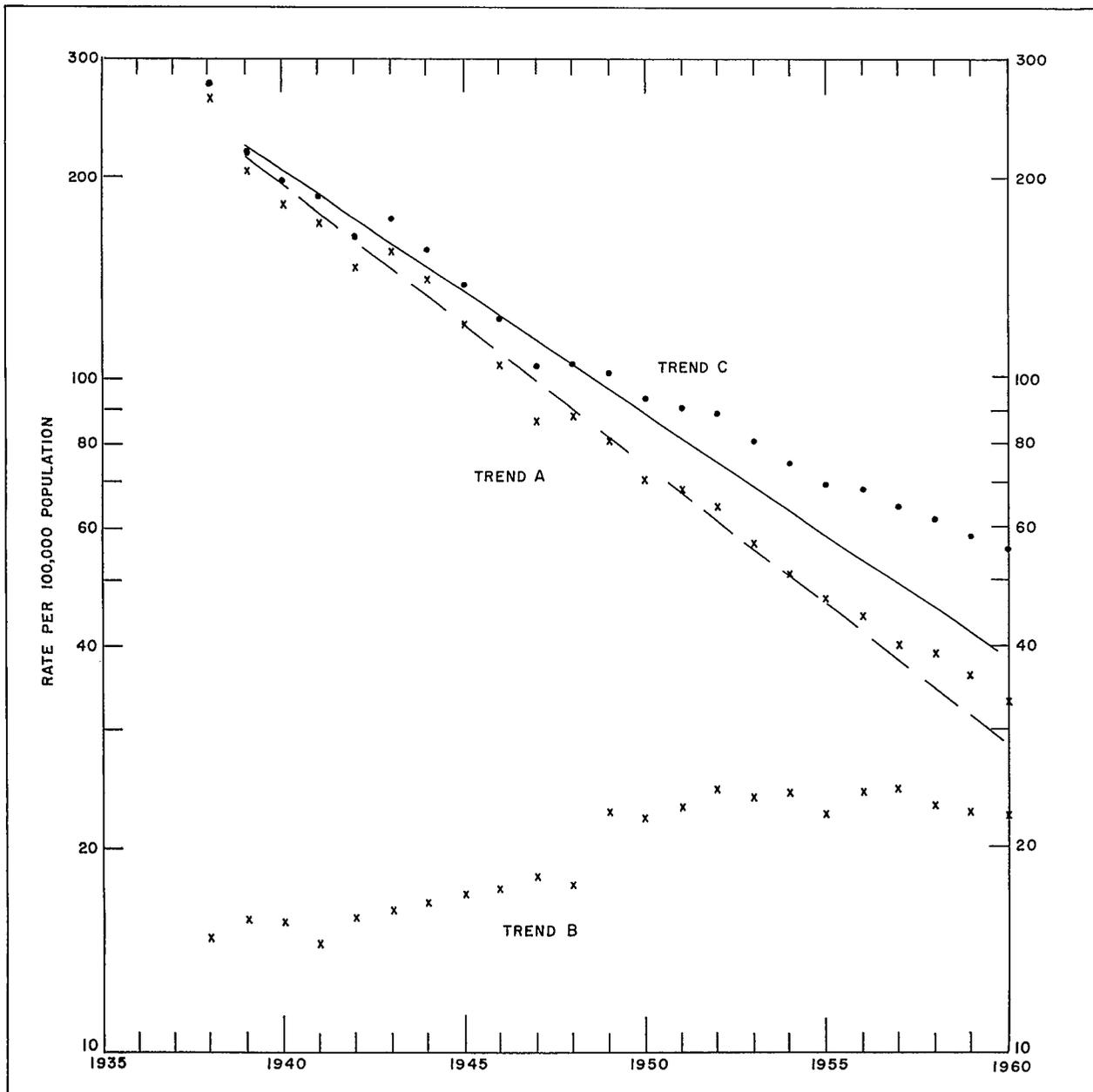


Figure 13. Example of interaction of mortality trends for groups of diseases producing change in trend of total death rates: United States, 1938-60.

Malignant neoplasms and congenital malformations assumed greater relative importance in terms of frequency of deaths in 1960. This is because of the rising mortality from these diseases and the declining mortality from the infectious diseases. Prior to the use of the Sixth Revision of the International Classification of Diseases in 1949, the death rate for malignant neoplasms was rising. With the revision in disease classification procedures, a large increase in the level of the death rate for malignant neoplasms occurred. This arose from the difficulty in maintaining a comparable series on cancer mortality for this age group. The chief problem is adjusting past data for the leukemias and lymphosarcomas which constitute about half of all deaths from malignant neoplasms for the 1-4 year age group. However, the significant fact with respect to the problem of general mortality trend for this age group is that the death rate for malignant neoplasms has been stationary or declining slightly during the past 10 years.

The death rate for congenital malformations increased slowly until 1953 or 1954 and then leveled off (fig. 14). This may be related to the possible prolongation of life of those with congenital defects, as is suggested by the corresponding rise in the death rate for congenital malformations in the following age group, 5-14 years.

The problem capable of solution, in view of present knowledge and facilities, is the prevention of deaths from infectious diseases. Much more can be done than has been accomplished during the past 10 years. However, there is a limit and it will become increasingly difficult to lower the total death rate by an attack solely on the infectious disease problem. The prospects of further reduction in mortality from the chronic diseases appear to be good, but the present rate of decline is fairly small. Therefore, unless major developments occur which would influence cancer mortality and deaths from congenital malformations among children of preschool age, large gains in the savings of lives cannot be expected.

#### Age Group 5-14 Years

Twenty years ago, accidental deaths accounted for the largest proportion of deaths among children of school age, except among nonwhite fe-

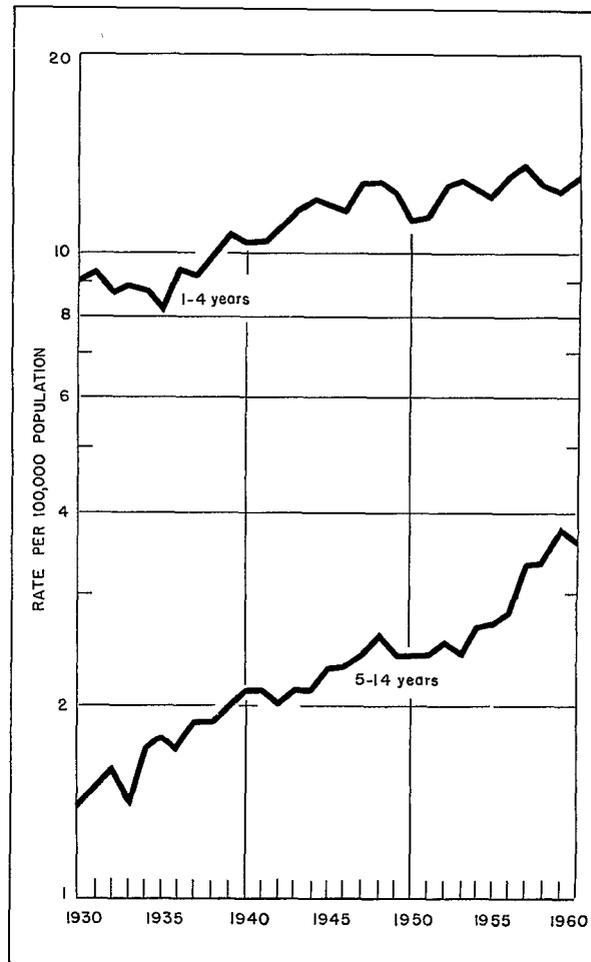


Figure 14. Death rates for congenital malformations, age groups 1-4 and 5-14 years: United States, 1930-60.

males. In this group, tuberculosis was the most frequent cause of death and accidents, second. Tuberculosis was also one of the five leading causes of death among nonwhite males and white females, whereas malignant neoplasms were a significant cause of death among white males. The diseases of the heart, appendicitis, and influenza and pneumonia made up the remainder of the five principal causes of death in this age group.

Despite the importance of accidents as a cause of death, the number of deaths from infective and parasitic diseases, including influenza and pneumonia, as a group exceeded the frequency of ac-

cidents as a cause of death for every group except white males. The mortality from the infective and parasitic diseases was especially high among the nonwhite children in 1940.

With the rapid decline in mortality from the infective and parasitic diseases and from appendicitis, accidents increased in relative importance. By 1960, malignant neoplasms had become second in importance to accidents as a cause of death in each color-sex group. Deaths from congenital malformations also moved into prominence, due partly to the increase in survivors with congenital defects from the 1-4 year age group. Despite the large decline in the influenza and pneumonia death rate, these respiratory diseases still remained one of the five leading causes of death in 1960. On the other hand, the number of deaths from appendicitis dropped to a low level, and appendicitis no longer appeared as one of the first five in the rank order of causes of death.

Of the numerically significant causes of death in this age group, influenza and pneumonia and infective and parasitic diseases are the only disease groups where the death rates have not followed a straight-line downward trend. However, the assumption of a continuous decline in the rates for these diseases and for diseases of the respiratory system for white males would account for less than one-third of the deviations between the observed and expected death rates for all causes of death in this age group in the period 1957-60.

The death rate for accidents among white children in 1960 was about one-half of the rate of 30 years ago. The rate of decline in the accident death rate for nonwhite children was not nearly so great, but the trend was definitely downward. Another significant change—which began in the mid-1940's—was the marked acceleration in the rate of decline of cardiovascular-renal mortality among children of school age. This may be attributed to the effects of antibiotic therapy on the deaths from rheumatic heart disease. Although heart disease still ranks as one of the five leading causes of death in this age group, the death rate is now at such a low level that it does not greatly affect the general death rate. On the other hand, the increasing death rates for malignant neoplasms and congenital malformations are opposing the general downward course of mortality for

this age group. These opposing trends do not now constitute a strong force, but they will exert increasing influence on the general mortality trend if the death rates for neoplasms and congenital malformations continue to increase. It is significant that almost one-half of the deaths from malignant neoplasms in 1960 were attributed to leukemia and aleukemia.

The difference between the observed and expected death rates for all causes is diverging at a rapid pace. However, the magnitude of the absolute difference of these deviations is still relatively small. At this point, it will not take a large change in the death rate for a particular disease or condition involving a relatively large frequency of deaths to significantly affect the present course of the general death rate. However, further reductions in infectious disease mortality cannot be expected to alter greatly the total death rate. Even if all the infective and parasitic diseases, including influenza and pneumonia, were eliminated as a cause of death, the death rate for children of school age would not decrease much more than 10 to 12 percent below the rate recorded for 1960.

The future course of mortality among children 5-14 years will depend primarily upon the death rate for accidental injuries. In 1960, accidents accounted for more than one-half of all deaths among nonwhite males in this age group, and close to one-half (47 percent) of deaths among white males. The proportionate mortality rate for females was lower, but still high, with 30 percent of the white and 37 percent of the nonwhite female deaths resulting from accidents. Because of this, substantial reductions in the total death rate cannot be expected unless greater decreases in the accident rate are obtained. The rate of decline of the present trend of the accident rate is apparently not sufficient to maintain a constant percentage decline of the general mortality trend.

### Age Group 15-24 Years

The pattern of causes of death in this age group is somewhat similar to that for the 5-14 year age group, with the additional risk of deaths in childbirth. The most frequent cause of death in the 15-24 year age group in 1940 was tuberculosis, except among white males. In this group,

tuberculosis ranked second to accidents. Influenza and pneumonia also appeared in the rank order of five principal causes of death for all color-sex groups. In general, it would seem that the problems in this age group 20 years ago were principally deaths from diseases of infective origin and from violence. For example, in 1940 the diseases of the heart and complications of pregnancy, childbirth, and the puerperium were the two groups of diseases in the rank order of five leading causes of death which do not necessarily involve infection. However, over 50 percent of the deaths from diseases of the heart related to rheumatic infections, and more than 40 percent of maternal deaths involved sepsis.

With the decline in the death rates for the infective diseases over this 20-year period, accident fatalities assumed an even greater relative importance as a cause of death in 1960 for this age group. Accidents became the leading cause of death in every sex-color group with the proportion of all deaths attributed to accidents ranging from 18 percent for nonwhite females to 64 percent for white males. Homicide and suicide also increased in relative frequency. In 1960, 69 percent of deaths among nonwhite males and 73 percent of deaths of white males were from some form of violence. The corresponding proportions for white females were 31 percent and for nonwhite females, 43 percent.

By 1960, tuberculosis and influenza and pneumonia were no longer of numerical significance as causes of death in this age group, and malignant neoplasms emerged into prominence. However, the increase in the relative importance of the latter is due partly to the effects of a change in disease classification procedures in 1949.

Substantial decreases in mortality from diseases of infectious origin have been experienced. However, the rate of decline in the death rate for influenza and pneumonia has decelerated during the past 10 years or so. The death rate for the total group of infective and parasitic diseases was higher in 1957-60 than had been expected on the basis of past trends. Also, the suicide rate for the 5 or 6 years before 1960 was higher than had been expected. However, none of these developments accounts for a large proportion of the change in the general mortality trends in this age group. Even collectively, the assumption of a

straight-line trend for these diseases and suicide would account for much less than one-third of the difference between the expected and the observed values of the general mortality trends for white females and nonwhite males. (Trend lines were not fitted to death rates for white males. Because so many men in this age group were in military service overseas, there is an artificial rise in the death rates during the war years.) For nonwhite females, a larger proportion of deviations from the trend line of death rates for all causes can be accounted for. However, if there were a deceleration in the rate of decline of the general death rate for this color-sex group, it was of extremely short duration.

The governing factor, with respect to future prospects for further declines in mortality in this age group, is mortality due to violence. The trend for violent deaths is virtually flat for white males and females. For nonwhites, there is a definite but slow downward trend. Unless a significant decrease occurs in the death rates for violence, there will be an increasing tendency for the general death rates in this age group to level off. The death rate for the infective and parasitic diseases has reached such a low level that further declines would not have a significant effect on the total death rate except, possibly, for nonwhite females. In this group, 11 percent of all deaths in 1960 were attributed to infective and parasitic diseases, including influenza and pneumonia.

#### Age Group 25-34 Years

The principal cause of death in this age group in 1940 was tuberculosis, except among white males. For this group, accidental injuries was the leading cause of death followed by tuberculosis. For females, the complications of pregnancy, childbirth, and the puerperium ranked second after tuberculosis. Malignant neoplasms, cardiovascular diseases, accidents and other forms of violence, and influenza and pneumonia were also significant mortality problems for this age group in 1940.

Significant declines in mortality were recorded between 1940 and 1960, particularly for the infective and parasitic diseases. The tuberculosis death rate, for example, dropped sharply, and numerically this disease is no longer of con-

sequence as a cause of death. The trend for the infective and parasitic diseases as a group, as well as for influenza and pneumonia and other diseases of the respiratory system, declined rapidly and then began to level off in the decade 1950-60. Similar changes in the movement of the death rate have occurred in the trends for cardiovascular-renal diseases and for maternal deaths for white females. The maternal death rate for nonwhite females is declining without interruption, but the level of the rate is still considerably higher than that for white females.

Except for the general mortality trend for nonwhite males, the decreasing rate of decline for the various specified disease trends appears to account for possibly 55 to 65 percent of the change in the general mortality trend. For nonwhite males, less than one-third of the difference between the observed and the expected death rates might be attributed to the leveling off of component parts of the total death rate.

It would appear that a good part of the leveling off of the general mortality trend for this age group is due to the fact that the death rate for accidents and other violence has been practically flat over the past 15 years or so for all color-sex groups. For nonwhites, the death rate for violence had been declining generally until about 1945, when the decline abruptly ceased. Since then, the trend for nonwhite males appears to be slightly downward, whereas for nonwhite females the direction of the trend seems to be slightly upward.

Violent deaths are numerically important, especially among males in this age group. More than half of the deaths in 1960 were from violence. The preponderance of deaths among white males were from accidents, whereas among nonwhite males there were almost as many homicidal deaths as there were accidental injuries. About one-fourth of the deaths of white females involved violence, while the corresponding proportion among nonwhite females was about 20 percent.

By 1960, malignant neoplasms had moved up in the ranking of causes of death for this age group although the death rate for malignancies remained unchanged. Cancer mortality accounted for 22 percent of all deaths among white females in 1960, whereas for white males and nonwhite females the proportionate mortality was about

one-half of that for white females. Only about 5 percent of all deaths recorded for nonwhite males was assigned to malignant neoplasms.

The future course of mortality in the 25-34 year age group will depend largely upon the trends of the death rates for violence and malignant neoplasms. Even the complete elimination of deaths from infective and parasitic diseases, including influenza and pneumonia, would not have too great an effect on the total death rate, except among nonwhite females. In this group, about 11 percent of all deaths are from infective and parasitic diseases, including influenza and pneumonia.

At this point in time, it appears that the primary forces that had been driving the death rate down have almost lost their effect. The general death rate will probably not decrease much further unless new forces come into play to accelerate the decline. Violence and cancer appear to be the principal problems of the 25-34 year age group.

#### Age Group 35-44 Years

With approaching middle age, the principal causes of death in this age group are a mixture of infective and parasitic diseases, accidents and other violence, and the chronic diseases, with the latter beginning to show predominance.

In 1940, diseases of the heart were the leading cause of death among white males and nonwhite females and the second ranking cause of death among white females and nonwhite males. Malignant neoplasms ranked first for white females and constituted one of the five leading causes among white males and nonwhite females. Tuberculosis was the most frequent cause of death among nonwhite males, the second ranking cause of death for nonwhite females, and third in the rank for white males and females. Syphilis was a significant cause of death among nonwhite males, as were maternal deaths for white females.

In the period 1940-60, mortality from tuberculosis declined to the point where it was no longer numerically large enough to appear in the rank order of the five leading causes of death. In fact, the proportion of infective and parasitic diseases, including influenza and pneumonia, in 1960 ranged from about one-fifth to one-third of the corresponding figures in 1940 for the various color-sex groups.

The major mortality problems in the 35-44 year age group in 1960 were the cardiovascular-renal diseases, malignant neoplasms, accidents and other forms of violence, and, for white males and females, cirrhosis of the liver. Influenza and pneumonia are assuming a position of greater numerical importance among nonwhite females.

During the decade 1950-60 the mortality trend for influenza and pneumonia definitely leveled off. For nonwhite females, there is a suggestion of an upturn in the influenza and pneumonia death rates. There was also a significant change in the trend for diseases of the respiratory system other than influenza and pneumonia which now is increasing after a period of steady decline. The death rate for infective and parasitic diseases has also leveled off since 1956. There has been a deceleration in the rate of decline in

cardiovascular-renal mortality among the white population in this age group, but no such change is clearly evident in the rates for nonwhites.

If it were assumed that no change occurred in the relative rate of decrease in the death rates for these diseases, the average difference between the expected general mortality trend and the observed rates would have been decreased by about 30 to 40 percent, depending upon sex and color. The other factors contributing to the change in trend are the present patterns of death rates for accidents and other violence, malignant neoplasms, and cirrhosis of the liver.

The death rate for accidents and other violence has been essentially level for the white population during the last 6 or 7 years; for nonwhites, the death rate has been level over a longer period of time. Because of the relatively high

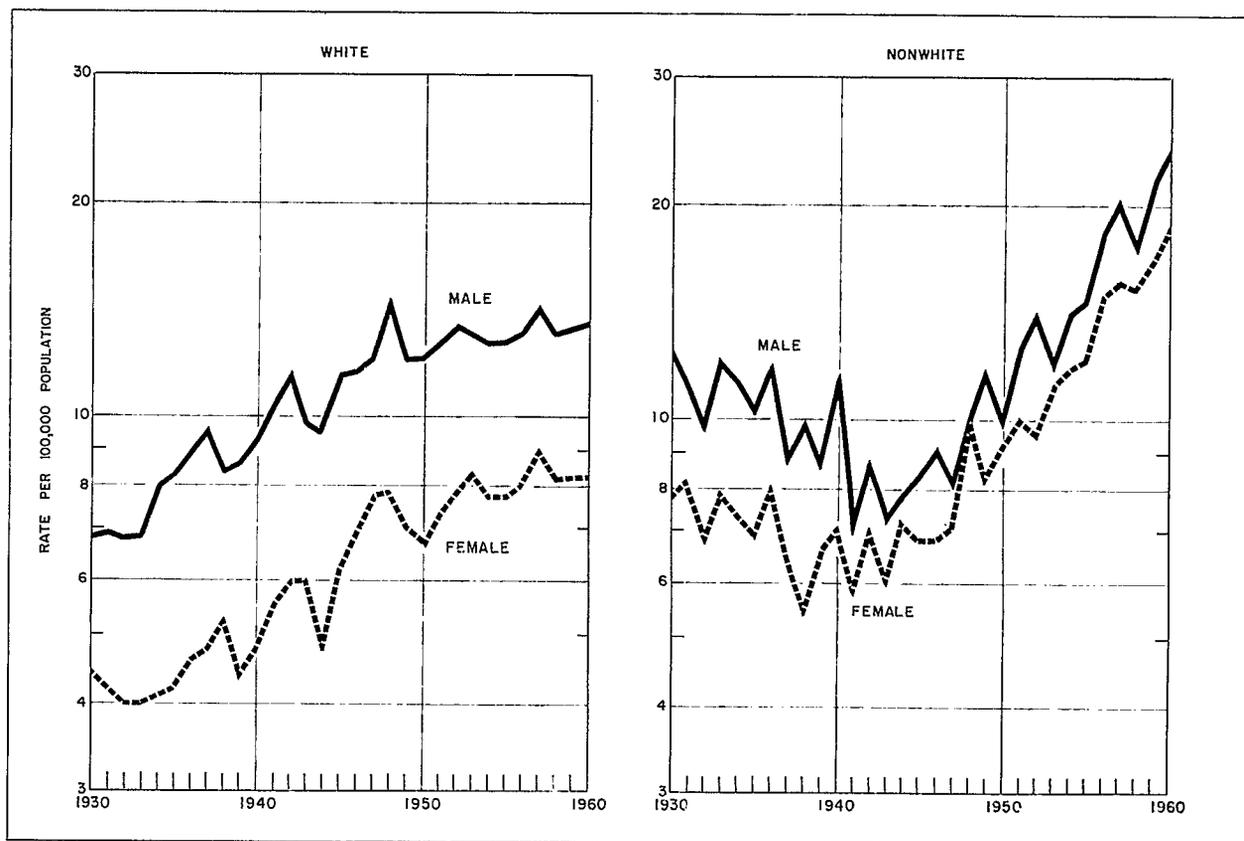


Figure 15. Death rates for cirrhosis of liver, 35-44 year age group, by color and sex: United States, 1930-60.

frequency of deaths from violence in this age group, this pattern of mortality will influence the general mortality trend.

Malignant neoplasms, particularly the increasing trend for males, also contributed significantly to the change in the general mortality trend. The cancer death rate for females is still decreasing slowly, but at a much lower rate of decline than that of the general mortality trend. Another contributory factor is mortality from cirrhosis of the liver. The magnitude of the rates is still relatively small, but the rising trend, especially in the nonwhite population, will have an increasing effect on the trend of the general death rate (fig. 15).

Future gains are expected to be comparatively small insofar as the prevention of infectious disease mortality in the white population is concerned; whereas for nonwhites there are still some 9 to 10 percent of all deaths attributed to infective and parasitic diseases and influenza and pneumonia. Judging from the trend of the cancer death rate, further declines in the total death rate for females may be expected, but the rate of decline will not be so great as in the past. The future prospects for males appear much poorer than those for females.

#### **Age Group 45-54 Years**

The problems of this group are similar to those of the 35-44 year age group, with the effects of the aging process becoming more evident in the nature of the principal causes of death. The acute hazards, namely infective and parasitic diseases and accidents, were, in 1940, still contributing significantly to the total death rate. By 1960 the pattern of mortality had changed. Only accidents, except for nonwhite females, and influenza and pneumonia in the nonwhite population appeared among the five principal causes of death. The chronic diseases now figured even more prominently as a cause of death in this age group. Cardiovascular-renal diseases and malignant neoplasms accounted for the majority of deaths. Cirrhosis of the liver in the white population and diabetes mellitus among nonwhite females constituted the remainder of the five most frequent causes of death.

The death rate declined rapidly for the in-

fective and parasitic diseases, influenza and pneumonia, and other diseases of the respiratory system. However, during the past 10 years, the rate of decline has slowed down markedly in the trend of mortality from infective and parasitic diseases; the downward movement of the influenza and pneumonia death rate has virtually stopped; and the death rate for diseases of the respiratory system other than influenza and pneumonia is now increasing significantly.

The recent changes in the course of the death rates for infective and parasitic diseases, influenza and pneumonia, and other diseases of the respiratory system may provide an explanation for more than half of the decrease in the rate of decline in the general mortality trend for white males and about one-third of the deviations from the expected trend for white females. For nonwhites, the effect is not easily determinable. The computed values involving diseases of infectious origin amounted to more than 100 percent of the differences between the expected and observed death rates for all causes. This was to be expected in the trend for nonwhite females because of the acceleration in the downward movement of the general death rate. This was not the case in the trend for nonwhite males. However, a reasonable explanation may be found in the trends of the cardiovascular-renal death rates. As seen in figure 10, the cardiovascular-renal trend for the nonwhite population which is curvilinear starts to turn down about 1944, and the rate of decline accelerates about 1953 or 1954. The downward turn of the cardiovascular-renal death rate for nonwhite females is much greater than that for nonwhite males. This is apparently the reason for the acceleration observed in the decline in the general mortality trend for nonwhite females in recent years. The rate of decrease of the cardiovascular-renal mortality trend for nonwhite males is not sufficient to counteract the forces increasing the general death rate.

The elimination of infective and parasitic diseases, including influenza and pneumonia, and violence as causes of death would not reduce the total death rate by more than 10 to 20 percent. Actually this reduction would be somewhat higher because intercurrent infections such as pneumonia would result in excess mortality from the chronic diseases. However, it seems clear that the

"acute" components of mortality in this age group are not nearly so important as the "aging" components.

The prospects of a further decline in mortality are much more favorable for females than for males. The death rate for cardiovascular-renal diseases for females is still decreasing at a fairly rapid pace, whereas for white males the rate is decreasing very slowly. The rate for nonwhite males is decreasing much faster than that for white males but not nearly so fast as that for nonwhite females. The death rate for malignant neoplasms is decreasing slowly for females, but it is not definite what the future course will be in view of the hint of an upturn in cancer mortality.

The death rate for cancer among males is rising fairly rapidly although the rate of increase has not been so great during the past 10 years.

The diabetes mortality trend is difficult to assess because of the major change in the disease classification procedures in 1949. However, there appears to be an unusual change in the pattern of mortality for this disease. Overlooking the large discontinuity in the diabetes death rate between 1948 and 1949 due to the change in classification procedures, it may be seen from figure 16 that the trend for females has been generally downward. However, the trend for white females appears to have definitely leveled off, and the same seems to be happening to the rates for non-



Figure 16. Death rates for diabetes, 45-54 year age group, by color and sex: United States, 1930-60.

white females. On the other hand, there has been a clear upturn in the diabetes death rate for males in the period 1955-60. In 1954 the death rate for white males for the first time exceeded the rate for white females, and this differential is widening rapidly. In the nonwhite population, mortality for females is still considerably higher than that for males. However, if the present increase in the mortality among males continues, it will not be long before it will exceed the mortality rate for females.

The death rate for cirrhosis of the liver is continuing to rise for all sex-color groups in this age range (fig. 17). There seems to have been a spurt in the increase, particularly among nonwhites, after World War II. The mortality from cirrhosis of the liver in the white population in 1960 was about 4 percent of the total (even less

for the nonwhite), but it is probable that this disease will increase in numerical importance as a cause of death.

### Age Group 55-64 Years

With increasing age, the cardiovascular-renal diseases increase in relative importance as a cause of death. In this age group, 55-64 years, the cardiovascular-renal diseases emerge for the first time with clear-cut superiority over other diseases as the leading cause of death in every sex-color group. Except for accidents among white males, and influenza and pneumonia in the nonwhite population, the leading causes of death in 1940 were the chronic diseases, principally cardiovascular-renal diseases and cancer.

In the period 1940 to 1960, these chronic dis-

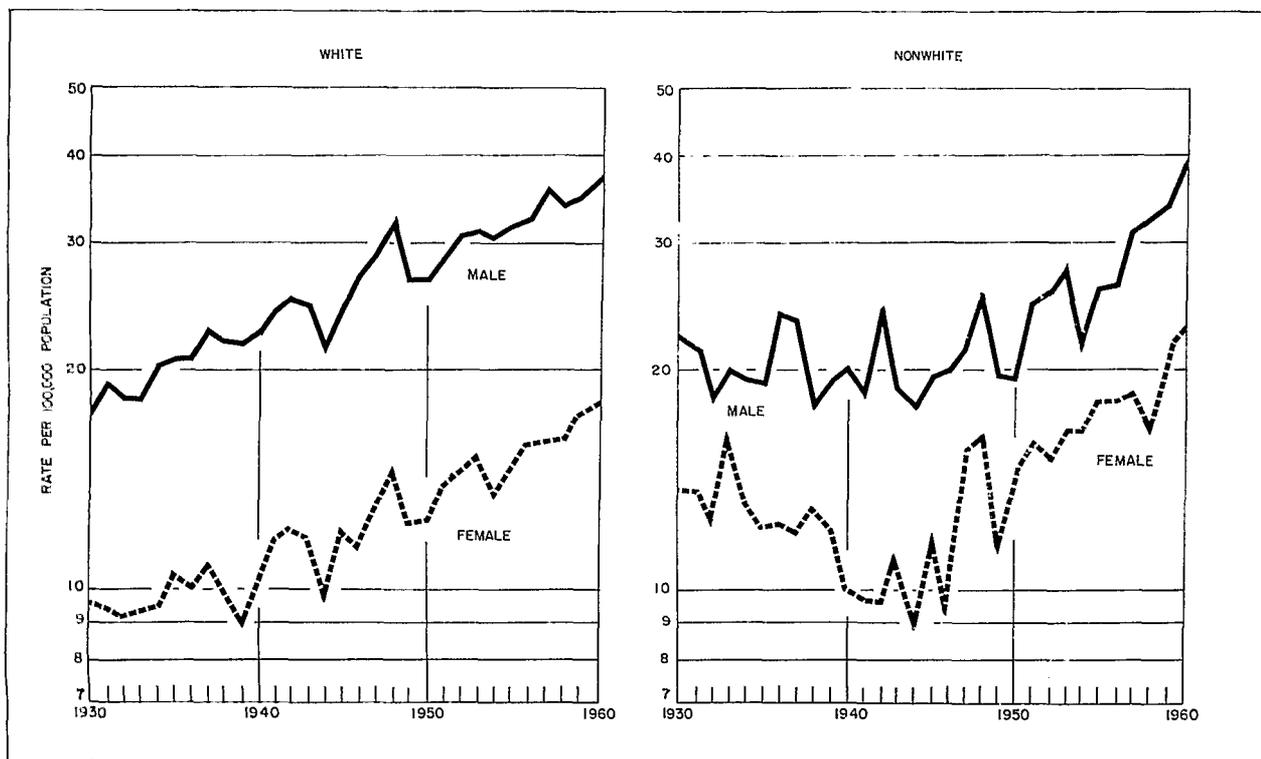


Figure 17. Death rates for cirrhosis of liver, 45-54 year age group, by color and sex: United States, 1930-60.

eases increased in numerical importance. Although the death rate for the infective diseases declined significantly, influenza and pneumonia advanced in the rank order as one of the five principal causes of death for white males. Diabetes for the female population and accidents for white females and nonwhite males assumed positions of greater relative importance. However, in 1960, deaths from violence and infective and parasitic diseases, including influenza and pneumonia, constituted less than 10 percent of all deaths in each color-sex group, except nonwhite males. For this group, the proportionate mortality was 13 percent. The death rate for accidents and other violence for the white population is still declining, but the trend is more or less level for nonwhite males and slightly upward for nonwhite females. The rate of decline in the death rate for infective and parasitic diseases is decelerating for the white population, but there is no evidence of a similar change in the trend for the nonwhite population. The influenza and pneumonia death rates have increased for all color-sex groups.

Of particular interest is the trend of the death rate for diseases of the respiratory system, excluding influenza and pneumonia. The mortality from these diseases had been declining steadily for females, but a sharp upturn may be observed in the rates recorded during 1950-60 (fig. 9). The trend of the death rate for white males was virtually level until 1948 when a large upsurge started. The rate for nonwhite males was declining slowly until about 1948 when, as with the death rate for white males, a sharp rise began.

The marked change in trend for the male population suggests that the revision in the classification of diseases and classification procedures adopted in 1949 might be responsible. However, the fact that the change in the trend for females did not occur until much later suggests that the classification revision was not the governing factor. There does not appear to be much question of increased reporting of these diseases in this age group. Whether this represents a real increase in mortality from the chronic bronchopulmonary diseases is a question. Although the magnitude of the rates is still relatively low, the trend for diseases of the respiratory system (chronic obstructive lung diseases) suggests an emerging public health problem.<sup>7,8</sup>

The course of mortality from the infective and parasitic, including influenza and pneumonia, and the chronic obstructive lung diseases may account for a relatively large proportion of the leveling off of the general death rate for white females, but not for the nonwhite population (less than 10 percent). For white males, this method of analysis involving projection of the general death rate gives rise to problems because of the discontinuity of trends.

With regard to the major chronic diseases, there has been little change in the death rate for white males for cardiovascular-renal diseases during the period 1940-60. The death rate for females has been declining without interruption, thereby increasing the gap between the mortality from cardiovascular-renal diseases for males and females. For the nonwhite population, the sex differential in mortality was negligible between 1935 and 1945 when the death rate for males started to increase. Since 1948, the death rate for males has been paralleling that for females at a higher level. The reason for the change in the cardiovascular-renal disease death rate for nonwhite males between 1945 and 1948 seems worth studying.

The course of mortality from malignant neoplasms shows a striking divergence in the death rates by sex (fig. 18). In both the white and nonwhite populations, the rate for males was at a much lower level than that for females in, for example, 1935. However, the death rates for white and nonwhite males have been increasing steadily whereas the rate for white females has been continuously downward. The trend for nonwhite females is slightly upward, but not increasing so fast as the trend for nonwhite males. The trends for the white population crossed about 1945, and those for the nonwhite about 1948. Another point of interest is the fact that the death rate for cancer for nonwhite males is now much higher than for white males.

With regard to diabetes, the downward trend in the death rate for white females appears to have accelerated in the past 10 years, whereas the rate for white males has been fairly level. The diabetes death rate for both the nonwhite males and females is now rising rather rapidly after a period of flat trend (fig. 19).

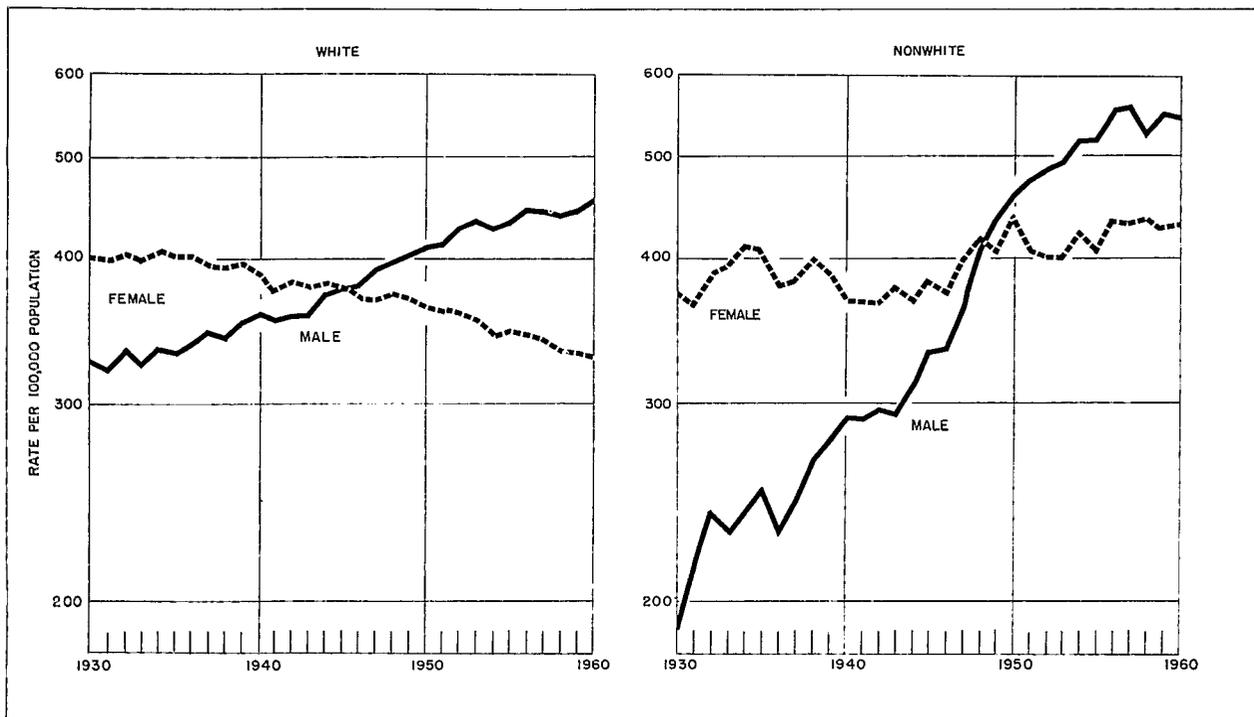


Figure 18. Death rates for malignant neoplasms, 55-64 year age group, by color and sex: United States, 1930-60.

The changes in mortality from the major chronic diseases suggest that the death rate for white males will continue in its upward movement whereas the general trend for white females will be downward for some time. On the other hand, the death rates for the nonwhites in this age group will probably begin to level off.

#### Age Group 65-74 Years

The principal causes of death in this age group in 1940 were the cardiovascular-renal diseases, malignant neoplasms, and influenza and pneumonia, except among white females where diabetes ranked in place of influenza and pneumonia. In the 20-year period between 1940 and 1960 there were several changes in the rank order. Accidents increased in relative importance among males, influenza and pneumonia among white females, and diabetes among nonwhite females.

The cyclical type of variation in the death

rates for the nonwhite population makes it difficult to ascertain any definite trends. However, the death rate for white females has leveled off and the rate for white males is now rising after a period of declining mortality. Part of the explanation may be in the change in the course of mortality from the infective and parasitic diseases, influenza and pneumonia, and other diseases of the respiratory system. The change in pattern for these diseases may account for a fairly large proportion of the change in the general death rate for white males and for a smaller proportion for white females.

Of significance is the changing mortality from diseases of the respiratory system excluding influenza and pneumonia. The death rate for these chronic obstructive lung diseases has increased rapidly during the past 10 years, especially among white males, contributing substantially to their rising death rate (fig. 9).

After a period of rapid decline, the influenza and pneumonia death rates began rising about 1955 for the white population. This upward movement was more violent than any experienced in the pre-

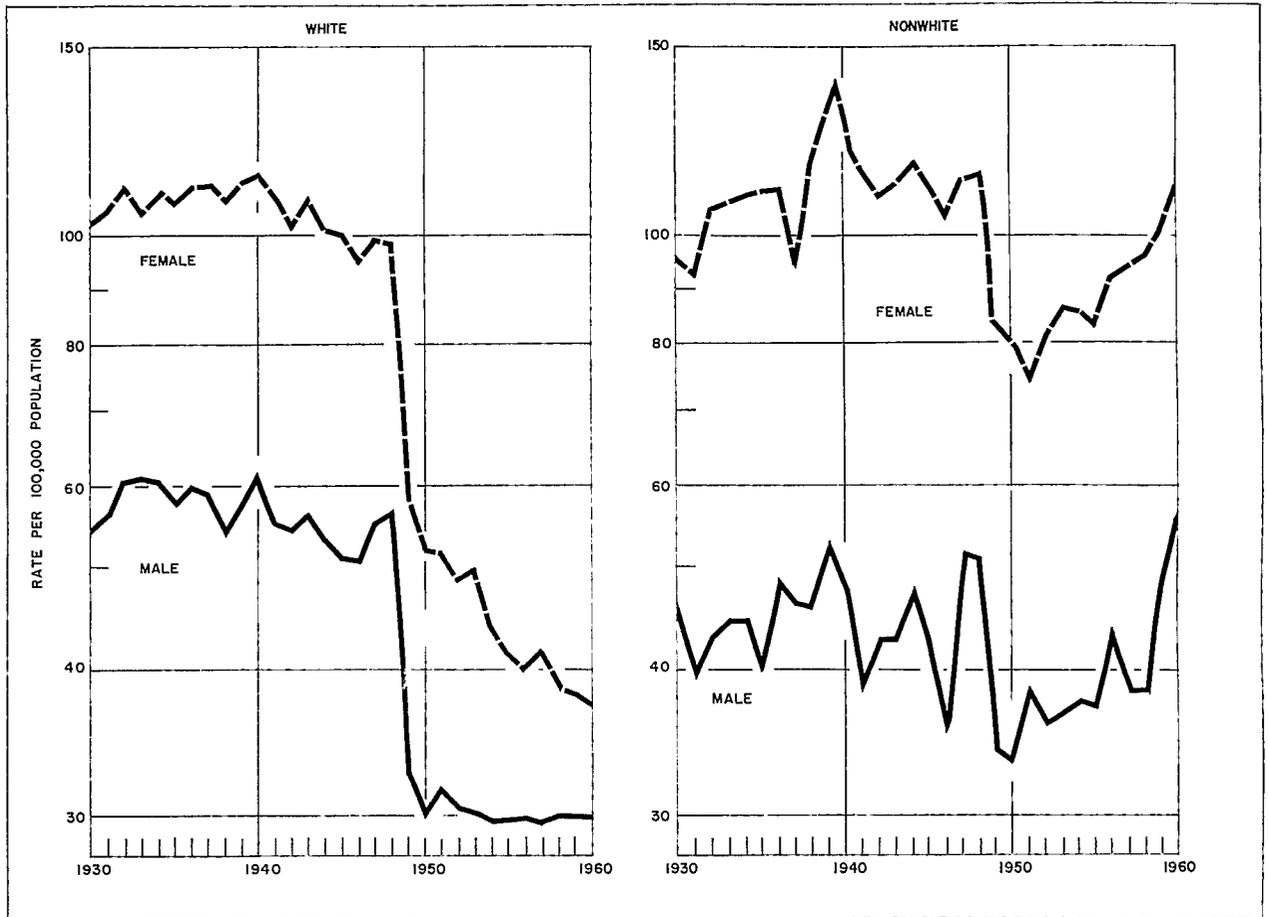


Figure 19. Death rates for diabetes, 55-64 year age group, by color and sex: United States, 1930-60.

vious 25 years. For the nonwhite population, the death rates for influenza and pneumonia began to level off in the late 1940's among males and in the early 1950's among females.

The trend of mortality from the cardiovascular-renal diseases is downward for females and virtually flat for males. The trends for white females and for white males are clearly diverging, but those for nonwhite are more or less parallel. As for malignant neoplasms, the death rate for white females is declining whereas the rate for white males is increasing relatively rapidly. Among nonwhites, the cancer death rates for females have not changed much since 1950 while the rates for males are increasing.

The diabetes death rate for white females is declining, but the rate for white males has not

changed much in past years. On the other hand, the diabetes death rates for both nonwhite males and females show a definite upward tendency in recent years.

Death rates for accidents and other violence show a steady downward trend for white males and females. The rate of decrease in the death rate is not so rapid for the nonwhite population, but there seems to be a tendency to decline.

The mortality trends for the various causes of death indicate that the rate of decline in the death rates for the various subpopulations in this age group may be further slowed down. The mortality outlook for white males and for the nonwhite population does not appear to be too favorable, but further decreases in the death rate for white females may be expected.

## Age Group 75—84 Years

The mortality problems in this age group are overwhelmingly cardiovascular-renal diseases. Malignant neoplasms are also relatively important causes of death but account for less than 15 percent of all deaths in this age group. The influenza-pneumonia group also appears in the rank order with a proportionate mortality of less than 5 percent in 1960.

The death rate for influenza and pneumonia stopped declining early in the 1950's and has increased in every sex-color group. However, this, in addition to the change in the death rate for diseases of the respiratory system excluding influenza and pneumonia, does not appear to account for a large part of the change in the general mortality trend.

The death rate for the major cardiovascular-renal diseases is declining slowly but steadily for white females, but the rate for white males has changed very little since 1945. For the non-white population, it is difficult to see any definite trend.

With regard to malignant neoplasms, the death rate for white females is decreasing slowly while the trend for white males appears to be rising slightly. For the nonwhites, particularly males, the trend is upward.

The death rate for accidents and other violence shows evidence of change in its downward course for white males and females. For the nonwhites, the wide swings in the death rate do not create a continuous pattern, but the general trend is definitely downward. However, even if all deaths from infective and parasitic diseases, including influenza and pneumonia, and accidents and other violence were completely eliminated, the total death rate for this group would not decrease by more than 7 to 10 percent. The future prospects of large gains in mortality are not very great except for the death rate for white females.

## DISCUSSION

It is possible that the leveling off of the death rate is due to an artifact, i.e., to changes in the completeness of death registration, errors in the

intercensal population estimates, and errors in the statement of age in the census enumeration and on death certificates. In order for these factors to have affected the trend, there must have been a large improvement in registration completeness starting about 1954, or a significant error in population estimates for the same period.

Although there has never been a reliable evaluation made of death registration completeness, it has always been assumed that virtually all deaths are reported in the United States. It is unlikely that more than 1 or 2 percent of deaths go unrecorded. It is also unlikely that this factor would be operative in the other countries of low mortality where death registration has not been considered a problem for many years.

With regard to errors in population estimates, Tomasson<sup>9</sup> observed a curious pattern of death rates for nonwhites in the latter part of each decade which suggested that the nonwhite population was being underestimated for the years at the end of the decade. This type of error could account for the leveling off of the death rate in recent years. That this could be a problem was clearly evident in this study when the death rates based on the postcensal estimates showed an upturn in the death rates for 1951 to 1959 for the older nonwhite population as compared with the corresponding rates computed on intercensal population estimates by age based on the 1950 and 1960 census returns. These errors in postcensal population estimates could be due to many factors. However, the revised estimates did not significantly influence the trend of the death rates for age groups under 55 years. Also, any errors in the population estimates would not have affected the infant mortality trend which does not depend upon population estimation procedures.

Because of these considerations, and because of the consistency in occurrence of the phenomenon in various parts of the world, the recent changes in mortality trends do not appear to be artifacts arising from death registration improvements or errors in population estimation.

This study indicates that the leveling off of the death rates can be accounted for by the combination of two sets of factors. The first is the dramatic drop in death rate for the diseases of infectious origin with the successive introduction

and application of pneumonia serum therapy, the sulfa drugs, and the antibiotics. The accelerated decline started about 1938 and then lost its impetus in the 1950's. By that time, the mortality from diseases of infectious origin had reached a level where it no longer contributed in a major way to the total number of deaths. Even if the trend of the death rates for the infective and parasitic diseases, including pneumonia and influenza, had continued downward without interruption, this would not have accounted for all of the leveling off of the total death rate.

However, the long-term decline in mortality from the infectious diseases resulted in a major realignment of the principal causes of death which uncovered a second set of factors. These factors involve the trends of mortality from the presently numerically important causes of death, namely, malignant neoplasms and cardiovascular-renal diseases at all ages, congenital malformations through the childhood years, accidents and other violence from childhood through middle age, cirrhosis of the liver in middle age, and diabetes mellitus from middle age into old age. Also, new problems are emerging. The dramatic upward trend of the chronic bronchopulmonary disease mortality from middle age onward seems particularly significant. None of the trends for these causes of death exhibits the same rate of decline as the trend for the infective diseases. In fact, many of the trends are rising by different degrees. The combined effect of these various trends is to slow down the rate of decline of the total death rate.

It is difficult to determine precisely the roles played by the different factors in affecting the general mortality trend. The indications are, however, that the leveling off of the death rates for the infective and parasitic diseases, influenza and pneumonia, and the other diseases of the respiratory system did not account for a large part of the deceleration of the rate of decline of the death rates for all causes for most age groups. Much more important seem to be the trends for the chronic diseases such as cardiovascular-renal diseases and malignant neoplasms in the adult population, malignant neoplasms and accidents and other violence in the younger population, and congenital malformations among children. These diseases and conditions consti-

tute the hard core for which prevention of deaths is more difficult. With the universal availability of antibiotics, the uncovering of this core may serve to explain the almost simultaneous leveling off of the death rate for the various countries and for the different population subgroups.

Further reductions in total mortality in the United States are possible, but any substantial decreases must come from the lowering of the death rates for the chronic noninfective diseases and for accidents and other violence. On the basis of a life table analysis of data for 1949-51, Woodhall and Jablon<sup>10</sup> concluded that large increases in longevity will result, not as a consequence of the solution of any single disease process, but as the result of a general breakthrough on the whole front of aging. The elimination of certain causes of death such as the infective and parasitic diseases, malignant neoplasms, diabetes, and accidents would result only in small increases in the average life expectancy. The largest increment would come from the elimination of cardiovascular diseases as a cause of death. The cardiovascular disease problem was noted as an exception to the generalization about future changes in life expectancy.

Although Woodhall and Jablon's study showed cardiovascular disease mortality to be the only significant factor in affecting the life expectancy at birth, it seems certain that the trends for malignant neoplasms and accidents and other violence will also play an important part in shaping the future course of the death rate for certain population subgroups. These are problems of long-standing importance. However, new problems may emerge. Cirrhosis of the liver has already come to the forefront as one of the five principal causes of death in the age groups 35-54 years, and the death rate for this disease is still increasing rapidly. The death rate for diabetes in the 45-54 year age group which had been declining is now leveling off for females and turning upward for males. In the 55-64 year age group, the diabetes death rate for the nonwhite population is increasing rapidly after a period of flat trend. In the groups over 65 years of age, the trends of diabetes mortality for the white population do not appear to be unusual, whereas for the nonwhite the trends are definitely upward. Since diabetes occurs more commonly in later

life, Dublin<sup>11</sup> expected an increasing diabetic population corresponding to the increase in the proportion of older persons in the population. This is not yet evident in the mortality data for the white population, but the increasing death rates for the nonwhites in the older age groups may be a reflection of the increasing prevalence of diabetes among the nonwhite population.

Another striking change in trend is presented by the death rates for diseases of the respiratory system other than influenza and pneumonia (fig. 9). These are, for the most part, the chronic obstructive lung diseases such as emphysema, bronchiectasis, and chronic bronchitis. The death rate for these chronic obstructive lung diseases is still at a relatively low level, but it has been increasing rapidly especially among males over 45 years of age. The rapidly rising death rate for cancer of lung and bronchus, another important chronic bronchopulmonary disease, has been well-recognized.

One of the most significant developments in modern medical history was the discovery and widespread application of antibiotics. This has had a tremendous effect on mortality trends. However, in the decade 1950-60, the death rates for infective and parasitic diseases and for influenza and pneumonia<sup>12</sup> (predominantly pneumonia) have leveled off or are turning upward (fig. 8). These diseases still contribute a relatively large proportion of deaths among infants and preschool children. In the other age groups, the proportionate mortality from diseases of infectious origin has decreased greatly, but the pneumonia death rate is high enough to constitute one of the five principal causes of death for certain sex-color groups. Pneumonia continues to be Osler's "friend of the aged."

An interesting and important question is why the rate of decline of the pneumonia death rate changed during the past decade after a period of impressive decrease (fig. 20). These changes in the rate for age groups in which the death rate has reached a low level are understandable. However, the pneumonia death rates are still high for the older age groups, and for infants and preschool children (fig. 8). Similarly, the rates for nonwhites are still higher than those for whites and the rates for males are higher than those for females. There is considerable differential

spread in the level of the death rates for the various age, color, and sex groups, but the leveling off of the pneumonia death rate for all groups has taken place in about the same period. This parallelism in the trends by sex, color, and age appears too regular to be true. If the changes in the rates of decline are not artifacts of disease classification, why should they have occurred at about the same time when the magnitude of the death rates differs so greatly when they start to level off? For some segments of the population, the rates are so low that for all practical purposes, the notion of an irreducible minimum can be accepted. For the other subgroups of the population, it would seem that there should be further prospects of reduction in the death rate. Actually, the pneumonia death rate is now increasing for the older age groups, indicating the possibility of antibiotic-resistant organisms playing an increasing role in older pneumonia patients.

With regard to the total death rate, there may be some question as to whether the irreducible minimum has been reached. The examination of the death rates by cause of death indicates that further declines are possible. Also, comparison of death rates by age and sex for the various countries of low mortality for the years 1959 and 1960, depending upon their availability, shows that the structure of the death rate for the United States is far from the lowest. By taking the lowest death rate recorded by any country of low mortality for each age-sex group and applying these rates to the population of the United States for 1960, the expected number of deaths was obtained. The difference between these numbers and the recorded number may be considered the excess number of deaths in the United States. If the lowest age-sex specific death rate achieved by any country of low mortality in 1959 and 1960 had been obtained in the United States in 1960, there would have been about 397,000 fewer deaths in the United States. This means that the crude death rate for the United States would have been 7.3 per 1,000 population as compared with the recorded death rate of 9.5 per 1,000 population. For males, the expected death rate would have been 7.8 as compared with the recorded rate of 11.0 per 1,000 population. For females the corresponding rates would have been 6.9 as compared with 8.1 per 1,000 population.

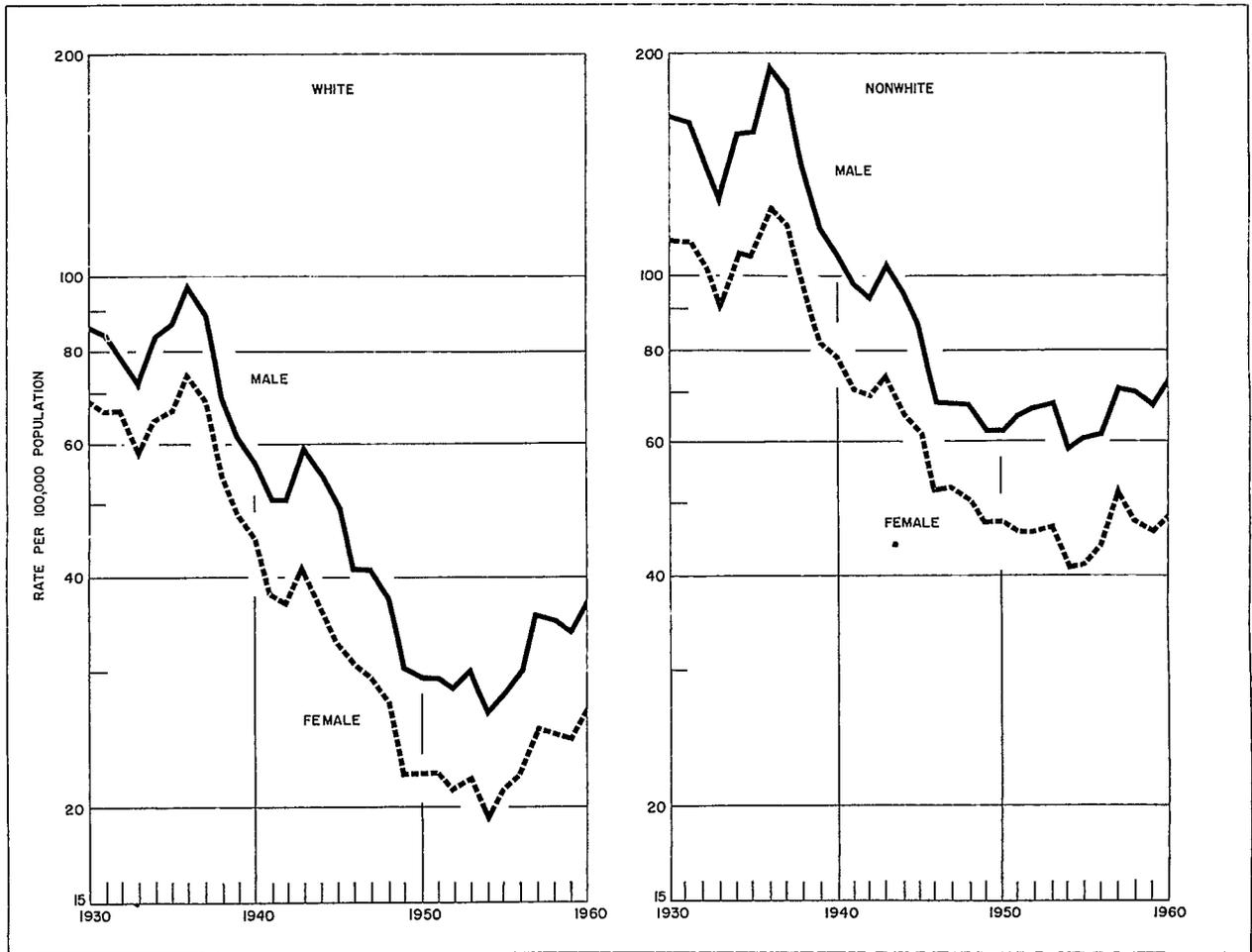


Figure 20. Death rates for pneumonia, by color and sex: United States, 1930-60.

As may be seen from figure 21, mortality in the U.S. population is favorable, compared with conditions in other countries, only in extreme old age. At other ages, there is considerable difference between the rates for the United States and for countries with the lowest death rates. This is especially true of mortality among the male population in the United States. For males, the excess mortality in *absolute numbers* among infants and age groups from 35-84 years accounted for the greatest part of the difference between the observed and expected number of deaths. For females, the excess mortality was greatest in the infant population and in the age groups from 45-

74 years, but not to the same extent as for males.

These differences between the age-specific death rates for the U.S. population and the corresponding rates for countries of low mortality show that the death rates in the United States have not yet reached the levels that have been attained elsewhere.

It is difficult to say what the biological irreducible minimum is. However, it is obvious that the death rates in the United States are far above the low levels established in the Scandinavian countries and in the Netherlands. Even for these countries, the rates cannot be considered the lowest possible figures because lower mortality

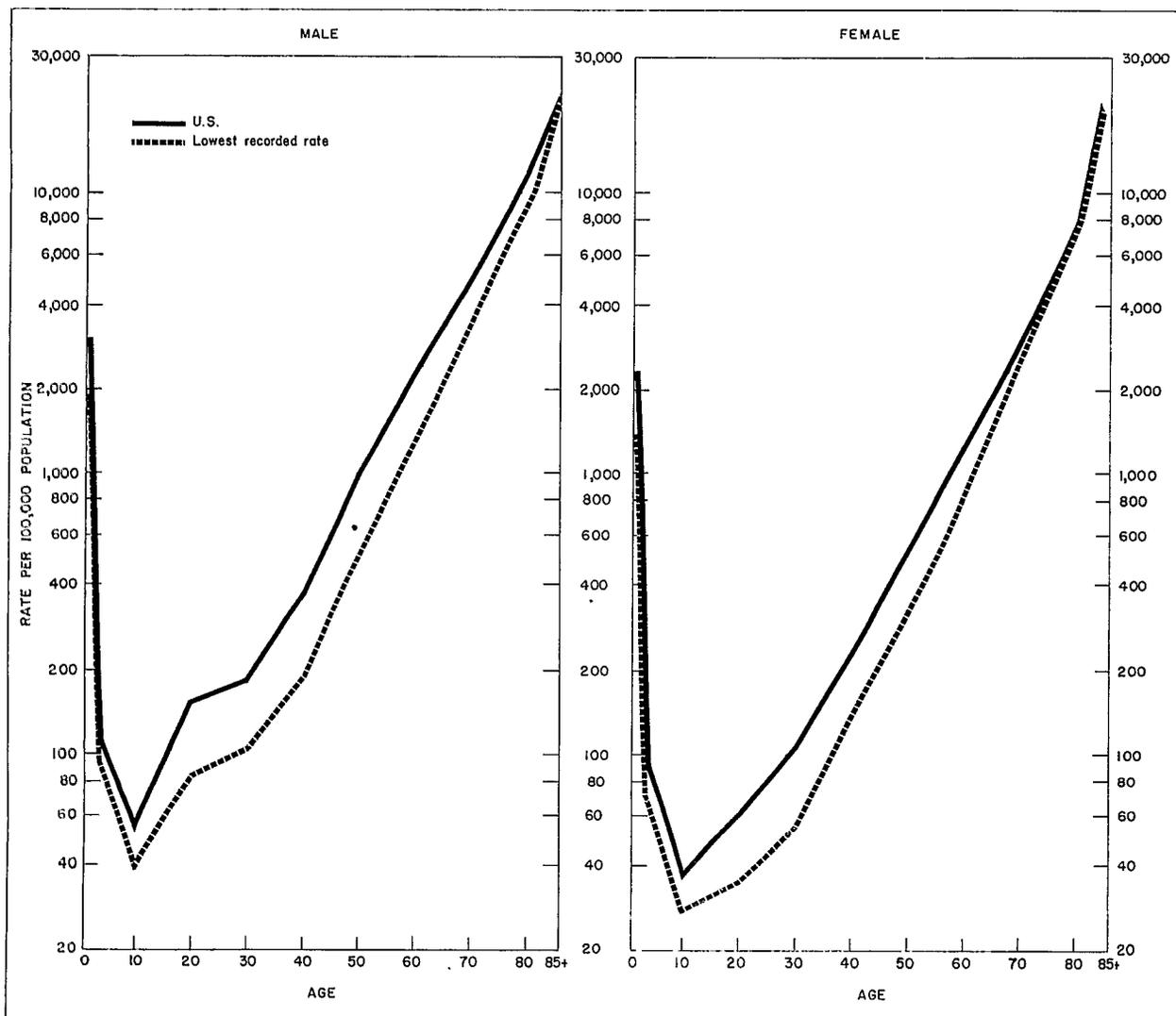


Figure 21. Death rates for the United States and lowest recorded death rates for countries of low mortality, by age and sex, 1959-60.

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rates than those recorded in 1959 or 1960 have been observed for some age groups in the years prior to 1959.

The recent change in the rate of decline of the death rates in the United States does not appear to be a temporary phenomenon. The provisional death rates of 9.3 and 9.5 per 1,000 population in 1961 and 1962, respectively, are low

relative to past rates, but they are far from the continuation of the downward trend established between 1938 and 1954. Further decreases may be recorded in the future, but it seems unlikely that the death rate for the United States will soon approach the levels already attained by various other countries.

## SUMMARY AND CONCLUSIONS

After a long period of rapid and substantial decline, the death rate for the United States has reached the point where further decreases as experienced in the past cannot be anticipated. The mortality trend for virtually every State has been affected. Similar changes in the trend of the crude death rate may be observed in the data for a number of other countries. Studies now in progress in several of these countries may provide further information on this problem.

In the United States, the mortality trends for every age group from infancy to late middle age or old age—whites as well as nonwhites, and females as well as males—have changed in recent years. The death rates for certain subpopulations in the older ages are now stationary or increasing.

The recent changes in trend cannot be attributed to the aging of the population or to artifacts in the mortality rates, but stem from a combination of two factors. The first of these relates to past successes in the prevention of deaths from diseases of infectious origin through antimicrobial therapy which contributed greatly to the downward trend of the general mortality rate. The impetus imparted by the reduction in the death rate for the infective diseases gradually diminished as the proportion of deaths from these diseases decreased. The leveling off of the death rate for diseases of infectious origin explains part of the deceleration in the rate of decline of the total death rate. For the most part, however, the downward trend of the death rate was checked by the current mortality trends of diseases and conditions which constitute the core of mortality in the present population, namely the chronic diseases and accidents and other violence. The direction or the rate of change of these trends is such that they would retard the downward course of the total death rate.

Certain important changes in the mortality pattern may be observed. The diabetes death rate for females in the 45-54 year age group appears to be leveling off while the death rate for males is increasing. The diabetes mortality in the non-white population over 55 years of age is now definitely increasing.

The chronic bronchopulmonary diseases are emerging as a serious mortality problem. The death rates for diseases of the respiratory system excluding influenza and pneumonia are rising at an accelerated pace in the older age groups, particularly among males.

The future course of mortality of males in the United States does not appear favorable as compared with the prospects for females. This is especially true of the trend for white males. In the past, the death rate among males was lower than that for females for at least two major disease components—diabetes and malignant neoplasms. This is no longer true. In almost every disease category, the death rate for males is higher than the corresponding death rate for females. Also, the death rate for females is still declining whereas the rate for males is decreasing more slowly or not at all.

Further declines in mortality are possible but they are likely to be modest ones. However, it does not appear that the death rate for the United States has reached the irreducible minimum. If the mortality rates in this country were to equal the lowest rates achieved by any country of low mortality in 1959 or 1960, the crude death rate for the United States would be 7.3 per 1,000 population as compared with the recorded rate of 9.5 in 1960. In view of the mortality experience for the past decade, it does not seem likely that the death rate for the United States will soon approach the levels already attained by various other countries.

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