SOME STATISTICAL ASPECTS OF INFANT MORTALITY.

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Although within recent years the risk to infants has diminished considerably, the rate of mortality in the first year of life is still higher than that in any other period of life prior to that at which we can hope for little more reduction. That there is scope for further improvement in the mortality experienced in early life is unquestioned, therefore a brief review of the statistical data relating to England and Wales and a study of some of the factors of causal import may not be inappropriate.

Since the beginning of the present century infant mortality has shown a considerable decrease in all areas of the country. Previously the death rates at later ages had already been falling, but the fate of infants and young children had failed to follow a similar course. In 1901, a fairly abrupt change occurred, and since then infant mortality has steadily declined, the rate of decline having shown no tendency to decrease, apart from minor annual fluctuations, until the last few years.

If the death rate under one year be further subdivided, it is found that the mortality experienced in the first few days of extra-uterine existence is far greater than at any other period, and from that point rapidly declines, the death rate in the last three months of the first year of life being only about 3 per cent. of that experienced in the first week, when reckoned *per unit of time*. A closer inspection of the trend of mortality at various ages under one year shows that all ages have not shared in this amelioration to the same extent. Each age period has been affected in varying degrees. The data presented in Table I show that, as a general rule, the nearer to birth the less has the mortality rate been affected.

Table I. *The distribution in age periods of the infant mortality rates per* 1000 *births.*

	Under 1 month	1–3 months	0–3 months	3–6 months	6–12 months	Under 1 year
1901–1905	—	—	70	28	40	138
1906–1910	40	23	63	22	32	117
1911–1915	39	20	59	20	31	110
1916–1920	37	17	54	14	22	90
1921–1925	33	13	46	12	18	76

Under one month the rate of mortality between the quinquennia 1906–10 and 1921–5 declined 17½ per cent., at one to three months 43½ per cent., all under three months 36 per cent., three to six months 57 per cent., and six to

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twelve months 55 per cent. The time of the appearance of this general change, however, was approximately the same in each of the separate age groups under one year, the death rates having risen to a maximum in the quinquennium 1896–1900. As a consequence of this differential decline, the proportion of deaths which occur at those ages has changed significantly, the deaths at and shortly after birth now forming a more important contribution to the total death roll.

These differences in the behaviour of the death rates at various ages under one year suggest that at each of these ages the several factors in the causation of infant mortality differ in their importance at each of these age groups. This we already know from general medical knowledge to be probably true. In early infancy the effects of pre-natal influences will scarcely have worn off, but the more distant from birth the less important are such factors likely to become. The effects of variations in obstetrical assistance (using the term in its widest sense) are also likely to be most clearly reflected on the mortality at and immediately succeeding birth, whereas maternal and environmental influences would appear to become of more and more importance as infancy advances.

It seems fairly obvious, therefore, that the death rate of infants under one year cannot be taken as a compact group and satisfactorily investigated as such. In infant life, at least four broad stages, perfectly definite in character although overlapping one another in time to a greater or less degree, can be recognised. First of all is the foetal or parasitic stage, extending from the period of conception until immediately the infant is born. Secondly, and included in the first, are the several stages of labour itself. Thirdly, a period of adjustment to a new mode of life which consists of the first few days or weeks of independent extra-uterine existence, and lastly, there is the remainder of infant life. There can be no doubt that each of these periods represent entirely different phenomena, and the mortality at each of these stages seems to require special investigation.

From the statistical returns of the Registrar-General and the Annual Reports of the Chief Medical Officer of the Ministry of Health, it is fairly easy to obtain a subdivision of the mortality of infants into parts which at least approach the classification suggested. No account can be taken of the loss of possible lives in early foetal life (abortions, etc.), but the notifications of still-births published in appendices to the Annual Reports of the Chief Medical Officer of the Ministry of Health represent, as accurately as can be done at the present time, the deaths of foetuses at any period between the 28th week of intra-uterine life and full time. Although in some parts of the country notifications may be somewhat defective, since these are not yet compulsory, the figures given probably represent fairly accurately the distribution of still-births throughout the country. The death rate of infants born alive may be subdivided simply into two categories: (*a*) the death rate from "congenital debility, malformation and premature birth" (number 28 of the short list of

causes of death given for each separate district in the Annual Reports of the Registrar-General), and (*b*) the remainder of infant deaths under one year. Group (*a*) consists of deaths from accidents of birth, prematurity, atelectasis, hydrocephalus and other developmental defects. This, for convenience, will be referred to as the *neo-natal death rate*. The remainder of infant deaths are mainly the result of gastro-enteric, respiratory and infectious diseases. These will be referred to as the *post-natal death rate*. Although no separate account can be taken of the deaths during the processes of labour itself, it will be seen that this subdivision into three groups corresponds fairly well with the stages of life suggested. Besides representing to some extent a biological classification it also represents fairly well a temporal subdivision, since the greater part of the area of the death curve from neo-natal causes is contained in the first month of life, whereas the common infectious, respiratory and enteric diseases are not very prevalent at this time.

1. The Relationship between Infant Mortality and Environment, Maternal Health and the Medical Assistance at Childbirth.

Of the numerous possible factors which may affect infant life at each of these stages, in the present paper an attempt has been made to measure three of the presumably chief ones:

(1) The quality of the obstetrical assistance in childbed.
(2) The health of the mother.
(3) Social and environmental conditions.

As a rough measure of (1) the total maternal mortality rate in child-bearing has been taken; but, since a great part of this death rate is formed by the group of conditions under the term puerperal sepsis, and since this is not determined to any significant extent by the proximity to medical aid in child-bearing, the two subgroups of the mortality in childbearing, puerperal sepsis and the remainder, have, in addition, been considered separately. As an index of the general level of the health of mothers in any district, the death rate in women aged 15–45 from all causes less those connected with childbearing has been used as the most exact measure which is available in any statistical returns. For social and environmental indices, the proportion of female indoor domestic servants per 1000 of the total population, the proportion of the population living more than two in a room, and the number of rooms per person have been used as general measures of these factors. Still-birth returns are not available for urban and rural districts separately, so that these have only been investigated in the counties of England and Wales, and separately for county boroughs. The remaining two groups of infant deaths have been analysed in counties, county boroughs, urban and rural districts. The rates of mortality have been calculated on the births and deaths occurring in the triennium 1921–3.

(*a*) *Counties*. The results for counties will be considered first. In Table II are given the mean death rates, their standard deviations and coefficients of

variation. Calculated per 1000 births, the post-natal death rate of infants is highest, and, both absolutely and relative to its mean value, the most variable. The average ante-natal death rate is much lower than this, and is also less variable. The neo-natal death rate is lowest of all, not only in its mean value, but also in its dispersion throughout the country. This comparison of averages, however, obviously gives a wrong impression of the force of mortality at these periods. The still-birth rate is calculated on all deaths which occur in the three months before full time, as well as those occurring during labour but before

Table II. *Means, standard deviations and coefficients of variation of the three infant death rates.*

	Mean	Standard deviation	Coefficient of variation
Ante-natal mortality	31·08	6·65	21·41
Neo-natal mortality	30·54	3·50	11·45
Post-natal mortality	38·08	10·92	28·67

the child is born; the neo-natal death rate is (roughly) confined to the first month after birth, and the remainder of the infant death rate is spread over the remaining eleven months of the year; so that if these separate mortality rates be reckoned approximately as death rates per 1000 births *per annum*, the mortality experienced in the short period succeeding birth is 360 per 1000 births, the ante-natal mortality 124 per 1000, and 40 per 1000 per annum in the remainder of infant life. (These figures are only crude approximations to the truth, as they are based on the false assumptions that the frequency distributions of these deaths at the three periods of life are rectangular and do not overlap one another; but they are sufficient to demonstrate that the *force* of mortality, the death rate per unit of time, in the period immediately subsequent to birth is about three times as great as that in the three months preceding birth and about nine times as high as that which occurs later in the first year of life.)

The crude correlation coefficients between these three death rates and the factors being considered in relation to them are given in Table III.

Table III. *Coefficients of correlation between each of the infant death rates and certain influential factors.*

	1. Ante-natal mortality	2. Neo-natal mortality	3. Post-natal mortality
4. Death rate in females, 15–45	·391±·087	·624±·063	·817±·034
5. Maternal mortality rate	·508±·076	·429±·084	·492±·078
6. Puerperal sepsis death rate	−·055±·103	·133±·101	·488±·078
7. Maternal death rate less sepsis ...	·603±·065	·418±·085	·310±·093
8. Per cent. living more than two per room	−·004±·103	·440±·083	·653±·059
9. Domestic servants per 1000 population	−·224±·098	−·654±·059	−·724±·049

From these it will be noted that the health of mothers is most closely related to the post-natal death rate, less so with the neo-natal death rate and least of all with the still-birth rate. With each of the death rates, the correlations are certainly significant with regard to the probable errors involved.

The total mortality rate of women in childbearing, curiously enough, shows but little difference in its relationship with the three groups of infantile deaths, a result which, if the maternal mortality rates were an exact index of the state of obstetrical supervision, would immediately lead to the suspicion that an indirect association due to some other factor had produced the result. But if the mortality due to puerperal sepsis be excluded, the remainder of the death rates of women in childbearing becomes less associated with the death rates of infants as age advances. In all instances the coefficients are significant, but the relationship with still-births is highest and that with the post-natal death rate lowest. Comparing the coefficients with those for health of the mother, the coefficients involving maternal health are, with still-births, lower than for those with the index used for the availability of obstetrical assistance; but, in the neo-natal and post-natal death rates, maternal health shows higher correlations than does the death rate of women in childbearing.

With external environmental and social conditions there is no significant relationship with the ante-natal death rate, but fairly high and certainly significant relations with both the neo-natal and post-natal mortalities, the post-natal rate showing a slightly closer association with both indices of environment than does the neo-natal death rate.

All the variables we are studying in relation to the mortalities of infancy are, as will be gathered from the coefficients collected in Table IV, inter-related to some extent, environment and the general health of women fairly

Table IV. *Coefficients of correlation.*

Variables	Correlation
Female death rate, 15–45, and maternal mortality rate	·4202 ± ·085
Female death rate, 15–45, and puerperal sepsis death rate	·3717 ± ·089
Female death rate, 15–45, and maternal mortality less puerperal sepsis	·3045 ± ·093
Female death rate, 15–45, and female indoor domestic servants	−·7320 ± ·048
Female indoor domestic servants and maternal mortality rate	−·2264 ± ·098
Female indoor domestic servants and puerperal sepsis death rate	−·3701 ± ·089
Female indoor domestic servants and maternal mortality less puerperal sepsis	−·0857 ± ·102

closely, maternal mortality significantly with maternal health and only slightly with environment, whereas the real criterion of obstetrical facilities (*i.e.* deaths in childbearing less puerperal sepsis) is less correlated with maternal health than is the total maternal mortality rate, and not at all with environment. Accordingly it seems of interest and importance to ascertain the extent to which each of these factors is related to the infant death rates when due allowance has been made for any indirect association which may be introduced by the correlation among the variables themselves; *i.e.* to calculate the coefficients of partial correlation between each of the infant death rates and any

one of these factors for constant values of the remaining two. In deducing the partial correlations, the number of domestic servants per 1000 population has been taken as the measure of environment. The results are collected in Table V.

Table V. *Coefficient of partial correlation**.

$r_{14.59} = \cdot 195 \pm \cdot 099$	$r_{24.59} = \cdot 159 \pm \cdot 100$	$r_{34.59} = \cdot 524 \pm \cdot 075$
$r_{15.49} = \cdot 404 \pm \cdot 086$	$r_{25.49} = \cdot 309 \pm \cdot 093$	$r_{35.49} = \cdot 348 \pm \cdot 090$
$r_{19.45} = \cdot 050 \pm \cdot 103$	$r_{29.45} = -\cdot 417 \pm \cdot 085$	$r_{39.45} = -\cdot 378 \pm \cdot 088$

* The subscripts are:

1 = Ante-natal mortality.	4 = Death rate females, 15–45.
2 = Neo-natal mortality.	5 = Maternal mortality rate.
3 = Post-natal mortality.	9 = Domestic servants per 1000 population.

These coefficients suffice to show that, of those investigated here, *the* important factor in determining still-birth mortality is the quality of obstetrical aid in child-birth. Maternal health shows a slight but insignificant positive relationship, and environment none at all.

The neo-natal death rate shows about equal relationship with environment and the maternal mortality rates in childbearing; but the health of the mother is not significantly related to the mortality rate at this period of infant life.

The post-natal death rate is most closely connected with variations in the health of women and somewhat less so with both environment and the total maternal mortality rate in childbed. It will also be noted that the partial correlation between the post-natal death rate and the childbearing mortality rate for constant values of environment and maternal health is of the same order of magnitude as that found for both the neo-natal and the still-birth rate. That there should be such a high residual correlation with the mortality of women in childbearing and the infant death rate at this stage of life is certainly contrary to what would have been predicted. We should expect that the effects on the mortality of infants of the quality of the assistance afforded to women while pregnant should diminish as the age of the infant increases; but from the results it would appear that this is not so. There are two possibilities, however, which must be borne in mind in this connection. (1) In places where many women lose their lives in childbed, many more are rendered invalids for a time from the effects of causes which they managed to survive, but which killed others, and because of this many infants must be deprived of proper maternal care. (2) The total death rate of women in pregnancy and parturition *is being used here as a measure of the quality of the* assistance provided for the mother during pregnancy and in labour; but, as has already been pointed out, it is only a rough measure of this factor, and we must not overlook the fact that it may equally well serve as a measure of some other factor which is associated not only with deaths of women in childbed, but also with some causes of infant deaths. For instance, in the present case, it might be suggested that some infant deaths late in the first year of life may be dependent on the ease with which competent medical assistance can be obtained. Cases such as these can easily be adduced. Here, then, it is quite

possible that the correlation may simply demonstrate a relationship between deaths which are preventable by timely medical intervention. But, before considering either of these possibilities, it seems advisable to enquire if similar results would be produced by taking the mortality rates in childbed from causes other than puerperal sepsis as indicative of variations in the available obstetrical facilities. Consequently, the partial correlations have been recalculated, using this variable instead of the total maternal mortality rate, and these are given in Table VI.

Table VI. *Coefficients of partial correlation**.

$r_{14.79} = \cdot172 \pm \cdot099$	$r_{24.79} = \cdot135 \pm \cdot101$	$r_{34.79} = \cdot552 \pm \cdot071$
$r_{17.49} = \cdot546 \pm \cdot072$	$r_{27.49} = \cdot424 \pm \cdot084$	$r_{37.49} = \cdot194 \pm \cdot099$
$r_{19.47} = -\cdot021 \pm \cdot103$	$r_{29.47} = -\cdot468 \pm \cdot080$	$r_{39.47} = -\cdot356 \pm \cdot090$

* The subscripts are:

1 = Ante-natal mortality.
2 = Neo-natal mortality.
3 = Post-natal mortality.
4 = Death rate females, 15–45.
7 = Death rate from causes in childbearing less puerperal sepsis.
9 = Domestic servants per 1000 population.

From these it will be seen that the coefficients involving this portion of the maternal death rate are now higher in both the ante-natal and neo-natal mortalities, but with the post-natal mortality the correlation has now no statistical significance. It may be concluded, then, that the provision of assistance to pregnant and parturient women is in counties reflected on the still-birth rate and slightly less so on the neo-natal mortality rate, and that after approximately the first month of life, the effects of this factor cease to have any significant influence on the death rates of infants.

Among infants born alive, it is to be noted that environment plays a greater part early in life than does the health of the mother, which at this period of infancy is apparently of no great importance, whereas after the neo-natal stage of life has been passed, the health of the mother would appear to take slight precedence over external environmental influences.

Finally, it remains to be determined what is the sum total effect of these three variables on the death rates at each of these three periods of infant life. Adopting Yule's (1922) notation, the multiple correlation coefficients between each of the infant death rates and these three factors have been calculated and are given in Table VII. The coefficient is smallest for the still-birth rate,

Table VII. *Coefficients of multiple correlation.*

$R_{1.459} = \cdot403 \pm \cdot086$
$R_{2.459} = \cdot556 \pm \cdot071$
$R_{3.459} = \cdot698 \pm \cdot053$

slightly higher for the neo-natal death rate and greatest for the post-natal death rate. A similar result is obtained if, instead of using the total maternal mortality rate, we use the death rates from all childbed causes less puerperal sepsis. These are given in Table VIII.

Table VIII. *Coefficients of multiple correlation.*

$R_{1.479} = \cdot483 \pm \cdot079$
$R_{2.479} = \cdot585 \pm \cdot068$
$R_{3.479} = \cdot681 \pm \cdot055$

An insignificant increase results in the total coefficients for the still-birth and neo-natal mortality, and an equally insignificant decrease with the post-natal death rate.

Assuming that variations in each of these three variables are capable of being to a great extent eliminated, in the case of environment by suitable administrative measures and in the remaining two, the health of the mother and the quality of assistance provided for the mother at the birth of the child, by organised medical efforts of control, these results show that least of all can be hoped for by improvement of these factors in the case of still-births, somewhat more with neo-natal deaths and most of all with the post-natal death rate. Although this is by no means a complete catalogue of all the conditions influencing infant life, and although the variables used here are, at their best, but imperfect measures of the factors we wish to investigate, these results fully demonstrate that there is still a problem to be solved. By eliminating fluctuations in all of these three important factors, the variations in the mortalities of infancy can only be reduced in the case of still-births by 12 per cent., neo-natal deaths 19 per cent. and post-natal deaths 27 per cent. Even if this could, therefore, be effected there would still remain appreciable differences, presumably determined by measurable causes, in the rates of mortality in different parts of the country.

(*b*) *County boroughs.* Since data similar in all respects to those already examined for counties are available for the separate county boroughs of England and Wales, the whole series of constants has been recalculated for these districts in 1921–3 for purposes of comparison.

Table IX. *Means, standard deviations and coefficients of variation of the three infant death rates in county boroughs.*

	Mean	Standard deviation	Coefficient of variation
Ante-natal mortality	35·18	9·75	27·70
Neo-natal mortality	33·27	5·53	16·62
Post-natal mortality	49·52	13·19	26·63

The mean death rates at each of the three periods of infant life and the variability in the distributions throughout the country are given in Table IX. Comparing these figures with those for counties, it will be noted that all the death rates are higher in large towns than in the country generally, but that the difference is greatest in the case of the post-natal death rate. In county boroughs the death rate at this period is 30 per cent. higher than in counties, whereas the still-birth rate is only 13 per cent. and the neo-natal mortality only 9 per cent. higher than in counties. Evidently, then, the conditions in urban communities prejudicial to infant life are reflected most clearly on the post-natal death rate, less so on the ante-natal, and least of all on the neo-natal death rate. With regard to variability in the rates of mortality, in county boroughs the coefficients of variation of the ante-natal and post-natal death rates are equal in magnitude, whereas in counties the post-natal death

rate showed a slightly greater dispersion than the still-birth rate. The neo-natal death rate, both absolutely and relative to its mean value, in county boroughs is only slightly more variable than in counties.

The crude coefficients of correlation between the three divisions of the infant death rate and the variables already referred to are given in Table X.

Table X. *Coefficients of correlations between each of the infant death rates and certain influential factors in county boroughs.*

	Ante-natal mortality	Neo-natal mortality	Post-natal mortality
Death rate in females, 15–45	·241 ± ·070	·418 ± ·061	·707 ± ·037
Maternal mortality rate	·383 ± ·064	·339 ± ·066	·183 ± ·072
Puerperal sepsis death rate	·280 ± ·069	·189 ± ·072	·153 ± ·073
Maternal death rate less sepsis ...	·319 ± ·067	·244 ± ·070	·109 ± ·074
Rooms per person	−·114 ± ·074	−·612 ± ·047	−·971 ± ·003
Domestic servants per 1000 population	−·171 ± ·072	−·437 ± ·060	−·658 ± ·042

These results compare very well with those already found for counties, and, although in most instances the coefficients seem smaller, none of the observed differences is of any statistical significance.

The coefficients of partial correlation are given in Table XI. Here again in all essential respects this series of coefficients agrees with the previous series.

Table XI. *Coefficients of partial correlations in county boroughs*.*

$r_{14.59} = \cdot 136 \pm \cdot 073$	$r_{24.59} = \cdot 173 \pm \cdot 072$	$r_{34.59} = \cdot 491 \pm \cdot 057$
$r_{15.49} = \cdot 359 \pm \cdot 065$	$r_{25.49} = \cdot 312 \pm \cdot 067$	$r_{35.49} = \cdot 106 \pm \cdot 074$
$r_{19.45} = -\cdot 030 \pm \cdot 074$	$r_{29.45} = -\cdot 261 \pm \cdot 069$	$r_{39.45} = -\cdot 393 \pm \cdot 063$

* The subscripts have the same meaning as the counties.

The total correlations (Table XII) are also of the same order of magnitude and show the same differences in the three sections of the infant death rate

Table XII. *Coefficients of multiple correlation in county boroughs.*

$R_{1.459} = \cdot 308 \pm \cdot 067$
$R_{2.459} = \cdot 405 \pm \cdot 062$
$R_{3.459} = \cdot 594 \pm \cdot 048$

as those already given for counties. Consequently, it would appear that all of these findings give support to the conclusions previously reached.

(*c*) *Urban and rural districts.* In urban and rural districts, returns of still-births are not available, but the statistical constants have been calculated for the neo-natal and post-natal death rates. As will be seen from Table XIII,

Table XIII. *Means, standard deviations and coefficients of variation of the infant death rates in urban and rural districts.*

	Urban districts		Rural districts	
	Neo-natal mortality	Post-natal mortality	Neo-natal mortality	Post-natal mortality
Mean	30·81	38·08	29·33	31·67
Standard deviation ...	4·27	10·18	4·02	9·42
Coefficient of variation	13·84	26·75	13·71	29·74

the rates of mortality in both periods of infant life are higher in urban than in rural districts, but that each of the death rates of these two aggregates of districts is lower than in county boroughs. Here again, however, it will be seen that the post-natal death rate varies more from town to country than does the neo-natal death rate. Comparing county boroughs and rural districts, the neo-natal rate is 13 per cent. higher, but the post-natal death rate in county boroughs is 56 per cent. higher than in rural districts. Similarly the aggregate of urban districts shows a neo-natal death rate 5 per cent. and a post-natal rate 20 per cent. higher than in rural districts. The coefficients of variation of the neo-natal mortality rates tend to be slightly greater in towns than in rural districts, whereas the variability in the post-natal death rate tends to diminish in passing from rural districts to large towns.

The coefficients of correlation are given in Table XIV. From these it appears that there are no great differences from the results already found.

Table XIV. *Coefficients of correlations between the infant death rates and certain influential factors in urban and rural districts.*

	Urban districts		Rural districts	
	Neo-natal mortality	Post-natal mortality	Neo-natal mortality	Post-natal mortality
Death rate in females, 15–45	·566 ± ·070	·772 ± ·042	·423 ± ·084	·587 ± ·067
Maternal mortality rate ...	·308 ± ·093	·341 ± ·091	·383 ± ·088	·528 ± ·074
Puerperal sepsis death rate	·043 ± ·103	·151 ± ·100	·180 ± ·100	·372 ± ·089
Maternal death rate less sepsis	·440 ± ·083	·377 ± ·088	·381 ± ·088	·436 ± ·083
Rooms per person	−·529 ± ·074	−·775 ± ·042	−·516 ± ·075	−·745 ± ·046
Domestic servants per 1000 population	−·576 ± ·069	−·648 ± ·060	−·497 ± ·077	−·629 ± ·062

The coefficients of partial correlation, however (Table XV), do show some distinct differences. Consider first the neo-natal death rates. In both urban and rural districts there is a positive and significant correlation with the index of environment, and these are of the same order of magnitude as already found

Table XV. *Coefficients of partial correlation.*

(*a*) *Urban districts.*

$r_{24.59} =$ ·229 ± ·097	$r_{34.59} =$ ·552 ± ·071
$r_{25.49} =$ ·142 ± ·101	$r_{35.49} =$ ·084 ± ·102
$r_{29.45} =$ −·323 ± ·092	$r_{39.45} =$ −·260 ± ·096

(*b*) *Rural districts.*

$r_{24.59} =$ ·077 ± ·102	$r_{34.59} =$ ·198 ± ·099
$r_{25.49} =$ ·273 ± ·095	$r_{35.49} =$ ·437 ± ·083
$r_{29.45} =$ −·341 ± ·091	$r_{39.45} =$ −·454 ± ·082

both for counties and county boroughs. Also in both aggregates of districts the health of the mother shows no significant relationship with the death rate at this period of life. With the total maternal mortality rate, however, the coefficient for rural districts is barely significant, and that for urban districts, although positive, is, with regard to its probable error, quite insignificant. These results, therefore, contrast with the previous findings. With the post-natal death rates, differences are also noticeable. In urban districts all the

coefficients agree with what has already been found. The index of maternal health shows the highest correlation, environment a smaller but apparently significant correlation, and the mortality rate of women in childbed no relationship. In rural districts, on the other hand, environment would seem to play a larger part than the health of the mother, which shows a positive but statistically insignificant correlation, whereas a definitely significant positive correlation is found with the maternal mortality rate in childbearing. A result similar to this was found for counties, but when, instead of the total maternal mortality, the death rate from causes in childbed other than puerperal sepsis was taken as the index of medical care of women in pregnancy and at childbirth, the final correlation became insignificant. Consequently, all the partial correlations have been recalculated in county boroughs and in urban and rural districts. These are given in Table XVI.

Table XVI. *Coefficients of partial correlation.*

	County boroughs	Urban districts	Rural districts
$r_{24.79}$	·191 ± ·072	·180 ± ·100	·083 ± ·102
$r_{27.49}$	·221 ± ·071	·378 ± ·088	·285 ± ·095
$r_{29.47}$	− ·252 ± ·070	− ·366 ± ·089	− ·342 ± ·091
$r_{34.79}$	·498 ± ·056	·540 ± ·073	·236 ± ·097
$r_{37.49}$	·036 ± ·074	·241 ± ·097	·324 ± ·092
$r_{39.47}$	− ·391 ± ·063	− ·282 ± ·095	− ·436 ± ·083

In county boroughs, it will be seen that no difference is made in any of the coefficients by substituting this second index of medical care. In urban districts, the neo-natal death rate now shows a significant positive correlation with this index, and the remaining two factors, environment and health of the mother, show no significant changes in their relationships. With the post-natal death rate, the correlation with this second index of the quality of obstetrical supervision is greater than that found by using the total maternal mortality rate, although it still does not reach the customary standard of significance. In rural districts the correlations involving the neo-natal death rate do not differ substantially from the results already found; but those involving the post-natal death rate show some slight change. The correlation with the measure of maternal health has been raised, but not to any significant degree; that with environment remains unchanged; but the association with the death rate of females from childbed causes other than sepsis, although somewhat lower than that which was found with the total maternal mortality rate, is still quite significant with regard to its probable error. Comparing the correlations with this factor in the three aggregates of districts, there seems to be a definite tendency for its value to increase as we pass from highly urbanised communities to scattered rural districts. A series of results such as this would, therefore, lead to the suspicion that this index of the medical supervision of pregnant and parturient women was also indicative of some other factor influential in infant life. It has been suggested previously that, as this death rate is dependent on the proximity to medical care, a relationship such as this might arise where, in any group of districts, a part of the death rates depended

on the rapidity with which competent medical skill could be summoned. The trend of this series of coefficients seems to be sufficiently definite to justify the assumption that some such explanation may suffice. If it be true, then it leads to the conclusion that in rural communities there is some portion of the post-natal death rate of infancy, due presumably to acute conditions, which could be prevented by the timely arrival of medical assistance, and that deaths such as these form an insignificant part of the death rates in urban communities.

The coefficients of multiple correlation for the two death rates, neo-natal and post-natal, in urban and rural districts are given in Table XVII. These

Table XVII. *Coefficients of multiple correlation.*

	Urban	Rural
$R_{2.459}$	·632 ± ·062	·568 ± ·070
$R_{3.459}$	·790 ± ·039	·749 ± ·045

agree very well both with one another and with those already found in counties and county boroughs, the coefficients being in both instances higher for the post-natal than for the neo-natal mortality rates.

These results for widely different parts of the country are so generally consistent one with another, both with regard to sign and magnitude, that the inferences to be drawn from them may be stated with a reasonable degree of assurance.

(1) *Ante-natal deaths.* The ante-natal death rate is definitely associated with the rates of mortality of mothers from causes of death peculiar to child-bearing. A reservation must, however, be made in that the main single cause of maternal death, puerperal sepsis, has no significant relationship with the death rate at this period of infant life. The size of the correlation between the two rates of mortality, however, is not of the order of magnitude which would lead to the belief that this was the *only* factor of importance in determining the height of the still-birth rate. Although the results seem to justify the hope that the increased attention to mothers during pregnancy and labour will be the means of reducing some causes of death of infants in ante-natal life, the actual saving of infant life at this stage will, in proportion to the total, not be very great. Further, so far as our data can be trusted, the health of the mother and differences in environment or social status do not, when allowance has been made for variations in the childbearing mortality rates, appear to have any influence on the still-birth rate. Although there is a significant correlation with maternal health, the partial correlation coefficients show that this is a secondary association due to the fact that both the ante-natal death rate and the general mortality of women of reproductive ages are related to the mortality rates of mothers in childbearing. These results are in accord with the findings of Bruce Murray (1924). The comparison of the weights and lengths of the offspring of primiparous women in the pre-war, war and post-war periods made by this author shows that the health and nutrition of the mother during pregnancy has no effect on the state of the nutrition of the infant at birth, and that "the foetus lives, like a true parasite, regardless of

the expense to the mother." It seems not unreasonable to conclude, then, that external factors acting on the mother do not affect the infant's chance of survival prior to birth. The coefficients of multiple correlation show that the sum total effect of these three factors on the ante-natal death rate is not very large, and leads to the conclusion that a large part of this death rate would still remain, even if it were possible to remove the conditions which these indices measure, and which are prejudicial to the survival of the foetus.

(2) *Neo-natal deaths.* The neo-natal death rate is also significantly associated with the death rates of mothers in childbearing, so that it seems justifiable to infer that some part of this early mortality is within the scope of an energetic obstetrical service. Further, our results show that at this stage of life, changes in environment seem to be factors of importance in determining the height of the mortality rate. This finding would appear to be contrary to accepted opinion. Brend (1917), comparing the average death rates from neo-natal causes in various groups of social class, concludes that "the great bulk of these deaths are due to some obscure internal derangement of normal processes in the mother or infant which are either independent of external environment or are due to some factor or factors in the external environment equally common among all classes under all circumstances." The figures quoted by Brend do, however, show a rise in the neo-natal mortality rates with descent in the social scale although the differences are not very great. But, as the present analysis shows, the variations exhibited in the mortality at this period of life are not nearly so wide as those shown by the post-natal death rate. Consequently, provided the correlations with social status were equal, a simple comparison of the mean values in different groups of social classes will not show such striking differences with the neo-natal as with the post-natal mortality rates. Our results show that, in spite of the low variability in the neo-natal mortality, these smaller variations are almost as intimately connected with changes in the external environment as are the wider variations in the post-natal death rates. The only difference between the two is that for equal changes in environment the neo-natal death rate will not show a reaction as extensive as will the post-natal death rate. That is, although the correlations are almost equal, the coefficient of regression on environment of the neo-natal rate is lower than that of the post-natal rate. That a relation such as this should exist so early in infancy is by no means absurd. Even if it be true that at birth infants of all social classes are equally likely to survive if they could be placed under similar circumstances after birth, it must be remembered that the infant has suffered a sudden and complete change in its mode of existence. *In utero*, all the functions characteristic of extra-uterine life had been performed for it by the mother. Its food is pre-digested and conveyed to the foetus in a form immediately available for assimilation, and aeration of its blood and the excretory processes are also carried out by the placental circulation and not by the foetal organs themselves. But examination of the amniotic fluid has revealed traces of foetal urinary constituents, and in obstructed delivery

meconium may be passed from the foetal bowel, so that in all probability, at term, foetal development has reached a stage when the organs are capable of performing the functions required of them in after-life. A comparison of the extra and intra-uterine environments, however, shows that immediately after birth a sudden difference occurs. *In utero*, the foetus lies bathed in a fluid of almost uniform (body) temperature, whereas at birth it is expelled into a much colder atmosphere. And it is obvious that the heat-regulating mechanism can have had no previous trial of its efficiency, as seems to be possible with the heart, kidneys, and bowel. Thus it does not seem unreasonable to suppose that one of the important factors at this stage of life is the adequate conservation of the body heat of the new-born child. In this connection some results recorded by Louise McIlroy (1925) are of extreme interest and importance in demonstrating the sensitiveness of the new-born to changes in environment. A series of babies at birth were cleaned with olive oil instead of by bathing, and it was found that these lost less weight after birth than did the infants who were bathed in the ordinary manner. Even better results were found when, in addition to being oiled, the infant was transferred to a cot with warm blankets and hot water bottles. These results show that the loss of heat is an important consideration to the infant at birth. Thus it does not seem improbable that, as our results show, differences in the environment into which an infant is born may be of no small importance. The health and nutrition of the mother do not seem to be factors of such great moment in determining the fate of the infant in this early stage of life. The coefficients of multiple correlation show that, together, these three factors can only account for 19 per cent. of the variability in the neo-natal rates of mortality. Here again we must recognise the existence of other factors than these determining the chance of survival.

(3) *Post-natal deaths.* The causes of death in post-natal life seem to be those which are most amenable to control by administrative measures or organised medical effort. At this stage, the health of the mother takes precedence over environment, whereas the effects of the obstetrical aid afforded to the mothers in childbearing have by this time worn off. It has also been suggested, from a comparison of the results found for large cities and scattered rural communities, that in the latter there is a portion of the post-natal death rate, and this most probably due to urgent conditions, which could be removed if medical assistance were more readily available.

2. THE CAUSES OF STILL-BIRTH.

In the official reports of this country there is no record of the causes of death among still-born infants. Table XVIII has, however, been prepared from the admirable statistical returns of the Netherlands to show the causes of ante-natal deaths in that country. The figures are given separately for males and females, and the rates of mortality per 1000 births and the percentage frequency of each of the causes of death are given together. The births and

deaths on which these rates and frequencies are based relate to the twelve years 1911–22.

Table XVIII. *Showing the proportional frequency of, and the mortality rate per* 10,000 *live-births from several causes of still-birth in the Netherlands*, 1911–22.

	Mortality		Frequency	
	Male	Female	Male	Female
Syphilis	0·58	0·64	1·44	1·81
Other general diseases of the mother	0·83	0·79	2·05	2·21
Habit abortion	0·36	0·36	0·89	1·01
Albuminuria	1·42	1·46	3·52	4·08
Traumatism and prolonged labour	0·28	0·25	0·70	0·69
Placenta praevia	2·84	2·50	7·02	7·01
Foetal deformities	2·48	2·95	6·14	8·27
Premature birth	7·11	6·04	17·59	16·93
Difficult labour	4·76	3·32	11·77	9·31
Torsion and compression of the umbilical cord	2·80	2·04	6·92	5·71
Foetal asphyxia	2·30	1·93	5·69	5·41
Unclassified causes	1·74	1·52	4·31	4·26
Unknown causes...	12·91	11·90	31·95	33·33
All causes	40·41	35·70	100·00	100·00

A grave objection which is most obvious in these figures is the large proportion of foetal deaths in which the death is registered from an unknown cause. The defect is one which prevents accurate comparison with any figures collected from a more accurate source, such as a hospital, in which the investigator in all probability will combine clinical examination of the pregnant woman with subsequent *post mortem* examination of the dead-born foetus. The proportion of deaths from unknown causes in this series is probably the result of the two factors: (1) that many of the women have not been seen by either a doctor or midwife before the infant was born, and (2) that *post mortem* examinations are seldom, if ever, carried out in general practice. If the defect in these figures were solely due to the fact that in all these cases the mother had not been attended until after the child was born, by distributing these deaths from unknown causes to each of the known cause groups according to the proportional frequency of each of these, a fair degree of comparability between these figures and more accurate statistics might be obtained. But since this is not the sole cause of such a proportion of unknown deaths, this procedure must obviously be wholly inaccurate, since it would amount to the assumption that all causes of foetal death were equally easy to diagnose—an extremely improbable assumption. On the other hand, these figures are of some value as a general guide to the most important causes of foetal death in a random sample of the total population. More accurate investigations, due to the selected nature of the material, normally afford a biassed view of the relative importance of certain causes of death. The type of selection will depend on the source of the data. Hospital statistics would be weighted in favour of foetal deaths from causes which at the same time endanger the life of the mother. Consequently these causes which endanger the lives of both mother and foetus *in utero* will be over-represented as causes of foetal death

as compared with the frequency pertaining to the general population; whereas foetal deaths due to conditions proper to the foetus, which cause neither disease in the mother, nor difficulties in delivery from disproportion between the presenting part and the maternal pelvis, will be under-represented. That this is the case can be shown by a comparison of the proportion of foetal deaths from a complication such as torsion of or pressure on the umbilical cord. This condition will of itself cause no difficulty to the mother, and consequently should be under-represented in a hospital population of still-births. In a recent report by Holland and Lane-Claypon (1926), in 41 out of 1673 dead-born infants, the death was due primarily to this complication. In the figures quoted here for the Netherlands, 5219 of the total 81,773 still-births were due to the same cause. In the former case the proportion, therefore, is 2·45 per cent., in the latter 6·38 per cent., that is more than double the proportion from this cause are found in the general population as compared with a selected hospital population. The group comprising foetal deformities does not offer the same grounds for comparison, because, although many of these are due to hydrocephalus and the obstruction resulting from the excessive size of the head in many instances causes interference with labour, other deformities, such as congenital cardiac malformations, will cause no obstruction to delivery; so that congenital malformations will only be included under causes of foetal death which also endanger the life of the mother provided that an excessive proportion of deformities are those causing obstruction to delivery. Actually in the Netherlands statistics, the proportion due to foetal deformities is 7·08 per cent., whereas in the report by Holland and Lane-Claypon 8·25 per cent. of the total still-births were from this cause.

Table XIX has been quoted from these authors to show the differences between the Dutch figures and those collected in their extensive special enquiry. (The figures for Holland relate to the years 1901–22.) The enormous

Table XIX. *Percentage frequency distribution of causes of dead-births.*

Cause of death	Dutch	Holland and Lane-Claypon
Diseases of father or mother:		
Syphilis	2·7	9·5
Other general diseases	4·3	2·7
Habitual abortion	1·4	—
Albuminuria	7·7	12·1
Precipitate labour	1·2	—
Placenta praevia	12·3	22·1
Deformities, including hydrocephalus	10·4	11·5
Premature labour not due to disease of father or mother	22·5	3·9
Pelvic deformities and malpresentations	15·3	33·0
Pressure or torsion of cord	11·2	3·4
Asphyxia at birth	7·4	0·7
Other causes	3·7	1·1

excess in the hospital series of such causes as placenta praevia, pelvic malformations and malpresentations, which are conditions obviously endangering *both* mother and child, the corresponding defect of such conditions as pressure and torsion of the cord, premature labour and asphyxia at birth, which, as

a rule, only endanger the child, support the suggestion that the data are not really *in pari materia*. We should expect such a difference of classification if the hospital data really included an over-average proportion of labours in which the mother's life was jeopardised, and need not attribute the whole of it to more accurate diagnosis. If we are to try to measure the advantage to be gained by the foetus by careful supervision of the parturient during pregnancy and at labour, it is surely better to err on the side of under rather than over-statement. Hence it is better to estimate the proportion of avoidable causes of foetal mortality on the basis of general population statistics, faulty, no doubt, but not open to the suspicion—as institutional records clearly are—that the relative frequency of factors endangering both mother and child is over-stated.

The total still-birth rate in Holland for the twelve years 1911–22 (irrespective of sex) is 3·90 per 1000 live-births compared with a rate of 3·11 per 1000 live-births for England and Wales (1921–3). In view of the small difference in the ante-natal loss of life in the two countries and in spite of the fact that there may be some international differences in the frequency of the several causes of death, probably something of value is to be gained from these figures and possibly the amelioration likely to be effected by intensive prophylactic efforts on the part of our national obstetrical services will be more conservatively judged from these than from the records of lying-in institutions. Table XVIII shows that the ante-natal mortality of males is 13 per cent. greater than that of females. For individual cause groups, the greatest proportional excess in the male death rate is in the group "difficult labour," and this is followed closely by the death rate from pressure on or torsion of the umbilical cord. The former group shows a death rate 43 per cent. higher in males than in females, the latter 37 per cent. excess in males. These figures might be taken as evidence in support of the view that the greater size of the male head is a cause of some greater difficulty in labour than there is with a female birth. The other group of causes of death in which such a factor might be revealed is the relatively unimportant cause, "traumatism and prolonged labour," in which, however, the male death rate is only 12 per cent. in excess of the female. The sole cause of death in which females have a fairly large excess death rate is from foetal deformities, in which the male death rate is 16 per cent. lower than the female. The doubtful figures for deaths from syphilis give a rate 9 per cent. lower in males than in females; but, as in this country, probably little reliance can be placed on these figures.

With regard to the relative importance of the causes of death, leaving out of consideration the deaths from unknown causes, premature birth claims the greatest number of the deaths both in males and females. Difficult labour is the second largest cause of death, and is followed closely by placenta praevia, and foetal deformities. Torsion and compression of the cord accounts for 6·4 per cent. of deaths, and albuminuria for only 2·1 per cent. It will be seen then that many of the causes of foetal death are also important causes of

maternal death, and gives reason for the belief that the further extension of care to pregnant women will result in benefit for both the mother and child. But if, as seems probable, the majority of the group of unknown causes is not associated with maternal distress (if so they would have been included under difficult labour or some similar category), and noting the large proportion of deaths from premature birth and foetal deformities, the latter being entirely, the former in great measure, without human control, it would appear that even with the best obstetrical services in the world, a high ante-natal loss of life will always remain. Hospital statistics in this connection are apt to produce a too optimistic outlook, since, as has been shown, these contain an undue proportion of foetal deaths from causes in which obstetrical supervision would benefit both mother and child. This results from the selected population studied. But the figures given here afford reason for some scepticism as to the advantages to the foetus of increasing attention to the mother.

3. VISCERAL VARIABILITY IN FOETAL AND INFANT LIFE.

In most statistical investigations of the mortalities in infancy probably more consideration is given to the effects of external factors acting on the infant than to the changes which take place in the infant itself as growth proceeds. Brownlee (1917), from a study of the mortality rates from various causes at specified ages in infancy and childhood, has shown that these obey certain definite laws, and his results serve to emphasise the importance of further exploration of the changes in the physiological processes of the developing child.

The biometric constants relating to man have in the past been practically always confined to the adult period of life. Visceral and skeletal measurements and interrelationships at this period are fairly well known; but until recent years little interest seems to have been taken in the foetal and early infant stages of life. Signs are not wanting, however, that the defect is being appreciated. Holland (1922), in a part of his investigation into the causes of foetal death, published data with regard to the weights of five viscera, in addition to body weight and length and placental weight in a series of dead-born infants collected from several lying-in hospitals. The total series of 300 foetuses is divided into three sets: (1) foetuses examined in the fresh state, (2) those born in a macerated condition, and (3) a small group of syphilitic foetuses. Since the autolytic processes associated with maceration affect the organ weights to varying degrees, depending for the most part on the enzyme content of the organ, and since such data can throw no light on the anatomical differences in health and disease, the short series of foetuses born and examined in the fresh state is only considered here.

(1) *Visceral variability in foetal life.* A difficulty which confronts any investigation of this kind is that analysis can only be carried out on the statistics of dead infants, and it is essential that the statistical constants be compared with some control series. Since we obviously cannot know what is

the degree of variation in the viscera of living healthy foetuses and infants, an attempt must be made to obtain the closest approximation to this. From the already short series of 142 fresh foetuses, 71 of these, in which the cause of death was prolonged labour, instrumental delivery or torsion of or pressure on the cord, have been extracted as a presumably normal series. This selection is, of course, open to the objection that most of these causes of death are probably associated with some pelvic deformity of the mother causing dystocia, so that the selection may be one of a series of foetuses from mothers whose general health is below the average. But it is the nearest approach to normality which can be extracted from the data, and, if our previous results can be trusted, the health of the mother does not appear to be of any significant importance in the life of the infant at this stage.

The analysis of these data will be confined to a discussion of (*a*) the relative variabilities in the foetal organs of the "normal" and total series, (*b*) a comparison of foetal with adult visceral variability, and (*c*) the differences in the variation of the sexes.

(*a*) Table XX contains the coefficients of variation in the two series of foetuses. In the normal series the thymus is the most variable organ and the kidney the least variable. Body weight and body length show less variation than does any of the viscera. In the total series, the spleen takes precedence

Table XX. *Showing the coefficients of variations for certain body characteristics of the foetus.*

	(*a*) "Normal" series	(*b*) Total series
Body weight	25·56	31·31
Body length	9·05	10·67
Thymus ...	43·79	47·32
Liver ...	33·59	37·62
Spleen ...	35·43	56·48
Suprarenals	33·65	41·47
Kidneys ...	30·24	34·79

over the thymus in variability, but the other organ weights show no change in their position relative one to another. Comparing the two series, it will be seen that, in every instance, the variation is greater in the total than in the normal series. The excess is more marked with body weight than with body length. Among the viscera, the spleen would appear to be the organ which suffers the greatest change in disease at this period of life. The suprarenal glands are also greatly affected, and the liver, kidneys, and thymus show the smallest changes. There is, however, an obvious objection to the above comparison. Our normal series consists of foetuses which have survived until full time and consequently are all of approximately the same age, whereas the total series consists of foetuses who have reached a stage of viability but whose ages differ more widely (although not to a very great degree). So that we have been comparing two groups of foetuses in one of which differences in age are so relatively small as to be negligible, whereas in the other, differences in age may be of great importance, since in the few months preceding full time, the

foetus is growing very rapidly. I have therefore proceeded a stage further and calculated in both series the coefficients of variation for constant body weight and length. This will remove as far as possible the limitations of the previous comparison. The new coefficients are collected in Table XXI. Except in kidney

Table XXI. *Showing the visceral coefficients of variations for constant body weight and length.*

	(*a*) "Normal" series	(*b*) Total series
Thymus ...	35·46	40·39
Liver ...	19·61	20·16
Spleen ...	28·72	52·88
Suprarenals	29·41	33·62
Kidneys ...	26·80	26·78

weights, the normal series still shows a less degree of variability than does the total series. It will also be seen that the liver is not affected to any significant extent in passing from a normal to a diseased population of foetuses. Further, the spleen still shows the greatest reaction in disease. The two ductless glands, thymus and suprarenals, are affected approximately to the same degree.

(*b*) The variability in the viscera of foetuses may now be compared with the following table (Table XXII) from Pearl (1905) showing the coefficients of variation in the adult "healthy" and "hospital" populations. In all the

Table XXII. *Showing the coefficients of variation in "healthy" and "hospital" populations (adults).*

	(*a*) Healthy	(*b*) Hospital
Liver ...	14·80	21·12
Spleen ...	38·21	50·58
Kidneys ...	16·80	24·63
Body weight	10·37	—
Body length	3·99	—
Heart ...	17·71	32·39

comparable data it will be noted that the foetal organs show a much wider range relatively than do all the organs of healthy adults, except the spleen. From this table also we see that, in comparing a healthy and a diseased population, the differences in variability produced by disease in adult life are much greater than are those found in the two foetal series given here. Since chronic diseases affect the organs to a greater extent than acutely fatal illnesses, we must conclude either that diseases affecting the foetus *in utero* are rapidly fatal conditions which allow but little time for the production of gross changes in the organs, or that the foetus is already in such an unstable condition physically that any untoward circumstance of however slight a character rapidly upsets the normal processes.

The results of the above comparison, therefore, lead to the conclusions that the foetal viscera are extremely variable both in health and disease; that disease affects the foetal organs to a less extent than does disease in adult life, and that to judge by analogy, foetal death from disease occurs very rapidly.

(*c*) The coefficients of variation for the sexes are given in Table XXIII. These show that the male foetus in every instance exceeds the female in

variability and, although here again the differences are small, the uniformity in the series is sufficiently striking to warrant the conclusion that the male at this stage of life is really the more variable. Pearson (1897) has shown that in adult life the female is slightly more variable than the male, and this he attributes to a relatively less intense struggle for existence. This explanation is obviously insufficient to account for differences in variability in intra-uterine life where any struggle for existence must be shared equally by the two sexes. The extremely high variability of both sexes in foetal life, however,

Table XXIII. *Showing the coefficients of variation for the sexes in the total series of foetuses.*

	Male	Female
Body weight	34·73	24·38
Body length	11·50	8·99
Thymus ...	53·07	41·06
Liver ...	38·43	31·93
Spleen ...	63·42	34·89
Suprarenals	40·54	40·35
Kidneys ...	35·38	33·75

can probably be explained on this assumption. Before birth, the foetus is a parasite, not depending on its own organs for carrying out the functions required of them in post-natal life, so that the organism has little need of them at this early stage, and it would appear "that each organ has a life and growth of its own, irrespective of the needs of the organism as a whole." The lack of any struggle for existence, therefore, would appear to be reflected on the physical characters of the foetal viscera.

(2) *Visceral variability in infancy.* From data collected by Prof. Turnbull in the Pathological Department of the London Hospital, and to which Prof. Greenwood has kindly allowed me access, a series of coefficients of variation have been calculated for certain organ weights and for body weight and length in the first year of life to show the changes that occur during this period. The data available are insufficient to extract from them a "healthy" series at each of the ages under one year, so that the vast majority of these infants have died from some disease processes. Still the short comparison which it has been possible to make reveals certain points of interest.

The coefficients of variation are given in Table XXIV. In nearly every instance the coefficients are lower both in males and females in the first age period (foetuses and deaths under one week) than in the immediately subsequent group. The values given for this early age compare reasonably well with the values given already for male and female foetuses. After the first week the variability shows a general tendency to decline as the infant grows up. Irregularities in some of the age groups are apparent, especially with the thymus and less so with the spleen, but the variability at the end of the first year of life has become definitely less than it was in the first month with the other organs. And, further, when it is remembered that the older the infant the greater is the chance of death from some chronic condition, and therefore that, other things being equal, the variability should *increase* with age in this

Table XXIV. *Showing the coefficients of variation for certain characters at several age periods in infant life.*

	Under 1 week	1 week–1 month	1–3 months	3–6 months	6–9 months	9–12 months
(*a*) Males						
Body weight	31·34	34·45	30·44	28·79	29·59	27·89
Body length	9·35	8·10	9·19	8·56	8·62	9·27
Heart ...	40·35	47·31	40·35	35·58	32·67	32·67
Spleen ...	70·31	91·21	82·83	63·37	76·89	52·02
Kidneys ...	40·48	50·86	42·64	36·86	31·91	29·03
Thymus ...	61·88	74·77	102·51	98·98	85·42	78·79
(*b*) Females						
Body weight	32·93	28·96	26·84	31·90	33·64	25·43
Body length	9·48	9·36	9·16	9·18	9·56	8·47
Heart ...	51·90	43·66	46·91	42·21	33·90	31·90
Spleen ...	52·68	73·79	105·45	76·54	59·99	57·02
Kidneys ...	52·84	45·49	49·71	42·66	33·97	26·25
Thymus ...	59·05	74·43	87·61	93·91	85·22	88·01

set of data, it would be even more likely that the decrease as represented by these figures is smaller than what actually does occur. With regard to the lower variability in the first week of life as compared with later ages, it is in all probability not a real phenomenon because all of these deaths are from accidents of birth, and consequently these cases really represent a more or less "healthy" population, so that the series of foetal deaths and deaths under one week are not really comparable with those occurring later in infancy, which are due chiefly to broncho-pneumonia or gastro-enteritis. In this series no constant differences in the sexes can be demonstrated.

From the foregoing analysis, then, it may be concluded that the variations in infant viscera tend to become smaller as age advances. Under a given environment, high variability is likely to be indicative of instability, and Greenwood (1904), from his comparison of the viscera in diseased and normal adults, has shown that this is typical of the diseased state in adult life. To this it seems justifiable now to add that high variability is also characteristic of certain phases of life, diseased conditions entirely apart. Instability in this sense is apparently present at puberty. It is also a feature in ante-natal life in which the male is probably more unstable than the female. In infancy, too, instability is evident, and, as the infant continues to grow, part of this wears off gradually.

SUMMARY AND CONCLUSIONS.

In the present study an attempt has been made to determine the relative importance of several factors on the mortality rates of infancy. In view of the differences in the rates at the several ages under one year and of the differential decline in these rates within recent years, it has been suggested that for any complete consideration of the death rates in infancy, some subdivision of the rate, either of a biological or temporal character, must be effected, and each of these subdivisions examined separately. The infant mortality rate has been treated in three broad categories, namely, the ante-natal, neo-natal and post-natal death rates; and it has been shown that each of these depends on different factors.

Considered as death rates per unit of time the neo-natal rate is much higher than at any other period of life. The ante-natal death rate is much lower than this, and the post-natal rate lowest of all.

In relation to these rates, the influence of three, presumably important, factors have been measured. These are:

1. The provision of skilled attendance to mothers in childbed.
2. The health of the mothers.
3. Environmental and social conditions.

The indices used as measures of these three variables and their limitations have been pointed out. The author feels only too conscious of these limitations and, with such vital statistical data as the only indices available of the factors the influence of which on the mortalities of infancy it is desired to measure, it is probable that any conclusions drawn from such an analysis should be accepted with some degree of caution and reserve. Nevertheless, I am firmly convinced that even these (to the clinician and administrator) rather crude results are immeasurably superior to expressions of opinion, unsupported by facts, so frequently found forming the basis of much of the medical literature on the subject. That we have so relatively little exact quantitative knowledge of the influential factors concerned in the growth, nutrition and mortality of infants is surely not for lack of opportunity of collecting the requisite data. An admirable machinery for such a purpose—the various maternity and child welfare centres—is in extensive operation throughout this country; and if the medical officers in charge of these centres could only be persuaded to collect *and analyse* (or have analysed) periodically the data contained in suitably framed and completed questionnaires, many questions of scientific importance as well as of the efficacy of administrative efforts would soon cease to be subjects of controversy.

Our results show that, of these factors, only the provision of skilled medical assistance to mothers in childbed is of importance in connection with ante-natal mortality. The general health of the mother and external environmental conditions have no direct influence on the death rate at this period of life. The magnitude of the correlation leads to the further conclusion that a great part of the still-birth rate is not to be controlled by improvements in even all of these factors.

The neo-natal death rate is related both to variations in external environment and in the obstetrical assistance available for mothers in childbed. At this state of life, again, the health of the mother has no substantial influence on the death rate. External surroundings and the quality of the obstetrical assistance afforded to the mother are of approximately equal importance in determining these rates; but here again the conclusion is advanced that the greater part of the death rate at this stage of life is beyond human efforts of control.

The post-natal death rate seems to offer the greatest scope for administrative measures. In this case the health of the mother would appear to come

first in order of importance, environment also is of some importance, whereas the effects of variations in obstetrical services have now ceased to be reflected on the mortality of infancy.

In isolated rural communities there is a part of the post-natal death rate which could be eliminated by the speedy arrival of skilled medical assistance.

Foreign statistics have been collected and analysed to enquire into the causation of still-births. An obvious defect in these was pointed out, namely, the large proportion of deaths due to unknown causes. A comparison of these figures with those collected from several maternity hospitals has shown that hospital figures give a biassed view of the problem. The proportion of deaths due to causes in which the life of the mother as well as that of the foetus is endangered is greatly magnified, and consequently will produce a too optimistic estimate of the amount of amelioration which will result from increased attention to pregnant and parturient women. The statistics which have been given in this section show that in a really random sample of the population only a small proportion of still-births is the result of causes which can be controlled by this method, and that the chief causes of ante-natal death are developmental defects of the foetus and prematurity.

A short study has been made of certain statistico-anatomical features of the foetus and infant. From this it has been inferred that the foetus is physically in a state of extreme instability, that the conditions which kill *in utero* are rapidly fatal to the foetus, and that this instability is a somewhat more prominent feature in the male than in the female. As infancy advances, visceral variability decreases steadily, so that it would seem probable that some time is necessary for the foetus to adapt itself to its new mode of existence after birth. This state of unstable equilibrium in early life may provide some reason for the higher mortalities at these ages.

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