

THE INFLUENCE OF THE AGE OF THE MOTHER AND ASSOCIATED FACTORS ON THE MORTALITY RATES IN CHILDBEARING.

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(With four Diagrams.)

INTRODUCTION.

WITH a general improvement in the death rates from most causes and at most ages, it is not surprising that more attention than their numerical importance might seem to justify is directed to those causes of mortality which deviate from the general trend. This is especially so with the mortality rates in childbed. From the point of view of mere numbers, the deaths of women in England and Wales, assignable to the effects of pregnancy and parturition, in comparison with those due to other causes of mortality, are perhaps scarcely sufficiently numerous to merit the amount of interest and efforts at control which have been directed towards them within recent years. But the problem is even from the numerical point of view of some importance, and derives further importance from its connection with other problems.

The national decline in effective fertility, and the fear engendered in some minds of depopulation, has been a means of focussing attention on the problems of the better conservation of infant life; and with the enormous decline in the rate of infant mortality as a whole, without a corresponding amelioration of the ante-natal and neo-natal death rate, it is only natural that we should seek the causes of this early mortality in conditions affecting the infant at and before birth. Since undoubtedly some of these ante- and neo-natal deaths are due to adverse circumstances at birth, while others may be the result of exposure of the mother during pregnancy to conditions which could be improved, we have been led to hope that by increased ante-natal, natal and post-natal care, not only will the infant's chance of life be greater, but also that the mortality and morbidity among the mothers may be diminished. Many of the main causes of foetal and early post-natal death are also important causes of maternal death, so that in these cases prophylaxis would reap a double benefit.

There is, furthermore, the emotional aspect of the case and the disorganisation of family life which must ensue on the death of the mother—features which give a special prominence to such deaths—but quite apart from this, these puerperal deaths occur for the most part in women in the

period of life at which the general death rate from all causes is relatively low, and further, married women, as will be shown later, represent a healthier set of lives than the average women of the same age, the excess of females over males at marriageable age perhaps having given rise to a selection of the fittest of the female sex for wives. The figures presented in Table I show in the various age periods of reproductive life the proportion of the total deaths

Table I. *Showing the proportion of the total female deaths at ages due to childbearing.*

Age	1911-13	1921-3
15-	2.54	1.58
20-	9.78	8.36
25-	13.29	12.21
30-	12.59	12.62
35-	9.92	10.13
40-	4.31	4.63
45-	0.42	0.52
15-50	7.10	6.80

due to conditions associated with childbearing. As births are not equally frequent in each of the quinquennial age groups, these ratios do not give a correct impression of the relative importance of childbed causes to all causes among mothers of different ages—for a true estimate of the additional risks which pregnancy entails, it would be necessary to compare the *rates* of mortality, as will be done later—but they suffice to show that the consequences of maternity form no insignificant part of the total death roll in women of reproductive ages.

Again, reproduction being a normal function of women, we are apt to believe that all deaths from causes incidental to the pregnant state are accidental, and partly because of this such deaths are considered as eminently within the scope of preventive medicine.

Finally, it must be remembered that a death rate is only in a crude general way an index of morbidity; so that, while the death rate may be absolutely small, we must, in any consideration of the welfare of pregnant women, take into account those who, although fortunate enough to have survived the diseases and accidents which have proved fatal to others, have nevertheless been left in a chronic state of ill-health—a condition which must also have its effect on the further procreation of children by these women.

The general medical aspect of the problem of maternal mortality has been the subject of wide discussion in medical and obstetrical journals, and although it is from the clinical and laboratory side that any further advance will probably be made, the present paper does not deal with specialised obstetrical problems, but mainly with a more general and somewhat neglected factor influencing the risk to mothers in the childbearing processes.

THE MEASUREMENT OF MATERNAL MORTALITY.

Hitherto, so far as I am aware, the only attempt to ascertain the death rates at ages of women in childbearing from the official statistical publications of this country, was made by Farr (1885). In England and Wales the births, on which a crude puerperal mortality rate is built up, have not, except for 1921, been distributed according to the age of the mother or order of birth, so that the secular trend in any district and interlocal comparisons on the basis of the crude rate may lead to erroneous deductions due to variations in the age distributions of parturient women, or in the proportions of primipara and multiparity. Both of these factors, from their relationship to fertility in women, will influence the birth rate and possibly the maternal mortality rate, unless the liability to accident and infection in pregnancy is the same at different ages in the reproductive period and in different pregnancies; *i.e.* unless there is no correlation between parity and age and the incidence of disease and death among mothers.

It is generally recognised that the ordinary method of stating the death toll as the number of maternal deaths from any or all causes per 1000 births is a near approach to the accurate measurement of the risks incidental to pregnant women. Other denominators, such as the total female population within the limits of the childbearing ages, or married women within the same group, have been used; but because childbearing is confined mainly to married women, and since women of different ages are not at the same risk of having a baby, these, at the best, are but rough approximations to the actual numbers at risk of death from childbearing.

The fact that the denominator should contain stillbirths in addition to livebirths and that a deduction should be made for multiple births to arrive at the number of confinements, was recognised by Farr. For example, in his remarks on puerperal deaths, he states: "The exact danger of childbirth to the mother is found by dividing the number of mothers who die by the number of childbearings. Now, excluding the stillborn, the number of childbearings is obtained by reducing the births in the proportion of 1 to 0.9902; but, taking the stillborn into account, the proportion of liveborn children must be as nearly 100 to every 102.531 mothers bearing children in the year." But even with this the limit of accuracy has not been reached. Certain causes of maternal death are those in which the products of conception are thrown off before reaching the age at which they would be included as births. In most cases of ectopic pregnancy, all cases of abortion, some eclamptics, and in other diseases such as hyperemesis gravidarum, labour ensues before the 28th week of pregnancy, and consequently these cases escape notification as births. At present, however, with the vital statistics available, any such refinement is impossible, and the number of livebirths, or the sum of the live- and stillbirths must be used as the most accurate measure of the number of females exposed to the risk of dying from causes incidental to pregnancy.

In the present study, I have only used the total livebirths in calculating the rates, since stillbirth figures were not available for all the periods studied, and, since these form only some 3 per cent. of all births, the resulting inaccuracy will not be very considerable.

Apart, however, from the fact that the exposed to risk cannot be truly measured by the registered births, there attaches to the puerperal death rate, as stated per 1000 births, all the inconveniences of a crude rate of any kind; and great significance cannot be attached to such as a method of comparison, either in time or space, until some at least of the chief influential variables, such as age, have been eliminated. Thus, in comparing different localities in the same or different epochs, in which the age distribution of potential mothers is divergent, some allowance must be made for this difference to correct as far as possible for the effect of the inverse correlation of fecundity and age.

The method adopted by Farr to ascertain the dangers of death by child-bearing in women of different ages was as follows: From the Swedish returns of 1831, he calculated the probable proportion of women, in decennial age groups from 15-55, who bear children within the year; and by applying the figures so obtained to the female population of England in 1851, in the corresponding age groups, he determined the probable number of them who became mothers during that year. Here, of course, the main sources of error in applying the probability of a woman of a given age bearing a child within the year in one country to the female population of another country, is the difference in the proportions of married and unmarried in the two countries. Actually, however, the annual average number of births for the seven years' period 1848-54 which he was studying was 603,045; the probable number of pregnancies given by the calculation 609,845—an excess of only 1.13 per cent.; and the mean annual number of births, corrected for multiple births and stillborn children, would, he said, represent nearly 609,845 childbearings¹. From these figures the death rates in decennial age groups from Metria and other accidents of childbirth were calculated, and these demonstrated a higher mortality at the extremes of reproductive life.

The birth rates in Sweden and England and Wales at that period had not declined to any appreciable extent, but the position now is quite different. In the present study, as a standard of female fecundity at ages, the data of Australia, given by Knibbs (1917), for the period 1907-14 for women between the ages 15-50 years have been used, since these limits will include all but a negligible proportion of the births and also of the deaths of mothers in child-bearing. From the figures given, the nuptial fertility rates, expressed as the ratio of the number of legitimate births per 1000 married women, have been calculated for the seven quinquennial age groups. These are given in Table II. From this it is clearly seen that fertility progressively declines with increasing age of the mother. If now we proceed in a manner akin to that used by Farr,

¹ Using the factor for correction previously given, the calculated number of childbearings is 1.38 per cent. in defect of the actual number.

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and apply these fertility rates to the existing age constitution of the married female population of England and Wales in 1911 and 1921, the probable numbers of legitimate births found are, for 1911, 918,745, and for 1921, 973,489¹, while the actual mean annual numbers of legitimate births for the

Table II. *Showing the fertility rates (absolute and relative) of married women aged 15-50 in Australia (1907-14) with those of Sweden (1891) for comparison.*

	Absolute fertility		Relative fertility	
	Australia	Sweden	Australia	Sweden
15-	481	518	1.0000	1.0000
20-	398	451	0.8275	0.8707
25-	305	375	0.6337	0.7239
30-	227	312	0.5198	0.6023
35-	160	250	0.3333	0.4826
40-	70	142	0.1456	0.2741
45-	8	20	0.0166	0.0386

triennia 1911-13 and 1921-3 are 840,898 and 760,930—the excess in the estimates being 9.26 per cent. and 27.93 per cent. respectively. Such wide discrepancies make it obvious that some other method of allocating the births to the quinquennial age groups must be adopted.

First method of distributing births to age groups of the mother.

The procedure first adopted is illustrated in Table III. From the rates of absolute fertility of women at ages, the relative fertility has been calculated, taking women of 15-20 as unity (Col. 2). The actual numbers of married

Table III. *Showing the first method adopted to distribute the births to the age groups of married women (1921 census figures).*

	1	2	3	4	5
15-	31,145	1.0000	31,145	0.015009	104,589
20-	459,789	0.8275	380,475	0.183359	1,277,725
25-	920,986	0.6337	583,629	0.281265	1,959,975
30-	1,059,538	0.5198	550,748	0.265417	1,849,540
35-	1,089,287	0.3333	363,059	0.174966	1,219,238
40-	1,035,109	0.1456	150,712	0.072631	506,124
45-	919,123	0.0166	15,257	0.007353	51,239
			2,075,025	1.000000	6,968,430

1 = Married female population in quinquennial age groups.

2 = Relative nuptial fertility.

3 = Married female population at ages weighted according to fertility.

4 = Proportional distribution of fertility-weighted population.

5 = Total births distributed in age groups.

women living in each quinquennial age group (Col. 1) are multiplied by their appropriate fertility ratio (Col. 2), giving a hypothetical number of married women of varying age but of equal reproductive capacity (Col. 3). The total

¹ Incidentally it has to be noted from these figures that the number and age constitution of the married female population at the last two censuses is such that, assuming equal reproductive capacity in the women at both periods, the legitimate birth rate in 1921 should have been 6 per cent. in excess of that in 1911. Accordingly the fall which has occurred in the birth rate within that period is not the result of changes in the married female population—a point which has already been brought out by Brownlee (1922) and Yule (1920).

births in the period 1915–23 (6,968,430) distributed to the quinquennial age groups in the proportion which each of these bears to the total population (Col. 4) are given in Col. 5. These births, then, would form the denominators on which the death rates at ages are calculated.

SOURCES OF ERROR IN THE DISTRIBUTION OF BIRTHS.

Before proceeding any further, it is necessary to point out and deal with objections which could be raised to the method suggested above. At least two sources of serious criticism are apparent.

(1) *The decline in the birth rate.* In the first place, we note that, in the method adopted of distributing the births to the quinquennial age groups, the fertility factors used to weight the absolute numbers of married women are based upon the experience of Australia before the War, since when, as in most other countries, the birth rate has progressively declined. This raises the question as to the effect which such a fall will have on the fertility of the various age sections of parturient women, relative one to another. To what extent the decline in the birth rate is due to the various factors suggested, such as postponement of marriage till later in life, an actual diminution in the fertility of the population at large, wilful prevention of conception, or some other factors is still a matter for discussion. Of those mentioned, the only factor likely to affect the relative values of these ratios is contraception. A racial phenomenon such as a decline in reproductive activity would be very unlikely to affect any special section of the reproductive period more than another; so that although absolute fertility would be lowered, the fertility of any age group relative to another would remain the same. So too with postponement of marriage. This would result solely in a diminution in the proportion of younger married women, but would not influence the relation between the fertility of different age groups, and, as shown previously (see footnote, p. 164), the age constitution now is more favourable to a high birth rate, than it was ten years previously. On the other hand, restriction of the size of the family, depending as it does so much on the individual, introduces a factor, the influence of which it is difficult to measure. Economic circumstances, for instance, might play some part in restraint to procreation, and, as these are generally not most favourable in early marriages, one might expect it to lead to a diminution in the fertility of younger women with a relative (and perhaps an absolute) increase in the later ages. Against this, however, can be placed the fact that early marriages are more common in the lower social classes and among these contraceptive measures are least used. For any proper consideration of the question, it would be necessary to compare the fertility rates at ages in women of the same country through a period of years with a changing birth rate. Unfortunately, such a comparative series for one country was not available, but in Table IV are collected some fertility data for different countries at different periods to compare with the factors used in this study. Apart from the interesting international

differences in fertility which are apparent in the statistics for the earlier years, evidently little objection can be offered to the method adopted of weighting the numbers of women according to fertility. There is no apparent correlation between reproductive activity as measured by the birth rate and the fertility of women of different ages relative one to another. Certain it is

Table IV. *Showing the relative fertility rates in quinquennial age groups of women in different countries¹.*

	15-	20-	25-	30-	35-	40-	45-
Edinburgh and Glasgow, 1855	100	84	69	53	41	16	3
Alsace and Lorraine, 1872	100	121	100	83	61	—	—
Norway, 1874-76	100	140	104	87	73	44	8
Finland, 1880-81	100	107	94	85	69	42	7
Denmark, 1880-89	100	69	57	44	32	16	2
Berlin, 1887-90	100	90	67	45	29	12	1
Buda-Pest, 1889-92	100	84	68	48	34	14	2
Sweden, 1891	100	87	72	60	48	27	4
Aberdeen, 1911	100	75	65	41	29	14	2
Brunswick, 1880-81	100	78	60	46	34	14	2
General average	100	97	79	62	47	21	3
Australia, 1907-14	100	83	63	52	33	15	2

that the fall has not specially affected the young women of 15-20. The tendency, if anything, is in the opposite direction. Comparison of Sweden (1891) with a crude birth rate of 28.3, Australia (1907-14) with 27.4 and Aberdeen (1911) with 24.5 per 1000 population shows that the fertility of women over 20 has declined more than that of the younger women of 15-20.

From figures published in the *Annuaire International de Statistique* (1916-17 and 1925) Table V has been prepared to compare the effects of the declining

Table V. *Showing the absolute and relative fertility per 1000 married women of different ages in France in the periods 1896-1905 and 1906-13.*

Age	Absolute fertility		Relative fertility	
	1896-1905	1906-1913	1896-1905	1906-1913
15-	437.6	439.8	1.0000	1.0000
20-	343.0	311.7	0.7838	0.7087
25-	247.1	187.3	0.5647	0.4259
30-	168.6	139.7	0.3853	0.3176
35-	109.8	88.6	0.2509	0.2015
40-	46.7	36.1	0.1067	0.0821
45-	7.3	4.0	0.0167	0.0091
15-50	153.7	126.6	0.3512	0.2879

birth rate on the fertility at ages of women in France. Unfortunately the rates are subject to a slight but inevitable inaccuracy, since, in the tables giving the births by age of the mother in this report, no distinction as to legitimacy of the birth is made, and in the table reproduced here the fertility rates are the *total* (i.e. legitimate and illegitimate) birth rates in terms of *married* women only. This point must be borne in mind in making the comparison here, since any great change in the proportion of illegitimacy in the two periods would specially affect the fertility rates of the younger married

¹ The Aberdeen figures are from the *Annual Report of the M.O.H. Aberdeen* (1916-21), the Australian from Knibbs (1917) and the remainder from Korosi (1894).

women. The two periods 1896–1905 and 1906–13 are not of equal length; but to include the War years would be worse than useless since, on investigation, it was found that the beginning of the War coincided with a great drop in the proportion of births from the youngest mothers, due probably to the younger men going first on active service; while during the War the decline spread to the later years of reproductive life. So far as the comparison is sound, however, we find that there was a decline of 21·4 per cent. in the birth rate of married women of 15–50 within the two periods; that the decline did not affect the youngest age group at all, whereas relatively and absolutely the fertility of the women in the later age periods declined.

As a necessary precautionary measure I have recalculated a series of rates, using the fertility factors of Sweden in 1891 as weights, to compare with those given later, but there is no essential difference in the final results as to the age distribution of the death rates—certainly none which is great enough to alter any argument which might have been based on the previous results; and further, it is also apparent that the effects of a diminishing fertility is not the explanation of the great fall in the death rate in younger women (which will be discussed later).

(2) *Illegitimate births.* A more serious objection, however, is that all the births, irrespective of legitimacy or otherwise, have been distributed only according to the proportions of married women between the ages of 15–50. The small number of legitimate births from mothers outside these limits, and all the illegitimate births are thus being wrongly distributed. The legitimate births which occur without these limits are probably so few as to be negligible, but it is not so with the illegitimates, which form some 4–5 per cent. of all live births, and which are born of mothers of an entirely different age distribution from that of married women. We must therefore enquire how far this factor will change our rates of mortality. In Table VI are given the

Table VI. *Showing the illegitimate births per 1000 unmarried women aged 15–50, in Australia (1907–14) and Aberdeen (1911).*

Age	Absolute rate		Relative rate	
	Australia	Aberdeen	Australia	Aberdeen
15–	8·66	14	100	100
20–	17·74	27	205	193
25–	15·53	24	179	171
30–	13·59	18	157	129
35–	12·14	17	140	121
40–	6·05	7	70	50
45–	1·09	—	13	—
15–50	12·39	19	—	—

illegitimate birth rates per 1000 unmarried women in quinquennial age groups for Australia (1907–14) and Aberdeen (1911)¹. The proportion of illegitimate births was for Aberdeen 10·64 per cent. (inclusive of 14 births from widowed women, this was raised to 10·95 per cent.), and for Australia 5·74 per cent.

¹ From the *Annual Report of the Medical Officer of Health of Aberdeen (1916–21)*.

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of the total births. Only a small number of illegitimate births occur in widowed women, so that this factor may be neglected. From the absolute rates the relative rates have again been calculated taking, as standard, the rate for unmarried women 15-20. It is interesting to note that, irrespective of the great difference in the actual rates of illegitimacy, the distribution of the relative values shows a very close similarity. For this reason, the assump-

Table VII. *Method of distributing births to quinquennial age groups of women.*

I	II	III	IV	V	VI	VII
15-	31,145	1.0000	31,145	0.0150	99,431	1,743,891
20-	459,789	0.8275	380,475	0.1834	1,214,714	1,237,151
25-	920,986	0.6337	583,629	0.2813	1,863,320	664,192
30-	1,059,538	0.5198	550,748	0.2654	1,758,332	394,465
35-	1,089,287	0.3333	363,059	0.1750	1,159,112	300,533
40-	1,035,109	0.1456	150,712	0.0726	481,165	247,127
45-	919,123	0.0166	15,257	0.0074	48,712	208,847
			2,075,025	1.0000	6,624,786	
I	VIII	IX	X	XI	XII	
15-	1.0000	1,743,891	0.2604	89,475	188,906	
20-	2.0473	2,532,819	0.3773	129,671	1,344,385	
25-	1.7933	1,191,096	0.1771	60,853	1,924,173	
30-	1.5693	619,034	0.0926	31,805	1,790,137	
35-	1.4018	421,287	0.0628	21,587	1,180,699	
40-	0.6986	172,643	0.0258	8,875	490,040	
45-	0.1259	26,294	0.0040	1,378	50,090	
		6,707,064	1.0000	343,644	6,968,430	

I = Age periods.

II = Married female population at quinquennial age groups.

III = Relative nuptial fertility (age 15-20 = standard).

IV = (II and III) married female population at ages weighted according to their fertility.

V = Proportions which each weighted age group bears to the total weighted population at reproductive ages.

VI = Legitimate births distributed to the age groups.

VII-XI = Distribution of illegitimate births to the age groups of unmarried women.

XII = Sum of legitimate and illegitimate births at ages.

tion that the proportional distribution of ex-nuptial fertility in England and Wales is the same as that given by the Australian data will probably not be far from the truth. To estimate the difference produced when account is, or is not, taken of the legitimacy or otherwise of the births, the total births have been redistributed in the following manner (Table VII).

Second method of distributing births to age groups of the mother.

Legitimate births alone are assigned to the various age groups in the proportion which the weighted numbers of married women at ages bear to the total. Illegitimate births are distributed in a similar fashion according to the proportions of unmarried women living at quinquennial age groups, after these have been weighted by their relative ex-nuptial fertility. The sum of the legitimate and illegitimate births at each age are now used as the number exposed to risk, and the rates were recalculated for all causes of death in childbearing. The mortality rates at ages per million births given in Table VIII show the differences between the results deduced by the two methods. It is quite apparent that the first method, by apportioning too few

births to the earlier ages, has over-estimated the death rate in women of 15-20. The probably more correct method gives a rate 45 per cent. lower in females of 15-20, 5 per cent. lower for females 20-25, and 2-3 per cent. higher for older women. Thus, the death rates calculated by the original method

Table VIII. *Showing the differences in the mortality rates deduced by the two methods of births distribution.*

Age	First method	Second method	Ratio of second to first
15-	7276	4028	0.55
20-	3297	3134	0.95
25-	3321	3383	1.02
30-	3700	3823	1.03
35-	5170	5339	1.03
40-	6380	6589	1.03
45-	7572	7746	1.02

would have to be multiplied by these ratios for a closer approximation to the true risk of death of mothers of different ages of reproductive life. In view of the rather drastic differences found when these two methods are employed, the rates of mortality at ages given subsequently are those which have been calculated by this second method, since this is more likely to be nearer the truth.

Recently an attempt has been made to classify births according to the age of the mother in England and Wales. This classification, obtained by an indirect method and not from the birth registers (since birth certification does not require that the age of the parents be submitted) is fully described in the *Annual Report of the Registrar-General for 1922* (text, p. 137 *et seq.*). The present study was begun in ignorance of these estimates for this country, but the procedure adopted in obtaining these fertility rates shows that at best they are but approximations to the truth, more especially in the case of ex-nuptial births; so that with any of the standards of fertility at present available, the distribution of births must always leave some margin of error. Unless some great divergence in the results given by the two methods is found it will not be justifiable to recalculate the rates on the basis of this experience, which, being for a single year, and that immediately succeeding "the climax of the temporary spurt in the birth rate which followed demobilisation," may be no more representative of the true state of affairs in this country, in the periods studied, than the rates originally used. If, however, these figures (Table IX) are compared with those of Australia (Tables

Table IX. *England and Wales—legitimate and illegitimate natality by age of mother, 1921.*

Age last birthday	Legitimate births for 1000 married women	Illegitimate births per 1000 spinsters and widows	Relative legitimate fertility	Relative illegitimate fertility
15-	447	7.65	1.0000	1.0000
20-	359	15.14	0.8031	1.9791
25-	268	8.71	0.5995	1.1386
30-	197	0.78	0.4407	0.1020
35-	131	—	0.2931	—
40-45	32	—	0.0716	—

II and VI), it will be noted that in the case of legitimate fertility, the age group 15–20 is relatively higher in the 1921 than in the 1907–14 figures, again suggesting that the fall in the birth rate is affecting least of all the first quinquennium of reproductive life. With illegitimate fertility also, the 15–20 age group is more prolific relative to the succeeding age groups in the English than in the Australian figures. Using the English fertility rates as weights, the death rates at ages from all causes in childbearing have been recalculated. These, with their respective ratios to the results deduced when the Australian figures were used, are given in Table X.

Table X. *Showing the death rate per million births from all puerperal causes 1915–23 calculated on the fertility rates for England and Wales (1921), with the ratio of these rates to those calculated on the Australian fertility rates (1907–14).*

Age	Death rate	Ratio
15–	3253	0·81
20–	2775	0·89
25–	3145	0·93
30–	4004	1·05
35–	5403	1·01
40–45	11184	1·70

Although the rates for the first three quinquennia are diminished (the first quinquennium most of all) and the succeeding ages increased, the general trend of the mortality curves shows no great alterations. Accordingly, the differences in the two measures of fertility do not seem to be sufficiently great to interfere with any of the conclusions to be drawn from those obtained by the use of the Australian fertility rates.

The value of age-specific death rates.

Age-specific death rates are of practical importance in various ways. There is, for instance, the purely statistical consideration that the variations in the ages of parturient women may explain some part of the variations in the puerperal mortality rates in different places; and a set of mortality rates at ages for the whole country could form the basis for the standardisation of the crude rates in different districts. The influence of these local variations of age distribution will be considered later.

From the medical side they deserve some consideration, not only with regard to their evident bearing on the question of prognosis (which however would be more accurately assessed by a case mortality rate) but also in that they may help to throw some light in a general way, on the relative importance of the etiological factors of pathological conditions in pregnant women, where several predisposing or causative factors exist. In any disease, for example, there will be one or more factors which account for the general level of the death rate, and these, or some additional phenomena, may lead to a specific type of age distribution. The morbid states associated with pregnancy result in some instances from congenital, in others, from acquired conditions, and,

a priori, if the former were prepotent etiologically, we should expect the death rate to decrease with age, whereas if acquired conditions be the result of previous childbearings, the death rate should increase with age. But here it must also be remembered that pregnant women are subject to the same law of mortality as non-pregnant women. The increase in the death rate with advancing age from causes apart from those peculiar to the pregnant state within the limits of reproductive life, although probably representing in some part a preventable loss of life, is also indicative of the general ageing of the tissues, which any additional physical strain must quickly reveal; and child-bearing, although physiological, is undoubtedly a great strain on the maternal functions. Probably the capacity of the mother to adjust herself to the novel conditions which a pregnancy entails will determine to a great extent the chance of a favourable termination. The necessary widespread alterations of function may be hindered by deviations from the normal healthy state, and with increasing age of the mother adjustment to accommodate a developing ovum may become progressively more difficult.

Finally, and probably most important of all, is the fact that mortality rates at ages may serve as a guide to where efforts of control are chiefly required. Although it is difficult to share the intense optimism of those who hope by sufficient care of the mother before, at and after parturition to eliminate entirely the mortality associated with childbearing, there is no doubt that certain causes of death are eminently amenable to organised medical effort in the present state of our knowledge. Practically all deaths from eclampsia, and many from accidents in the processes of labour, are in this category. The absolute magnitude of the death rate at any age will serve to indicate the periods of greatest risk to a woman in childbearing, and, other things being equal, where medical efforts at control are likely to meet with the maximum degree of success.

Death rates at ages from various causes.

For the general consideration of the age distribution of mortality from the various cause groups of death, the rates have been calculated from the experience of England and Wales in the nine years' period 1915-23. Unless a fairly long experience such as this is considered the annual number of deaths from some causes will be too small to give stable death rates at ages. Since the total registered livebirths in the period 1915-23 were 6,968,430 and the maternal deaths 28,248, this experience is probably sufficient to calculate death rates which at least will not be subject to violent fluctuations.

The necessary data with regard to the age distribution of married and unmarried women were obtained from the *Census Reports* for 1911 and 1921, and the births and maternal deaths from the *Annual Reports* of the Registrar-General.

The mortality rates at ages from the various causes of death are shown in Table XI and in Diagrams 1, *a-c*. Examination of these results shows

that the causes of death can be grouped primarily in two broad categories: (a) those which increase gradually from the beginning till the end of reproductive life, and (b) those in which the rate, starting from a high value in young women, declines to a minimum at ages 20-30 and thereafter gradually increases. Group (a) includes haemorrhage of pregnancy, placenta praevia,

Table XI. Showing the death rates at ages per million births from the several groups of causes of puerperal deaths in England and Wales 1915-23.

	15-	20-	25-	30-	35-	40-	45-	15-50
Abortion	95	65	85	148	242	318	319	142
Haemorrhage of pregnancy	11	25	38	73	126	290	599	91
Uncontrollable vomiting	48	37	38	34	52	53	80	41
Ectopic pregnancy	32	42	79	106	160	131	260	96
Other accidents of pregnancy	37	34	25	25	55	53	279	36
Placenta praevia	32	61	144	241	472	677	719	247
Other puerperal haemorrhage	190	167	216	252	490	663	519	295
Accidents of childbirth	349	316	366	398	639	798	898	445
Puerperal nephritis	228	187	202	251	327	414	409	251
Puerperal convulsions	1366	666	473	444	498	635	579	543
Phlegmasia alba dolens	159	205	288	378	530	661	978	364
Puerperal insanity	37	32	42	32	40	49	60	38
Puerperal diseases of the breast	32	13	7	11	13	24	20	12
Puerperal sepsis	1413	1286	1378	1429	1630	1822	1937	1453
All causes	4028	3134	3383	3823	5339	6589	7746	4054

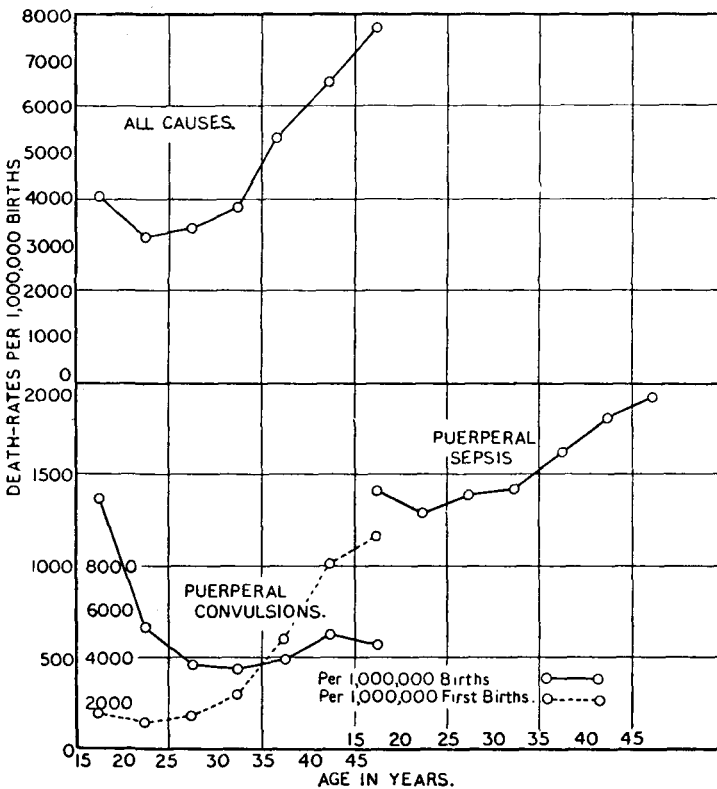


Diagram 1 a. Showing the death rates from various causes of maternal mortality at different periods of reproductive life.

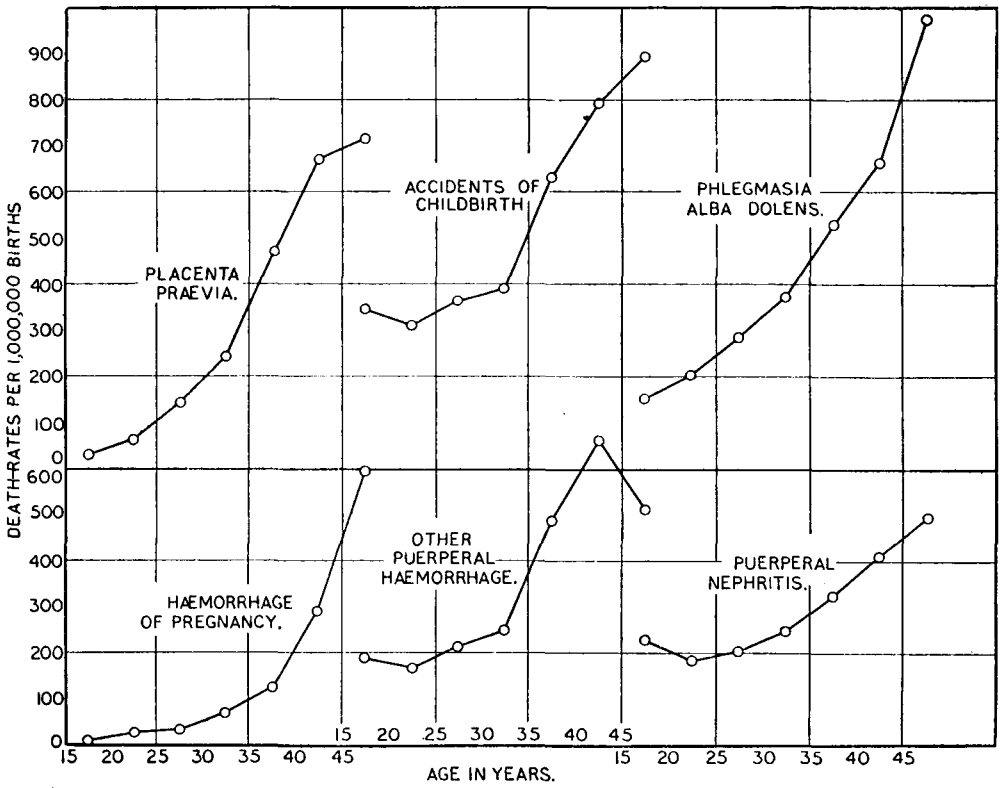


Diagram 1 b. Death rate at ages (continued).

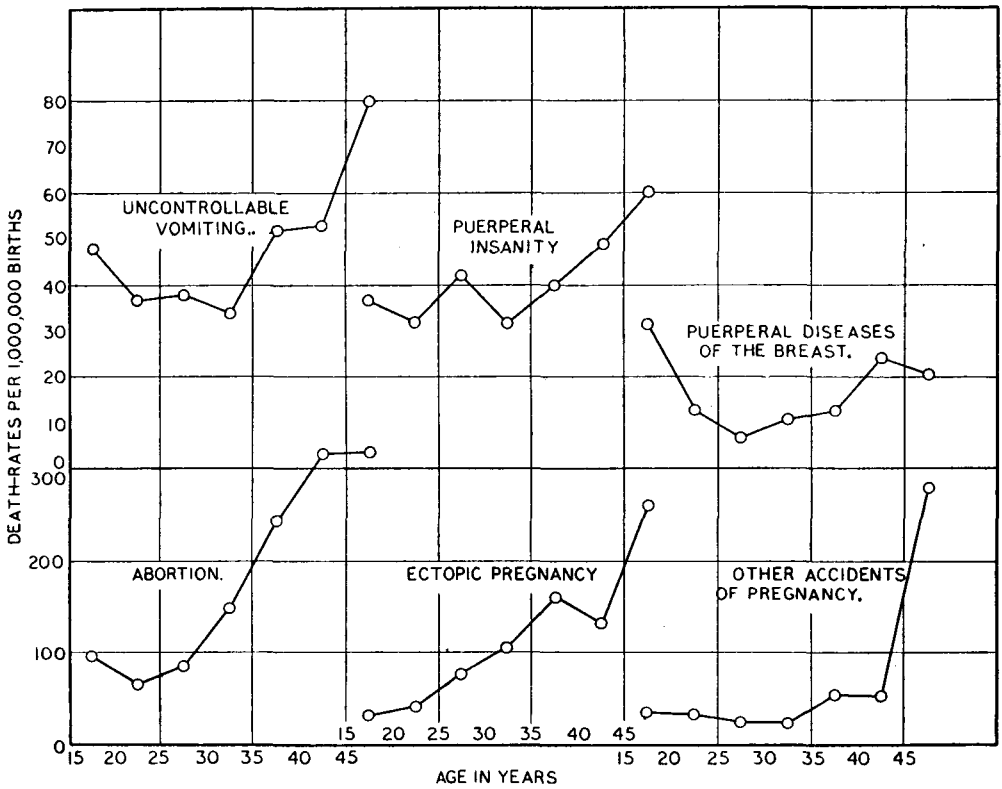


Diagram 1 c. Death rate at ages (continued).

ectopic pregnancy, other accidents of pregnancy and phlegmasia alba dolens. Group (b) includes all the other causes of death. These groups could be subjected to a further process of subdivision according to the relative risk of death at each age. In the first group, for instance, the slope of the line representing the increasing risks with advancing age, varies in different causes of death, and in the second, although the limits of reproductive life are subject to a higher mortality than the intervening ages, there is a difference in the relation between young and old mothers. In puerperal convulsions, for example, mothers at the beginning of life have a much higher death rate than those at the end; but in the other causes of mortality included in this group, older mothers have a higher death rate than the younger. Puerperal convulsions are of further interest in that the minimum death rate occurs at a later period of life than other causes included in this group. The death rate falls steadily from the beginning of reproductive life to its lowest value in the quinquennium 30–35 and thereafter progressively increases but never again attains the level found for women aged 15–20. As is well known, however, eclampsia, of which this group is almost wholly composed, is mainly a primiparous condition (Stander, 1929). Clearly, if we base the death rate from convulsions on the number of primiparous instead of on total births, we shall reach a clearer conception of the true mortality from this condition at different periods of life. Using the figures given subsequently (Table XIII) as an approximation to the proportion of first births among all births in each quinquennium, the numbers of primiparae in each age period were estimated, and from these the death rates per million first births have been calculated. These are shown in Table XII and in Diagram 1 *a*. Mortality from eclampsia

Table XII. *Showing the death rates at ages from puerperal convulsions based on (a) total births and (b) primiparous births.*

Age	Death rate per million births	Death rate per million first births
15–	1366	1607
20–	666	1185
25–	473	1443
30–	444	2445
35–	498	4826
40–	635	8116
45–	579	9337

is evidently much greater in older than in younger primiparae, and, apart from a slightly higher rate in the first compared with the immediately succeeding quinquennium, increases steadily with age. The true course of mortality with age will lie somewhere between these two estimates; but, when allowance is made for the unique parity distribution of this condition, it is probable that the age distribution of mortality from convulsions will resemble other conditions in (b) both in general trend and in that older parturients are subject to a higher mortality than younger.

From these results it is clear that, except for the higher puerperal mortality of the youngest age group of mothers, the childbearing death rate manifests

with respect to age a close parallelism with the death rate of females from other causes altogether apart from childbearing. As is well known, the general death rate in women increases gradually and steadily from 15 years onwards—the quinquennium 15–20 suffers less heavily than any subsequent age group; but in respect of childbed mortality this early age would appear to be a more dangerous period for mothers than the succeeding two or three quinquennia of reproductive life. It seems of importance, therefore, to examine some of the factors which may account for the differences in the age distribution of this mortality.

General factors influencing the age distribution of the maternal death rate.

The type of age distribution of any cause of maternal mortality will no doubt suggest correlated etiological factors, but with only national statistics available, an examination and discussion of the influence of local conditions in the pelvic organs is obviously impossible, so that only general conditions which have some influence can be considered.

(1) *Primiparity.* Various writers, among others Matthews Duncan (1866) and Coghlan (1898), have shown that first births are much more dangerous than all other subsequent births up to the ninth or tenth, and thereafter, although the evidence on this point is conflicting, the risks again seem to be magnified in subsequent deliveries. The effect of this on the death rate as a whole has been discussed by Greenwood and Stevenson (1924), who came to the conclusion that the decline in the birth rate with the consequent increased percentage of primiparae would not affect the puerperal mortality rate to any very substantial extent. The proportion of first births to the total births varies greatly at different ages of the reproductive period. The birth statistics of New Zealand (1924) give the percentage distribution of primiparity at ages (legitimate births only) shown in Table XIII. The results found by Duncan

Table XIII. *Percentage distribution of primiparity at ages (New Zealand, 1924).*

Age of mother	Per cent. primiparae
15–	85
20–	56
25–	33
30–	18
35–	10
40–	8
45–	6

and Coghlan with regard to the relative maternal mortality in different pregnancies are presented in Table XIV, in which the mortality among primiparae is taken as unity and that in later pregnancies expressed as a proportion of the primiparous death rate. The numbers available for births after the tenth are so small that the ratios must be subject to high probable errors. Families of over ten are not common at the present time. If, then, first births are considered in relation only to all subsequent births up to the tenth, the

death rates are in the ratio of 1.46 to 1 for Coghlan's, and 1.62 to 1 for Duncan's data. From these data a crude correction can be made in the age distribution of the death rate for the excessive dangers of primiparity. For example, in the age group 15-20 there were 188,906 births and 761 maternal deaths in the period under review. Of the total births 85 per cent. (*i.e.* 160,570) occurred among primiparae. The risk incurred by the mother in a first pregnancy being

Table XIV. *Relative maternal mortality in different pregnancies.*

No. of pregnancy	Maternal mortality	
	Duncan's data	Coghlan's data
1	1.00	1.00
2	0.62	0.53
3	0.73	0.66
4	0.48	0.57
5	0.63	0.74
6	0.43	0.75
7	0.61	0.73
8	0.93	0.87
9	0.53	1.21
10+	0.46	1.24

equivalent to that in 1.62 multiparous births (taking the figure given by Duncan to eliminate the excessive risks of primiparity), the denominator must be made more lenient the greater the proportion of primiparae. Thus the denominator for the death rate in the age group 15-20, instead of 188,906, becomes $28,336 + 1.62 \times 160,570 = 288,459$ births, and the death rate itself is reduced from 4028 to 2638 per million births. A similar process has been applied to the remaining age groups, using the data contained in Table XIII as a guide to the probable proportions of first births at different ages. Table XV gives the rates of mortality corrected for primiparity which follow from this procedure. This crude approximation shows that, apart from the

Table XV. *Maternal mortality rates at ages corrected for primiparity.*

Age	Puerperal sepsis	All causes
15-	953	2679
20-	1010	2614
25-	1204	2943
30-	1330	3542
35-	1567	5129
40-	1761	6381
45-	1892	7563

excessive dangers of primiparous births, the mortality from all causes still tends to be higher in the earlier age group than in the next two quinquennia and thereafter to increase steadily till the end of reproductive life. Thus, primiparity is not the sole cause of the skewness of the age distribution of the total maternal death rate. In the case of puerperal sepsis, however, if we can safely regard primiparity as of such etiological importance as to be represented by the factor 1.62, then it may quite well be that the high death rate in the quinquennium 15-20 as compared with the two immediately succeeding age groups is the result of the greater proportion of primiparous births at that age. Under those conditions, the death rate from puerperal

septicaemia would increase steadily from the beginning till the end of reproductive life. There are, nevertheless, other factors to be considered before this simple explanation can be accepted without question.

(2) *The general mortality at childbearing ages.* The second problem that arises relates to the general health of the mother, the influence of which on the risks consequent on maternity will scarcely be doubted. From all causes of death within the limits of reproductive life mortality increases gradually with age—there is no rise in the 15–20 age group. That this factor has any relation to the form of the age distribution of the death rate from puerperal causes would consequently seem improbable, and will depend on whether or not mothers of different ages form a random sample in respect of general mortality of the total female population at that age. The presence or absence of any such selection must therefore be determined in the first instance, and, if present, its relation to age will have to be noted. *A priori*, it would seem that selection of the healthier of the female sex for wives would, in general, be the result of the preponderance of females over males at reproductive ages, and we should expect to find the death rate in married females lower than in the unmarried. As examination of Table XVI shows, this is only partially

Table XVI. *Showing the death rates per 100,000 from all causes in married and unmarried women, with the ratio of the married to the unmarried death rate for the period 1915–23.*

Age	Married female death rate	Unmarried female death rate	Ratio
15–	426	318	1.34
20–	406	377	1.38
25–	456	451	1.01
30–	485	512	0.95
35–	542	565	0.96
40–	612	697	0.88
45–	764	894	0.85

true. From all causes, mortality in the first three quinquennia of reproductive life is higher in married than in unmarried women, and the difference, greatest in the first age group, gradually diminishes until at ages 30–35 and in subsequent quinquennia married women have the more favourable death rate. So far as mortality from all causes is concerned, there is one obvious source of incomparability between women of different civil states. The majority of births are derived from married females, and since fertility diminishes with advancing age, these younger women, especially married women, are exposed to the special risks of the pregnant to a greater degree than others. A direct comparison of the mortality rates from causes apart from childbed deaths would, therefore, be desirable, but is rendered difficult because maternal deaths in childbearing in the official reports of this country are not given with distinction as to civil state of the mother. To overcome this objection and to reach an approximate result, maternal deaths have been assigned to married and single women in the proportion which legitimate and illegitimate births bear to the total births in the several age groups. The validity of the

procedure will depend on the relation between the puerperal mortality rates in single and married mothers. Coghlan (1898) has produced evidence that, age for age, the former have a higher puerperal mortality rate than the latter, so that, if this be true for England and Wales¹, the number of deaths deducted from the total married female deaths will be too small, and, of course, the resulting death rate from all causes less childbirth will be too high. In Table XVII are shown the percentage of illegitimate births in the different

Table XVII. *Showing the percentage of illegitimate to total births in the several age groups for the period 1915-23.*

Age	Per cent. illegitimacy
15-	47.36
20-	9.65
25-	3.16
30-	1.78
35-	1.83
40-	1.81
45-	2.75

age groups which is found by distributing the births to these ages in the manner previously described. If now we deduct the deaths due to child-bearing causes from the total deaths in married and single women according to the proportions of legitimate and illegitimate births in the several age groups, the death rates from all causes less puerperal can be calculated, and these are shown in Table XVIII. At all ages married women have now a

Table XVIII. *Showing the death rates per 100,000 from all causes less puerperal in married and unmarried women, with the ratio of the married to the unmarried death rate for the period 1915-23.*

Age	Married female death rate	Unmarried female death rate	Ratio
15-	283	316	0.90
20-	314	373	0.84
25-	380	447	0.85
30-	415	509	0.82
35-	479	561	0.85
40-	577	695	0.83
45-	759	894	0.85

lower death rate than unmarried, but the difference between them is least of all in the first quinquennium. And it is to be noted that the possible fallacy inherent in the distribution of the maternal deaths to the two groups will weigh more in favour of the view that the married women of the 15-20 age group are a much less well selected sample of the total population than are those of the subsequent years, since, assuming that a higher illegitimate than legitimate maternal mortality holds for England and Wales, too few deaths have been assigned to single women, and consequently the death rate from

¹ A comparison of the crude rates of death of married women per 1000 legitimate births and unmarried women per 1000 illegitimate births is an incorrect statement of the true relative risk, and cannot, of itself, be taken as evidence of a higher force of mortality in unmarried mothers, since illegitimates are in the main first births, and the mothers are generally young and possibly selected.

all causes less childbirth is higher than the true value. The resulting ratio of married to unmarried (0.90) puts the actual position of young married females in a too favourable light. These results, therefore, lead to the conclusion that, while in general married women are a healthier set of lives than single women, the young married women of 15-20 have not the same relative advantage as older married women.

That this relative disadvantage of young mothers is possibly the result of differences in the reproductive habits of the different social strata of the population is suggested by other findings from official statistics. The correlation between the proportion which married women of 15-20 bear to all married women between 15-50 and social conditions, as measured by the number of rooms per person, is (from the census figures for 1921) for Administrative Counties with associated County Boroughs = -0.6349 ± 0.054 , and for Metropolitan Boroughs = -0.6389 ± 0.054 . The proportions of the youngest married women are thus highest in districts where overcrowding is greatest and social conditions worst.

A similar result is obtained by taking other indices of social status, such as the number of domestic servants per 100 families, the proportion of the population living more than two in a room, or the crude death rate from all forms of tuberculosis. For Metropolitan Boroughs (1921) the results are collected in Table XIX.

Table XIX. *Correlation between the proportion of young married women (15-20) and various indices of social status.*

Index of social status	Correlation
Proportion living more than two per room	0.7831 \pm 0.049
Domestic servants per 100 families	-0.3217 \pm 0.182
Crude death rate from tuberculosis	0.6854 \pm 0.068

Additional, and probably more direct, evidence of the manner in which the proportion of younger married women is related to differences in social level is afforded by Table XX, in which are shown the proportion of all

Table XX¹. *Proportion of marriages at ages 15-20 in different social classes.*

Social class ²	Per cent. of marriages between the ages 15 and 20 years
Upper and middle classes	5.8
Skilled workmen	12.4
Unskilled workmen	17.4

¹ From Table XXIX of the fertility of marriage Report 1911, Part II, which contains much fuller evidence on this point.

² For the exact composition of these and other social classes, see Table XXVIII *a* of the *Annual Report* of the Registrar-General for 1911.

marriages occurring between the ages of 15 and 20 in three groups of social status (as evidenced by the occupation of the husband). Early marriages evidently are proportionately more frequent in the lower social classes of the country, and, allowing for the probability that even in this restricted

part of the community a certain amount of sexual selection may go on, it is nevertheless true that, considering the relation of the mortality in married and unmarried women in the country as a whole, the young mothers of 15–20 are an adversely selected sample of the total female population at that age as regards their general health.

Clearly, therefore, if the health of the mother is a factor of importance in determining the puerperal mortality rate, this selection of the younger age group of married women may also play its part in determining, in whole or in part, the higher mortality at this early age; and would also explain the complete trend of the death rate with age—the older (and on the average, therefore, the less healthy) the mother, the greater is her chance of dying from sepsis and other causes during reproduction.

(3) *An optimum period for reproduction.* With regard to this, the possibility that the age distribution of the puerperal death rate may simply represent the fitness of women of various ages to become mothers (*i.e.* in the sense of an optimum period for procreation, as opposed to fitness in the eugenic sense), no available information can confirm or refute such a suggestion; but a hypothesis such as this should, in my opinion, be reserved as a last resort, and only given serious weight when the trend of the death rate in childbearing fails to be explained in any other manner. As described above, allowance has been made, as far as possible, for the excessive risks incident to a primiparous birth, but even so, there still remains a slight excess in the total death rate of mothers in the first quinquennium of reproductive life, although, as has been shown, this might possibly account wholly for the excess early death rate in the case of puerperal sepsis. How much of the excess in the total maternal death rate or in the death rate from puerperal septicaemia in young mothers would be removed were it practicable to eliminate the effects of this adverse selection with respect to their general health (as evidenced by the general death rate to which these mothers are subject, and the social and economic class to which they belong) is not possible to predict at present; but, if after doing so, the excess in the death rate still remained at this age, there might then be some reason for believing that the trend of the mortality rate with age was at least in part representative of an optimum period for procreation. Part of the evidence on which the belief in a climax in the reproductive life of women is based is unsound; the remainder is open to other, possibly more likely explanations. For instance, Duncan (1866) postulates a climax in fecundity, the evidence presented in favour of this being birth rates at ages based on the number of women *without respect to civil state*. Although the birth rates of women, married, single and widowed together, increase from the 15th up to the 29th year and then gradually fall, calculated as the number of legitimate births per 1000 married women of given ages, these have already been shown to decline steadily from the beginning till the end of reproductive life. Part of this high reproductive activity in early life is no doubt artificial, some of the

marriages being from necessity ("forced" marriages, due to antenuptial conception) and others from the relative lack of knowledge among younger women of the methods of contraception. Still the majority of fertility rates at ages shows a gradual decline in reproductive capacity from the commencement of reproductive life till the menopause. The other observation which Duncan brings forward in support of this hypothetical optimum is the skew regression on the age of the mother of the weights and lengths of the offspring at birth. The weights and lengths of babies increase with the age of the mother up to about the 25th–30th year, and the infants born of older women are lighter and shorter than those born to mothers of 25–30 years of life. There are so many other possible explanations of these observations (*e.g.* the duration of pregnancy, variations in the feeding of the mother during pregnancy, economic circumstances, etc.) that it seems needless to postulate a climax in reproductive life. Further, this inferiority of the infants born of the youngest mothers remains only for a short period of life (Noël Paton and L. Findlay, 1926). These authors found that by the end of the first year the weights and lengths of the offspring showed a steady decrease with increasing age of the mother. Accordingly the evidence would support the view that little stress should be laid on the doubtful immaturity of women of 15–20 as a factor in the production of the higher death rate at that age compared with those of the immediately subsequent age groups.

These two general conditions, primiparity and varying intensities of selection of married women at different ages, have thus a possible causal relationship with the observed age distribution of puerperal mortality in general. If we could assume that these were wholly responsible for the higher death rate in the first quinquennial age group compared with the two immediately subsequent groups—a not improbable assumption—it would follow that in a population of women selected at random as regards their general health and dissociated from the excessive dangers of primiparity, the death rate in maternity should follow the age distribution of the mortality of females in general from all other causes of death, *i.e.* a death rate gradually and steadily increasing with age; and, further, will raise some doubt as to whether the age distribution of the conditions included in the first groups—group (*a*)—are influenced to any significant extent by these factors. Consequently in these conditions our attention would be specially directed to the effects of other conditions, possibly local, such as those in the uterus and adnexa.

Age-standardised rates of maternal mortality.

The influence of variations in the age and civil constitution of women of reproductive ages in different geographical areas has been assessed in the following manner. For each county the total births are first distributed to quinquennial age groups of mothers as has been done previously for the whole country (Table VII). The mortality rates which would have occurred in the county, had the death rates at ages been the same as those of the standard

population, are now calculated by applying the mortality rates found for England and Wales to the number of births at each age, summing the expected numbers of maternal deaths and dividing by the total births. The death rate of the standard population divided by the expected death rate of the county furnishes a factor for correction which, when in excess or defect of unity, denotes the existence of a female reproductive population constituted with respect to danger of death in childbearing favourably or adversely respectively. (The method after the distribution of births is effected, is the ordinary "indirect" method of standardisation.) The correcting factors are given in Table XXI. This lengthy process has sufficed to demonstrate one

Table XXI. *Showing the factors for correcting for age in the maternal mortality rates in the counties of England and Wales, 1921-3.*

Bedford	0.9910	Somerset	0.9834
Berkshire	0.9839	Southampton	0.9969
Buckingham	0.9830	Stafford	1.0127
Cambridge	0.9947	Suffolk	0.9923
Cheshire	0.9898	Surrey	0.9725
Cornwall	0.9946	Sussex	0.9789
Cumberland	1.0034	Warwick	1.0021
Derby	1.0105	Westmorland	0.9778
Devon	0.9916	Wiltshire	0.9888
Dorset	0.9861	Worcester	0.9997
Durham	1.0251	East Riding	1.0065
Essex	0.9936	North Riding	1.0069
Gloucester	0.9929	West Riding	0.9875
Hereford	0.9961	Anglesey	0.9838
Hertford	0.9775	Brecknock	1.0077
Kent	0.9937	Cardigan	0.9686
Lancashire	0.9954	Carmarthen	1.0051
Leicester	1.0002	Carnarvon	0.9692
Lincoln	1.0044	Denbigh	0.9918
Middlesex	0.9813	Flint	0.9839
Norfolk	0.9925	Glamorgan	1.0197
Northampton	0.9942	Merioneth	0.9701
Northumberland	1.0136	Monmouth	1.0244
Nottingham	1.0082	Montgomery	0.9868
Oxford... ..	0.9866	Pembroke	1.0005
Shropshire	0.9917	Radnor	0.9807

significant point. In no case is the factor sufficiently divergent from unity to make any substantial difference in the crude rate per 1000 births. Hence we are entitled to conclude that, in spite of the age of the mother being an important factor in determining her chance of dying in childbearing, the variations in the age constitution of the female population of the counties of England and Wales are of negligible importance in the causation of geographical variations in maternal mortality. One of the influential factors, and one, moreover, not amenable to efforts of administrative control, may thus be dismissed in any consideration of inter-local variations of puerperal mortality in this country.

Factors modifying the course of the puerperal mortality rates.

Within recent years the crude maternal mortality rate has not declined; but various changes are taking place in the female reproductive section of

the community which are not favourable to a declining death rate. The tendency if anything is in the opposite direction.

(1) The fall in the birth rate results in an increased proportion of primiparous births with its attendant increased chances of death for the mother.

(2) There has been, besides, a change in the age constitution of married women between the last two censuses. The mean age of married women between 15-50 is, for 1921, 36.11 years, and for 1911, 35.67 years—an increase of about half a year. When the age groups are weighted according to their fertilities, the mean ages of the weighted distributions are, for 1921, 30.75, and for 1911, 30.78, *i.e.* the average ages are practically identical. The distributions at age, however, are somewhat different. Table XXII shows the

Table XXII. *Percentage age distribution of married women (fertility-weighted) at the censuses 1911 and 1921.*

Age	Percentage frequency	
	1911	1921
15-	1.03	1.50
20-	17.05	18.33
25-	29.28	28.13
30-	28.27	26.54
35-	17.27	17.50
40-	6.48	7.26
45-	0.62	0.74
15-50	100.00	100.00

proportions of married women living at the several age groups (weighted according to their fertilities) at the two censuses. (These figures really give the proportions of the total legitimate births which come from mothers of these ages.) There has been apparently a slight increase in the percentage of probable mothers in the first two and last three quinquennia, with a corresponding defect in the intermediate age periods. Slight as is this change, it is certainly in the direction of causing an increase in the crude maternal mortality rate, because of the smaller proportion of the total births now coming from mothers of those ages at which the puerperal mortality is lowest.

(3) The selective character of the birth rate in respect of the greater fertility of the classes lowest in the economic scale might have become more intense within the periods studied; but, on investigation, this would not appear to be a factor of any importance in the present connection. The coefficients of correlation between the percentage decline in the legitimate birth rate which took place within the two triennia 1911-13 and 1921-3 and indices of social level for the counties of England and Wales, excluding London, and separately for the 28 metropolitan boroughs are given in Table XXIII. Two measures of fertility have been used in measuring the rate of decline in different districts; (a) the ordinary crude legitimate birth rate calculated per 1000 of the total population, and (b) a corrected birth rate, which removes the objections pertaining to the crude rate. The denominator of the corrected

rate in any district is the fertility-weighted married female population between the ages of 15 and 50 years. The influence of variations in the proportion of women of reproductive ages to total population and of differences in the age distribution within the reproductive section of the female population itself, the two objections to the use of a crude birth rate as a measure of fertility, are thus eliminated. Of the correlations collected in Table XXIII only two can be regarded as statistically significant, each of which barely exceeds the

Table XXIII. *Showing the correlations between the decline from 1911-13 to 1921-3 in the crude and corrected birth rates and social status.*

Index of social status	Crude birth rate	Corrected birth rate
<i>(a) 52 counties excluding London:</i>		
Per cent. population living more than two per room	-0.0964 ± 0.093	-0.0942 ± 0.093
Rooms per person	0.2692 ± 0.087	0.1931 ± 0.090
<i>(b) 28 Metropolitan boroughs:</i>		
Per cent. population living more than two per room	-0.2852 ± 0.117	0.1925 ± 0.123
Number of domestic servants per 100 families	0.3654 ± 0.110	-0.0604 ± 0.127

standard of significance and both involve crude rates. All correlations found by the use of corrected birth rates are insignificant with regard to their probable errors. The rate of decline of the birth rate within the period studied would, therefore, appear to be independent of differences in social level, and in consequence the possible effect on maternal mortality of a more intense social selection of births must be dismissed as unimportant.

Still with the above two factors antagonistic to a declining mortality—a lower birth rate, and a change for the worse in the age constitution of mothers—it is possible that changes may have occurred in the death rates at some ages, but that these have been obscured by using a crude rate of mortality.

The effect produced by the declining birth rate on the crude rate of mortality from puerperal convulsions.

To illustrate the fallacy that might occur from the use of crude rates, and from taking no note of the age or parity of the mother, a good example is that of eclampsia—a feature associated almost exclusively with primiparity. The group puerperal convulsions is almost entirely composed of eclampsia and, expressed in the usual manner, the rate was in 1911-13, 549 per million births; in 1921-3, 485 per million births; that is, there was a decrease of 12 per cent. in the decennium. But the fall in the birth rate of necessity results in a rise in the proportion of first births, so that the denominator in the first period is too lenient relative to that in the succeeding period. I have attempted to estimate the effect of this in the following manner. From the data relating to the 28 registration states of the Births Registration Area (U.S.A.) in 1923, in which the notifications of births require a statement of the order of birth, and proportion of first born children (x) was calculated

for each state and correlated with the crude birth rate (y). The following are the constants deduced:

$$\begin{aligned} \bar{x} &= 27.6107 \text{ per cent. first born children.} \\ \bar{y} &= 22.5679 \text{ births per 1000 total population.} \\ \sigma x &= 2.9766 \text{ per cent. first born children.} \\ \sigma y &= 3.0492 \text{ births per 1000 total population.} \\ r_{xy} &= -0.6979 \pm 0.065. \end{aligned}$$

Connecting these two variables by a simple regression equation of the first order we find that:

$$x = 42.9853 - 0.6813 y.$$

In other words, a fall of 1 per 1000 population in the crude birth rate corresponds on the average to an increase of 0.6813 per cent. in the proportion of first born children. The standard error in prediction from this equation is 2.13 per cent. From the accompanying diagram (Diagram 2) it will be seen

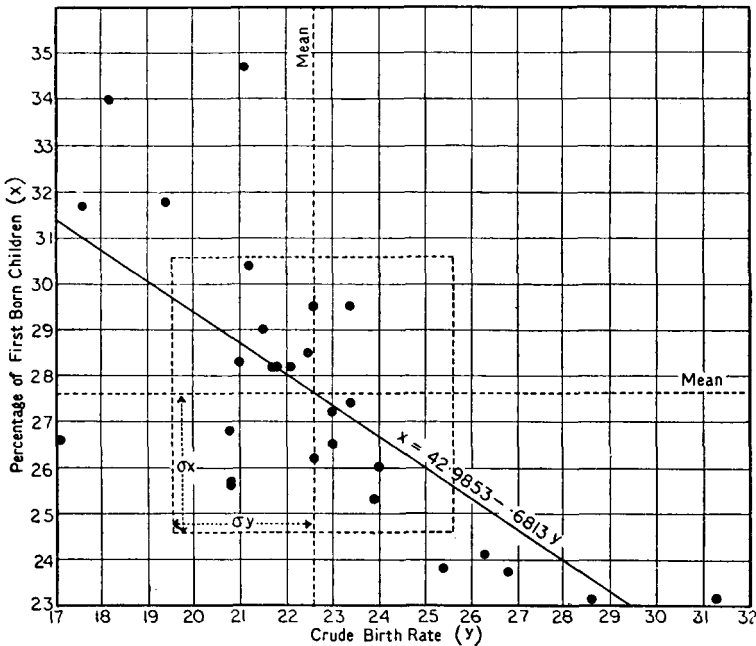


Diagram 2. Showing the correlation between the crude birth rate and the percentage of primiparous births.

that the fit is by no means very good, but that a straight line is likely to be as good for prediction within the range of the observations as any curve of higher order. Applied to the statistics of England and Wales, this simple relationship will allow us to form a rough general estimate of the number of primiparae in the two triennia. In 1911-13 the mean crude birth rate was 24.03 per 1000 population which, substituted in the above equation, gives a probable proportion of first born of 26.6137 per cent. Similarly for 1921-3,

a crude birth rate of 20·83 corresponds to a proportion of 28·7938 per cent. The total number of births in 1911–13 was 2,635,765; so that of these 701,475 were first born. In 1921–3 the total number of births was 2,059,768; so that 687,328 of these were first born. Assuming that all the deaths in the group puerperal convulsions were eclamptic, and that these in turn all occurred in primiparae, the above figures give rates of 2064 and 1685 per million first pregnancies in 1911–13 and 1921–3 respectively; that is, there has been a decrease of 19 per cent. in the death rate—a decrease over 50 per cent. greater than that estimated by using all births as the denominator. This result, therefore, clearly shows how in certain cases a crude rate of mortality may lead to erroneous deductions.

*Changes in the mortality rates from puerperal causes
at ages within recent years.*

The births having been distributed to the different ages of mothers, the death rates at ages for the two triennia 1911–13 and 1921–3 were calculated. These are given in Table XXIV. With the figures available it is impossible

Table XXIV. *Showing the death rates at ages per million births in England and Wales for the periods 1911–13 (a) and 1921–3 (b) with the percentage ratio of 1921–3 death rate to that of 1911–13 from the several groups of causes of death.*

		15–	20–	25–	30–	35–	40–	45–	15–50
Abortion	(a)	74	65	93	101	233	235	440	124
	(b)	98	46	76	138	195	320	233	125
	(c)	132	71	82	137	84	136	53	101
Ectopic pregnancy	(a)	19	46	51	86	133	181	126	82
	(b)	16	41	94	128	170	184	233	111
	(c)	84	89	184	149	128	102	185	135
Other accidents of pregnancy	(a)	186	80	89	138	319	494	377	169
	(b)	114	127	100	141	308	433	822	181
	(c)	61	159	112	102	97	88	231	107
Puerperal haemorrhage	(a)	408	279	337	528	1049	1446	1760	576
	(b)	244	214	371	495	924	1365	1163	531
	(c)	59	77	110	94	88	94	66	92
Other accidents of childbirth	(a)	408	262	295	365	619	946	1195	411
	(b)	195	325	345	364	581	736	930	414
	(c)	48	124	117	100	94	78	78	101
Phlegmasia alba dolens	(a)	408	249	289	347	656	807	1132	400
	(b)	114	199	265	419	547	736	1279	377
	(c)	28	80	92	121	83	91	113	94
Puerperal insanity	(a)	37	38	33	40	61	12	63	39
	(b)	49	31	32	31	37	53	58	34
	(c)	132	82	97	78	61	442	92	87
Puerperal nephritis	(a)	390	184	183	184	269	355	503	215
	(b)	179	162	168	214	303	356	523	218
	(c)	46	88	92	117	113	100	104	101
Puerperal convulsions	(a)	2840	682	464	409	488	572	754	549
	(b)	1189	594	436	395	461	499	639	485
	(c)	42	87	94	97	94	87	85	88
Puerperal sepsis	(a)	1615	1364	1246	1302	1503	1650	1509	1361
	(b)	1368	1195	1254	1295	1559	1786	2500	1354
	(c)	85	88	101	99	104	108	166	100
All causes	(a)	6386	3249	3082	3499	5330	6698	7859	3922
	(b)	3566	2933	3140	3621	5084	6469	8429	3839
	(c)	56	90	102	103	95	97	107	98

to dissociate the influence of age and parity of the mother, and this is a point of some importance not only with regard to the etiology of pathological conditions in childbearing, but also, as has been shown, in comparing the death rates at different epochs when both age of the mother and the average degree of parity are changing concomitantly, as is happening at the present time in connection with the declining birth rate. The only method which would give absolutely satisfactory results is a comparison between women of equal age and varying parity and vice versa; but the present consideration of the relation between the age-specific death rates in 1911-13 and 1921-3 has thrown some light on the subject. It is to be specially noticed that while the general crude maternal mortality rate shows practically no change in the decennial interval, in all the chief causes of death there has been a great reduction in the death rates at ages 15-20. The majority of these women are primiparae, so that we are really comparing the rates in a group of women of approximately the same age and parity—and the death rate has apparently been reduced by half in the decennial interval. Objection might be raised that the method of computing the death rates by age of mother may have assigned too few or too many births to these mothers, since we do not know how the fall in the birth rate has affected the actual fecundity at various ages in the women of England and Wales. But this cannot possibly account for the whole of this enormous decrease, since if there had been no actual decrease, if the apparent drop was solely due to erroneous methods of graduation, then twice as many births as actually did occur have been allotted to women of 15-20 in 1921-3 as compared with 1911-13. No doubt there may be some error in apportioning the births and too many given to the premier age group relative to what were given in the previous triennium—this can be well understood if the fall in the birth rate had specially characterised young mothers—but the previous comparison of fertility rates at ages for different countries at different periods has shown that this is almost certainly not the case. If the decline in fecundity of women in England and Wales has affected the various age groups in the manner in which the above comparison would seem to indicate, then we have in the latter triennium actually underestimated the number of births to be assigned to women of 15-20. The method has thus overestimated the death rate at that age relative to the corresponding group in the preceding triennium, and consequently has obscured some of the decrease in the intervening period. Accordingly, I am inclined to believe the amelioration is a real one, and not due to fallacies connected with the methods of distributing births.

While there is also a change for the better in the rates for women of 20-25, in which group about 20 per cent. of the total births occur, there is no unequivocal evidence of any significant divergence of the rates at the other ages for 1921-3 from those in the preceding years.

The interpretation of the changes in the mortality rates at ages.

The possibility of explaining this significant decline in the mortality of younger mothers is limited by the available data. The increase in the attention (ante-natal, natal and post-natal) given to mothers, improvements in the general sanitation of homes, advances in the further provision of hospital accommodation for women needing help in confinement, and improvement in the general health of parturients would all require consideration. But to assign any value to the efforts specially directed towards mothers (*i.e.* obstetric control) it will be necessary, in view of the restriction of the improvement in maternal mortality to the younger ages, to show that these efforts have been in the main confined to these ages. Improvements designed to ameliorate the condition of the people in general (not specially the mother), such as improvements in general hygiene, would operate selectively on some ages more than others, provided that a greater part of the deaths at these ages is the result, directly or indirectly, of unhygienic conditions, *i.e.* if a greater part of these is preventable.

At present I have not had access to any data sufficient or suitable for the evaluation of the effects of these factors, but it is possible to enquire what changes, if any, have occurred in the health of women in different civil states, in these two periods. In Table XXV are collected the mortality rates at ages

Table XXV. *Showing the death rates from all causes in married and unmarried women in 1911-13 and 1921-3, with the percentage ratio of the married to the unmarried death rate.*

Age	Married		Unmarried		Married death rate per cent. of unmarried	
	1911-13	1921-3	1911-13	1921-3	1911-13	1921-3
15-	630	411	266	257	237	160
20-	387	343	293	304	132	113
25-	388	355	320	343	121	104
30-	452	388	372	386	121	101
35-	592	462	468	447	126	103
40-	734	551	716	605	103	91
45-	944	721	1031	815	92	88

of married and unmarried women from all causes for the two triennia which have been studied. It will be seen that at most ages there has been an improvement in the health of both sets of women, but that this has specially been so in the case of married women. Consequently the ratio of the death rate of married to unmarried has declined significantly within the period. In the first quinquennium the greatest difference is apparent. The ratio of 237 per cent. in 1911-13 has declined in the intervening ten years to 160 per cent. Similarly, but to a much less significant extent, the ratios have declined in the later ages. But the enormous decline in childbed causes must have contributed in some degree to this result; so that, in a manner similar to that employed before, the puerperal deaths have been deducted from the married and unmarried in the proportion of the illegitimate to total births at each age,

and the death rates recalculated for all causes less those pertaining to pregnancy. These are given in Table XXVI. Although childbed causes have contributed in great part to the difference, there is still apparent a very definite amelioration in the general death rate of married as compared with unmarried women within the decennium. Further, it will be noted that the greatest improvement is in the 15-20 age group, somewhat less in the next,

Table XXVI. *Showing the death rates from all causes less puerperal in married and unmarried women in 1911-13 and 1921-3, with the percentage ratio of the married to the unmarried death rate.*

Age	Married		Unmarried		Married death rate per cent. of unmarried	
	1911-13	1921-3	1911-13	1921-3	1911-13	1921-3
15-	363	280	264	255	138	110
20-	275	254	289	301	95	84
25-	277	275	325	340	85	81
30-	308	319	423	383	73	83
35-	419	400	533	444	79	90
40-	611	516	700	603	87	86
45-	905	716	992	814	91	88

still less in the third quinquennium, while in the last four quinquennia there is no significant favourable change in the relationship. To what degree this result should be credited to the opportunity given by the loss of male lives in the War for a better selection of the fittest of the females for marriage, or to other causes, such as changes in the age at marriage in the different social classes, is not a point which need concern us here. Certain it is that there has been a substantial change for the better in the health of young mothers quite apart from the risks of maternity.

That there is some relation between general health and the risks of dying in childbed can scarcely be doubted. The curve of puerperal mortality when corrected for primiparity shows a close parallelism with the general mortality curve of women at these ages except in the first quinquennium or reproductive life, and it has been shown that these young mothers are a selection from the lower social classes in which, as is well known, the general health is below that of the average.

The above comparison would therefore appear to strengthen the assumption that the childbed mortality was to some extent influenced by the general state of well-being of the parturient, and similarly that the improvement in the type of young mothers has been the main factor which has determined the great decline in maternal mortality at the younger ages within the past decennium.

SUMMARY AND CONCLUSIONS.

In the present paper an attempt has been made to devise a method of determining mortality rates at ages from causes of death associated with childbearing. The sources of possible fallacy in this procedure have been discussed, and it is probable that the results found will represent fairly accurately the true course of mortality in this country.

From all causes of death in childbearing, mortality follows this course: beginning with a high value in the age group 15–20, the rate drops to a minimum in the second quinquennium of reproductive life and thereafter gradually increases with age.

The main components of the death rate exhibit a similar age distribution, but other less important causes of death show an uninterrupted increase with age from the commencement of the reproductive period.

Eclampsia is much more common in young women, but this may be entirely due to the greater proportion of primiparae at these young ages. Estimated in terms of first births the death rate increases rapidly and steadily with age, subject to a small exception in the first quinquennium which may possibly be a consequence of unfavourable marital selection at that age.

The high puerperal mortality of young mothers cannot wholly be accounted for by the excessive dangers of primiparity. Evidence has, however, been submitted that these young women are, on the average, a less healthy sample of the total female population at that age and that, apart from primiparity and adverse selection, the death rate from childbed causes probably follows the same law of mortality as of women in general from all other causes of death.

There has been within recent years a decline of nearly 50 per cent. in the puerperal mortality in young mothers of 15–20 and a smaller decrease in the second quinquennium of reproductive life; but there is no evidence of any improvement at later ages. These phenomena have been brought into relation with the change which has taken place in the death rate from all other causes in married women at these ages. The youngest group of married women, relative to unmarried of the same age, were in the more recent period studied in a much more favourable position with regard to their mortality from causes other than those connected with childbearing than they had been formerly. No corresponding improvement has taken place in the relative mortalities from all other causes in older women within the childbearing ages.

These results suggest that the general health of the mother is a factor of great importance in determining the height of the mortality rate in pregnancy.

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