SOCIAL AND BIOLOGICAL FACTORS IN INFANT MORTALITY*

VIII. MORTALITY IN THE POST-NEONATAL PERIOD

BY

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This paper reports further results from the inquiry into the social and biological background of all the stillbirths and infant deaths that occurred among the 1½ million children born in England and Wales during 1949 and 1950. The method of the inquiry was described in the first paper of the series (Morris and Heady, 1955a) as follows:

'The present inquiry, which is an epidemiological exercise in the vital statistics of infant mortality, uses the documents of birth and death registration of England and Wales, and for the first time brings them together. Information about the mother's age, the number of her children, the duration of her marriage before the birth, and whether the birth was single or multiple, is obtained at birth registration (but not for the public record); while other data, such as the age of the infant, and the cause of death, are obtained when the death is registered. Information on the social circumstances surrounding the birth or death, such as the father's occupation, the community in which the family lived, and the infant's legitimacy is also available. All this material will be brought together for the two years 1949-50, and for the whole of England and Wales. Since similar information for stillbirths was easily available at the same time they are also included in the inquiry. In addition, mortality in the second year of life of children born in 1949 is being studied.'

The factors considered here in relation to deaths occurring between the end of the fourth week of life and the end of the first year, the post-neonatal period, are: the age of the mother at delivery, the birth rank of the child,† the duration of the mother's marriage, the occupation and social class of the

father, the region of the country where the parents were living at the time of the birth; the age of the infant at death, the cause of death, and the place of death, that is, whether the death occurred in hospital or not. Part I of the paper is concerned mainly with the relationship between the mother's age, the birth rank of the child, and mortality in the post-neonatal period; Part II is concerned with the certified causes of that mortality.

Material

The figures given here relate to all the 1,322,150 single legitimate live births that occurred in England and Wales in 1949 and 1950; illegitimate and multiple births are not considered in this paper. For technical reasons, some of the tables and diagrams are based on births which occurred only in 1949 or only in 1950.

Presentation

The basic data are presented in Tables 1 and 2 and Appendix Table A. The main diagrams present the mortality rates given in the tables in the form of mortality ratios calculated from these rates. In each part of the diagrams the overall mortality rate for the infants of mothers of all ages and parities is taken as 100 and the mortality rate for infants of mothers of a particular age and parity group is represented as a percentage of this overall rate. For example, in Fig. 1, the overall mortality rate for all infants in the period 4 weeks to 6 months is 7·8 per 1,000. For the second and third children

* A series of articles reporting an inquiry made jointly by the Social Medicine Research Unit (Medical Research Council) and the General Register Office. These articles (see References) were prepared by the Unit in collaboration with the General Register Office, and have been approved for publication by the joint working party responsible for the inquiry.

† Birth rank is defined here as the number of children borne by the mother, surviving, dead or stillborn, including the present one. The terms 'parity' and 'family size' are also used with precisely the same meaning.

of mothers aged 20-24 years the rate is 13.7 per 1,000. If 7.8 is taken as 100, 13.7 becomes 176 and this is the ratio plotted in the figure.* Similarly, in the first section of Fig. 3 the mortality rate for all infants in social classes I and II is 5.5 per 1,000 and this rate is taken as 100. The mortality ratio is used rather than the rate because attention is paid here to the variation of mortality within each part of the diagrams. If crude rates were used the scale would obscure even large proportionate variations in the smaller rates.

To make the diagrams more easily read, birth ranks have been combined into three groups: first children, second and third children, and fourth and subsequent children. This grouping summarizes the main trends.

The vertical scale of the principal diagrams is a logarithmic one in order to give equal proportionate differences between ratios the same importance. For example, a mortality ratio of 50% is the same

distance below the 100% base line as one of 200% is above it; on an arithmetic scale, 50% would be only half the distance below the base line of 100% that 200% would be above it.

Part I: Effects of Birth Rank and Mother's Age

Fig. 1 illustrates the pattern of stillbirth and infant death ratios for five periods from birth to the end of the second year of life, in relation both to the birth rank of the infant and the mother's age.†

It can be seen that there are two periods with distinctive patterns; stillbirths, and deaths during the period 4 weeks to 6 months. The stillbirth pattern is well known, the rates increasing sharply with increasing maternal age in each birth rank group, from, for example, 17.8 per 1,000 births for first infants of mothers aged 16-19 years to 55.8 per 1,000 for first infants of mothers aged 40-44 years.

* The ratios plotted in the figures cannot be precisely checked from the tables since these ratios were calculated from rates worked to two decimal places.

† The numbers and rates on which this figure is based are given in the seventh paper of the series (Heady and Morris, 1959).

FIG. 1.—Variation of mortality with birth rank of infant and the mother's age: stillbirths, infant mortality and deaths in the second year of life. The date '1949' in the last section indicates 'births of 1949'. The single, legitimate births of England and Wales, 1949-50.

In the first part of the post-neonatal period (from the age of 4 weeks to 6 months), ratios are lowest for mothers aged 30-39 years in each of the birth rank groups. There is a slight rise for mothers aged 40 and above and a steep rise of ratios with decreasing age from 30-34 to 16-19 years. The highest ratios in each birth rank group, therefore, are found in the youngest mothers. In Fig. 1a the ratios for the same period are shown with three maternal age groups plotted against birth rank. For mothers in each age group, the ratios rise sharply with increasing birth rank, the increase being greater for young than for older mothers. In sum, the larger the family the greater is the risk for the baby; with similar size of family, the baby of the younger mother is at a higher risk of death than that of the older mother.

In the second half of the post-neonatal period (6 months to 1 year), the variation in ratios is less but a similar pattern is present. There are differences, however, the two most noticeable ones being the now more U-shaped curve for first children, and the much smaller rise in ratios for later children of young mothers, i.e. the effect of mother's age is less important than in the earlier period. In the second year of life, mortality ratios no longer show a very distinct pattern in relation to the mother's age.

In Fig. 2 the post-neonatal period is shown in more detail.* There are slight differences between the periods 4 weeks to 3 months and 3 months to 6 months, but it is clear that the main difference

* Numbers of deaths and rates for four stages of the post-neonatal period are given in Appendix Table A.

FIG. 1a.—Variation of mortality between 4 weeks and 6 months with birth rank of infant: mothers of different ages compared. The single, legitimate live births of England and Wales, 1949-50.

occurs between the periods 4 weeks to 6 months and 6 months to 1 year. Fig. 2 also shows that, because the majority of post-neonatal deaths occur in the period 4 weeks to 6 months, the pattern of mortality in the whole period is very similar to that of the first part of it. Thus, while the other figures given in this paper refer to the whole post-neonatal period, the pattern they show is predominantly that of its first half.

In the post-neonatal period (4 weeks to 12 months)

FIG. 2.—Variation of mortality with birth rank of infant and the mother's age: three stages of the post-neonatal period and the whole period. The single, legitimate live births of England and Wales, 1949-50.

then, we have shown that there are large variations in infant death rates according to the age and parity of the mother. For example, the third children of mothers under 25 years of age have death rates three times those of third children of mothers over 30 years of age.

Social Class.* It is well known that post-neonatal mortality rates rise steadily from social class I to social class V. In Table I death rates are given by birth rank and maternal age for three social class groupings and it can be seen that the expected social class trends occur in each maternal age—birth rank compartment, i.e. for mothers of a particular age and infants of a particular birth rank, the classical picture of steadily rising rates from classes I and II to classes IV and V appears. Fig. 3 presents these rates in the form of mortality ratios. Very similar patterns appear in each of the three social class groupings, with the highest ratios in the same 'vulnerable' group in each class, i.e. the later infants of young mothers.

* The Registrar General allocates occupations to social classes according to the following scheme: class I—leading professions and business, class II—'lesser' professions etc., class III—clerks and skilled workers, class IV—semi-skilled workers, class V—unskilled labourers. Infants are allocated to social classes according to the occupation of the father.

FIG. 3.—Variation of post-neonatal mortality with birth rank of infant and the mother's age: three social class groupings. The single, legitimate live births of England and Wales, 1949-50.

The mortality ratio (though not, of course, the actual mortality rate) for fourth and later children is in fact higher in classes I and II than in the other classes. It is clear, therefore, that the relatively high mortality rates among infants of young mothers with large families are not a phenomenon peculiar to any one social class due to some simple poverty factor. It is also true that the higher death rates in classes IV and V cannot be

TABLE I
POST-NEONATAL MORTALITY IN THREE SOCIAL CLASS GROUPINGS IN RELATION TO BIRTH RANK AND MOTHER'S AGE
DEATHS OF INFANTS AGED 4 WEEKS TO 1 YEAR AND RATES PER 1,000 LIVE BIRTHS*
Single, Legitimate Live Births, England and Wales, 1949 and 1950

Mother's Age (yr.)	Social Class of Father																	
	I and II						III						IV and V					
	I			Birth Rank 2, 3			I			Birth Rank 2, 3			I			Birth Rank 2, 3		
	D	R		D	R		D	R		D	R		D	R		D	R	
16-19	16	7.7		1	8.4	7	365	13.9		83	24.9		255	15.6		90	33.0	
20-24	121	4.4		90	5.6	37	1,122	8.2		1,232	16.5		688	11.4		992	21.9	
25-29	138	4.0		219	5.6	37	537	5.8		1,495	10.5		282	9.2		889	14.7	
30-34	55	3.8		170	5.0	53	183	6.0		633	7.8		82	8.2		328	10.8	
35-39	25	4.0		110	5.6	55	70	5.6		333	8.0		57	12.1		170	10.7	
40+	11	7.6		33	7.3	32	26	9.4		73	8.0		16	13.9		38	10.1	
All Ages and Birth Ranks†				Deaths (D) 1,177			Rate (R) 5.5			Deaths 7,690			Rate 10.3			Deaths 5,327		

* Rates are not shown where there are fewer than 10 deaths.

† Including the few cases where either the mother's age or the birth rank was not stated.

Mother's age refers to age attained on her last birthday before the present birth.

Birth rank refers to the number of children, surviving, dead and stillborn (and including the present birth), by the mother's present and any previous husband. Abortions before 28 weeks of pregnancy are excluded.

The absence of an entry for deaths indicates that there were none.

explained by the concentration of young mothers with large families in these classes.

Geographical Distribution. In addition to social class differences in post-neonatal mortality, regional differences have long been recognized, in particular the higher rates in the North of England and in Wales. However, analysis of the mortality rates by mother's age and parity in four regional groupings (South-East England, Midlands and South-West, Northern England, and Wales), showed that the typical pattern of mortality ratios appeared in each regional group. It was not possible to make a similar analysis for smaller areas.

Duration of Marriage. Another factor apparently related to post-neonatal mortality is the duration of the mother's marriage. This, together with parity, can give an indication of birth spacing and it is possible to compare the mortality rates of infants born shortly after a previous child with those where there has probably been a longer gap. (The measure used is an indirect one, since a woman of 30 who has been married for five years before having her second child may have had the first one only shortly before. However, there is more likely to have been a longer period between the children than if she had had her

FIG. 4a.—Comparison between post-neonatal mortality of 'closely spaced' and other births: three maternal age groups. The single, legitimate live births of England and Wales, 1949-50.

FIG. 4b.—Comparison between post-neonatal mortality of first children born in less than one year of marriage and after more than one year of marriage: three maternal age groups. The single, legitimate live births of England and Wales, 1949-50.

second child within two years of marriage.) Fig. 4a compares the mortality rates of 'closely spaced' births (defined as second and third births in less than two and three years of marriage respectively) with all other second and third births in three age groups of mothers. In each age group, the 'closely spaced' births have higher mortality rates than the others.

In Fig. 4b the mortality rates of first children born after less than one year of marriage are compared with those for first children born after a longer period. In the three maternal age groups, those born after less than one year are at a disadvantage. 'Duration of marriage', then, apparently reflects something in addition to birth spacing, since first children are also affected by it. 'Rapidly of breeding' cannot be the explanation.

Figs. 5a and b show the same phenomena in the three social class groupings. Once again, it is clear that this finding occurs within each social class group, and therefore cannot be 'explained' by social class differences, i.e. by assuming that most 'closely spaced' births occur in social classes IV and V, in the families of unskilled and semi-skilled labourers.

Other Factors. The social class and regional differences in mortality have long been known. The fact that the same patterns of mortality according to birth rank and mother's age are found in each of these classes, and in each of the regional groups indicates that there are also factors cutting across social class which affect the survival of infants in all social classes and regions. It is interesting that in

FIG. 5a.—Comparison between post-neonatal mortality of 'closely spaced' and other births: three social class groupings. The single, legitimate live births of England and Wales, 1949-50.

one group of infants, fourth and later children of mothers aged 20 to 24 years, the most vulnerable group, the differences between the classes is almost obliterated (Table 1). The rates for these infants are as follows: classes I and II—26.3*, class III—34.1, classes IV and V—35.3. In other words, the babies of young mothers with three or more other children are at an almost equally high risk of dying whether their fathers are professional men or unskilled labourers.

Part II: The Cause of Death

Fig. 6 illustrates the maternal age and birth rank pattern of mortality in the post-neonatal period for the six main groups of registered causes of death. The numbers and rates on which the diagram is based are given in Table 2, and the detailed composition of the cause groups in Table 3. Respiratory infections are the main cause of death in this period.

It will be noticed that the basic pattern shown in Part I for all causes of mortality (Fig. 2) appears in each of the cause groups of Fig. 6 except congenital malformations. For these latter deaths the differences between infants of mothers of various ages and

of different parities are much less than in the other groups.† In deaths attributed to 'accidents' the pattern is most striking, with the highest ratio twenty times that of the lowest. The highest mortality rate is 5.9 per 1,000 for fourth and later children of mothers aged 20-24 years, and the lowest is 0.3 per 1,000 for first children of mothers aged 25-34. That is to say, while one out of 3,333 first children of mothers aged 25-34 years died from an 'accident' in the post-neonatal period, the comparable figure for fourth and later children of mothers aged 20-24 years was one death out of every 169 such children born.

It appears, then, that variations in mortality with maternal age and parity cannot be explained in terms of any single cause of death; all the major causes (with the exception of congenital malformations) show the same pattern. Of these causes only 'accidents' appears at first glance to be unrelated to infection and since 'accidents' also show the most striking variations in rates, it may be worth looking more closely at them.

'Accidents.' There has been considerable interest recently in the problem of accidental death in infancy. The hypothesis has been advanced in this country (Davison, 1945), in Australia (Bowden,

† The numbers of deaths in the post-neonatal period due to congenital malformations are too small to enable maternal age—parity patterns to be shown for individual malformations since more than 60% of the deaths certified as due to congenital malformations occur in the neonatal period.

FIG. 5b.—Comparison between post-neonatal mortality of first children born in less than one year of marriage and after more than one year of marriage: three social class groupings. The single, legitimate live births of England and Wales, 1949-50.

* This figure does not appear in Table 1 as it is calculated from less than 10 deaths.

FIG. 6.—Variation of post-neonatal mortality with birth rank of infant and the mother's age: six cause groups. The single, legitimate live births of England and Wales, 1949-50.

1950) and in the United States (*J. Amer. med. Ass.*, 1950), that many of these deaths are due to a fulminating respiratory infection. For infants born in 1950, it is possible to subdivide the accidental deaths that occurred into two groups. The first, which contains only 12% of all the deaths attributed to 'accidents', includes falls, burns and traffic accidents. The second group, containing 88% of these deaths, comprises 'accidental inhalation and ingestion of food' (E921,922)* and 'accidental mechanical suffocation' (E924), and it is this group that includes most of the sudden, unexpected deaths in the post-neonatal period. Fig. 7 illustrates the death rates in the second group according to the season of birth of the infants, expressed as percentages of the rate for the whole year. The variation of the death rates is very similar to that of bronchopneumonia, with the highest rates amongst children born in the last two quarters of the year. That is to say, infants aged between 1 and 6 months during the winter months were at a much higher risk of

FIG. 7.—Variation of post-neonatal mortality for various causes according to season of birth. The single, legitimate live births of England and Wales, 1950.

* An explanation of these international code numbers is given in the footnote of Table 3.

TABLE 2

POST-NEONATAL MORTALITY IN SIX CAUSE GROUPS IN RELATION TO BIRTH RANK AND MOTHER'S AGE
DEATHS OF INFANTS AGED 4 WEEKS TO 1 YEAR AND RATES PER 1,000 LIVE BIRTHS*

Single, Legitimate Live Births, England and Wales, 1949 and 1950

Mother's Age (yr.)	Cause Groups†																	
	'Accidents'						Diarrhoea and Enteritis						Respiratory Diseases					
	Birth Rank						Birth Rank						Birth Rank					
	1		2, 3		4 and over		1		2, 3		4 and over		1		2, 3		4 and over	
	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R
16-19	52	1.2	27	4.3			94	2.1	27	4.3			253	5.6	72	11.4		
20-24	125	0.6	254	1.9	37	5.9	266	1.2	325	2.5			706	3.1	998	7.6	94	14.9
25-29	49	0.3	179	0.7	71	1.8	122	0.8	337	1.4	138	3.5	314	2.0	1,028	4.2	404	10.1
30-34	15	0.3	50	0.3	47	0.9	28	0.5	148	1.0	118	2.2	87	1.6	396	2.7	382	7.1
35-39	3		33	0.4	25	0.5	29	1.2	68	0.9	117	2.1	47	2.0	219	2.8	300	5.4
40+	3		4		8		7		20	1.2	54	2.0	17	3.2	60	3.5	212	8.0
All Ages and Birth Ranks‡	Deaths (D)			Rate (R)			Deaths			Rate			Deaths			Rate		
	987			0.7			1,939			1.5			5,604			4.2		
Mother's Age (yr.)	Other Infections						Congenital Malformations						All Other Causes					
	Birth Rank						Birth Rank						Birth Rank					
	1		2, 3		4 and over		1		2, 3		4 and over		1		2, 3		4 and over	
	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R
16-19	51	1.1	7				83	1.9	18	2.9			104	2.3	23	3.7		
20-24	188	0.8	183	1.4	17	2.7	328	1.5	225	1.7	8		326	1.5	333	2.6	23	3.6
25-29	68	0.4	264	1.1	77	1.9	211	1.3	379	1.6	75	1.9	197	1.2	417	1.7	118	3.0
30-34	35	0.6	121	0.8	74	1.4	75	1.4	198	1.4	85	1.6	79	1.5	221	1.5	141	2.6
35-39	10	0.4	43	0.6	70	1.3	34	1.5	128	1.7	115	2.1	29	1.2	123	1.6	112	2.0
40+	4		14	0.8	31	1.2	10	1.9	20	1.2	60	2.3	9		28	1.6	85	3.2
All Ages and Birth Ranks‡	Deaths			Rate			Deaths			Rate			Deaths			Rate		
	1,262			1.0			2,058			1.6			2,372			1.8		

* Rates are not shown where there are fewer than 10 deaths.

† The detailed composition of the groups is given in Table 3.

‡ Including the few cases where either the mother's age or parity was not stated.

TABLE 3
COMPOSITION OF CAUSE GROUPS

(1) 'Accidents'	All deaths attributed to an accident (E800-965)*.
(2) Diarrhoea and enteritis ..	Enteritis and diarrhoea (571, 764).
(3) Respiratory diseases ..	Pneumonia (490-493, 763), bronchitis (500-502), other diseases of respiratory system (470-483, 510-527)
(4) Other infections ..	Tuberculosis (001-008, 010-019), whooping cough (056), measles (085), other infective and parasitic diseases (020-055, 057-084, 086-138)
(5) Congenital malformations	All congenital malformations (750-759)
(6) All other causes ..	All other causes of death

* Numbers in brackets refer to the code numbers of the International Statistical Classification of Diseases, Injuries and Causes of Death, 6th Revision. (World Health Organization, 1948.)

dying from an 'accident' than were those infants aged between 1 and 6 months during the summer. It has been shown before (Registrar General, 1954) that total infant mortality rates from 'accidents' are higher in the winter than in the summer.

It may be, therefore, that the majority of 'accidental' deaths in the post-neonatal period are due to infection and that infection in its broadest

sense is the predominant cause of all deaths in this period.

We have shown, then, that the infants of young mothers, and especially of those with more than one child, are particularly liable to die of infection in the first part of the post-neonatal period, i.e. from 4 weeks to 6 months. Thereafter, this special vulnerability is less noticeable. This vulnerability is found in relation to other infants in the same social class and living in the same geographical area and it is increased if the mother has been married for only a relatively short time before the child is born (i.e. less than one year for the first child, less than two years for the second, less than three years for the third). In addition, these 'vulnerable' infants are, like others, exposed to increased risk with descending social class and with residence in the North of England or in Wales.

Once variations in mortality have been demonstrated between the infants of mothers of differing parities and ages, and in different social classes, three possibilities arise: either there are variations in the incidence of disease, or in the case fatality, or in both. This inquiry provides no evidence about

the incidence of disease; it does provide indirect evidence about case fatality in so far as it may be assumed that infants who have had more attention from the medical services suffer a lower case fatality than others. The indirect evidence is found in the comparison of deaths occurring in hospital and at home.

Place of Death. To consider first the social class differences, it can be seen from Table 4 that the percentage of deaths in the post-neonatal period occurring in hospital in 1950 fell from 70% in class I to 52% in class V. (The striking difference is between class I and the rest.) In class I, therefore, probably 70% of those children who died had been under the care of paediatricians in hospital while in class V (whose total mortality was nearly four times that of class I) only 52% of such children could have had that care. Either a much larger proportion of deaths in class V were sudden, or there was a failure to admit the seriously ill child to hospital. Although 'where the average standard of housing is relatively good . . . the paediatrician and family doctor . . . can often treat serious illness partly or wholly in the home' (Gairdner, 1956), it seems highly unlikely that deliberate selection of this kind would lead to more labourers' children than children of professional people being treated at home. It is more likely that a considerable proportion of the serious illness in infants of all classes except class I in 1950 was not under the care of specialists at all. In the most important cause of death in this period, respiratory infections, less than half the deaths in classes II to V occurred in hospital.

Fig. 8 shows the relationship between the mortality rate of maternal age—parity groups and the percentage of deaths in the group occurring in hospital. Like the social class distribution, the groups with the highest death rates, later children of young mothers, have the lowest percentage of deaths in hospital. From this point of view also, it appears that in 1950 infants at the greatest risk did not come under the care of paediatricians.

These differences in the amount of medical care provided suggest that some of the variations in mortality rates between social classes and between maternal age—parity groups may be attributable to differences in case fatalities arising from differences in the quality of the medical care received.

Douglas (1951) and Grundy and Lewis-Faning (1957) have shown that the incidence of disease increases with descending social class. Thus probably both factors (incidence and case-fatality) vary with social class and may account for the different mortality rates between classes. The only evidence

TABLE 4
PLACE (HOSPITAL OR ELSEWHERE) WHERE POST-NEONATAL DEATHS OCCURRED: BY SOCIAL CLASS
England and Wales, 1950

Social Class of Father	Deaths			
	In hospital (no.)	Elsewhere (no.)	In hospital (%)	Elsewhere (%)
I .	78	34	70	30
II .	240	200	55	45
III .	1,993	1,607	55	45
IV .	698	653	52	48
V .	608	553	52	48
All classes*	3,623	3,054	54	46

* Including the few where the social class was not stated.

AGE-BIRTH RANK GROUPS WITH HIGHEST % DEATHS IN HOSPITAL	Mother's Age	Birth Rank
1	30-34	1
2	40+	1
3	35-39	2, 3
4	25-29	4+
5	16-19	2, 3
6	20-24	4+

FIG. 8.—Relation between post-neonatal death rates of maternal age and birth rank groups and percentage of post-neonatal deaths in hospital. The single legitimate live births of England and Wales, 1950.

we can find about variations of incidence with maternal age and birth rank is given by Lowe and McKeown (1954). Their figures apply to 'infectious episodes in the first three years of life' and they show that in equivalent housing conditions, the number of such episodes increases with increasing birth rank and, for the same birth rank, is higher for children of mothers under 30 than over 30. The high mortality rates of later infants of young mothers may reflect, therefore, both a higher incidence of disease and a higher case fatality.

Comment

Social class differences in post-neonatal mortality rates have long been recognized; these differences, and also those between occupations in the same social class (for example, miners and clerks in class III), appear to have remained relatively constant from 1911 until 1950 (Morris and Heady, 1955b). Regional differences are also well known but these now appear to be diminishing.* The closing of the social class gap is obviously going to be a long-term process. The finding of the same vulnerable groups of infants, later babies of young mothers, and the similarity of the patterns of mortality by maternal age and birth rank within social classes seem to merit attention for two main reasons. First, because the special attention of the medical services to these vulnerable groups may be a way of speeding the reduction of the overall post-neonatal mortality rates; and second, because it is possible that variations in mortality by maternal age and birth rank will become of increasing importance if and when differences between classes diminish.

We have shown that infant death rates are closely related to birth rank and mother's age and also that the majority of deaths in the post-neonatal period are probably due to infection. In other words, the pattern of mortality may reflect the impact of infection. It is interesting to look back to Fig. 1 in the light of this suggestion. The patterns of mortality ratios for stillbirths and for post-neonatal deaths are radically different but the neonatal pattern can be described as a mixture of these two patterns. The neonatal pattern may be a combination of two quite different patterns, that of the pre-natal period (due to pre-natal causes), and that of the post-neonatal period (due predominantly to infection). In Fig. 1, then, the curves are consistent with the idea that during the neonatal period the infant is still exposed to the effects of some pre-natal causes of disease and is also meeting external infection for the first time.

There are two independent findings to consider: first, that in the same birth rank, the babies of younger mothers have higher death rates; second, that for the same maternal age, babies of higher birth ranks have higher death rates.

To take first the infants of mothers of the same age, we have shown an increase in mortality with increasing birth rank in each maternal age-group, the greatest increase being for infants of mothers under 25 years of age. In addition the death rates

of infants born after a relatively short duration of marriage were higher than those of other infants. Taken together, these facts suggest that the difficulty of looking after a larger family where, especially if there are other very young children, there is a greater risk of infection, increases the risk of death for babies in such families. Badger, Dingle, Feller, Hodges, Jordan and Rammelkamp (1953) have shown that the incidence of respiratory infections in pre-school children rises with increasing size of family, while Brimblecombe, Cruickshank, Masters, Reid, Stewart and Sanderson (1958) have shown that crowding within the family is an important factor in the spread of acute respiratory infection, and such crowding is more likely in the larger families. However, an increased risk also applies to a first child born within a year of marriage compared to those born after a longer interval, which suggests that some less obvious factor also plays a part. Table 5 provides further evidence against the hypothesis that the greater difficulties of rearing a larger family account for all the observed differences in mortality rates. The mortality rate for infants of mothers who have lost a previous child from any cause are higher than for other infants, that is, the higher rates are in the families that are smaller by at least one child. Deaths from diarrhoea and enteritis, from bronchopneumonia and from 'other respiratory diseases' have been selected for this comparison to obviate the possibility that previous loss of a child may have some purely medical bearing on the loss of the present one; it seems unlikely that previous loss would lead directly to increased risk of dying from gastro-enteritis or respiratory disease of a later infant.

Variations in the mortality rates of infants of the same birth rank with maternal age cannot be explained by any obvious hypothesis. For instance, the rates for first children rise from 5.7 per 1,000 for mothers aged 30-34 years to 14.2 per 1,000 for mothers of 16-19 years. It will be remembered that similar variations occurred within social classes

TABLE 5
POST-NEONATAL MORTALITY RATE FROM VARIOUS
CAUSES PER 1,000 LIVE BIRTHS IN RELATION TO DEATH
OF PREVIOUS CHILDREN
BIRTH RANKS 2, 3 AND 4
England and Wales, 1950

Cause of Death	All Previous Children Living (rate)	One or More Previous Children Dead (rate)
Diarrhoea and enteritis ..	1.2	1.3
Broncho-pneumonia ..	3.1	3.9
Other respiratory infections ..	1.5	1.8

* In the third paper of this series (Daly, Heady and Morris, 1955) it was shown that in 1949 post-neonatal death rates ranged from 7.0 in the Eastern Region to 17.9 in the Northern. In 1956, the range was from 5.3 in the South Western Region to 8.4 in the North Western Region (Registrar General, 1958).

(Fig. 3) and are therefore independent of social class.

It appears, then, that factors other than mere family size and the environmental factors such as income which are fairly directly reflected by the father's occupation must be sought to explain the patterns of mortality by maternal age and parity. There is no evidence from this inquiry about any variation of the incidence of disease by maternal age and parity or direct evidence about variations of case fatality rates. However, evidence that infants in the 'vulnerable group' may be failing to reach the care of paediatricians has been presented (Fig. 8) and it was suggested that this may influence the case fatality rates of these infants. The reason for this failure could be either that the standard of general practitioner care available to them was below average, or that the mothers of this group failed to call for medical aid as promptly as did other mothers. It is unlikely that variations in the standard of general practitioners are responsible since the same 'vulnerable group' is found amongst mothers in social classes I and II as well as amongst those in classes IV and V. The second possibility is supported by the facts shown in Fig. 9. Since autopsies of patients dying at home are usually performed on a coroner's order, it may be presumed that in these cases either there has been some doubt in the attending doctor's mind about the cause of death, or that he has not attended the patient during the last illness. The higher percentage of autopsies on infants in the 'vulnerable group' who died at home may be an indication, therefore, that a higher proportion of the mothers of this group have not called in their general practitioners at a sufficiently early stage.

An interesting relationship has recently been demonstrated between the proportion of infant deaths in hospital and the use of medical services by mothers. Douglas and Blomfield (1958), in their survey of children born in the first week of March, 1946, were able to identify a group of 558 mothers who made 'good use' of the ante-natal services (that is, had attended in the first three months of pregnancy) and to match this group (for sex, social group, birth rank of the child, and geographical area) with a similar number of 'poor users' (who attended in the last three months). They found that, out of five deaths in the post-neonatal period among infants of 'good use' mothers, four occurred in hospital, while out of 10 deaths among infants of 'poor users', only one occurred in hospital. Douglas and Blomfield (1958) write: 'We can infer that . . . "poor users" sought medical care at a later stage in their children's illnesses than did . . . "good

users"'. Whether this was because they failed to recognize serious illness or because they relied upon the advice of someone other than the doctor, we cannot say.'

There is other evidence that the mothers of infants in the vulnerable groups do not use the 'extra' medical services, child welfare clinics, as fully as do other mothers. For example, in Newcastle (Spence, Walton, Miller and Court, 1954) the percentage of attendances at Welfare Clinics dropped from 71% of first children to 60% of fourth and subsequent children. The same picture was found in a new housing estate in Hertfordshire (McDonald, 1957).

FIG. 9.—Percentage of autopsies among deaths at home for later infants of young mothers, the 'vulnerable group', and for all other infants. The single, legitimate live births of England and Wales, 1950.

In addition McDonald found that there was a tendency for Health Visitors to visit the homes of attenders at the clinics more often than the homes of non-attenders. It has also been noted (Douglas, 1951) that there may be a considerable delay before the Health Visitor makes her first call, and the young mother may be left to her own devices at perhaps her most difficult time, the first weeks following her return from hospital, or, in a home confinement, after the midwife has stopped visiting.

The hypothesis suggested by these facts is that young mothers are slower to seek medical advice about their infants, possibly because they are less able to recognize serious illness. This may be an indication of generally lower standards of maternal care. In other words, the factor which may be responsible for the higher mortality rates of infants of young mothers is poor maternal care. Maternal care is of recognized importance in the prevention of infant deaths but efforts to grade mothers according to their capability have not been very successful. For example, two recent studies (Spence *et al.*, 1954; Grundy and Lewis-Faning, 1957) placed mothers

on a scale of capability retrospectively and it is difficult to escape the conclusion that such facts as the size of the family and the baby's health influenced the judgment.

Investigations in Aberdeen on a prospective basis may be relevant to this problem. A series of studies of married women during their first pregnancy were carried out by Professor Baird and his colleagues together with the Social Medicine Research Unit. Some of their findings may help to throw light on the variations in post-neonatal mortality rates recorded here and the relevant information is summarized below.

(1) Older mothers tended to make more use of sources of information about pregnancy and labour and 'irrespective of social class, give the impression of being more careful in their planning and preparation' (Baird and Scott, 1953).

(2) The successful use of contraception is associated with a higher intelligence test grading of the wife within each social class (Baird and Scott, 1953).

(3) Within social classes the mother's consumption of milk and vitamin concentrates rose steadily as maternal age increased (Marr, Hope, Stevenson and Thomson, 1955).

The overall suggestion is that the younger mothers in each social class take less care during pregnancy and may well provide poorer care for their infants in the post-neonatal period.

The link between these findings relating to women having their first baby and the higher mortality rates of later infants of young mothers may be provided by another Aberdeen study which found that the younger the mother and the shorter the interval between marriage and the first birth, the greater the number of subsequent children (Baird, 1946).

It appears, then, that the relatively high post-neonatal mortality rates of both first and later infants of young mothers in all social classes may be related to a lower standard of maternal care. In other words, the 'biological' factors of maternal age, parity and duration of marriage, may, in the post-neonatal period, reflect social factors, i.e. standards of maternal care.

This is not to say that the standard of maternal care is the whole answer to this question of differential post-neonatal mortality rates within social classes. It is possible that real biological factors affect the vitality of the baby and its capacity to meet environmental stresses. It has been shown that the post-neonatal mortality rates of premature infants are considerably higher than those of mature infants (Gibson and McKeown, 1951); it is possible that variations in the mortality rates of mature infants

may be related to poor nutrition or 'pregnancy stress' in the mother (Stott, 1957). The work of Drillien (1957) and Illsley (1955) suggests that the childhood environment of the mother herself may play a part in this problem.

Epidemiology and Clinical Paediatrics. The inquiry reported here is an epidemiological approach to the problems of infant mortality. The uses of epidemiology (Morris, 1957) may be described at three levels. First, it aims at providing a total or representative picture of a situation, in the present instance the relationship between infant mortality rates and maternal age and the birth rank of the child. Patterns become obvious that could not be seen by the individual clinician; it is one way of 'completing the clinical picture' and 'identifying syndromes'. Secondly, it discovers problems; by locating vulnerable groups it shows empirically, regardless of the stage of understanding of aetiology, where health services should be concentrated. Lastly, by demonstrating differences between the death rates of various groups of infants it provides clues to aetiology.

An illustration of these three uses of epidemiology is provided by the analysis of 'accidental' deaths. At the first level, no clinician could see enough children with and without accidents to recognize the very striking relationship between the mother's age, the birth rank of the child, and post-neonatal death rates from accidents. At the second level, it can be shown (from Table 2 and Appendix Table A) that 40% of the 'accidental' deaths occurred amongst a group of infants who comprised less than one-sixth of the births. This is the 'vulnerable group', the later infants of young mothers, and it provides a manageable target for Public Health and clinical services. If special attention were to be paid to this small group of infants (small in relation to all births), and their death rate brought down to that of other babies, there would be a reduction of 25% in the total post-neonatal deaths due to 'accidents'.

At the third level, in the search for causes, the data given here support the hypothesis that many 'accidental' deaths are due to respiratory infections. Barrett (1954) doubts the validity of the fulminating infection theory and the data given here showing the concentration of accidental deaths amongst the later infants of young mothers does suggest that failure to recognize illness may be more important in these cases than a sudden overwhelming infection. Another epidemiological study on a smaller scale (Emery and Crowley, 1956) throws light on the causation of these deaths. Emery and Crowley investigated 50 'sudden unexpected deaths' and

found that there were often symptoms in the infants for a few days before death. Unfortunately they did not give the maternal age and parity, but their study does confirm the hypothesis that the mothers of infants dying from 'accidents' are less able to recognize the symptoms of serious illness.

Although the post-neonatal mortality rate for England and Wales has fallen from 11.1 per 1,000 in 1950 to 6.9 per 1,000 in 1956 (Registrar General, 1958), there is no reason to believe that the differences in rates according to maternal age and parity presented here have disappeared. It must, therefore, be important for the medical services to pay particular attention to these young mothers and to try to reduce the differential mortality within social classes as well as between them.

Summary

A distinctive pattern of mortality by maternal age and birth rank has been demonstrated in the post-neonatal period. This pattern shows relatively high death rates for the infants of young mothers, with particularly high rates for the later children of such mothers; they form a vulnerable group of infants. The same pattern was found within the social classes and within geographical regions. It has also been shown that, independently of social class, the post-neonatal mortality rate is higher for the infants of mothers whose duration of marriage is short in relation to the number of children they have borne.

The same pattern of mortality rates was found for all the major causes of death except congenital malformations. The seasonal distribution of deaths due to 'accidents' provides another indication that infection may play a part in such deaths.

The proportion of post-neonatal deaths which occurred in hospital declined from social class I to social class V; in addition, this percentage was smaller for the vulnerable group of infants, that is, the later infants of young mothers. It appears possible that paediatricians in 1949-50 were not treating much more than half the cases of the most serious illness in babies aged between 1 month and 1 year.

Some relationships between epidemiology and clinical paediatrics are considered.

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See next page for Appendix Table A.

APPENDIX TABLE A
MORTALITY RATES PER 1,000 LIVE BIRTHS AT FOUR STAGES IN THE POST-NEONATAL PERIOD IN RELATION TO BIRTH RANK AND MOTHER'S AGE*

Single, Legitimate Live Births, England and Wales, 1949 and 1950

Birth Rank	Stage	Mother's Age (years)														Not Stated		Total All Ages	
		16-19		20-24		25-29		30-34		35-39		40-44		45 +					
		D†	R‡	D	R	D	R	D	R	D	R	D	R	D	R	D	R		
1	Deaths between 4 wk.-3 mth.	260	5.8	752	3.3	349	2.2	123	2.2	58	2.5	20	3.9	1		1		1,564	3.0
	3-6 mth.	224	5.0	626	2.8	306	1.9	95	1.7	44	1.9	10	2.0	1		2		1,308	2.5
	6-9 mth.	94	2.1	351	1.6	182	1.1	61	1.1	32	1.4	12	2.3					732	1.4
	9 mth.-1 yr.	59	1.3	210	0.9	124	0.8	40	0.7	18	0.8	6						457	0.9
	Live Births	44,840		225,096		159,519		55,153		23,499		5,140		254		754		514,255	
2	Deaths between 4 wk.-3 mth.	75	12.7	741	7.1	629	3.7	256	2.8	138	3.2	21	2.5	5		2		1,867	4.4
	3-6 mth.	57	9.7	542	5.2	473	2.8	189	2.1	76	1.8	18	2.2	1		4		1,360	3.2
	6-9 mth.	19	3.2	235	2.3	283	1.7	97	1.1	51	1.2	9		1				695	1.6
	9 mth.-1 yr.	6		141	1.4	157	0.9	82	0.9	38	0.9	13	1.6					437	1.0
	Live Births	5,892		104,487		169,727		90,461		43,092		8,258		378		884		423,179	
3	Deaths between 4 wk.-3 mth.	6		276	10.5	455	6.3	181	3.3	121	3.5	34	4.1			2		1,075	5.4
	3-6 mth.	7		236	9.0	332	4.6	160	2.9	96	2.8	20	2.4	1		1		853	4.3
	6-9 mth.	4		95	3.6	165	2.3	95	1.7	54	1.6	13	1.6			1		427	2.2
	9 mth.-1 yr.			52	2.0	110	1.5	74	1.3	40	1.2	9		1		1		287	1.5
	Live Births	407		26,366		72,828		55,261		34,458		8,371		402		458		198,551	
4	Deaths between 4 wk.-3 mth.			88	16.9	204	7.8	138	5.1	88	4.2	27	4.2			2		547	6.3
	3-6 mth.			49	9.4	179	6.8	104	3.9	66	3.1	23	3.6			4		425	4.9
	6-9 mth.			20	3.9	90	3.4	52	1.9	38	1.8	20	3.1	2		2		224	2.6
	9 mth.-1 yr.			10	1.9	52	2.0	46	1.7	31	1.5	12	1.9	3		1		155	1.8
	Live Births	28		5,194		26,234		26,946		21,171		6,416		396		246		86,631	
5	Deaths between 4 wk.-3 mth.			17	18.4	88	9.6	75	5.7	46	3.7	19	4.0					245	6.0
	3-6 mth.			19	20.6	73	8.0	72	5.5	42	3.4	28	5.9	2		1		237	5.8
	6-9 mth.			5		38	4.2	44	3.4	37	3.0	16	3.4	2				142	3.5
	9 mth.-1 yr.			1		22	2.4	22	1.7	19	1.5	3						67	1.6
	Live Births	2		922		9,165		13,147		12,544		4,769		343		123		41,015	
6-10	Deaths between 4 wk.-3 mth.			3		45	9.8	108	8.1	129	6.4	76	6.9	5		1		367	7.3
	3-6 mth.			2		54	11.7	100	7.5	114	5.6	64	5.8	8				342	6.8
	6-9 mth.			2		30	6.5	47	3.5	55	2.7	36	3.3	7		1		178	3.5
	9 mth.-1 yr.					8		33	2.5	43	2.1	31	2.8	7				122	2.4
	Live Births			187		4,605		13,275		20,251		11,016		1,122		196		50,652	
11 +	Deaths between 4 wk.-3 mth.							1		16	11.4	13	6.6	3				33	8.1
	3-6 mth.							3		12	8.6	19	9.6	2				36	8.8
	6-9 mth.							2		2		13	6.6	4				21	5.2
	9 mth.-1 yr.									1		3		2				6	
	Live Births					11		269		1,403		1,971		409		17		4,080	
Not Stated	Deaths between 4 wk.-3 mth.			1		1				1						4		7	
	3-6 mth.					1		1								2		4	
	6-9 mth.															1		2	
	9 mth.-1 yr.																		
	Live Births	89		982		1,095		595		331		95		5		595		3,787	
Total All Birth Ranks	Deaths between 4 wk.-3 mth.	341	6.7	1,878	5.2	1,771	4.0	882	3.5	597	3.8	210	4.6	14	4.2	12	3.7	5,705	4.3
	3-6 mth.	288	5.6	1,474	4.1	1,418	3.2	724	2.8	450	2.9	182	4.0	15	4.5	14	4.3	4,565	3.5
	6-9 mth.	117	2.3	708	2.0	788	1.8	399	1.6	269	1.7	119	2.6	16	4.8	5		2,421	1.8
	9 mth.-1 yr.	65	1.3	414	1.1	473	1.1	297	1.2	190	1.2	77	1.7	13	3.9	2		1,531	1.2
	Live Births	51,258		363,234		443,184		255,107		156,749		46,036		3,309		3,273		1,322,150	

* Rates are not shown where there are fewer than 10 deaths.

† D=Deaths R=Rates