Recent Change in Infant Mortality Trend

IWAO M. MORIYAMA, Ph.D.

FOR MANY YEARS the rapid annual decline in infant mortality was noted with considerable satisfaction by health authorities. Because of this continuing decline, the increases in the infant mortality rate in 1957–58 have been viewed with some concern. No specific factors or disease outbreaks have been identified wholly to account for these rises in infant mortality.

At the request of the Children's Bureau, an examination of available information on infant mortality was made. It would appear from this study that there has been a basic change in the infant mortality trend beginning about 1949 or 1950. The events of the past few years served more to call attention to a problem which apparently had its genesis some years ago.

For years, the infant mortality rate declined at a rapid pace (fig. 1). During the period 1933–49, the infant mortality rate for all races decreased about 4.3 percent each year (slope computed by the method of least squares). However, beginning about 1950, the rate of decrease in infant mortality dropped to 2.0 percent per annum.

The mortality experience of white infants follows the same pattern as for the total infant mortality trend. For the nonwhites, the deceleration in the downward trend is even more marked. In the period 1933–49, the nonwhite infant mortality rate decreased 4.6 percent per annum. Between 1950 and 1956, the rate of decline slowed down to 1.2 percent per year.

In 1957, the infant mortality rate increased as a result of the widespread outbreak of influenza. A further rise was noted in the provisional data for 1958, but this change is not clearly attributable solely to the influenza epidemic, which continued into 1958. The infant mortality rate for each month of 1958 except January and November was higher than the rate for the corresponding month of 1957. Taking into consideration the provisional data for 1958 and 1959, it would appear that the national infant mortality trend has almost completely leveled off, starting in 1953.

Significant changes have taken place over the years in the distribution of live births by age of mother, birth order, birth weight, and so on. It was thought that these changes might account for the change in trend of the infant mortality rate. Because mortality among infants of higher birth order or among those born to older mothers is higher than that for lower parity-age of mother groups, it is

Dr. Moriyama is chief, Mortality Analysis Section, National Office of Vital Statistics, Public Health Service.

Figure 1. Infant mortality rates, by race, United States, 1933–57

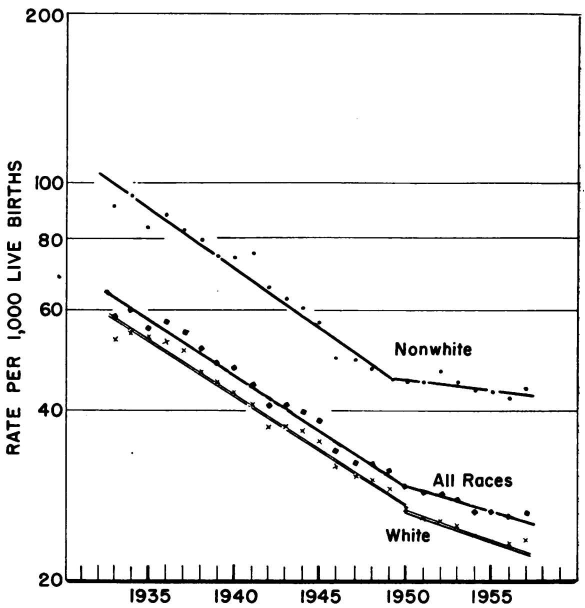


Figure 2. Neonatal and postneonatal mortality rates, by race, United States, 1933–57

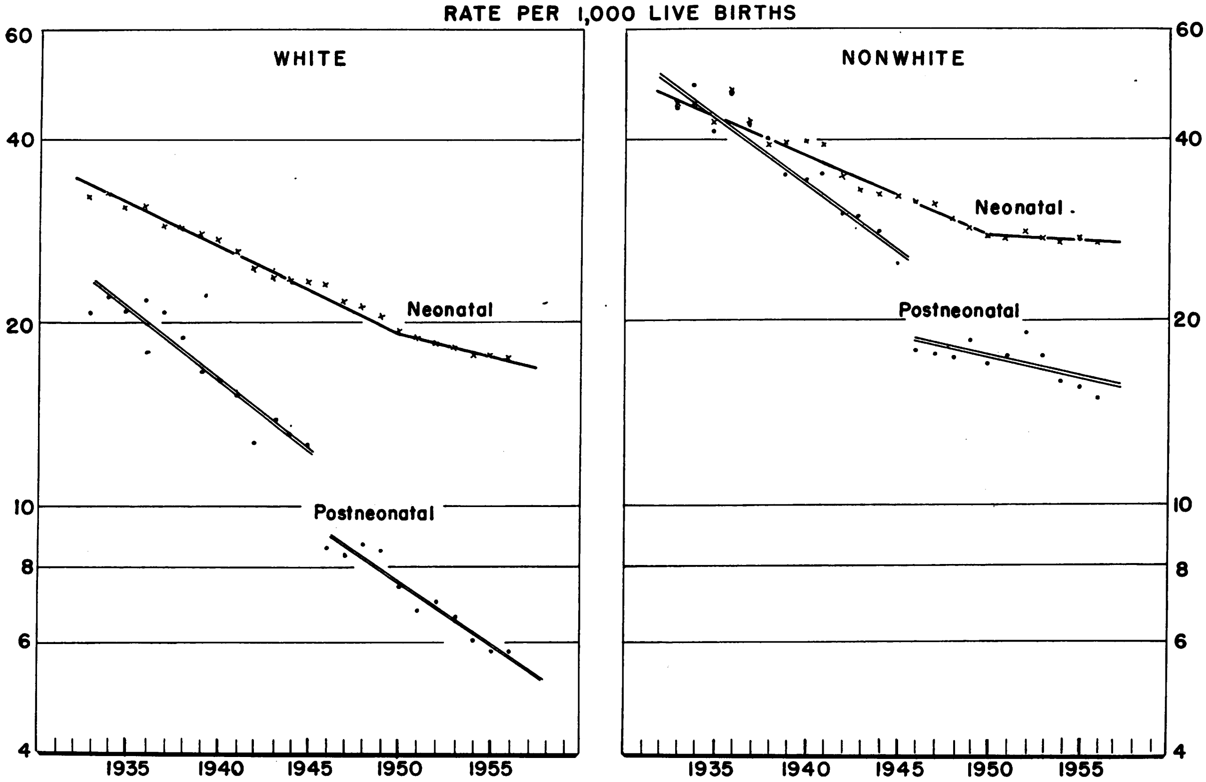
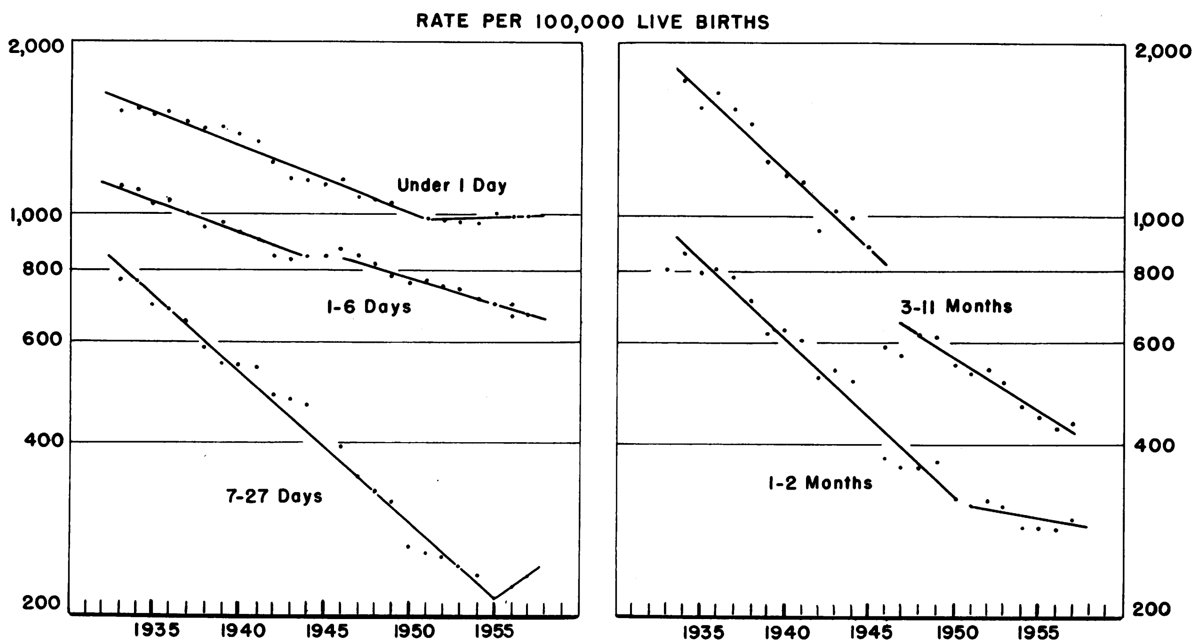


Figure 3. Infant mortality trend, by age, United States, 1933–57



possible for total mortality to be affected by the change in proportion of births by parity, and so on, even if the force of mortality remained unchanged. Adjustment of rates for the changing distribution of live births by birth order and age of mother indicates that these factors do not account for the change in the infant mortality trend. Neither does the changing number of annual births explain this phenomenon.

Although there is no evidence to suggest this possibility, infant mortality rates could be affected by changes in registration practices. For example, it is known that deaths of some babies dying soon after birth are registered as fetal deaths rather than as infant deaths. In a significant number of cases, the total infant mortality rate and, more particularly, the neonatal mortality rate could be affected by this practice. However, there is no indication from the examination of the perinatal (fetal deaths 20 weeks and over and neonatal deaths) mortality rates that such an artifact is involved. All in all, there is little to suggest that the recent change in the infant mortality trend is not real.

In seeking an explanation for the change in the trend of infant mortality, other data were examined. Figure 2 shows the neonatal (under 1 month of age) and the postneonatal (1 to 11 months of age) mortality rates by race. The neonatal mortality rates for whites and nonwhites declined at about the same rate (3.0 percent per year) between 1935 and 1949. About 1950 the rate of decline of neonatal mortality for nonwhite infants leveled off to about 0.4 percent per year. For white infants, the rate of decline after 1950 dropped to 1.7 percent. The same kind of break in trend also occurs in the postneonatal rates, but at an earlier period. For nonwhites, the annual rate of decline prior to 1946 was about 5 percent. Since 1946, the rate of decrease dropped to 1.5 percent per year. For the white infants in the postneonatal period, the rate of decline was 5.2 percent before 1946 as compared with 4.6 percent after 1945. These rates of change were computed by the method of least squares.

A significant feature of the postneonatal mortality trends is the sharp drop in the rates between 1945 and 1946. Data by cause of death indicate a substantial decrease in the death rates for influenza and pneumonia and for diarrhea and enteritis in 1946, with the consequent change in level of mortality from these causes after 1946. The decline in mortality from influenza and pneumonia and diarrhea and enteritis in 1946 accounted for about 58 percent of the drop in the total postneonatal mortality rate. Smaller but significant decreases in death rates were recorded for congenital malformations, congenital debility, whooping cough, and dysentery.

Age Subdivisions

Because both neonatal and postneonatal mortality have leveled off, it seemed worthwhile examining the data in greater detail to see if the change is concentrated in any particular age group in infancy. A change in trend (fig. 3) is apparent for each age group except 1 to 6 days. Most of the infants that die in the first week of life are born and die in hospitals. The effect of nursery care should be most evident in this age group. While the mortality trend for infants in the first day of life has flattened out, the rate of decline for infants 1 to 6 days old appears to be unchanged throughout the whole period 1933–57, except for a slight break in 1944 and 1945.

For infants 1 to 4 weeks old, the rate of decrease in mortality rates was fairly steep between 1933 and 1955. It is not possible to tell whether or not there has been a change in trend for this group, but the rates for 1956 and 1957 are successively higher than the rate for 1955. For babies 1 month and 2 months of age, the trends appear to have definitely leveled off. For the older infants, 3 to 11 months old, the rate of decline has slowed down since 1946.

Urban-Rural Trends

Examination of infant mortality trends by population-size groups indicates that the trends for cities of every size are affected, but not to the same extent. Although figure 4 presents data only for the dichotomy urban and rural, the trends for each city-size group show that they have flattened out for residents of cities over 25,000 population. The trends for urban places under 25,000 show very much the con-

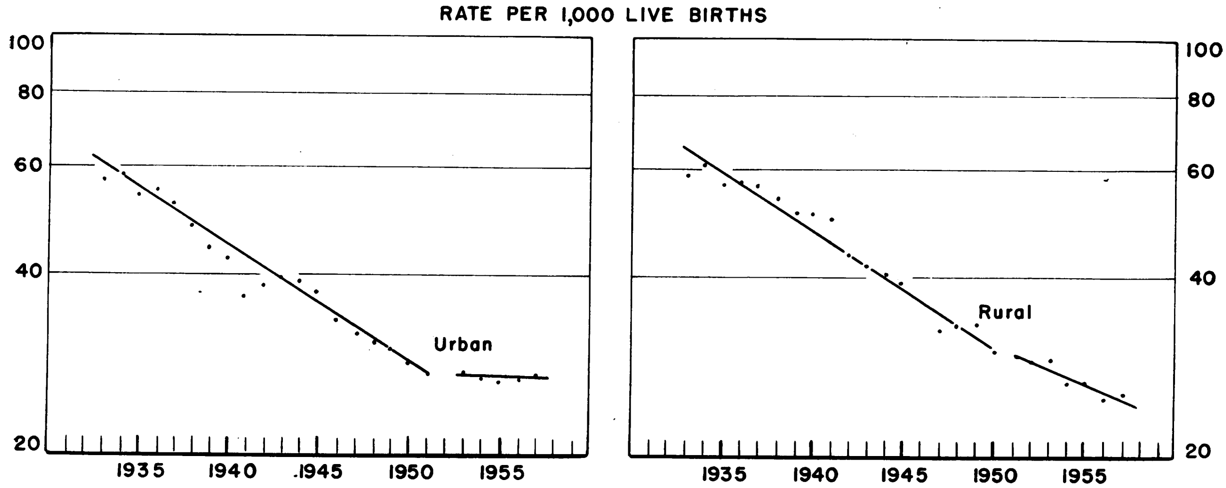
Table 1. Annual percent change in infant mortality rates by race and point of change in trend: each State, 1933–56

Area	White			Nonwhite		
	I	II	Inflection point	I	II	Inflection point
New England						
Maine	−3	−3	1947			
New Hampshire	−4	0	1953			
Vermont	−4	0	1953			
Massachusetts	−4	0	1951	−4	−4	------------
Rhode Island	−4	0	1950			
Connecticut	−5	0	1951	−6	+1	1947
Middle Atlantic						
New York	−4	0	1951	−5	0	1949
New Jersey	−4	0	1950	−4	0	1950
Pennsylvania	−4	−1	1951	−4	−1	1950
East North Central						
Ohio	−4	−2	1950	−5	0	1949
Indiana	−4	−2	1950	−3	−3	------------
Illinois	−4	−1	1950	−4	+2	1950
Michigan	−4	−1	1950	−4	0	1950
Wisconsin	−4	−2	1951			
West North Central						
Minnesota	−4	0	1952			
Iowa	−4	−2	1950			
Missouri	−5	−2	1949	−5	−2	1949
North Dakota	−4	0	1950			
South Dakota	−4	0	1949			
Nebraska	−3	0	1952			
Kansas	−4	−1	1950	−5	−4	1950
South Atlantic						
Delaware	−5	−5	1952	−4	−1	1946
Maryland	−6	0	1950	−6	+2	1950
District of Columbia	−4	0	1948	−6	+4	1948
Virginia	−5	−3	1950	−5	−2	1948
West Virginia	−2	−5	1947	−5	−2	1947
North Carolina	−6	−2	1951	−5	0	1947
South Carolina	−4	−3	1947	−7	−1	1948
Georgia	−5	−3	1947	−5	0	1947
Florida	−3	−1	1948	−3	+1	1947
East South Central						
Kentucky	−4	−4	(1)	−4	−2	1947
Tennessee	−4	−4	(1)	−5	−1	1949
Alabama	−4	−4	(1)	−5	−1	1947
Mississippi	−1	−3	1941	−3	+1	1947
West South Central						
Arkansas	−7	−2	1947	−3	+3	1945
Louisiana	−5	−1	1950	−1	−2	1946
Oklahoma	−4	−3	1945	−5	−2	1945
Texas	−5	−5	(1)	−4	0	1953
Mountain						
Montana	−4	−1	1951			
Idaho	−4	−4	(1)			
Wyoming	−3	−3	(1)			
Colorado	−5	−2	1950			
New Mexico	−4	−7	1947	−5	−9	1950
Arizona	−6	−6	(1)	−6	−6	
Utah	−5	−1	1950			
Nevada	−3	−3	(1)			
Pacific						
Washington	−2	−2	1947	−1	−3	1944
Oregon	−3	0	1950			
California	−4	−1	1950	−5	0	1951

[1] No inflection point.

NOTE: "I" refers to trend for period before point of inflection; "II" to trend after change in trend.

Figure 4. Infant mortality trends for urban and rural residents, United States, 1933–57



figuration seen for the rural trend in figure 4. The rates of decline are not as great as those for the larger cities, but the trends have slowed down in an unmistakable manner.

State Trends by Race

Infant mortality rates for individual States were plotted and trend lines were fitted by eye. The annual rate of change or the slope of the trend line is therefore an approximation. For States with a relatively small proportion of nonwhites in the population, data for total infants only were examined. The results are shown under data for white infants in table 1, since the "total" in these cases relates primarily to the experience for white infants.

The infant mortality trends for individual States generally show the same pattern as those for the country as a whole. For the majority of the States, there has been a marked slowing up of the rate of decline in the past 7 to 10 years. A typical trend is depicted by the data for Vermont (fig. 5).

There are several other patterns involving some 17 States and the District of Columbia. In one of these, there is an apparent reversal in trend, and the rates are now rising. The infant mortality trend for nonwhites in Maryland in figure 5 typifies this pattern. Table 2 lists the States in which the mortality trend for nonwhite infants is rising.

In another small group of States there has been a significant acceleration in the rate of decline in the infant mortality rate (see data for New Mexico, fig. 5). These areas are shown in table 3.

Another pattern involves some 10 States in which there has been no apparent change in

Table 2. States with rising mortality trend for nonwhite infants

State	Approximate point of change	Annual rate of change in percent	
		Prior to point of change	After point of change
Arkansas	1947	−3	+3
District of Columbia	1948	−6	+4
Illinois	1950	−4	+2
Maryland	1950	−6	+2
Mississippi	1941	−3	+1

Table 3. States with accelerated rate of decline in infant mortality rate

Area	Race	Approximate point of change	Annual rate of change (percent)	
			Prior to change	After change
New Mexico	White	1947	−4	−7
Do	Nonwhite	1950	−5	−9
Washington	do	1944	−1	−3
West Virginia	White	1947	−2	−5

the rate of decline of the infant mortality trend (see trend for Wyoming, fig. 5). With the exception of Maine, the general trend has been continuously downward in these areas. In Maine, the infant mortality rate took a relatively large drop about 1947 and then continued to decrease at about the same rate as before. The population groups for which no change in the trend could be observed are as follows:

State	*Population group*
Maine	Total
Massachusetts	Nonwhite
Kentucky	White
Tennessee	White
Alabama	White
Texas	White
Idaho	Total
Wyoming	Total
Arizona	White
Arizona	Nonwhite
Nevada	Total

With the exception of Massachusetts and Arizona, the above groups generally involve white infants. Most of these States are in the South or in the Mountain division and they represent about one-third of the States in their respective geographic divisions.

Point of Change by Race

Estimates of the point of inflection indicate that the changes in trend did not occur at the same time in all States. For the States which experienced a slowing down of the rate of change or an actual increase in mortality, the point of change came between 1945 and 1953. For the nonwhites, the modal year was 1947, whereas for the whites the mode came several years later in 1950.

The following table shows the points of inflection in the infant mortality rates by States for those racial groups for which there has been a deceleration in the rate of decline, or a reversal in trend.

Point of inflection	*White*	*Nonwhite*
1953	2	1
1952	3	0
1951	7	1
1950	16	6
1949	2	4
1948	2	3
1947	4	8
1946	1	2
1945	0	2

The point of inflection in the trend line is significant since it indicates the time when some element was introduced or when the cumulative effects of some factor or factors started to produce a change in the infant mortality trend. For more precise estimates of the inflection point, it will be necessary to fit a mathematical curve to the mortality rates.

For a number of States, there appear to be two inflection points. This occurs where there has been a rapid drop in mortality rates over a period of 2 or 3 years before the resumption of a second trend. In 10 States, the infant mortality rates for whites show an abrupt discontinuity in the trend. In nine States, the rates for nonwhites showed a similar break in trend. In only four States, Delaware, Florida, Mississippi, and Washington, did the trends for both whites and nonwhites have two points of inflection.

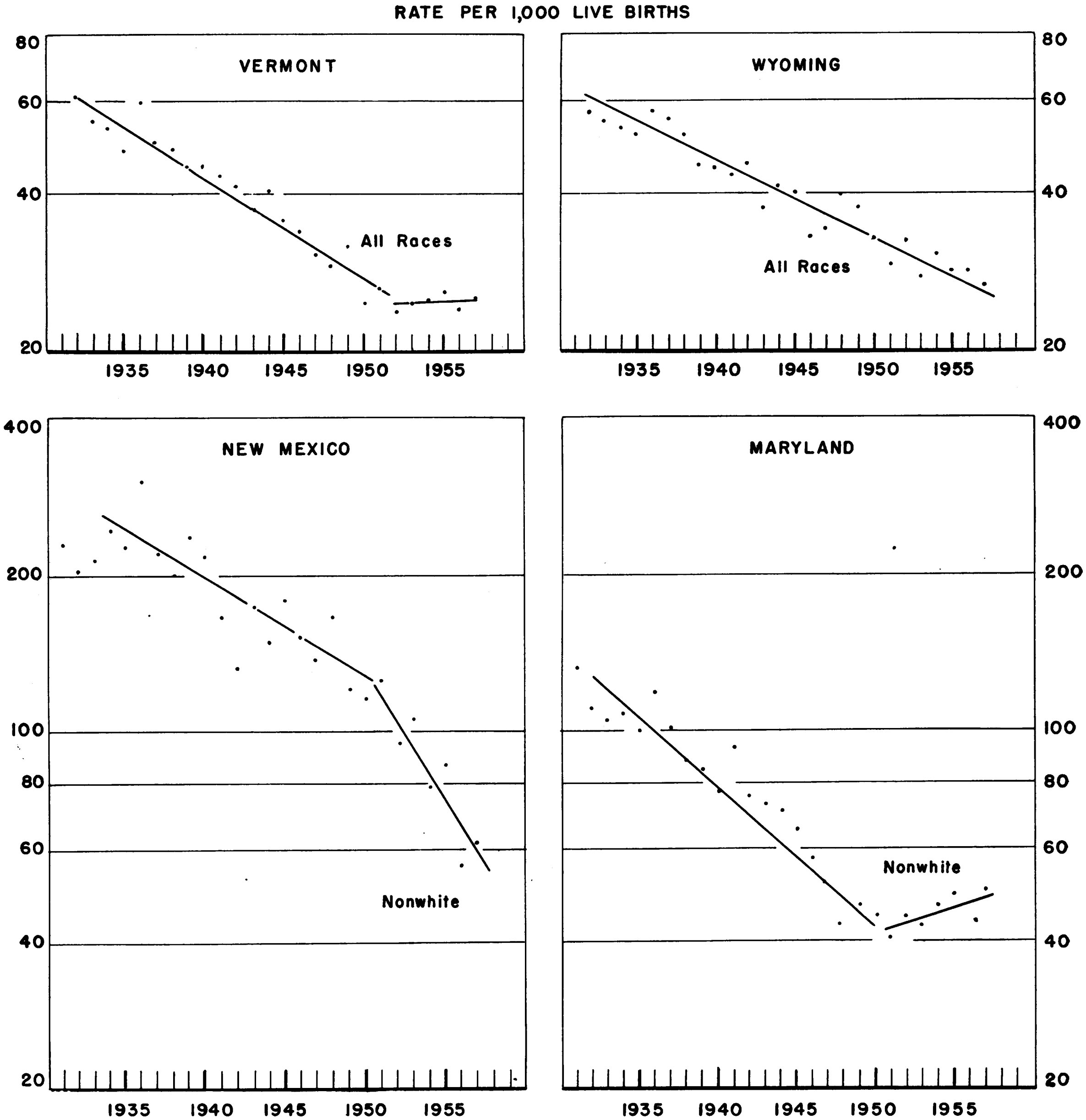
State Trends by Age

Data by age more clearly delineate the medical problems involved in the death of infants than do those by race (table 4). The District of Columbia is the only area where there has been a reversal in trend for both the neonatal and postneonatal mortality rates. A similar reversal may also be observed in the postneonatal trend for Connecticut. The rates for infants in the postneonatal period in the District of Columbia and Connecticut appear to be increasing about 3 percent a year after decreasing about 8 percent or more up to 1949 or so.

In only two States, West Virginia and New Mexico, has the neonatal mortality been declining faster in the postwar than in the prewar period. On the other hand, there are 13 States where the rate of decline has not changed, and the rates have been decreasing uniformly over the whole period. These States are: Maine, Indiana, Iowa, Missouri, Delaware, Tennessee, Mississippi, Oklahoma, Texas, Idaho, Wyoming, Arizona, and Nevada.

For infants in the postneonatal period the rates are decreasing faster than before in seven States, namely, Maine, West Virginia, Kentucky, Tennessee, Texas, Colorado, and New Mexico. In three States, Wyoming, Arizona, and Nevada, the postneonatal mortality rate has continued to decline without interruption.

Figure 5. Infant mortality trends for selected States, 1933–57



Point of Change in Trends

Of the States experiencing a change in mortality trends, the point at which the change in trend occurred is concentrated around 1950 for the neonatal rates (21 States), whereas the modal group for the postneonatal rates (10 States) is 5 years earlier, 1945. The following shows the distribution of the inflection points for the States where the rate of decline showed a marked deceleration or an increase:

Inflection point	Number of States: Neonatal	Number of States: Post-neonatal
1954–52	7	2
1951–49	21	11
1948–46	3	11
1945–43	2	10
Total	33	34

Although the neonatal mortality trend apparently started to change in a few States about the same time as the postneonatal mortality rates, most of the changes took place

Table 4. Annual percent change in neonatal and postneonatal mortality rates and point of change in trend: each State, 1933–56

Area	Neonatal			Postneonatal		
	I	II	Inflection point	I	II	Inflection point
New England						
Maine	−4	−4	1948	−3	−6	1946
New Hampshire	−4	0	1949	−7	0	1947
Vermont	−4	0	1950	−7	+1	1950
Massachusetts	−3	0	1952	−9	0	1950
Rhode Island	−4	−1	1950	−10	0	1948
Connecticut	−4	0	1950	−9	+3	1949
Middle Atlantic						
New York	−3	0	1952	−8	−2	1950
New Jersey	−3	−1	1954	−8	0	1951
Pennsylvania	−3	−1	1953	−8	−3	1952
East North Central						
Ohio	−3	−1	1950	−6	−4	1946
Indiana	−3	−3	—	−5	−5	1946
Illinois	−3	−1	1950	−7	0	1951
Michigan	−3	0	1951	−6	−4	1946
Wisconsin	−3	−2	1950	−7	−2	1949
West North Central						
Minnesota	−3	0	1953	−6	0	1951
Iowa	−3	−3	—	−8	−3	1949
Missouri	−3	−3	—	−6	−4	1945
North Dakota	−4	0	1951	−9	−6	1946
South Dakota	−4	−1	1947	−7	0	1951
Nebraska	−3	0	1952	−7	0	1950
Kansas	−3	−2	1950	−9	−2	1950
South Atlantic						
Delaware	−2	−2	1945	−7	−3	1945
Maryland	−4	−1	1951	−11	−2	1949
District of Columbia	−2	+2	1947	−8	+3	1949
Virginia	−4	−2	1950	−6	−5	1946
West Virginia	−3	−4	1946	−4	−8	1946
North Carolina	−4	−1	1950	−5	−1	1945
South Carolina	−4	−3	1949	−6	−1	1945
Georgia	−5	−1	1950	−6	−1	1945
Florida	−3	−2	1948	−5	0	1945
East South Central						
Kentucky	−3	−1	1949	−5	−7	1949
Tennessee	−3	−3	—	−5	−6	1946
Alabama	−1	−2	1941	−5	−2	1945
Mississippi	0	−1	1944	−7	0	1945
West South Central						
Arkansas	−1	−1	1941	−10	−4	1948
Louisiana	−3	+1	1952	−8	−4	1945
Oklahoma	−3	−3	—	−6	−4	1945
Texas	−3	−3	—	−6	−8	1949
Mountain						
Montana	−3	−2	1949	−10	−2	1947
Idaho	−3	−3	—	−7	0	1953
Wyoming	−2	−2	—	−6	−6	—
Colorado	−3	−1	1950	−5	−6	1945
New Mexico	−3	−5	1947	−5	−10	1947
Arizona	−4	−4	—	−9	−9	—
Utah	−4	−1	1949	−8	−4	1948
Nevada	−2	−2	—	−6	−6	—
Pacific						
Washington	−3	−2	1947	−5	−1	1947
Oregon	−3	−1	1950	−7	−1	1948
California	−3	0	1950	−8	−1	1950

NOTE: "I" refers to trend for period before point of inflection; "II" to trend after change in trend.

in 1950. On the other hand, the postneonatal mortality trends started to change earlier in a relatively large group of States in 1945 and in each succeeding period through 1951. Whatever factors were operating to change the trend of mortality of infants in the postneonatal period had their effects earlier and involved an increasing number of States in the years between 1945 and 1951. For the neonatal group, the trends were affected in two-thirds of the States in the period 1949 to 1951.

Trend by Cause of Death

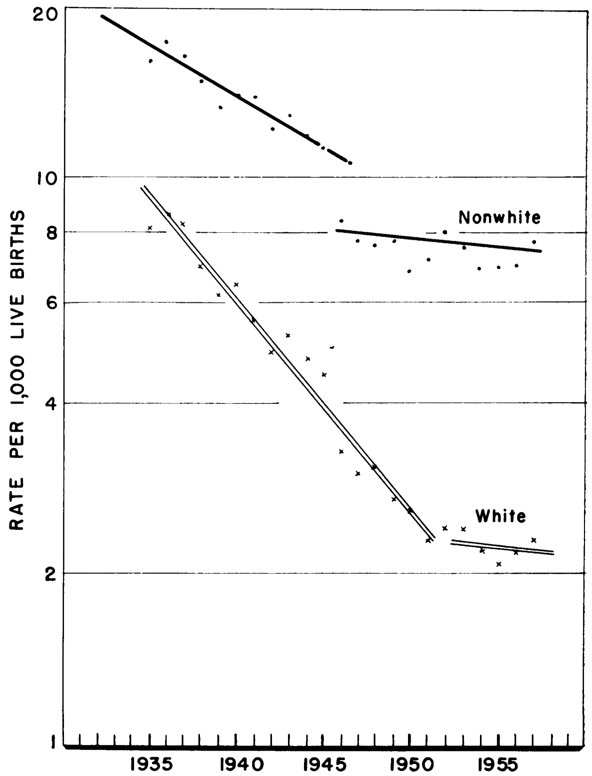
The usefulness of available information on causes of death among infants is somewhat limited on a time-trend basis because data by detailed age subdivisions have been tabulated only for a list of 45 selected causes. Another problem is that of comparability of data over a long time period. The major changes in the section on "Diseases of Early Infancy" in the Sixth Revision of the International Classification of Diseases and Causes of Death limit the interpretation of data for a number of conditions.

Despite these limitations, certain findings appear pertinent. One significant feature is the remarkable drop between 1945 and 1946 in the infectious and parasitic disease mortality rate, including influenza and pneumonia and diarrhea and enteritis. In one year, the infant mortality rate for these diseases dropped about 30 percent. By and large, there has been a general and fairly rapid decline in mortality rates for infectious diseases such as tuberculosis, syphilis, whooping cough, and dysentery. The death rates for these diseases are now practically at the vanishing point.

Mortality from diarrhea and enteritis, which is still a relatively frequent cause of death among infants in the postneonatal period, but not in the neonatal ages, shows a different pattern of trends. For the postneonatal white infants, there is a continuous declining trend. For nonwhites in the same age group, there does not appear to be any tendency for a continuation of the downward trend after the large decrease in 1946.

The rate of decline of the mortality trend for influenza and pneumonia has changed signifi-

Figure 6. Infant mortality rates for influenza and pneumonia, by race, United States, 1939–57



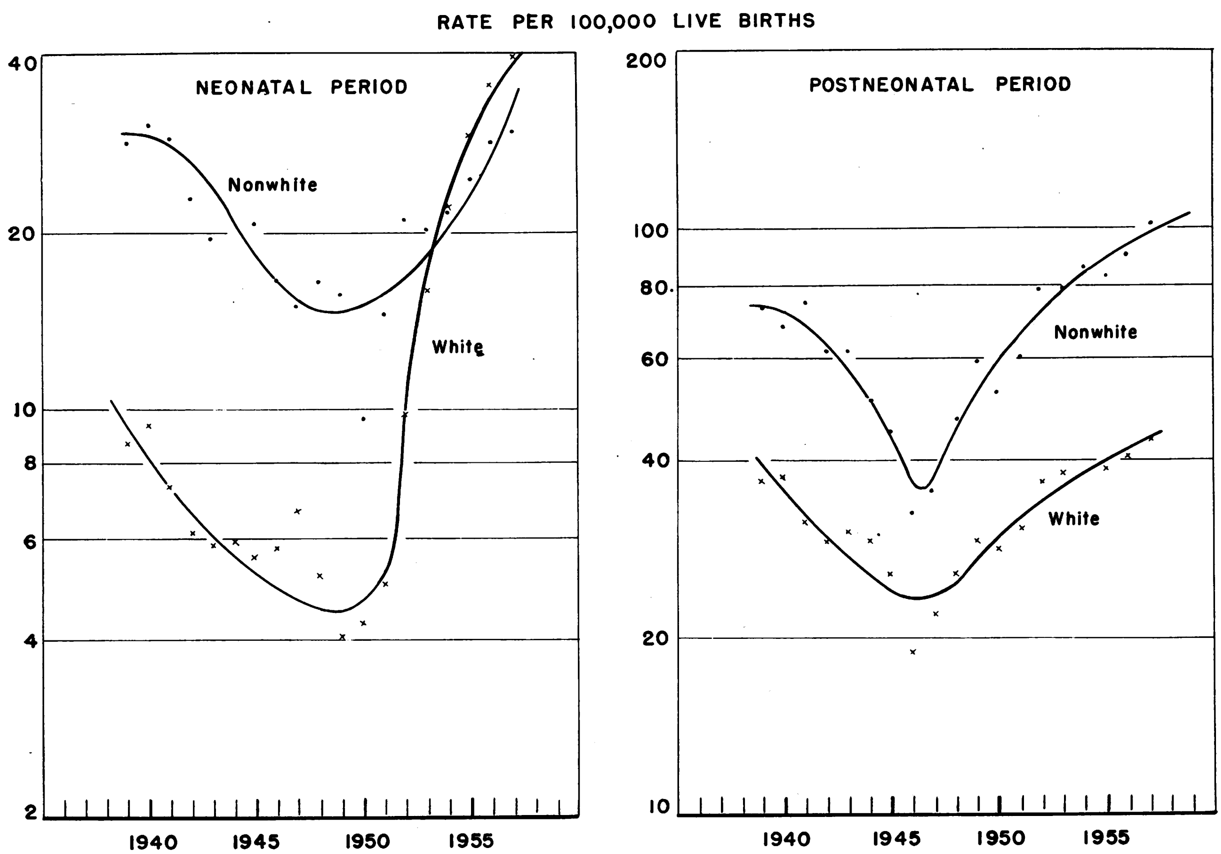
cantly (fig. 6). For both white and nonwhite infants in the first month of life, there was a marked flattening out of the trend for influenza and pneumonia starting about 1950. For nonwhite neonates, the influenza and pneumonia mortality rates subsequent to 1950 are at a higher level than they have been during the preceding 5-year period. Among infants in the postneonatal period, the influenza and pneumonia trend for nonwhites leveled off shortly after the precipitous drop in 1946. The trend for whites continued to decline until it leveled off starting about 1951.

A most dramatic reversal of trend may be seen in the death rates for respiratory diseases other than influenza and pneumonia (fig. 7). For infants in the neonatal period, the infant mortality rates for this group of respiratory diseases declined until about 1950 and then rose rapidly. The neonatal rate for whites showed a tenfold increase in about 8 years. The rate for nonwhites did not increase as rapidly as the rate for whites but the curve is definitely U-shaped. The same kind of reversal in trend may be seen in the postneonatal mortality rates for this group of respiratory diseases as in the neonatal rates. The rise in the trend of the postneonatal rates started around 1947, whereas that for the neonatal rates started about 1950.

The main components of the group of respiratory diseases other than pneumonia and influenza, for which mortality rates are undergoing an apparent reversal in trend, appear to be hyaline membrane disease for the neonates, and fibrosis of lung and chronic or unspecified interstitial pneumonia for infants in the postneonatal ages. Hyaline membrane disease not otherwise specified is classified under the category "Other diseases of lung and pleura" (International List No. 527.2). Most of the 1,596 deaths classified to "Other diseases of lung and pleura" in 1957 are probably those reported as hyaline membrane disease. This disease is being reported with increasing frequency. Prior to the recognition of the condition, it was probably reported as immaturity, unqualified, or asphyxia.

Although deaths attributed to hyaline membrane disease probably represent most of the neonatal deaths from respiratory diseases other than pneumonia and influenza, the category "Other chronic interstitial pneumonia" accounts for only a relatively small proportion of postneonatal respiratory disease mortality. In 1957, 709 deaths among infants over 1 month old were assigned to "Other chronic interstitial pneumonia," out of a total of 2,221 deaths for this age group classified as diseases of the respiratory system other than influenza and pneumonia. In some 1,253 postneonatal deaths from this group of respiratory diseases, the precise nature of the diseases involved cannot be identified without further tabulation. Of the possible causes, bronchiectasis may be the

Figure 7. Infant mortality rates for certain respiratory diseases other than influenza and pneumonia, by race, United States, 1939–57



condition which accounts for a large part of the deaths from diseases of the respiratory system other than pneumonia and influenza in the postneonatal period.

The infant mortality rate for congenital malformations is declining for white infants, while for nonwhite infants it is increasing (fig. 8). In both cases, the rate of change in the trend is relatively small.

For the group of diseases classified as diseases of early infancy but excluding pneumonia and diarrhea of the newborn, there has been a relatively steady decline in mortality trend (fig. 8). The rate of decrease is greater for white infants than for nonwhites. However, there is no break in these trends which serves to explain the change in the overall infant mortality trends.

The ill-defined and unknown causes of death among infants represent a relatively large frequency. However, the mortality trend for causes of death so attributed has been declining fairly regularly for all except the postneonatal rates for nonwhite infants. The rate for this group has leveled off somewhat since 1947.

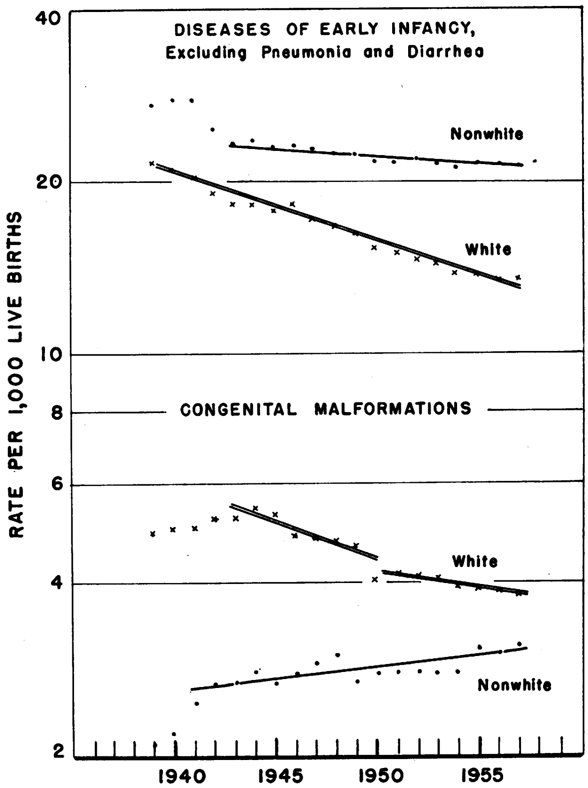
Accidents constitute a relatively frequent cause of death among infants. However, there is nothing unusual in the trend of mortality from violence which can account for the changes in the overall trend. On the other hand, the trend for the residual group, "All other causes," levels out after a period of decline. It was not possible from the data at hand to examine separately the diseases and conditions involved in this residual group.

In summary, it seems clear that influenza and pneumonia are primarily responsible for the change in the infant mortality trend. Although the infant mortality rate for diseases of the respiratory system other than influenza and pneumonia is now less than one-third of the rate for influenza and pneumonia, it is increasing rapidly. Unless it is checked, it will, before too long, exceed the mortality from influenza and pneumonia among infants.

The impact of any change in trend of mortality from any disease on the total mortality trend depends on the relative frequency of the disease. As may be seen in table 5, approximately three-fourths of all neonatal deaths are attributable to the diseases of early infancy, which are comprised principally of birth injuries, postnatal asphyxia, and prematurity. Next in the order of frequency are the congenital malformations. The infectious diseases rank third, but their relative frequency amounts to only about 9 percent of all deaths in the neonatal period. The pneumonias and other infections of the newborn and hyaline membrane disease are the most significant problems that can be categorized under the infectious diseases. In this connection, there is the problem of classifying hyaline membrane disease because deaths involving this disease may be attributed to atelectasis, pneumonia of newborn, or other diseases of lung and pleura, depending upon the physician's statement of causes of death.

For infants in the postneonatal period, deaths from the infectious diseases predominate. Influenza and pneumonia, and diarrhea and enteritis appear to be the principal problems. There also appear to be certain diseases of the respiratory system, possibly bronchiec-

Figure 8. Infant mortality rates, by race, United States, 1939–57



tasis and pulmonary congestion and hypostasis which seem worth while looking into. The diseases of early infancy are no longer of importance in the postneonatal ages, but congenital malformations become relatively of greater significance. Also, deaths from accidents begin to assume greater importance to infants in this age group.

Experience in Other Countries

Data for a number of countries of low infant mortality were examined. These were Norway, Sweden, Denmark, the Netherlands (not shown in chart), England and Wales, New Zealand, and Australia. The infant mortality trends for all of these countries, except New Zealand (not shown in chart), show the same kind of configuration as that observed for the United States (fig. 9). The infant mortality rates for New Zealand have been rather erratic, but the leveling-off effect is there from 1954. In the other countries, the turning point in the trend appears to be between 1949 and 1954.

The trend for Japan, a country with a relatively high infant mortality, suggests that the magnitude of mortality is not a factor in determining whether or not a leveling-off effect occurs. The infant mortality rates for the various States in the United States also demonstrate this point.

Discussion

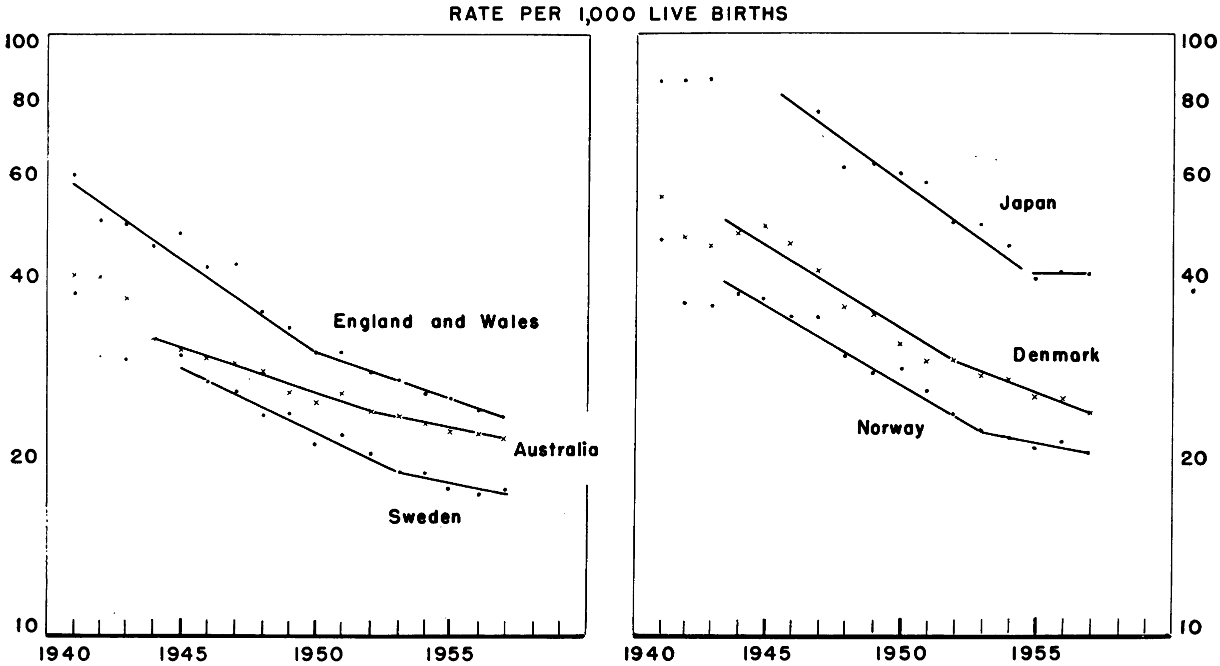
The situation with respect to infant mortality trends may be summarized as follows: For years, the infant mortality rates in the United States declined rapidly, principally because of the reduction in mortality from the infectious diseases. Between 1945 and 1946, there was an unusually sharp break in the death rate for the infectious diseases coincident with the availability of penicillin for civilian use. Also a possible factor was the availability of DDT, which had its impact on mortality from the diarrheal diseases. This was followed by a basic change in the overall infant mortality trend. The trends for both whites and nonwhites, and more particularly the latter, have been affected. The sharp leveling off of the trend for nonwhite infants started about 1946; that for white infants, about 1950. The neonatal mortality trend has changed to a greater extent than that for the postneonatal rates.

Table 5. Number of deaths among infants, by cause, age, and race: United States, 1957

Cause of death	Total		White		Nonwhite	
	Neonatal	Post-neonatal	Neonatal	Post-neonatal	Neonatal	Post-neonatal
All causes	81, 088	31, 006	63, 491	20, 921	17, 597	10, 085
Infectious diseases	7, 043	16, 220	4, 940	10, 119	2, 103	6, 101
Influenza and pneumonia [1]	3, 792	9, 534	2, 510	5, 930	1, 282	3, 604
Other diseases of respiratory system [2]	1, 624	2, 221	1, 437	1, 578	187	643
Other chronic interstitial pneumonia	17	709	16	512	1	197
Other diseases of lung and pleura [3]	1, 354	242	1, 224	158	130	84
Other	253	1, 270	197	908	56	362
Diarrhea and enteritis [4]	524	3, 088	268	1, 650	256	1, 438
Other infections of newborn	838	18	559	14	279	4
Other [5]	265	1, 359	166	947	99	412
Congenital malformations	10, 102	5, 699	8, 971	4, 884	1, 131	815
Diseases of early infancy [6]	60, 833	1, 452	47, 000	838	13, 033	614
Accident and infanticide	376	3, 421	264	2, 358	112	1, 063
Ill defined and unknown	1, 192	1, 365	476	605	716	760
All other	2, 342	2, 849	1, 840	2, 117	502	732

[1] Includes pneumonia of newborn.
[2] International List categories 470–475, 500–527.
[3] Hyaline membrane disease probably constitutes bulk of this category.
[4] Includes diarrhea of newborn.
[5] International List categories 001–138, 765–768.
[6] Excludes pneumonia and diarrhea of newborn and other infections of newborn.

Figure 9. Infant mortality rates for certain countries of low mortality, 1941–57



However, the postneonatal mortality trend has also been influenced. The infant mortality trends for urban places of 25,000 or more have almost completely flattened out. For smaller cities and rural areas, the rates are still declining, but the rates of decrease have slowed down markedly.

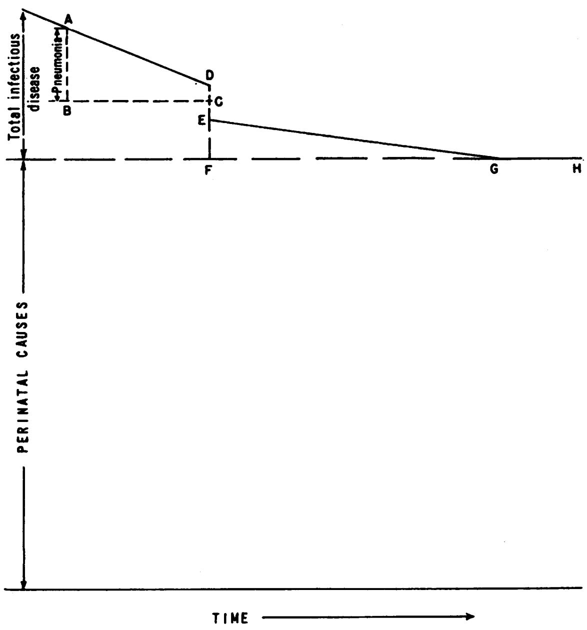
The change in mortality trend has not been limited to any particular section of the country, although the continuing downward trend for many Mountain States has been remarkably unaffected. In a few States, there has been an acceleration in the decline. The degree of leveling off of the trend is not uniform in various parts of the country. In a few areas, the trend of infant mortality appears to be rising.

The problem of the development of drug-resistant strains of organisms has been mentioned frequently. If this were the total explanation for the change in trend of infant mortality, the resistant organisms must have become a problem for the nonwhites almost immediately after the introduction of penicillin whereas, for the white infants, it took several years before the effects became evident. Unfortunately, there is relatively little statistical information on this subject for the country as a whole. Dauer (*1*) has reported a steady and rapid increase in deaths from staphylococcal septicemia and pyemia in the total population since 1949, as well as in the deaths from sepsis of the newborn. However, the total number of deaths attributable to such infections is still relatively small. Unless these deaths are indicative of the much greater problem of staphylococcal infections, they do not serve to explain the change in the infant mortality trend.

The change in infant mortality trend appears to be due to the combination of two factors, the change in the rate of decline of mortality from influenza and pneumonia and the slow-changing character of the trend for the perinatal causes of mortality; that is, congenital malformations and certain diseases of early infancy. This may be depicted schematically (fig. 10).

For purposes of simplification, it may be assumed that mortality among infants is due to two major factors, infectious diseases and perinatal causes. Furthermore, it may be assumed that there is no change in the trend for the perinatal causes. Suppose that, at point A, bactericidal agents such as the sulfa drugs were introduced for therapeutic purposes. If these drugs were 100 percent effective in the treatment of pneumonia, for example, and if all infants with pneumonia were treated with these drugs, the infant mortality rate would drop from A to B in 1 year. In subsequent years, the trend would continue in a straight line BC. However, the drugs do not completely prevent deaths. Furthermore, not all the infant population with pneumonia comes under drug therapy. Therefore, the actual movement of mortality would follow the curve AD. At point D, a new therapeutic agent is introduced, say, penicillin. Assume that this agent is effective in preventing mortality from pneumonia and all other infectious diseases. If the drug were 100 percent effective and all infectious diseases were treated, the mortality rate should drop from D to F and a new trend, FG, would be established. However, not all the infants contracting infectious diseases are treated nor is the antibiotic 100 percent effective. On the other hand, the sharp drop in mortality from D to E is indicative of the effectiveness of penicillin in reducing mortality. A new trend, EG, is established until infectious disease mortality reaches zero at point G. With the elimination of infectious diseases as

Figure 10. Schematic diagram of course of infant mortality, assuming certain changes in mortality from infectious diseases and perinatal cause mortality



causes of death, the infant mortality trend follows the course of mortality from the perinatal causes, G to H, which is essentially flat.

In the recorded data for total infant mortality, the declining trend prior to 1945 may be observed. There is a drop in mortality between 1945 and 1946 followed by a continuation in the downward trend but at a smaller rate of decline. For all infants, this suggests that infectious disease mortality is approaching an asymptote. The rising trend of mortality from respiratory diseases other than influenza and pneumonia is a relatively small but contributing factor in slowing up the rate of decline in infectious disease mortality. The notion of any asymptote for infectious disease mortality as shown in the schematic diagram might be applicable here, but the evidence does not completely support this point of view. The infectious disease mortality rates for nonwhite infants started to level off at a much higher point than for the whites. Also, these rates declined at a much slower rate for nonwhites than for whites immediately after the large decrease in 1946. For white infants, the relative reduction in infectious disease mortality rate in 1946 was much greater than for nonwhites. However, the trend for white infants continued downward without interruption until 1951 when the rates started to decline more slowly but not as slowly as those for nonwhite infants. The difference in pattern between the trends for whites and nonwhites suggests possible differences in the method of treatment of infectious diseases or the extent of use of available therapeutic agents or procedures. On the other hand, the consistency of the pattern of infant mortality trends internationally indicates a more basic problem which is not peculiar to the United States.

Because the proportion of infectious disease mortality to total deaths is so different in the neonatal as compared with the postneonatal period, the pattern of trends is different. For infants in the neonatal period, deaths from infectious diseases constitute less than 10 percent of mortality from all causes in this group, and most of the deaths (74 percent) are due to the diseases of early infancy. Because the mortality trends of diseases of early infancy and congenital malformations are relatively flat, the combined effect of these trends exerts considerable influence on the trend for all neonatal deaths. Therefore, the neonatal mortality trend has practically leveled off.

For infants in the postneonatal period, the infectious disease mortality still amounts to slightly less than half of all postneonatal deaths among white infants, and over 60 percent for nonwhites. For this group of infants, there is not the same solid floor provided by the congenital malformations and diseases of early infancy as in the case of the neonates.

Therefore, the leveling-off effect of the infectious disease trend is not reinforced as much by the relatively flat trends of mortality from congenital malformations and diseases of early infancy.

The overall infant mortality trend is affected more by the pattern of neonatal mortality trend than by postneonatal death rates. For every three postneonatal deaths, there are now eight neonatal deaths.

From the examination of these data, it would appear that no marked change downward in the infant mortality rate can be expected until the attack on influenza and pneumonia is altered. There is need for detailed epidemiological studies of the circumstances surrounding infant deaths from these infectious diseases to determine the possible causes of their failure to respond to therapy as might be expected. The factors surrounding deaths presently attributed to hyaline membrane disease and other respiratory diseases appear worthwhile exploring.

No substantial progress in reducing infant mortality will be made until there is a breakthrough in dealing with congenital malformations and the diseases of early infancy, such as birth injuries, postnatal asphyxia, and premature delivery of infants. The hard core of the problem has been relatively untouched.

Although a relatively low infant mortality rate has been achieved, the number of infant deaths occurring annually in the United States is exceedingly high, due to the unprecedented number of births since World War II. The total number of infant deaths in the United States in 1958 was 113,789, the largest number ever recorded in the history of the country. The infant mortality problem of today does not appear to be one which can be viewed with complacency.

REFERENCE

(*1*) Dauer, C. C.: Septicemia. Epidemiological notes. Pub. Health Rep. 74: 354, April 1959.

Community Survey of Polio Vaccinated Urged

Supplies of unused polio vaccine total 26.4 million doses, although more than 90 million Americans still need to be vaccinated, according to Dr. Leroy E. Burney, Surgeon General of the Public Health Service.

For the past 4 years, he pointed out, there has been a surplus of vaccine in the spring and winter followed by a shortage in the summer when the rise of poliomyelitis cases reminds people they should get vaccinated. The problem can be solved only if the following facts are stressed:

- The vaccine is most effective if used before poliomyelitis is prevalent.
- The vaccine manufacturing process takes about 4 months; if demand for vaccine is low in the spring, supplies are likely to be low in the summer, since the spring supply may be outdated by then.
- It is the third shot, due 7 months or more after the first two that gives the greatest protection. A fourth shot a year after the third adds even greater protection.

Most poliomyelitis epidemics start in neighborhoods with concentrations of unvaccinated people. Infants and children under 5 years of age have accounted for almost half of all paralytic cases in the past 2 years, Dr. Burney said, yet about half of the children in these age groups still lack optimum protection against the disease.

He urged leaders of local medical societies, health departments, and National Foundation chapters to carry out surveys in their communities to find the unvaccinated and persuade them to be vaccinated promptly. Surveys can be completed within a few days through use of a system developed by the Public Health Service, which will be provided to interested communities.

Radiation Exposure

These comments were offered by Secretary of Health, Education, and Welfare Arthur S. Flemming in response to questions at his news conference of February 25, 1960.

The February 19, 1960, issue of *Science* contains a report of the Ad Hoc Committee of the National Committee on Radiation Protection and Measurements and a covering note by the chairman, Dr. Lauriston S. Taylor. The Ad Hoc Committee report contains no specific numerical recommendations on maximum permissible limits. It does, however, indicate that such limits should be based on factors above natural background radiation, rather than factors below levels at which demonstrable injury has occurred.

The covering note by Dr. Taylor states that the National Committee on Radiation Protection recommends the interim use of the levels recommended by the International Committee on Radiation Protection until the NCRP has completed its study of the recommendations of its subcommittee I. The number for strontium 90 would be 33 micromicrocuries per liter.

It should be emphasized that the so-called permissible limits are only calculated estimates. They will continue to be subject to change one way or another as more and better scientific data are developed about radioactive elements and their effect on the human body.

There has been for some time considerable discussion related to possible lowering of the recommended levels for some elements, such as strontium 90. Further consideration should continue to be given to the amount of strontium 90 which is distributed and retained in the body. A great deal more research is needed to provide data for a more accurate correlation between the amounts found in foodstuffs and their lodgment in the body.

The levels recommended by the NCRP represent thus far the most informed scientific opinion available to us. Pending recommendations to the President by the Federal Radiation Council and the President's action on these recommendations, the Department of Health, Education, and Welfare will continue, as in the past, to relate levels of strontium 90 in milk, water, and food to the values recommended by the NCRP as permissible for lifetime exposure. This means that for the time being, the Department will use a factor of 33 micromicrocuries per liter for strontium 90 rather than the earlier factor of 80 micromicrocuries per liter.

The Department of Health, Education, and Welfare has never indicated that exposures below these benchmark levels were absolutely safe. At the same time, we have pointed out that the recommended levels relate to exposure over an entire lifetime and may be exceeded by varying amounts and for varying periods without causing appreciable harm to the individual. Measurements of radiation levels in air, water, milk, and food in various parts of the country are useful primarily as indicators of the scope and nature of health problems which may be developing for specific population groups and as guides for corrective action.

It should be noted that the highest count for radiation in the milk sampling network was 37.3 micromicrocuries per liter at St. Louis in April 1959. The highest annual average was 21.1 micromicrocuries per liter at St. Louis for the year ending October 1959.

☆ ☆ ☆

ED. NOTE: The report of the Ad Hoc Committee of the National Committee on Radiation Protection and Measurements contains these statements in the conclusions:

"The committee believes that present evidence is not sufficient to establish the dose-response curve for somatic effects at low doses. In the absence of such information, the committee has chosen to make the cautious *assumption* that there is a proportional relation between dose and effect and that the effect is independent of dose rate or dose fractionation.

"On this, or any other nonthreshold assumption, it follows that even the smallest dose is associated with some risk. Under these circumstances, the exposure of the population to any increase in radiation should not occur unless there is reason to expect some compensatory benefits."

The report proceeds then to say:

"We believe that the population permissible somatic dose from manmade radiations, excluding medical and dental sources, should not be larger than that due to natural background radiation, without a careful examination of the reasons for, and the expected benefits to society from a larger dose."