

THE DECLINE IN INFANT MORTALITY.

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(With 1 Diagram.)

ALTHOUGH many measures which may influence the mortality of infants have within recent years come into operation, it is convenient and permissible to classify these into one or other of two broad categories. In the first place, many general measures intended to ameliorate the life and health of the people at all ages must be taken into consideration. Here we have such improvements as have been effected or attempted in the unhealthy conditions of urban life, in particular, improved housing, improved domestic and municipal sanitation, control of the milk supply, etc. The manner in which these may affect the health of infancy is obvious and need not be enlarged upon. In the second instance, we have to consider the effects of those measures which have been specially directed to the infant and the pregnant or nursing mother. From a small beginning in private philanthropic work has now sprung a vast national machinery of maternity and child welfare, a scheme which resolves itself into component parts directed towards improvements in the conditions affecting the three special periods of infant life, the ante-natal, natal and post-natal. The aims and objects of ante-natal supervision may be summed up briefly. The scheme is designed (Fairbairn, 1925) to maintain the health of the mother during pregnancy, to prepare her for the nursing and general management of her infant after its birth, to attempt to preserve the pregnancy to full-time and, above all, to foresee and take steps to avoid the preventable difficulties in labour. Obviously work of this nature, efficiently carried out, should influence the death-rates at each of the three periods of infant life in a definite manner. It should (1) reduce the preventable sickness and mortality among the mothers themselves, (2) reduce the proportion of pregnancies which do not reach full-time, (3) reduce the number of deaths of infants and mothers from accidents of childbirth, and (4) in the post-natal period should result in a diminution in those causes of death which are mainly dependent on the lack of intelligent maternal care. Natal work resolves itself into the adequate provision of lying-in accommodation and skilled obstetrical assistance till the end of the puerperium. Its effects will be manifested by reduction of the death-rates of mothers and infants from diseases and accidents complicating labour. The post-natal or welfare clinic is mainly educative and advisory. For purposes of treatment, which does not form part of the usual routine of the clinic, special treatment clinics have in some instances been formed to work in co-operation with the welfare clinic; but in places where these have not

been instituted many of the ordinary ailments of infancy can be treated at the welfare clinic and the more serious cases referred to hospital. The total effect of the maternity and child welfare movement should be that more intelligent maternal care is bestowed on the infant and that diseases are treated at an earlier stage and therefore more effectively. Apart from all such deliberate efforts to conserve infant life, two great vital statistical changes, namely, the improvement in the health of persons of reproductive ages and the decline in the birth-rate, deserve consideration because of the effects which they may have had on infant mortality.

ANALYSIS OF THE DATA.

The present study deals only with the rates of mortality of the years 1911-25 inclusive. The differences in the classification of the causes of death introduced in 1911 and the non-distribution of births and deaths prior to that date preclude for the most part comparisons over a longer period of time. Since the rates from the several causes of death vary so much in actual magnitude, to ensure comparability in the changes which have taken place in the different causes of death, index numbers have been calculated for each of the 15 years, taking as base line the mean rate for the whole period. Each annual death-rate is then expressed as a percentage of the mean, and the regression coefficients calculated for each series. In some instances the actual death-rates do not follow with any measure of exactitude the course indicated by the regression straight line; but since our object is to obtain a simple and at the same time reasonably accurate expression of a general tendency, any attempt to follow irregularities in the trend of mortality by more complicated curves would defeat the end in view. Diagram 1, which shows for some of the main causes of infant mortality the actual course and that indicated by the straight line, brings out with what degree of accuracy the regression coefficient represents the changes which have taken place within the period under consideration. In the tables which follow a negative coefficient represents a decreasing, a positive coefficient an increasing death-rate. The appended errors are standard errors, so that as a rough criterion of the significance attaching to any change twice the standard error may be taken. If the coefficient does not exceed this standard, it may be inferred that there has been no definitely proven tendency for that death-rate to rise or fall within the period under review.

(a) *Post-natal mortality.* Table I shows the rate of decline in infant mortality as a whole and in several cause groups of death under one year in England and Wales. In the country generally within the 15 years studied there has been quite an appreciable decline at the rate of $3\frac{1}{2}$ per cent. annually in the total death-rate under one year. In the separate causes of death, however, there are great variations from this average rate of change. In view of the widely different sizes of the standard errors involved, it is impossible to say whether or not the actual magnitude of the coefficient of the regression line

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serves to place the separate cause groups of death in any definite order. Some causes have declined on the average much more than others, but the course has been very erratic. Good examples are furnished in the case of epidemic infectious diseases, e.g. measles, in which violent fluctuations may occur from year to year, although on the average of several years' experience a decline

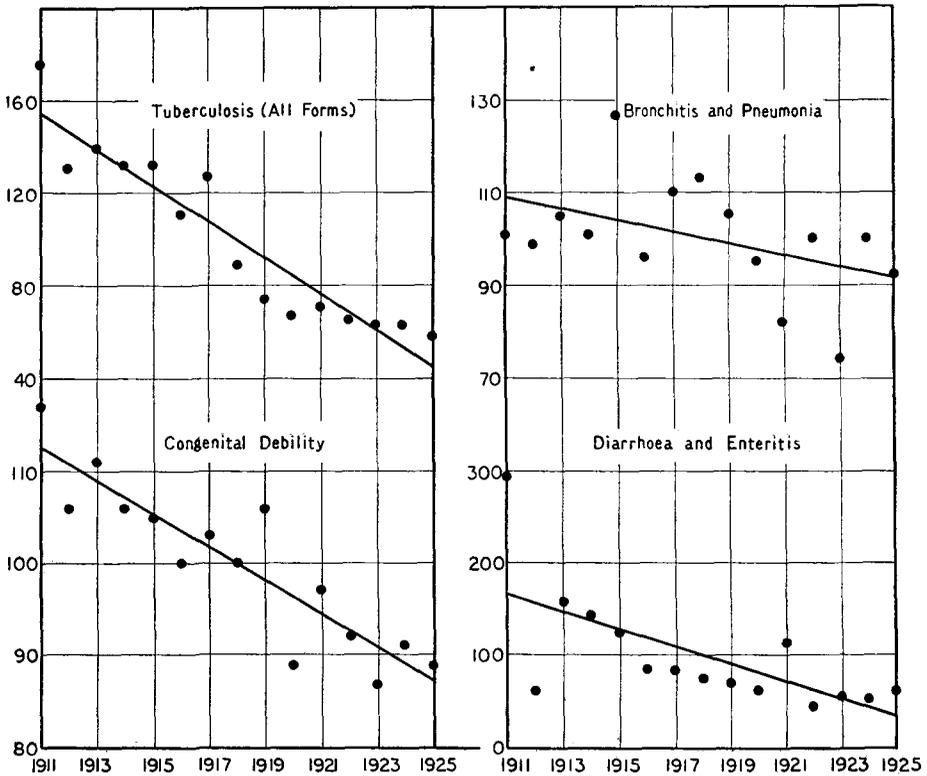


Diagram 1.

Table I. *Decline in Various Causes of Infant Mortality in England and Wales (1911-25).*

| Cause of death | Regression coefficient |
|--------------------------------|------------------------|
| Tuberculosis (all forms) | - 7.90 ± 0.73 |
| Diarrhoea and enteritis | - 9.69 ± 2.74 |
| Infectious diseases | - 4.54 ± 1.43 |
| Measles | - 6.98 ± 1.94 |
| Whooping cough | - 3.24 ± 1.65 |
| Bronchitis and pneumonia | - 1.28 ± 0.64 |
| Abdominal tuberculosis | - 11.73 ± 1.06 |
| Syphilis | - 2.55 ± 1.24 |
| Convulsions | - 6.52 ± 0.36 |
| Malformations | + 0.98 ± 0.28 |
| Injury at birth | + 2.21 ± 0.41 |
| Premature birth | - 0.66 ± 0.27 |
| Atrophy, debility and marasmus | - 6.52 ± 0.39 |
| Meningitis | - 7.15 ± 0.70 |
| Overlying | - 8.29 ± 0.72 |
| Infant mortality (all causes) | - 3.59 ± 0.46 |

may be manifested. On the other hand, with a group such as congenital debility the percentage decline may not appear so startling, but the consistency of the downward trend is a cause for satisfaction as great as, probably much greater than, a more decided decline but one subject to gross annual fluctuations from the general course. Probably all that can be done in this connection is to have three groups, namely, those (1) with a significant decline, (2) with questionable or no decline and (3) with an increase. In the first group the gastro-enteric infections, diarrhoea and abdominal tuberculosis, have declined most of all. Other causes included in (1) are overlying, meningitis, measles, atrophy, debility and marasmus, and infantile convulsions. Infectious diseases generally have been significantly reduced, but this is mainly attributable to the decline in measles mortality. Whooping cough, syphilis, bronchitis and pneumonia and premature birth, all of which show insignificant changes, compose group (2); whereas malformations and injury at birth have shown a definite tendency to increase.

(b) *Ante-natal mortality.* To complete the mortality list of infants it would be necessary to consider the death-rate in intra-uterine life. This, however, can only be done in a very imperfect way. Still-births, *i.e.* deaths after the 28th week of intra-uterine life, are notifiable, but since the introduction of notification there has, as will be gathered from Table II, been no tendency

Table II. *Still-birth Rates per cent. of Live Births in England and Wales.*

| | | | | | |
|------|-----|-----|------|-----|-----|
| 1918 | ... | 3.0 | 1922 | ... | 3.2 |
| 1919 | ... | 3.2 | 1923 | ... | 3.3 |
| 1920 | ... | 3.1 | 1924 | ... | 3.3 |
| 1921 | ... | 3.2 | 1925 | ... | 3.2 |

for this rate to diminish. It is only fair, however, to point out that the obvious conclusion from these figures is but doubtfully justifiable. Notification of still-births is not yet compulsory, and more complete returns might, with reason, be held to obscure a real downward tendency and to produce an apparently stationary or increasing rate of mortality. No records are, unfortunately, available of the loss of foetal life before the attainment of viable age, and it is possible that this may be just as great as the more immediate ante-natal loss. *A priori*, it seems reasonable to suppose that the secondary sex-ratio (the sex-ratio at birth) would furnish a useful index of the total pre-natal loss of life. The sex-ratio at conception (the primary sex-ratio) is much higher than that at birth, and, since the intra-uterine mortality also is predominantly male, it might appear that the lower the secondary sex-ratio the higher had been the previous ante-natal loss of life. Parkes (1924) has shown that the foetal elimination in man is large (16.5 per cent. of all pregnancies), and quite sufficient, therefore, provided intra-uterine mortality is differential with regard to sex, to affect profoundly the sex-ratio at birth. That there is a definite excess of males among foetal deaths is borne out by all statistics. The male sex-ratio of live-births varies approximately between 104 and 108, whereas for still-births (Huxley, 1924) the male ratio lies between 124.6 and

142.2 in various European countries. The several factors which are known to influence the birth sex-ratio, *e.g.* age and parity of the mother, social status, etc., do so probably more by varying the ante-natal loss of life than by modifying the sex proportions at conception. The experimental work of Parkes (1924 *a*) shows that, for mice at least, there is a strong degree of association between the secondary sex-ratio and the amount of foetal wastage. Adverse pre-natal environment accentuates the foetal loss and decreases the sex-ratio of live-births. Under normal conditions, in which the embryo loss amounts to 10.8 per cent., the sex-ratio is 118 males per 100 females. In mice allowed to become pregnant immediately following parturition and to continue suckling the young for less than 6 days the embryo loss rises to 17.6 per cent. and the birth-ratio falls to 80.4. With more intensely adverse environmental conditions the foetal loss rises to 23.1 per cent. and the secondary sex-ratio falls to 62.1. If these results were applicable to man, the male-ratio at birth would evidently provide a suitable index of ante-natal loss; but it is doubtful if the human secondary sex-ratio forms such a solid foundation for deduction as to the course of ante-natal mortality as would appear from results found under controlled laboratory conditions. In the first place the sex-ratio at birth of legitimate is almost equal to that of illegitimate infants. In the period 1911–25 of all legitimate births 51.10 per cent. and of illegitimate 51.06 per cent. were males. A higher pre-natal mortality is to be expected among illegitimates, because most of these mothers are primiparae and the dangers of first pregnancies are greatest; the ante-natal environment to which the infants are subject is probably much worse than is that of legitimate infants; and, still more, because a relatively great proportion is infected with venereal diseases. That the sex-ratios are so little different would rather seem to invalidate conclusions regarding the course of foetal loss which are drawn from the evidence of these ratios alone. In this instance, however, the lower average age of unmarried mothers will offset to an unknown extent the effect of those factors tending towards a low secondary sex-ratio among illegitimate infants. In the second place, there is no correlation between the notified still-birth rate and the secondary sex-ratio. Table III shows the correlations between these two

Table III. *Correlations between the Still-birth Rates and Secondary Sex-ratios (1921–3).*

| | | |
|-------------------------|--------|----------------|
| Metropolitan boroughs | ... | 0.496 ± .127 |
| County boroughs | | – 0.358 ± .074 |
| Administrative counties | ... | 0.840 ± .102 |

variables found in the three large aggregates of England and Wales in the triennium 1921–23. These coefficients are neither significant with regard to their probable errors nor are they consistent with regard to sign, and therefore may be taken to indicate that the secondary sex-ratio is not related in any way to the preceding still-birth rate. Here again, however, we have really no strong argument against the sex-ratio at birth as an index of the *total* ante-natal loss, because we are ignorant both of the magnitude of the loss of

non-viable foetuses and of the correlation between this and the death-rate in the period when viability has been attained. Taken together, however, these two findings cause reasonable doubt as to the use of the suggested index of foetal wastage; but, for what it is worth, it may be said that, although there have been variations in the ratio of male : female live-births, especially in the immediate post-war period, a regression line fitted to these ratios has a slope which is insignificant when compared with its standard error, *i.e.* there has been no significant general change in the sex-ratio at birth within this period. In so far, then, as this is indicative of what we want to measure, and taken in conjunction with the course followed by that part of the ante-natal death-rate which is notifiable, it may provisionally be concluded that no improvement has taken place at this period of infant life. The difficulties in the accurate measurement of the course of ante-natal mortality might make it seem unreasonable to draw any conclusions in this connection; but even if the evidence submitted only suggests, and cannot with certainty demonstrate a lack of improvement in the trend of foetal mortality, there are at least no certain grounds for the contrary opinion that there has been any amelioration.

(c) *Maternal Mortality.* The cognate subject of puerperal mortality must now be reviewed briefly. In Table IV are collected the coefficients representing

Table IV. *Decline in Various Causes of Maternal Mortality in England and Wales (1911-25).*

| Cause of death | Regression coefficient |
|-------------------------------|------------------------|
| Accidents of pregnancy | + 0.82 ± 0.54 |
| Abortion | + 0.05 ± 0.90 |
| Ectopic pregnancy | + 2.85 ± 0.61 |
| Other accidents of pregnancy | + 0.30 ± 0.96 |
| Puerperal haemorrhage | - 0.59 ± 0.27 |
| Other accidents of childbirth | + 0.05 ± 0.48 |
| Puerperal sepsis | + 0.34 ± 0.62 |
| Albuminuria and convulsions | - 0.63 ± 0.42 |
| Phlegmasia alba dolens | - 1.01 ± 0.33 |
| Puerperal insanity | - 1.87 ± 1.13 |
| All causes | - 0.10 ± 0.27 |

the course of the rates of mortality from all causes and from several separate cause groups of death in child-bearing women. The coefficient for the total maternal death-rate shows that its course in the period studied is practically horizontal, and that, therefore, there has been no change in the welfare of mothers as a whole. Among the separate causes of death, only two, namely, phlegmasia alba dolens and puerperal haemorrhage, show sensible improvement; and even in these cases the coefficients are small and but just statistically significant. Causes of death in early pregnancy have shown a tendency to increase. In each instance the regression coefficient is positive in sign, although in only one case, that of ectopic pregnancy, can it be deemed substantial. Later in the child-bearing period the chief cause of death, albuminuria and convulsions, has shown an insignificant tendency to decline. As is

well known, however, eclampsia (which forms the greater part of this group) is in the majority of cases a primiparous condition, and, since a declining birth-rate is associated with an increasing proportion of primiparous births, by basing the death-rate from this cause on total births, any tendency towards decline will be minimised and might be effaced. Thus if it were possible to calculate the mortality due to this cause on the more accurate denominator of primiparous instead of total births, it might quite well be that there has been real improvement. This possibility can only be mentioned because there are in this country no records of the number of primiparae. Apart from puerperal haemorrhage, causes of maternal death at and immediately after the birth of the child have remained practically steady within this period. The remaining, and chief single cause of maternal death, puerperal sepsis, has, if anything, shown a tendency towards increase, but no statistical significance can be attached to the coefficient. On the whole, therefore, we may conclude from a study of these figures that but little has been accomplished within recent years in promoting the well-being of the child-bearing woman.

To summarise briefly, it may be stated that, as regards maternity and child welfare in England and Wales generally, any significant improvement, so far at least as mortality is concerned, has been confined to the post-natal period of infancy. At and before the birth of the child conditions appear to have remained practically stationary in the last 15 years.

DISCUSSION.

It remains now to seek some reasonable explanation of these changes. We have seen that the death-rates from various causes have declined at different rates; and we now wish to enquire how far these differences coincide with any reasonable classification of the causes of infant deaths. The simplest would be a dichotomy into avoidable and unavoidable; and, if it could be shown that the decline in infant mortality had been confined to the avoidable group and left unaffected the non-preventible group, there would then be some basis for the belief that the decline had been due solely to intentional efforts of control. Although in the majority of cases no difficulty will be found as to which of these two classes any cause of death should be relegated, there will always be a residuum which leaves room for difference of opinion. For example, Pearl (1920) gives the following tentative classification (Table V).

In the group of causes of death not controlled, the inclusion of tuberculosis probably does not accord with the greater part of medical opinion. The main type of infection at this period of life is either abdominal or meningeal and not pulmonary, and although the effects of treatment of adult tuberculosis are doubtful, efforts to prevent infant tuberculosis, which is caused rather by ingestion than inhalation of tubercular material, should be more successful. Control of the milk supply and proper infant feeding should surely do something to lessen this cause of mortality. Also in this group is included infant syphilis, with regard to which the results of treatment are admirable.

Table V. *Tentative Classification of Principal Causes of Infant Mortality (Pearl).*

| | |
|---|-----------------------------------|
| A. Causes of death actually now well controlled or capable <i>theoretically</i> of direct control in greater or less degree | B. Causes of death not controlled |
| Measles | T.B. of lungs |
| Scarlet fever | T.B. meningitis |
| Whooping cough | Other forms of T.B. |
| Diphtheria and croup | Syphilis |
| Dysentery | Organic diseases of the heart |
| Erysipelas | Malformations |
| Tetanus | Premature birth |
| Meningitis | Congenital debility |
| Convulsions | Injuries at birth |
| Acute bronchitis | |
| Pneumonia | |
| Bronchopneumonia | |
| Diseases of the stomach | |
| Diarrhoea and enteritis | |
| External causes | |

For example, Sir George Newman (1926) quotes some figures relating to the treatment between 1917 and 1924 of 164 women, most of whom were suffering from secondary syphilis. There were 152 babies born, 51 with positive and 101 with negative Wasserman reactions. Of these infants 12 were stillborn, as treatment was commenced too late in pregnancy, 4 babies died within two months of birth, the remainder continued well. These figures give a mortality-rate of 3 per cent. among infants born alive, compared with a mortality-rate of 75 per cent. before immediate treatment was given to the infants. Syphilitic children treated with mercury and salvarsan from the date of birth thrive well and compare favourably in physique and health with the average children of their own age. With results such as these there should be no doubt as to which class syphilis belongs. The reason for its inclusion in the group of uncontrolled causes of death by this author is probably the difficulty in getting these infants and their mothers under treatment at a sufficiently early stage. It is here that ante-natal work would be most beneficial. Unless special search is made (and it is impracticable and probably undesirable to subject all women to direct blood examination) many women suffering from syphilis will be overlooked during pregnancy. But even in the absence of blood examination by means of the Wasserman technique, and even if none of the usual physical manifestations of the disease be present, careful attention to the previous obstetric history often leads to presumptive evidence that the mother is infected, and with such an efficient weapon at the disposal of the medical officer it does not seem unlikely that special attention would be paid to this. The exclusion of syphilis and accidents of birth from controllable causes of infant mortality would remove two of the great hopes engendered by intensive ante-natal supervision. In the controlled or controllable group, again, it is more than doubtful whether one should include some of the specific infectious diseases. That the death-rate or case incidence of a particular disease has fallen is no certain reason for the belief that it is controlled or capable of control; and to arrogate to intentional efforts, medical or other, any such amelioration

without clear statistical proof of the efficacy of the remedy gives rise to hopes which are only dispelled by a recrudescence of the disease in spite of the continued application of orthodox methods.

But although there are many difficulties in the way of classifying causes of death in infancy, it is certainly a necessary procedure before we can offer any satisfactory explanation of the factors which have been responsible for the changes in the mortality rates of infancy. The difficulty is to put forward any other classification for which we can offer statistical justification. In assessing the values of maternity and child welfare schemes, for example, there are, apart from prosecuting local, carefully controlled inquiries, only two methods of inquiry available, both of which are inferior to local investigation. One of these depends, as above, on arranging the causes of mortality in the order in which they might be expected to be affected—a matter of personal opinion; the other is to compare the rates of decline in parts of the country in which the extent to which these schemes have been prosecuted differs. So far as those causes of death which might reasonably be expected to react favourably to ante-natal supervision, namely, ante-natal and natal deaths of infants and the mortality of child-bearing women, there is no evidence that any appreciable amelioration has taken place (Tables I–III). The second method, that of interlocal comparison of the rates of decline, is also not without difficulty. There are no exact means of measuring the extent to which preventive work has been carried on in different districts; so that the comparisons must necessarily be crude. The number of ante-natal or child welfare centres in the large aggregates of the country is an imperfect measure of the amount of work done because of the differences in the populations to be supplied. The number of clinics per 1000 births or the average number of visits to a clinic per birth are better, but still doubtful indices, since they take no account of the work done by health visitors. The average number of ante-natal and infant welfare clinics per 1000 births in the three large aggregates of England and Wales are given in Table VI. To compare with these indices, the rates of decline for the separate causes of death in maternity and infancy are given in Table VII. The feature of interest here is that both as a whole and in all the separate cause groups of death examined there are few instances of a statistically significant difference in the rates of decline in the main subdivisions of the country. The differences which are evident, however, though small, are of importance. Syphilis and premature birth show substantially more decline in London than elsewhere, and injury at birth in London, although for all practical purposes stationary, compares favourably with the significantly positive coefficients in the rest of the country. The death-rate from congenital malformations, too, which has remained unchanged in London, shows significant increase in other subdivisions of the country. In two other causes of infant mortality, convulsions and overlying, local differences in the rates of decline are apparent. In both instances the coefficient of regression is lowest in rural districts, somewhat higher in urban

districts and highest of all in County Boroughs and London. Although the differences in the rates of decline in the death-rates from syphilis, injury at birth and premature birth would appear to be related to the amount of ante-natal work done (as measured by the imperfect index given above), it is evident from the size of the coefficients how little the total mortality from these causes has been affected. Further, since there are no indications of any similar relationship in the cause groups of maternal mortality between the changes in

Table VI. *Number of Ante-natal and Infant Welfare Centres per 1000 Births. (Average 1924-6.)*

| | Ante-natal | Infant welfare |
|-------------------------|------------|----------------|
| London | 1.40 | 2.70 |
| County boroughs | 0.75 | 1.88 |
| Administrative counties | 1.03 | 3.69 |

Table VII. *Decline in Various Causes of Infant and Maternal Mortality in Different Parts of England and Wales. (1911-25.)*

| Cause of death | London | County boroughs | Urban districts | Rural districts |
|--------------------------------|----------------|-----------------|-----------------|-----------------|
| Infant mortality | - 3.95 ± 0.63 | - 3.42 ± 0.44 | - 3.87 ± 0.54 | - 3.04 ± 0.38 |
| Tuberculosis (all forms) | - 8.40 ± 1.10 | - 7.79 ± 0.78 | - 7.81 ± 0.79 | - 7.28 ± 0.68 |
| Diarrhoea | - 8.43 ± 2.14 | - 9.05 ± 2.51 | - 10.53 ± 3.26 | - 9.28 ± 2.75 |
| Infectious diseases | - 3.73 ± 1.95 | - 4.16 ± 1.34 | - 5.18 ± 1.62 | - 5.24 ± 1.28 |
| Measles | - 6.61 ± 2.74 | - 6.25 ± 1.65 | - 7.79 ± 2.44 | - 8.06 ± 2.47 |
| Whooping cough | - 1.89 ± 2.37 | - 2.78 ± 1.72 | - 3.73 ± 1.62 | - 4.19 ± 1.32 |
| Bronchitis and pneumonia | - 1.85 ± 0.99 | - 0.66 ± 0.56 | - 1.58 ± 0.70 | - 2.15 ± 0.78 |
| Abdominal tuberculosis | - 13.84 ± 1.77 | - 11.90 ± 1.13 | - 11.16 ± 1.31 | - 10.94 ± 1.10 |
| Syphilis | - 5.65 ± 1.55 | - 2.25 ± 1.18 | - 2.71 ± 1.21 | + 0.78 ± 1.50 |
| Convulsions | - 8.34 ± 0.56 | - 7.21 ± 0.28 | - 6.03 ± 0.37 | - 5.99 ± 0.39 |
| Malformations | + 0.05 ± 0.51 | + 1.25 ± 0.30 | + 0.95 ± 0.31 | + 1.15 ± 0.36 |
| Injury at birth | - 0.23 ± 0.73 | + 2.77 ± 0.61 | + 2.79 ± 0.58 | + 1.85 ± 0.55 |
| Premature birth | - 1.45 ± 0.42 | - 0.63 ± 0.23 | - 0.64 ± 0.31 | - 0.33 ± 0.22 |
| Atrophy, debility and marasmus | - 6.51 ± 0.70 | - 6.63 ± 0.37 | - 6.44 ± 0.37 | - 5.59 ± 0.42 |
| Meningitis | - 8.13 ± 1.83 | - 7.42 ± 0.62 | - 7.47 ± 0.60 | - 5.35 ± 0.90 |
| Overlying | - 11.61 ± 1.04 | - 9.75 ± 0.81 | - 5.68 ± 0.68 | - 3.46 ± 0.73 |
| Maternal mortality | + 0.10 ± 0.24 | + 0.23 ± 0.37 | - 1.12 ± 0.65 | - 0.48 ± 0.33 |
| Accidents of pregnancy | - 0.54 ± 1.17 | + 1.41 ± 0.71 | + 1.05 ± 0.51 | - 0.36 ± 0.66 |
| Puerperal haemorrhage | + 1.89 ± 0.91 | - 1.04 ± 0.57 | - 0.54 ± 0.58 | - 1.49 ± 0.81 |
| Other accidents of childbirth | + 0.68 ± 1.28 | - 0.28 ± 0.51 | - 0.31 ± 0.61 | + 0.94 ± 0.71 |
| Puerperal sepsis | - 0.31 ± 0.77 | + 1.14 ± 0.68 | - 0.35 ± 0.64 | + 0.28 ± 0.71 |
| Albuminuria and convulsions | + 0.56 ± 1.18 | - 1.15 ± 0.70 | - 0.82 ± 0.49 | + 0.01 ± 0.46 |
| Phlegmasia alba dolens | + 0.51 ± 1.16 | - 0.32 ± 0.44 | - 1.38 ± 0.65 | - 1.63 ± 0.68 |
| Puerperal insanity | - 3.31 ± 3.04 | - 0.16 ± 1.54 | - 1.62 ± 2.18 | - 4.56 ± 2.61 |

the death-rates and the extent of ante-natal supervision, it is possible that other factors are at the root of these changes. For example, the differences found in such causes as syphilis, premature birth and possibly congenital malformations might be due to the lessened incidence or more effective treatment of venereal diseases in the adult population. The results contained in Tables VI and VII, therefore, are at the best only doubtful evidence of correspondence between effort and result.

In suggesting any other classification of causes of death, it should be remembered that there are three main external factors on which the life of the infant depends:

- (1) The care bestowed on it by the mother.

(2) Medical care, or the neglect to call in medical assistance in illness—a factor which is obviously related to the intelligence and efficiency of the mother, and

(3) Environment other than maternal.

It is not pretended that this is the order of importance of each of these, or that these are the only influential factors; but since these are certainly the most important, and since it is possible to separate each of these in some degree by comparison of figures from the Annual Reports of the Registrar-General, it seemed of interest to study them in relation to the changes in mortality already referred to.

The effect produced by a combination of maternal neglect and lack of proper medical care may be studied best on a large scale by a comparison of the rates of mortality from separate causes of death among legitimate and illegitimate infants. The illegitimate infant is unwanted, and so long as it lives there attaches to the mother a stigma which only the death of the infant can efface. The baby, therefore, in many cases is deprived of the benefits of both intelligent maternal and medical attention. The special features connected with the evils of unfavourable surroundings can be demonstrated by comparing the death-rates by causes in the County Boroughs of the North with those of the Rural Districts of the South of England. It is not to be expected that these two comparisons will show any clear-cut division, because maternal neglect and unhealthy environment are to some extent correlated; but by studying the differences between these two, and comparing them with the observed rates of decline in the various causes of infant mortality, we may be enabled to reach some fairly definite conclusion.

These two comparisons are given in Table VIII. As might have been expected from the nature of the case, syphilis heads the list in column (2). The ratio found may be far higher than is actually the case, both because of the unwillingness to certify this as a cause of death, more especially when the

Table VIII. *Indices of (1) Adverse Environmental Conditions and (2) Maternal Neglect.*

(1) = Ratio per cent. of Death-rates of County Boroughs of the North : Rural Districts of the South.
(2) = Ratio per cent. of Death-rates of Illegitimate : Legitimate Infants.

| | (1) | | (2) |
|--------------------------------|-----|--------------------------------|-----|
| Measles | 955 | Syphilis | 732 |
| Diarrhoea and enteritis | 365 | Overlying | 316 |
| Syphilis | 359 | Atrophy, debility and marasmus | 253 |
| Bronchitis and pneumonia | 317 | Diarrhoea | 240 |
| Infectious diseases | 268 | Abdominal tuberculosis | 228 |
| Infantile convulsions | 202 | Infantile convulsions | 179 |
| Tuberculosis (all forms) | 193 | Measles | 175 |
| Meningitis | 186 | Tuberculosis (all forms) | 167 |
| Whooping cough | 175 | Premature birth | 166 |
| Atrophy, debility and marasmus | 144 | Injury at birth | 162 |
| Premature birth | 139 | Bronchitis and pneumonia | 144 |
| Overlying | 112 | Infectious diseases | 142 |
| Malformations | 110 | Whooping cough | 124 |
| Injury at birth | 110 | Meningitis | 116 |
| | | Malformations | 115 |

birth is legitimate, and because a greater proportion of illegitimate births occur in hospital where diagnosis and certification are probably more accurate; but in all probability syphilis is the cause which has the greatest excess among illegitimate babies. Among other causes it will be seen that some of the groups occupy high positions in both columns, but that the chief differences are (a) overlying and atrophy, debility and marasmus, both of which groups occupy high places in column (2) and low places in column (1); and (b) infectious diseases as a whole, measles, bronchitis and pneumonia and whooping cough, all of which have noticeably higher places in column (1) than in column (2). Unfortunately abdominal tuberculosis is not given separately in the Registrar-General's reports for County Boroughs of the North and Rural Districts of the South, so that this cause must be omitted from consideration.

If the chief causes of the decline in infant mortality had been those measures designed to lessen or remove the evils of insanitary and overcrowded surroundings, then we should expect that those diseases in which the proportional excess was greatest under these conditions would have declined to a greater extent; but as will be seen on reference to the table of regressions (Table I) numerous exceptions to this rule occur. In particular, bronchitis and pneumonia, infectious diseases generally, atrophy, debility and marasmus and overlying may be mentioned. Comparing now the observed decline in the death-rates with the position of the diseases occupied in column (2), Table VIII, we find a much more striking agreement. Here we have only two exceptions, namely, meningitis not of tubercular origin and syphilis. It is not pretended that the decline is in exact relation to the position occupied by the disease in column (2). Some of these cause groups of death will be observed to have declined on the average to the same extent, but the wide differences in the standard errors, which are a measure of the stability of the decline, show that the same significance cannot be attached to those in which the slope of the line is the same. Why meningitis should upset the relation we have no means of discovering, but the disease is not numerically an important cause of mortality, and is one of those cause groups which may be influenced by difficulties in diagnosis especially with infectious diseases in childhood. With syphilis, of course, we are on entirely different grounds. That the death-rate from this condition has not declined is not at all the fault of the mother. Even the most intelligent and careful woman will not be able to do anything towards curing herself or her child of the disease without the aid of efficient therapeutic remedies.

The previous discussion, however, suggests at least one method by which a rational classification of the causes of infant death may be made. The classes which the comparisons indicate are three, namely:

(1) *Capable of Direct Control*. Those conditions in which medical and surgical measures can effect a cure or sufficient amelioration to prolong the life of the individual and in which maternal care of itself is of no avail. In this group we would include infantile syphilis, injuries at birth, diphtheria,

and some causes of still-birth and premature birth, such as eclampsia and bleeding.

(2) *Capable of Indirect Control* (and chiefly by proper maternal care). Here we would include tuberculosis in all its forms in infancy but more especially the abdominal type, diarrhoea and enteritis, atrophy, debility and marasmus, overlying and probably convulsions.

(3) *Uncontrollable Causes*. Infectious diseases, such as whooping cough, scarlet fever, etc., malformations, meningitis and premature birth, probably also measles and bronchitis and pneumonia. The fairly high position in column (2) of premature birth might make it doubtful if this should be included; here it is probable that some of this excess in itself represents indirectly the greater prevalence of venereal infection among illegitimate babies, miscarriage and premature birth being common features in the obstetric history of a syphilitic mother.

Although objections may well be raised in some respects to this classification, it at least possesses some statistical basis, and, moreover, it must be recognised that it is difficult, if not impossible, to draw hard and fast lines between the groups. All that is suggested is that in controllable illness in infancy and childhood, there is to be considered the effect which a good mother may have in preventing the disease, and also that there are certain conditions in which, no matter how intelligent and careful the mother be, the end result can only be influenced by skilled medical treatment; and the classification given here simply suggests which, in my opinion, of these two factors is the more important in the several causes of death. It may be noted, however, that the classification states implicitly that the evil effects of domestic and municipal overcrowding and insanitation can, except in the case of infectious diseases, be overcome by intelligent and conscientious motherhood.

If such a classification be permissible and is anywhere near the truth, then within the last 15 years, group (2) is the only one which has shown any significant decline, whereas groups (1) and (3) have remained practically stationary.

Sir George Newman (1920), in reference to the health of the mother and child, remarks (p. 44): "Immense progress has been made in this subject within recent years. The Midwives Act of 1902, the School Medical Service organised in 1907, the Insurance Act Provisions for Maternity Benefit in 1911, and the Maternity and Child Welfare Act of 1918 are the mile-stones of a forward-looking nation. The results have been very remarkable. The decline in the death rate of infants from 150 per 1000 born in 1900 to 89 in 1918 must be attributed in large measure to the action taken. It is one of the two or three significant triumphs of preventive medicine in the present century." Further, he says: "It is a movement springing in a large degree from the people themselves, and resulting in a new social conscience in respect of the physical well-being of mothers and children."

The two statements are mutually contradictory unless they are related as cause and effect. There is no doubt about the amount of administrative

action that has been taken. The difficulty is to know if it has had any effect. It has been taken too much for granted, I think, that welfare work and the decline in infant mortality are causally-related phenomena. The decline which has taken place in the different causes of death among infants serves to show clearly that in diseases amenable to medical treatment alone (group 1 of the suggested classification) practically nothing has been accomplished, and that the causes which have declined are those in which the main factor responsible is probably the mother herself. It is, moreover, worthy of note that the decline which has taken place in the death-rates of infancy began *before* the introduction of deliberate national efforts at teaching or treating mothers, and that inspection of the death curve shows no acceleration in the rate of decline on the introduction of these measures. I am well aware of the fallacies inherent in this type of argument and that legislative enactment in many instances only represents the climax of a steadily increasing amount of private philanthropic work; but this point should be remembered and carry some weight in any discussion of the subject. Further, although more adequate maternal care bestowed on the infant may in all probability be the result of welfare work—the birth and growth of a new social conscience among present-day mothers—we must not overlook the fact that a similar result may follow on deliberate restriction of the size of the family to the desired number. The precise interpretation of the relation between the birth and infant mortality rates is not a simple one, but it does seem probable that limitation of the number of children born may in part be due to a praiseworthy attempt of the parents to provide the family with the best prospect of survival and success in life. If, however, the decline in the mortality of infancy can be justly attributed to deliberate attempts at preservation of infant life, it follows that the link between supervision and facilities for adequate treatment is missing, and that with more effective co-ordination we may hope for a still further amelioration.

REFERENCES.

- FAIRBAIRN, J. S. (1925). *Brit. Med. J.* 1, 295.
HUXLEY, J. S. (1924). *Med. Sci.* 10, 91.
NEWMAN, G. (1920). *Annual Report of the Chief Medical Officer of the Ministry of Health, 1919-20.*
— (1926). *Ibid.* 1925.
PARKES, A. S. (1924). *Sci. Progress*, 71, 426.
— (1924 a). *Proc. Royal Society, B*, 95, 551.
PEARL, R. (1920). *Trans. American Child Hyg. Assoc., St Louis.*

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