

THE TREND OF MATERNAL-MORTALITY RATES IN THE UNITED STATES DEATH-REGISTRATION AREA, 1900-1921^a

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THE MATERNAL-MORTALITY rate in the United States death-registration area is increasing, if the statistics can be accepted. Apart from the question of the reliability of the figures, such a conclusion is surprising in view of the increased attention paid to medical education and to public-health administration and the increasing interest that the public takes in questions of health. Before the conclusion is accepted, therefore, the evidence for the increase in the rate of maternal mortality should be examined critically.

In Table I the death rates from all puerperal causes per 100,000 population are given for the expanding death-registration area. The rate from all causes apparently increased from 13.3 in 1900 to 16.9 in 1921. From puerperal septicemia it increased from 5.7 in 1900 to a maximum of 7.4 in 1911, from which point it decreased to 6.8 in 1921. From other puerperal causes it increased from 7.6 in 1900 to 10.1 in 1921.

In this comparison rates expressed in terms of population are used because satisfactory birth statistics are not available throughout the period for the whole area. But the real risk of death from puerperal causes can best be measured by reference to the number of cases exposed to the risk, namely, the number of births. Since the birth rate is falling, a constant puerperal mortality as measured in terms of births would show a slight decrease if measured in terms of population; and hence these rates expressed in terms of population understate the increase in risk rates from puerperal mortality during this period. Furthermore, the slight apparent decline in the mortality from

TABLE I.

TREND OF MORTALITY RATES FROM PUERPERAL CAUSES, EXPANDING DEATH-REGISTRATION AREA, 1900-1921.

Year.	Deaths from puerperal causes, per 100,000 population.		
	Total	Puerperal septicemia	Other puerperal causes
1900.....	13.3	5.7	7.6
1901.....	13.7	6.0	7.7
1902.....	13.0	5.7	7.3
1903.....	14.0	6.1	7.9
1904.....	15.3	6.9	8.5
1905.....	14.9	6.8	8.1
1906.....	15.1	6.2	8.9
1907.....	15.6	6.8	8.9
1908.....	15.7	7.0	8.7
1909.....	15.3	6.7	8.6
1910.....	15.7	7.2	8.5
1911.....	16.0	7.4	8.6
1912.....	15.0	6.5	8.5
1913.....	15.8	7.2	8.7
1914.....	16.0	7.1	8.9
1915.....	15.3	6.3	9.0
1916.....	16.3	6.7	9.6
1917.....	16.7	6.9	9.8
1918.....	22.3	6.5	15.9
1919.....	17.0	5.8	11.2
1920.....	19.0	6.6	12.5
1921.....	16.9	6.8	10.1

puerperal septicemia since 1911 may be the result of a stationary or even slightly increasing mortality from puerperal septicemia masked by the falling birth rate.

With the possible exception of mortality from puerperal septicemia since 1911, the figures indicate a marked increase in maternal death rates during the twenty-year period covered by the statistics. Before definite conclusions are drawn as to the extent of this increase or as to the real trend in puerperal mortality, the influence of the factors must be considered: (1) the expansion of the registration area, (2) the decrease in the birth rate, and (3) improvements in certification of cause of death.

Since these figures relate to the expanding death-registration area, the first questions which must be answered are, How much, if any, of the apparent increase is due merely to the addition to this area of states with higher puerperal-

^a. A summary of a chapter in a report on maternal mortality, by Robert M. Woodbury, to be published by the U. S. Children's Bureau.

mortality rates than those in the original area, and how much is due to an increase in mortality rates in the original or in the added areas? In 1900 the death-registration area included 40.5 per cent of the population of the United States; in 1920 it included more than twice as large a proportion, 82.2 per cent. A study of the mortality rates in the original registration states (including the District of Columbia but excluding registration cities in nonregistration states) and in states added during each year shows that the result of additions of new states to the area was to increase slightly the mortality rates from all puerperal causes in 1906, 1911, 1913, 1916, 1917, and 1919, and to decrease them slightly in 1908, 1909, 1910, 1914, 1918, and 1920 relatively to what they would have been if no additions had been made.

The influence of changes in territory may be eliminated in either of two ways: The first and simpler way is to study the trend of mortality in the original registration states of 1900. In this area the rate from all causes rose from 13.4 in 1900 to 17.5 in 1920. From puerperal septicemia it rose from 5.8 in 1900 to a maximum of 7.1 in 1911, and fell to 6.1 in 1920. From all other puerperal causes, however, it showed a continuous increase from 7.6 to 11.5 during the twenty-year period under review. These increases in each case are slightly less than the increases shown in the expanding area.

This method does not take into account, however, changes in rates in the states which were added to the original registration area. In most of the added states, but not in all, the rate from all puerperal causes was higher in 1921 than in the year of admission.

A method of taking into account changes in mortality rates within the added as well as within the original territory—giving to each change its due weight in the calculation—is as follows: The percentage of change in rate from each year to the next in the territory common to both years is first ascertained.

The initial rate in 1900 is multiplied by the percentage of change from 1900 to 1901 in the territory common to both years; the result is then multiplied by the percentage of change from 1901 to 1902 in the territory common to these years; and similarly each successive result is multiplied by the corresponding percentage of change. The final result is a series of adjusted figures which measure the change in maternal mortality in the expanding area after the influence of differences in initial rates in the added states is eliminated.

The series of figures so constructed is compared in Table II with the rates in the expanding area and with those in the original registration states. A comparison of these three groups of figures shows that eliminating the influence of the expansion of the area gives a trend not far different from the trend of the rates from puerperal causes in the original registration states.

As for the second factor which must be considered before definite conclusions can be drawn, since the birth rate decreased during the twenty years from 1900 to 1920, the maternal-mortality rate, when expressed in terms of deaths per 1,000 births, would show a greater increase than when expressed in terms of deaths per 100,000 population. To estimate the influence of the fall in birth rate upon the apparent changes in rates of puerperal mortality, it is necessary first to ascertain the amount of this fall; with this information its influence upon the puerperal-mortality rate as stated in terms of population can easily be calculated.^b

The chief difficulty in making a correction for the fall in birth rates is to ascertain the rates themselves. The registration of births in many of the states composing the death-registration area of 1900 is incomplete, and statistics based upon

b. If B_1 , B_2 are birth rates in different years, and $b = \frac{B_2}{B_1}$ (i.e., the proportion that the second birth rate is of the first, and p_1 , p_2 are the rates of puerperal mortality per 100,000 population in the same years, then if p_2 is divided by b the result will be comparable with p_1 so far as any change in birth rate is concerned.

TABLE II
TREND OF MATERNAL-MORTALITY RATES, U. S. DEATH-REGISTRATION AREA, 1900-1921.

Year	Maternal-mortality rates per 100,000 population		Ratio to 1900 rate ^a		Index number of rates in expanding area ^d
	Expanding death-registration area ¹	Original death-registration States ²	Expanding death-registration area	Original death-registration States	
1900	13.4	13.4	100.0	100.0	100.0
1901	13.2	13.2	98.8	98.8	98.8
1902	12.6	12.6	94.0	94.0	94.0
1903	13.1	13.1	97.5	97.5	97.5
1904	14.9	14.9	110.8	110.8	110.8
1905	14.6	14.6	108.8	108.8	108.8
1906	15.0	14.4	111.9	107.1	106.9
1907	15.5	15.1	115.4	112.3	110.4
1908	15.5	14.3	115.9	106.9	111.5
1909	15.0	14.4	112.2	107.6	108.6
1910	15.4	15.1	114.5	112.5	111.8
1911	15.5	15.5	115.8	115.6	111.6
1912	14.4	14.1	107.7	105.4	103.8
1913	15.5	14.9	115.3	111.5	110.2
1914	15.4	15.4	115.2	114.5	110.6
1915	14.8	14.8	110.5	110.0	106.2
1916	16.0	14.8	119.6	110.0	109.9
1917	16.5	15.5	123.0	115.2	112.6
1918	22.1	20.5	165.0	153.1	152.7
1919	16.8	15.3	125.5	113.8	114.5
1920	19.0	17.5	141.5	130.8	129.3
1921	16.7	15.1	124.5	112.6	113.8

¹ Exclusive of cities in non-registration States.

² Includes the six New England States, New York, New Jersey, District of Columbia, Indiana, and Michigan.

³ The 1900 figures=100.0.

⁴ For method of calculation see preceding text.

registered births during the period from 1900 to 1920 are subject, therefore, to errors of varying size due to omissions. Perhaps the most satisfactory method is to estimate the average number of births for the five years preceding each census date (1900, 1910, and 1920) from the enumerated populations under five years and the statistics of deaths of children under five.^c This method gives estimated birth rates for the original death-registration states of 25.6 in 1900, 24.0 in 1910, and 23.2 in 1920; the birth rate, therefore, appears to have decreased 9.5 per cent during these twenty years. Assuming that these estimates give a fairly ac-

curate picture of the fluctuations in the actual birth rates during this period, Table III indicates the trend, after allowance is made for the falling birth rate, of maternal mortality in the original death-registration states from all causes, from puerperal septicemia, and from other causes.

As would be expected, the result of this correction is to make still larger the apparent increase in mortality from puerperal causes. The rapid fall shown in the crude death rates from 1900 to 1902 appears to be caused in large part by the markedly lower birth rates in the years 1901 and 1902 as compared with that in

^c The number of births during the five-year period prior to the date of the census can be approximated by adding to the enumerated population under five years the number of children born during that period who died prior to the date of the census. The latter number is approximately equal to the sum of (1) infants who had died under one year of age in the four years prior to the date of the census and 71 per cent of those who had died under one year of age in the fifth year before the date of the census; (2) children who had died at one year of age during the three years prior, and 59 per cent of those who had died at one year of age in the fourth year prior to the date of the census; (3) children who had died at two years of age during the two years prior, and 53 per cent of those who had died at this age in the third year prior to the date of the census; (4) children who had died at three years of age during the year immediately prior, and 52 per cent of those who had died at this age in the second year prior to the date of the census; (5) 52 per cent of the children who had

died at four years of age in the year immediately prior to the census date. (For method see United States Life Tables, 1890, 1901, 1910, 1901-1910, p. 340.) By this method estimates of births were made for the periods 1895-99, 1905-09, 1915-19; the deaths under five years in the years 1895-99 were estimated from those in the period from 1900-04 by reducing them in the same proportion that the estimated number of births in 1895-99 was less than the estimated number of births in 1900-04. From these figures birth rates for each year from 1900 to 1920 were calculated on the assumption of a uniform rate of fall; these were then modified to take account of fluctuations in the birth rate from year to year by multiplying by a factor found by dividing the actual number of registered births in each year by one-fifth the sum of the actual number of registered births in the five-year period in which the particular year was the middle one. In this calculation no allowance was made for omissions from the census population under five years nor for variations in the proportion of such omissions.

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TABLE III

TREND IN MATERNAL-MORTALITY RATES AFTER ALLOWANCE IS MADE FOR FALLING BIRTH RATE, 1900-1921; U. S. DEATH-REGISTRATION STATES OF 1900.

Year	Trend in birth rate: 1900 rate=100.0	Trend in death rates: 1900 rate=100.0.					
		All puerperal causes		Puerperal septicemia		Other puerperal causes	
		Crude figures	Adjusted for falling birth rate	Crude figures	Adjusted for falling birth rate	Crude figures	Adjusted for falling birth rate
1900	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1901	96.5	98.8	102.4	95.3	98.8	101.4	105.0
1902	96.1	94.0	97.9	91.8	94.5	96.5	100.4
1903	97.4	97.5	100.2	94.0	96.5	100.2	102.9
1904	95.8	110.8	115.6	112.2	117.1	109.6	114.5
1905	93.6	108.8	116.2	109.9	117.4	107.9	115.3
1906	95.8	107.1	111.8	100.3	104.7	112.3	117.1
1907	97.0	112.3	115.8	111.6	119.6	112.8	116.3
1908	97.4	106.9	109.7	106.3	109.1	107.4	110.2
1909	92.6	107.6	116.2	106.1	114.6	108.7	117.4
1910	93.8	112.5	120.0	116.5	124.3	109.5	116.7
1911	94.3	115.6	122.6	123.3	130.8	109.8	116.4
1912	93.4	105.4	112.9	103.3	110.6	107.1	114.6
1913	92.4	111.5	120.6	113.5	122.8	109.9	119.0
1914	93.8	114.5	122.0	113.3	120.8	115.3	122.9
1915	92.8	110.0	118.5	102.4	110.3	115.7	124.7
1916	92.3	110.0	119.2	105.6	114.4	113.3	122.8
1917	95.0	115.2	121.2	110.4	116.2	118.9	125.1
1918	94.0	153.1	162.8	97.2	103.3	195.4	207.8
1919	86.5	113.8	131.6	89.7	103.7	132.1	152.7
1920	90.5	131.4	144.4	104.7	115.7	150.5	166.2
1921	91.2	112.6	123.4	105.1	115.2	118.3	129.6

1900, which was unusually high. The decrease in mortality from puerperal septicemia from 1911 to 1921, which in the crude figures appeared to be 14.8 per cent, was reduced, after allowance was made for the falling birth rate, to 11.9 per cent. The conclusion might be drawn that though, since 1911 at least, the mortality from puerperal septicemia in the original death-registration states has actually decreased, the trend of the rates from "other puerperal causes" appears even more definitely upward than would be inferred from the crude figures.

The improvement in the certification of causes of death during the period from 1900 to 1920 is the third factor which must be taken into account in determining whether the mortality from puerperal causes is actually increasing. The result of the campaign for obtaining more accurate reporting of causes of death and for querying unsatisfactory causes reported has been to make the statistics for the later years of the period more nearly correct than those for the earlier years.

So far as mortality from puerperal septicemia is concerned, the first inquiries put out directly by the Bureau of the Census to the physicians concerned

related to deaths in 1911, and in that year the death rate from puerperal septicemia reached its maximum. Since in the changes made as a result of the inquiries the number of cases added to puerperal septicemia has always exceeded the number of cases subtracted from it, the decrease in the rate since that year points to an improvement in mortality from this cause. The real improvement is greater than appears on the face of the figures, because it is in part masked by the continual betterment of certification resulting from extension of the system of querying unsatisfactory certifications of cause.

The influence of the improvement in accuracy of certification, so far as the net additions made to puerperal deaths as a direct result of letters of inquiry to physicians are concerned, may be eliminated by subtracting the additions. The numbers of cases added are given in Mortality Statistics for the entire death-registration area for each year since 1911, with the exception of 1912, 1913, and 1918. But these numbers added were in no case over 3.5 per cent, a percentage which represents therefore the maximum correction for such additions.

This method of correction, however, obviously cannot eliminate additions resulting indirectly from the system of letters of inquiry because of the fact that physicians who have received such letters are likely to be more careful afterwards in reporting causes of death.

The influence of the increasing accuracy in certification which is reflected in a decrease in the proportion of deaths classified as due to ill-defined and unknown causes may be estimated and eliminated, so far as transfers from these indefinite to puerperal causes are concerned. In 1900 the proportion of deaths from ill-defined and unknown causes in the death-registration states was 3.8 per cent, whereas in 1920 in the same area it was only 0.2 per cent. In 1921 only 942 deaths in this area were classified as due to ill-defined and unknown causes, as compared with 13,199 that would have been so classified if the proportion that prevailed in 1900 had prevailed also in 1921. Of the deaths from these indefinite causes in 1900, 2.8 per cent were of women between the ages of ten and fifty years. Assuming that the same proportion of these were connected with pregnancy or childbirth as the puerperal deaths formed of the total at these ages from known causes (11.7 per cent), then it may be estimated that 0.33 per cent of the total deaths from ill-defined causes were maternal. On this assumption the number probably added to puerperal deaths by transfer from ill-defined causes has been estimated; but this correction reduces the index number for the later years, showing the trend of mortality from 1900 only from 1 to 2 per cent.

Neither of the preceding methods, however, takes account of improvements due to the campaign for better certification of causes of death, so far as they have reduced the mortality ascribed either to such poorly defined terms as septicemia and convulsions or to terminal conditions such as peritonitis and nephritis, the true or underlying cause of which may be puerperal. An estimate of

the effect of such improvements in certification can be made on the following assumptions: First, that the excess in the actual number of female deaths at ages fifteen to forty-nine over the number expected—if the ratio of female to male deaths at these ages were the same as the average ratio of female to male deaths under fifteen and over fifty years of age—represents transfers from causes of death peculiar to women; and secondly, that 80 per cent of these were transfers from puerperal causes.^d On the basis of these assumptions the total number of maternal deaths, including those ascribed to poorly defined terms and terminal conditions, in each year from 1900 to 1921 has been calculated; and in Table IV the rates based upon a comparison of these deaths with the estimated births are given to indicate the trend in maternal mortality after allowance is made for improvements in certification in these cases.

The trend in the maternal-mortality rates, after allowance has been made for transfers from these five poorly defined terms and terminal conditions and from ill-defined and unknown causes, is strikingly different from that shown in preceding tables. From all causes the trend appears to have been very slightly downward, the highest rate, with the exception of that for 1918 when influenza was a factor, being for 1900. The trend of mortality from puerperal septicemia, however, appears to have been sharply downwards throughout the period, the figures indicating a decrease of 36 per cent during these twenty years. From other puerperal causes the rates appear fairly uniform except in 1918, 1919, and 1920, when they were abnormally high.

The validity of these conclusions rests obviously upon the validity of the method of estimate of the number of puerperal deaths that were roughly classified in past

d. Of all deaths from ten to forty-nine years of age from causes peculiar to women 77.5 per cent were puerperal in 1900 and 80.1 per cent in 1920; 80 per cent is taken as a rough approximation to an average percentage.

TABLE IV

ESTIMATED TREND IN MATERNAL-MORTALITY RATES BY CAUSE OF DEATH, AFTER ALLOWANCE IS MADE FOR IMPROVEMENT IN CERTIFICATION OF CAUSES OF DEATH; U. S. DEATH-REGISTRATION STATES AS OF 1900, 1900-1920. ⁴

Year	Estimated death rates per 1,000 live births.					
	Puerperal causes		Puerperal septicemia		All other	
	Rate	Trend: 1900 rate= 100.0	Rate	Trend: 1900 rate= 100.0	Rate	Trend: 1900 rate= 100.0
1900	8.5	100.0	4.3	100.0	4.2	100.0
1901	8.0	94.3	3.7	86.8	4.3	101.9
1902	7.4	86.8	3.6	83.2	3.8	90.4
1903	7.0	82.1	3.3	78.2	3.6	86.1
1904	7.9	92.6	3.9	91.0	4.0	94.2
1905	8.0	94.2	3.8	88.1	4.2	100.5
1906	7.1	83.5	3.2	73.8	3.9	93.2
1907	7.2	85.0	3.3	77.8	3.9	92.3
1908	6.7	79.2	3.0	71.1	3.7	87.4
1909	7.0	82.6	2.9	69.0	4.1	96.4
1910	6.9	81.0	3.1	72.8	3.8	89.4
1911	7.0	82.5	3.2	75.4	3.8	89.6
1912	6.5	76.6	2.7	63.0	3.8	90.3
1913	6.8	80.0	2.9	67.6	3.9	92.4
1914	7.1	83.2	2.9	68.0	4.2	98.5
1915	6.9	81.2	2.6	60.9	4.3	101.8
1916	6.7	78.8	2.7	63.0	4.0	94.8
1917	6.6	78.3	2.8	64.8	3.9	91.9
1918	9.3	109.2	2.5	58.2	6.8	160.8
1919	7.5	88.2	2.4	57.4	5.0	119.5
1920	7.8	91.8	2.7	64.0	5.1	120.0

⁴ For method of calculation see text. The allowance made is for estimated additions to puerperal deaths from ill-defined and unknown causes and from peritonitis, septicemia, convulsions (unqualified), acute nephritis and Bright's disease.

years as due to poorly defined and terminal, rather than to causal, conditions. In support of the method it should be mentioned that marked decreases in mortality from "septicemia," "peritonitis," and "convulsions (unqualified)" have occurred during the twenty-year period, and that, in part at least, deaths from these causes have been transferred to puerperal septicemia and other puerperal causes. Furthermore, a decrease in maternal mortality would be expected in

view of the experience of other countries and especially in view of the marked improvement in standards of medical education and medical licensure in this country.

The figures, therefore, raise a strong presumption that the mortality from puerperal septicemia actually decreased throughout the period from 1900 to 1920, while that from other puerperal causes remained approximately the same.