THE CHANGING PATTERN OF MORTALITY IN ENGLAND AND WALES

I. INFANT MORTALITY

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1. INTRODUCTION

Planning the requirements of a Health Service pre-supposes the possibility of intelligent anticipation in a situation now changing in two ways:

- (a) the risks of incurring any one disease in one and the same age group are not constant from year to year and in any one year may differ widely in different age groups;
- (b) the age structure of the population of most industrialized communities—in Britain especially—is rapidly changing at the present time.

Such anticipation itself implies extrapolation; and no judgments which involve extrapolation can be final. They will be intelligent only in so far as they state foreseeable consequences within limits circumscribed by certain assumptions about the continued predominant influence of agencies operative at the present time and in the immediate past. While recognizing the dangers and limitations of such extrapolation, we need not lose sight of the fact that the future is in large measure predetermined by the past. Thus we can assign with no reservation an upper limit to the number of persons over 40 years of age in 1990 because all of them will be persons whose birth has been recorded already. With the reservation that mortality experience will not deteriorate as the result of a world war, mass unemployment, or other circumstance, we can also assign a lower limit. Such reservations will be less or more weighty in the measure that we do or do not extrapolate too far ahead of what current experience seemingly endorses.

To clarify the prospect as a basis for planning in the decade ahead, it is necessary to interpret current morbidity rates and their trends against the background of what we can now confidently forecast about the future age composition of the population. For the second, official sources are available. For the former it will be necessary to make an *ad hoc* study by recourse to data not as yet on record for a closed and representative population at risk. Such

an inquiry, now planned in the Birmingham University Department of Medical Statistics with the assistance of the Rockefeller Foundation, is costly and beset with difficulties. Meanwhile, the series of preliminary communications, of which this is the first, aims at making available a preview of mortality changes *pari passu* with the changing age structure of the community.

It is a commonplace that most deaths occur in the first year of life or after the fifth decade; and our concern in this context is with infant mortality alone. Here our experience of change goes back less than half a century. The 20th century is the century of the conservation of child life, having witnessed a sustained quinquennial decline from a level lower than any previously recorded only since its first quinquennium. The study of this change has led different writers to widely different opinions. Thus Karl Pearson (1902) maintained that poverty had little to do with differential infant death rates and that the preservation of weaklings by welfare legislation would sooner or later exact its toll by producing more parents of low stamina. Contrariwise, Woolf and Waterhouse (1945) regard bad housing, employment of women, and other changeable features of the social environment as largely responsible for the differentials recorded up till 1940.

Of Pearson's views it suffices to say that the present tempo of decline is greater than ever before. As regards the views expressed by Woolf and Waterhouse, it is worthy of comment that several recent investigations have cast doubt on the importance of social agencies contributory to differential morbidity of infants in the post-war situation (Grundy, 1949; Dykes, Grundy, and Lewis-Faning, 1953, Lowe and McKeown, 1954). Such findings may signify that there has been a relevant change, that social agencies affect morbidity less than mortality, that the methods of population sampling employed have not been sufficiently sensitive to the supposedly relevant social agencies, or that a clear view of the situation demands both a refined classification of diseases responsible for death and a

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judicious selection of population units with sharply definable and divergent social indices.

If Pearson's prognostications have hitherto proved to be false, it is of interest to record that current figures have reached the target value deemed by Woolf and Waterhouse to be realizable as the outcome of drastic social reforms. Clearly, we can hope to make no intelligent prognostication of foreseeable changes in the next decade unless we scrutinize the trend of deaths attributable to different diseases; and it will facilitate the task of doing so if we clarify at the outset certain terms we shall use.

First it is necessary to define a *sustained decline*. By this we mean a decline which has continued from a certain date D to the present time on the understanding that:

- it reached on date D a level as low as in any previous year;
- we neglect annual fluctuations if the mean figure for a given quinquennium from D onwards is no greater than its predecessor.

Accordingly, we use *moving averages* (Fig. 1) in plotting the accompanying charts. Needless to say, a sufficient reason for neglecting annual variations is the confused picture which emerges from comparison of successive individual years in which even one large-scale epidemic may distort our interpretation of the course of events.

FIG. 1.—Infant mortality rates per 1,000 related live-born, 1911–50 (logarithmic scales).

It is necessary to emphasize our criterion of a sustained decline because it is relevant to what we shall speak of as the *hard-core* of the diagnostic breakdown. This hard-core includes deaths associated with congenital malformations and other categories of which we *cannot* predicate a sustained

decline in the sense defined above. The rate for congenital malformations declined from a peak of 6.32 in the quinquennium 1936–40 to 6.04 for 1941–45 and 4.75 for 1946–50, but it is still well above 3.81, the figure for 1911–15. Thus no experience of the period 1911–15 justifies us in discounting the possibility that it may rise again, least of all that it will continue to fall below its present level.

It is also necessary to define precisely what we mean by the *tempo* of change, because we shall not deem a short-term forecast to be unduly optimistic if we make it on the understanding that:

- the tempo will increase no further;
- experience to date has shown that the tempo has been lately increasing.

To define it we need to remind ourselves that a 10 per cent. drop from a 30 per cent. level is *proportionately* three times as great as a 10 per cent. drop from a 90 per cent. level, and that a drop of 4 per cent. from a 30 per cent. level is indeed proportionately equivalent to a drop of 12 per cent. from a 90 per cent. level. A 1 per cent. drop from 2 to 1 per cent. is equivalent to a 50 per cent. reduction whereas a 1 per cent. drop from 50 to 49 per cent. is equivalent to only a 2 per cent. reduction. Thus an ordinary graph of rates against time will disclose a linear decline for the sequence 90, 80, 70, 60, 50 . . . whereas the proportionate decline will follow the course: . . . 11.1, 12.5, 14.3, 16.7 . . . The optical illusion disclosed by an ordinary graph of rates against time disappears when we plot the sequence on semi-log paper (Fig. 2, opposite). A fixed proportionate decline then follows the course of a straight line and an increasing proportionate decline the course of a line concave downwards. Since we speak of the tempo of decline as increasing or diminishing when the proportionate decrease is increasing or diminishing, the writer has plotted rates referable to each cause of death on a semi-log grid to get a general picture of the period; but all the data relevant to subsequent remarks about the changing tempo are to hand in Table IV.

These refinements of discourse are still necessary, because we too often read of “striking trends” when it is not quite clear what the word “trend” means in the context. If we look at the period from 1911–51, during which we can say with certainty that there has been a sustained decline of the infant death rate, we may distinguish four phases (Fig. 1):

- a decennium of quick tempo, circa 1913–22;
- a quinquennium of steady tempo, circa 1923–28;
- three quinquennia of increasing tempo, 1929–43;
- a quinquennium of quick tempo, 1944–49.

FIG. 2.—Logarithmic and arithmetic scales compared for diarrhoea and enteritis, 1911–50 (annual rates).

A superficial view of the increasing tempo during the period which covers the great depression and the beginning of a world war might lead us to be elated or depressed to the extent that we embrace a superficial eugenic or a superficial environmental view of the situation. The fact is that all short-term interpretations of time sequences of this sort are liable to error for several reasons, more especially the following:

(i) The date at which a measure of social reform receives its legal sanction may be many years before its full factual implementation, the implementation being gradual, not necessarily at an even tempo. We have but to think of the Multilateral School or Group Practice provisions of recent Acts. These likewise recall the law's delays and the lethargy of office after the Education Act of 1902, and the Act which replaced the Local Government Board by the Ministry of Health nearly 20 years later.

(ii) Similar remarks apply to the introduction of curative treatments, and in some measure to preventive procedures, if brought in by permissive legislation. The discovery itself may date from the year in which a few in the forefront of medicine first used a new treatment; but the education of the profession to use it sagaciously is a long story and the tempo of competent use is difficult to assess.

(iii) In any period, several putatively contributory agencies may be operative. To disentangle their several, not necessarily complementary effects, would be extremely difficult, if, as is often the case, we have no more to guide us than the date of an Act of Parliament or of a publication in a learned journal.

(iv) Agencies which may appear to have great importance in the light of later knowledge may be unsuspected till many years after they have ceased to be operative.

What we can discuss informatively with confidence is what individual diseases contributed more or less to the toll of infant mortality in the four periods we have here found it descriptively convenient to distinguish. The basic data are given in Table I, and Tables II–IV (overleaf) are based thereon to clarify their interpretation. If we loosely use the term *disease* for an entry on the death certificate, in contradistinction to a differential diagnosis, we may say that sixteen diseases appear ostensibly as causes of 91 per cent. of all infant deaths at the beginning and 87 per cent. at the end of the 40-year period.

The most spectacular event of the first period is the decline of summer diarrhoea. This is not a particularly novel disclosure, but it has an interest *vis-à-vis* (iv) above. It occurred in the decade of the swat-the-fly campaign and of the cheapening of motor transport which led to a reduction in the horse manure which encouraged the breeding of flies. How much the decrease in the fly population had to do with the decline of summer diarrhoea, no one can safely say. What we can say is that this guess is

TABLE I
QUINQUENNIAL AVERAGE RATES OF INFANT MORTALITY

Cause of Death	1911–15	1916–	1921–	1926–	1931–	1936–	1941–	1946–50
1 Diarrhoea and Enteritis	19.05	9.46	7.83	6.42	5.62	4.94	4.96	3.35
2 Pneumonia	10.86	10.81	10.63	10.44	9.40	8.62	8.21	5.78
3 Tuberculosis	3.06	2.03	1.36	1.06	0.81	0.59	0.52	0.29
4 Non-meningococcal Meningitis	1.26	0.88	0.65	0.45	0.38	0.34	0.28	0.22
5 Whooping Cough	4.06	3.06	2.89	2.54	1.62	1.10	1.06	0.56
6 Diphtheria	0.24	0.23	0.19	0.19	0.10	0.10	0.07	0.01
7 Congenital Syphilis	1.41	1.76	1.05	0.70	0.38	0.19	0.18	0.09
8 Influenza	0.31	1.46	0.76	0.68	0.59	0.41	0.34	0.19
9 Measles	2.93	1.79	1.29	1.22	0.84	0.50	0.33	0.15
10 Bronchitis	8.26	8.04	5.25	3.74	3.35	2.31	1.93	0.86
11 Premature Birth	19.57	19.59	18.09	17.87	17.14	15.27	12.88	8.52
12 Congenital Malformation	3.81	4.03	4.16	4.92	6.02	6.32	6.04	4.75
13 Congenital Debility	12.56	9.78	6.07	4.11	2.89	2.05	1.42	0.55
14 Atelectasis and Asphyxia	1.69	1.58	1.53	1.56	1.87	2.15	2.15	3.05
15 Convulsions	8.75	6.88	4.27	2.76	1.93	1.29	0.86	0.26
16 Birth Injury	1.12	1.14	1.37	1.88	2.34	2.68	2.51	2.65
17 Remainder	9.94	8.73	7.05	6.93	6.51	6.49	6.54	4.82
Total	108.88	91.25	74.44	67.47	61.79	55.35	50.28	36.10

as good as any, and if true was obvious at the time neither to vital statisticians with eugenic prejudices nor to those with a sympathetic ear to the local medical officer of health.

In the same period, we note an appreciable decline but at a slower tempo of infections including tuberculosis but excluding pneumonia. Pneumonia shows a slight decline from 1916-30 but declines at a quicker

TABLE II
PERCENTAGE CAUSE OF INFANT MORTALITY

Cause of Death	1911-15	1916-	1921-	1926-	1931-	1936-	1941-	1946-50
1 Diarrhoea and Enteritis ..	17.5	10.4	10.5	9.5	9.1	8.9	9.9	9.3
2 Pneumonia ..	10.0	11.8	14.3	15.5	15.2	15.6	16.3	16.0
3 Tuberculosis ..	2.8	2.2	1.8	1.6	1.3	1.1	1.0	0.8
5 Non-meningococcal Meningitis ..	1.2	1.0	0.9	0.7	0.6	0.6	0.6	0.6
5 Whooping Cough ..	3.7	3.4	3.9	3.8	2.6	2.0	2.1	1.6
6 Diphtheria ..	0.2	0.3	0.3	0.3	0.2	0.2	0.1	—
7 Congenital Syphilis ..	1.3	1.9	1.4	1.0	0.6	0.3	0.4	0.2
8 Influenza ..	0.3	1.6	1.0	1.0	1.0	0.7	0.7	0.5
9 Measles ..	2.7	2.0	1.7	1.8	1.4	0.9	0.7	0.4
10 Bronchitis ..	7.6	8.8	7.1	5.5	5.4	4.2	3.8	2.4
11 Premature Birth ..	18.0	21.5	24.3	26.5	27.7	27.6	25.6	23.6
12 Congenital Malformation ..	3.5	4.4	5.6	7.3	9.7	11.4	12.0	13.2
13 Congenital Debility ..	11.5	10.7	8.2	6.1	4.7	3.7	2.8	1.5
14 Atelectasis and Asphyxia ..	1.6	1.7	2.1	2.3	3.0	3.9	4.3	8.4
15 Convulsions ..	8.0	7.5	5.7	4.1	3.1	2.3	1.7	0.7
16 Birth Injury ..	1.0	1.2	1.8	2.8	3.8	4.8	5.0	7.3
17 Remainder ..	9.1	9.6	9.5	10.3	10.5	11.7	13.0	13.4
Total ..	100	100	100	100	100	100	100	100

TABLE III
PROPORTIONATE MEAN QUINQUENNIAL INFANT MORTALITY RATES

Cause of Death	1911-15	1916-	1921-	1926-	1931-	1936-	1941-	1946-
1 Diarrhoea and Enteritis ..	100	49.7	41.1	33.7	29.5	25.9	26.0	17.6
2 Pneumonia ..	100	99.5	97.9	96.1	86.6	79.4	75.6	53.2
3 Tuberculosis ..	100	66.3	44.4	34.6	26.5	19.3	17.0	9.5
5 Non-meningococcal Meningitis ..	100	69.8	51.6	35.7	30.2	27.0	22.2	17.5
5 Whooping Cough ..	100	75.4	71.2	62.6	39.9	27.1	26.1	13.8
6 Diphtheria ..	100	95.8	79.2	79.2	41.7	41.7	29.2	4.2
7 Congenital Syphilis ..	100	124.8	74.5	49.6	27.0	13.5	12.8	6.4
8 Influenza ..	100	471.0	245.2	219.4	190.3	132.3	109.7	61.3
9 Measles ..	100	61.1	44.0	41.6	28.7	17.1	11.3	5.1
10 Bronchitis ..	100	97.3	63.6	45.3	40.6	28.0	23.4	10.4
11 Premature Birth ..	100	100.1	92.4	91.3	87.6	78.0	65.8	43.5
12 Congenital Malformation ..	100	105.8	109.2	129.1	158.0	165.9	158.5	124.7
13 Congenital Debility ..	100	77.9	48.3	32.7	23.0	16.3	11.3	4.4
14 Atelectasis and Asphyxia ..	100	93.5	90.5	92.3	110.7	127.2	127.2	180.5
15 Convulsions ..	100	78.6	48.8	31.5	22.1	14.7	9.8	3.0
16 Birth Injury ..	100	101.8	122.3	167.9	208.9	239.3	224.1	236.6
17 Remainder ..	100	87.8	70.9	69.7	65.5	65.3	65.8	48.5
Total ..	100	83.8	68.4	62.0	56.8	50.8	46.2	33.2

TABLE IV
TEMPO OF CHANGE

Each figure cited for a given quinquennium is the quinquennial rate expressed as a percentage of that of the previous quinquennium to exhibit the tempo of decline

Cause of Death	1916-20	1921-25	1926-30	1931-35	1936-40	1941-45	1946-50
1 Diarrhoea and Enteritis ..	49.7	82.8	82.0	87.5	87.9	100.4	67.5
2 Pneumonia ..	99.5	98.3	98.2	90.0	91.7	95.2	70.4
3 Tuberculosis ..	66.3	67.0	77.9	76.4	72.8	88.1	55.8
5 Non-meningococcal Meningitis ..	69.8	73.9	69.2	84.4	89.5	82.4	78.6
5 Whooping Cough ..	75.4	94.4	87.9	63.8	67.9	96.4	52.8
6 Diphtheria ..	95.8	82.6	100.0	52.6	100.0	70.0	14.3
7 Congenital Syphilis ..	124.8	59.7	66.7	54.3	50.0	94.7	50.0
8 Influenza ..	471.0	52.1	89.5	86.8	69.5	82.9	55.9
9 Measles ..	61.1	72.1	94.6	68.9	59.5	66.0	45.5
10 Bronchitis ..	97.3	65.3	71.2	89.6	69.0	83.5	44.6
11 Premature Birth ..	100.1	92.3	98.8	95.9	89.1	84.3	66.1
12 Congenital Malformation ..	105.8	103.2	118.3	122.4	105.0	95.6	78.6
13 Congenital Debility ..	77.9	62.1	67.7	70.3	70.9	69.3	38.7
14 Atelectasis and Asphyxia ..	93.5	96.8	102.0	119.9	115.0	100.0	141.9
15 Convulsions ..	78.6	62.1	64.6	69.9	66.8	66.7	30.2
16 Birth Injury ..	101.8	120.2	137.2	124.5	114.5	93.7	105.6
17 Remainder ..	87.8	80.8	98.3	93.9	99.7	100.8	73.7
Total ..	83.8	81.6	90.6	91.6	89.6	90.8	71.8

tempo after 1931. That the sulphonamides played some part in this is not unlikely; but the decline had noticeably gained momentum in the quinquennium (1931–35) before the introduction of sulphapyridine.

An outstanding feature of the last decade—our fourth period—is the tempo of decline of deaths attributed to premature births and the evanescent contribution of the infections—including tuberculosis. The *hard-core* of death categories of which we can record no sustained decline subsumes three major items:

- (i) birth injuries;
- (ii) asphyxia and atelectasis;
- (iii) congenital malformations.

It is noteworthy both that the decade of mass unemployment signalizes no rise of any rate already declining, and that the present phase of higher tempo starts before the end of the second world war, when there was a great housing shortage. Neither the one nor the other indicates that remediable social evils play a minor or trivial role in determining the incidence of infant deaths; but if not, one conclusion is inescapable.

The cumulative effects of other agencies which had been gaining momentum in the antecedent period exercised an overriding effect in sustaining a decline which, but for these evils, would otherwise have proceeded at a much higher tempo. In short, we see in the health statistics of the 20th century an *inertia* which we may regard as the result of many *conceivably* contributory agencies not necessarily operating towards the same end: immunization, new therapies and free clinics, higher standards of medical and general education, improved sanitation, cleaner and dung-free roads, fewer flies, slum clearance and housing shortages, free meals and unemployment, sterile milk bottles, hire-purchase vacuum cleaners, new standards of personal cleanliness with a concomitant reduction of fleas and lice. Thus, the very complexity, which defies legitimate confidence in evaluation of the causal nexus in a time sequence, *operates to counteract any abrupt reversal of an established trend.*

For this reason, in short because the immediate future has been already conceived in the womb of the immediate past, we can take stock of the present situation in the light of past experience to forecast with some assurance an upper and a lower limit to the probable infant death rate at the end of the decade.

The outstanding features of the present situation are as follows:

Causes of Death	Average Rate (per thousand) 1946–50	As Percentage of 1941–45 Rate
Premature Birth ..	8.52	66.1
Pneumonia ..	5.78	70.4
Other Infections ..	5.72	59.2
Hard-Core ..	10.45	(97.7)
Remainder ..	5.63	63.8
Total	36.10	—

The figure in brackets against “Hard-Core” is not meaningful. The diseases included have not displayed any evidence of a decline, but have fluctuated throughout the period. The recorded figure (10.45) for 1946–50 is actually higher than for the quinquennium 1911–15 (6.62). Clearly an overall reduction of 50 per cent. referable to other categories in the decade 1951–60 is not unduly optimistic. This would bring the annual rate down to about 23.3, a figure which is still above that recorded in 1950 for Northampton, *viz.* 18. The writer hopes in a later communication to sharpen the outlines of the background picture for such a prognosis by analysis of local variations from sources other than the annual review of the Registrar General. Meanwhile, however, it will help us to an intelligent anticipation of the immediate future if we consider the main lethal diseases in greater detail, to bring the inertia of change into sharper focus. For sources and materials the reader may refer to the Appendix.

2. THE INERTIA OF CHANGE

Of the sixteen so-called causes of death only three retrogress frequently in the period 1911–51. These are the three categories (12, 14, and 16 in Tables I–III) already designated the “hard-core”. If we regard as *no change* a trivial rise of the death rate for diarrhoea and enteritis during the second war (from 4.94 for 1936–40 to 4.96 for 1941–45), there is only one exception to the rule that the hard-core accounts for every increase of a specific quinquennial rate to a higher level than that of its predecessor. The exception (influenza (8) in the quinquennium of the great epidemic after the first world war) scarcely calls for comment. This appears from the following figures for crude increases and decreases:

Quinquennium		1916 to 1920	1921 to 1925	1926 to 1930	1931 to 1935	1936 to 1940	1941 to 1945	1946 to 1950
Change* in 16 Causes	None ..	2	—	1	—	1	2	—
	Fall ..	10	14	12	13	12	14	14
	Rise ..	4	2	3	3	3	—	2
No. of Rising Causes .. (see Table III)		8, 12, 14, 16	12, 16	12, 14, 16	12, 14, 16	12, 14, 16		14, 16

* One per cent has been the critical level for assessing a change.

Seen in these terms, the period 1911–51 is a record of consistent progress, except in so far as the hard-core fluctuates without any indication of progression. This uniformity takes no stock of the *tempo* of change. A different picture emerges, Table IV, if we classify the period in terms of disease rates which show a higher, lower or zero proportionate change, as below:

Quinquennium		1916 to 1920	1921 to 1925	1926 to 1930	1931 to 1935	1936 to 1940	1941 to 1945	1946 to 1950
Disease Rates	Rise	4	7	12	7	4	8	2
	Fall	10	9	2	9	10	7	14
	No Change	2	1	2	—	2	1	—

This exhibits clearly the force of previous remarks with reference to the period of unemployment and to the second world war. It sufficiently justifies a rough and ready four-fold division of the period as above. As elsewhere stated, the worst quinquennium is 1926–30—immediately *before* the great depression, and it would be idle to attempt an explanation of this.* It merely illustrates the difficulties of interpreting a time sequence when an agency dated on paper at D may not become fully operative in practice till $D + x$, the x being unknown. From our present viewpoint, what it brings into focus most clearly is that the last two quinquennia have witnessed a steepening decline embracing nearly all categories other than the hard-core. From our experience of the inertia of change during the past 50 years, we may anticipate with little misgiving that external events other than an atomic war will accomplish no more than a retardation of the present tempo of decline in the forthcoming decade.

3. DISEASE PATTERNS

The unwisdom of seeking to isolate any social agencies responsible for a declining total death rate comes into focus when we compare more closely the courses pursued by each of the thirteen lethal diseases which have consistently and concurrently declined in the period covered by Tables I–III. As Table II shows, the proportionate contribution of all epidemic or communicable diseases has declined from 47·3 per cent. in 1911–15 to 31·8 per cent. in 1946–50. For the same periods diarrhoea and enteritis contributed 17·5 per cent. in 1911–15 and 9·3 per cent. in 1946–50, pneumonia 10 per cent. in 1911–15 and 16·0 per cent. in 1946–50. In the

absence of any indications that the hard-core will yield, the *pace-makers* of decline in the forthcoming decade will be pneumonia, diarrhoea and enteritis, and premature birth, their proportionate contributions in 1946–50 being respectively 16, 9·3, and 23·6 per cent. (in all 48·9 per cent.). The proportionate contribution of the hard-core was then 28·9 per cent.

FIG. 3.—Infantile death rates for the "hard-core", 1911–50.

Of the communicable and epidemic diseases, some (notably *diphtheria* and *measles*) have virtually disappeared as ostensible causes of infant deaths. In disappearing they have lost the statistical *facies* of the epidemic category. The annual figures no longer record such violent fluctuations for whooping cough or for diarrhoea and enteritis. This is not true of influenza, but the highest quinquennial rate recorded for influenza is 1·46 per thousand (1916–20), and the highest annual rate over the same period (1911–50) is 3·73 for 1918. This means that a large-scale influenza epidemic might appreciably compromise a reasonable single year forecast, say for 1960; but not greatly the quinquennium of which it is the mid-year. Otherwise, the lethal diseases which call for special comment are:

- (1) *Diarrhoea and Enteritis*.—Table IV discloses four phases of a sustained decline: quick tempo 1911–20, steady slow tempo 1921–40, no change 1941–45, quick tempo 1946–51.
- (2) *Pneumonia* declined at a steady slow tempo from 1911–45. The quinquennium 1946–50 records a quick tempo of decline.
- (3) *Premature Births* declined at a steady slow tempo from 1921–45. The quinquennium 1946–50 records a quick tempo of decline.

* The general strike, of course, occurred in 1926, and before and after this date there was large-scale unemployment in the coal mining districts. It may well have been that these areas of notoriously high mortality were partly responsible for the substantial increases recorded for England and Wales.

The foregoing remarks show that the last quinquennium signalizes a new rapid tempo of decline for each of the three so-called causes of death specified above as the pace-makers of the current situation. The same remarks apply specifically to diphtheria, non-meningococcal meningitis, tuberculosis, diphtheria, whooping cough, influenza, congenital syphilis, measles, and bronchitis, diseases whose individual contribution is trivial, though collectively appreciable. With three exceptions all the communicable and epidemic diseases have consistently declined as so-called causes of death throughout the whole period 1911–50. The exceptions, other than diarrhoea and enteritis (1941–45), are influenza and congenital syphilis, which declined from 1921–25.

However, the tempo of decline is very variable. Diphtheria declined as a cause of infant deaths very slowly till the quinquennium 1941–45, then with gathering momentum. Congenital syphilis declined rapidly after 1920 except during the second world war (1941–45), which almost completely arrested the decline. For meningitis (non-meningococcal) and whooping cough, the quinquennium 1916–20 registers rapid decline, the next quinquennium a slow one. The reverse is true of influenza and bronchitis. The tempo of decline for measles remained fairly rapid throughout the period, except in the quinquennium 1926–30; nonetheless, the increased tempo of decline in the quinquennium 1946–50 is outstanding. Further comment is unnecessary. The Tables show that agencies contributory to the composite picture of a sustained decline clearly discriminate between different diseases, whence no attempt to identify the causal nexus is likely to succeed without due regard to the specific disease components.

4. STILLBIRTHS AND NEONATAL MORTALITY

Our specification of the hard-core on the one hand and of premature birth on the other as one of the three pace-makers in the present situation calls for a brief comment on neonatal mortality and stillbirths. Table V cites all infant (under one year) and neonatal (first month) annual death rates for the 40-year period, together with annual stillbirth rates since they were first officially recorded as such. Both columns exhibit what we all know and what we might

TABLE V
TOTAL INFANT MORTALITY, NEONATAL MORTALITY,
AND STILLBIRTH RATE

Year	Total Infant Mortality		Neonatal Mortality		Stillbirth Rate	
1911	129.4	1,000	40.6	1,000	—	—
1912	94.6	731	38.4	946	—	—
1913	108.8	841	39.5	973	—	—
1914	104.5	808	38.5	948	—	—
1915	107.2	828	37.7	929	—	—
1916	90.2	697	36.9	909	—	—
1917	91.7	709	37.1	914	—	—
1918	96.9	749	36.6	901	—	—
1919	90.3	698	40.4	995	—	—
1920	87.2	674	35.0	862	—	—
1921	79.7	616	35.2	867	—	—
1922	75.1	580	33.9	835	—	—
1923	68.8	532	31.9	786	—	—
1924	74.2	573	33.0	813	—	—
1925	74.4	575	32.3	796	—	—
1926	69.7	539	31.8	783	—	—
1927	68.4	529	32.2	793	—	—
1928	65.3	1,000	31.1	1,000	40.1	1,000
1929	73.8	1,130	32.8	1,055	40.0	998
1930	60.1	920	30.9	994	40.8	1,017
1931	65.8	1,008	31.5	1,013	40.9	1,020
1932	64.5	988	31.5	1,013	41.3	1,030
1933	62.6	959	32.1	1,032	41.4	1,032
1934	59.1	905	31.4	1,010	40.5	1,010
1935	57.0	873	30.4	977	40.7	1,015
1936	58.7	899	30.2	971	39.7	990
1937	57.8	885	29.7	955	39.0	973
1938	52.9	810	28.3	910	38.3	955
1939	50.6	775	28.3	910	38.1	950
1940	56.7	868	29.6	952	37.2	928
1941	59.3	908	29.0	932	34.8	868
1942	51.2	784	27.2	875	33.2	828
1943	49.6	760	25.2	810	30.1	751
1944	45.7	700	24.4	785	27.6	688
1945	45.6	698	24.8	797	27.6	688
1946	43.1	660	24.5	788	27.2	678
1947	42.7	654	22.7	730	24.1	601
1948	33.2	508	19.7	633	23.2	579
1949	32.1	492	19.3	621	22.7	566

expect from the components of the hard core, viz. that both the stillbirth rate and the neonatal birth rate have declined less steeply than the total infant death rate. What is of more interest is whether the course of the stillbirth rate can throw any light on the vagaries of the hard-core, and hence on whether we need attach any importance to the fact that the recorded incidence of congenital malformations has declined steeply since the peak quinquennium of 1936–40. The quinquennial figures reveal no clear tie-up between stillbirths and deaths attributable to congenital malformations or to birth injuries; but stillbirths decline *pari passu* with a rise of deaths attributable to asphyxia and atelectasis. Till 1940 deaths due to congenital malformations rose while the total neonatal death rate was falling.

Cause of Death		1911–15	1916–21	1921–25	1926–30	1931–35	1936–40	1941–45	1946–50
1	Stillbirth	—	—	—	40.3*	41.0	38.5	30.7	24.3
2	Neonatal mortality	38.9	37.2	33.3	31.8	31.4	29.2	26.1	21.5
3	Congenital Malformation	3.81	4.03	4.16	4.92	6.02	6.32	6.04	4.75
4	Birth Injury	1.12	1.14	1.37	1.88	2.34	2.68	2.51	2.65
5	Atelectasis and Asphyxia	1.69	1.58	1.53	1.56	1.87	2.15	2.15	3.05
6	Total Infant Mortality	108.88	91.25	74.44	67.47	61.79	55.35	50.28	36.10

* 1928–30

The annual rates disclose a positive correlation (*product-moment*) of 0.56 between deaths attributable to birth injuries and deaths attributable to asphyxia and atelectasis for the period 1931-49. These were rising in 1941-49 while the death rate with regard to congenital malformations was falling (Fig. 3). Did considerable positive or negative correlation exist between the latter and stillbirths, we might venture to answer the question stated above in one way or another. As matters stand, we can make no reasonable forecast to the effect that the contribution of the hard-core to the infant death rate in the forthcoming decade will be a little higher or a little lower at the end of it.

5. IMMEDIATE PROSPECT

We have seen that the inertia of change encourages us to anticipate no abrupt reversal of a composite trend. If we assume that the mean tempo of change with regard to deaths attributable to all sources other than the hard-core stabilizes at the 1946-50 level, the figure we should assign to 1960 would lie in the range 20.3 to 22.3 on the alternative assumptions that the rate referable to the hard core remains at the 1950 level or retrogresses to the 1940 level. If we assign the peak quinquennial figure for the period 1911-50 as the hard-core quota of 1960, we get as the total rate 21.8. As stated, in any single year a grave epidemic of influenza might substantially raise the level. On a very conservative view, we may alternatively suppose that the decline continues at the tempo of the 1946-50 quinquennium, through the ensuing quinquennium without any further decline in the next. This would assign to 1960 a rate of about 26.5.

As a more optimistic view the figures cited in Table VI were obtained by a least-squares fit of a negative exponential to each item separately, the origin being the date at which the present phase appears to have begun.

In a recent communication (Taylor, 1952), the writer put forward the view that perhaps Pearson's pessimistic prognostication that attempts to reduce infant mortality are self-defeating inasmuch as they favour the survival of genetically inferior stock might soon prove to be correct, although it was certainly untrue in Pearson's own day. The results of this investigation show clearly that we are not yet near such a residual level of infant mortality. Moreover, the so-called *expectation of life* is increasing annually for all age groups, at a time when infant mortality rates are declining. Presumably therefore, Pearson's "genetically impoverished" children must be contributing to this progress. The writer accordingly adheres more firmly to his original view (Taylor, 1951) that we are nowhere near a state when further conservation of infant life will produce only such as fail to run their normal span of life.

6. SUMMARY

1. Throughout the period 1911-50, sixteen named categories of disease have been the ostensible cause of 87 per cent. or more of all infant deaths. With respect to all but three of these (*congenital malformations, birth injuries, and asphyxia or atelectasis*) herein called the *hard-core*, we may record a *sustained decline* in a sense precisely defined on p. 2.

2. For all categories except the *hard-core*, the last two quinquennia have witnessed an increasing tempo of decline in the sense precisely defined on p. 2.

TABLE VI
PRESENT AND PREDICTED INFANT MORTALITY RATES

Cause of Death		1940	1945	1950	1955	1960	1965
1	Diarrhoea and Enteritis	4.75	4.87	1.83	0.49	0.13	0.04
2	Pneumonia	8.02	6.94	6.01	5.21	4.51	3.91
3	Tuberculosis	0.55	0.39	0.29	0.21	0.15	0.11
4	Non-meningococcal Meningitis	0.29	0.23	0.18	0.14	0.11	0.08
5	Whooping Cough	1.14	0.78	0.53	0.36	0.25	0.17
6	Diphtheria	0.10	0.03	—	—	—	—
7	Congenital Syphilis	0.17	0.15	0.04	0.02	0.01	—
8	Influenza	0.47	0.26	0.14	0.08	0.04	0.02
9	Measles	0.36	0.20	0.12	0.07	0.04	0.02
10	Bronchitis	1.95	1.28	0.84	0.55	0.36	0.24
11	Premature Birth	16.58	10.97	7.26	4.81	3.18	2.11
12	Congenital Malformation	6.62	5.52	4.39	4.39	4.39	4.39
13	Congenital Debility	1.91	0.95	0.47	0.23	0.12	0.06
14	Atelectasis and Asphyxia	2.43	2.43	2.43	2.43	2.43	2.43
15	Convulsions	1.23	0.56	0.08	0.01	—	—
16	Birth Injury	2.62	2.62	2.62	2.62	2.62	2.62
17	Remainder*	7.38	5.73	4.08	3.24	2.75	2.43
Total		56.57	43.91	31.31	24.86	21.09	18.63

* The remainder has been taken as a constant 15 per cent. of all specific items, i.e. it is the least calculable and least reliable factor. The 1940 and 1945 values are not those recorded but those "expected" on the same basis as the extrapolation. It can be seen that in fact they differ little from the recorded values.

3. At the beginning of the 40-year period, the hard-core accounted for 6.1 per cent. of all infant deaths, at the end for 28.9 per cent. of all deaths. Thus we have still far to go before we can see the end of the continuous decline of the infant death rate during the 20th century.

4. In the absence of unforeseen agencies which will attack the hard-core, the pace-makers of decline in the forthcoming decade are *diarrhoea* and *enteritis*, *pneumonia*, and *premature birth*. These together accounted for 48.9 per cent. of all infant deaths in 1950.

5. Detailed study of the causes of death at different periods from 1900–50 lead us to conclude that a phase of decline has an inherent *inertia*, in virtue of which short-term extrapolation is legitimate with due reservations. With such reservations, we have seen good reason to anticipate in 1960 an infant death rate not appreciably higher than 20 per 1,000.

6. With due regard to the components of the total infant death rate, one need anticipate no grounds for pessimism of the sort expressed by Karl Pearson until it has fallen far below what is likely to be the level in 1960. Indeed a reasonable target value is not much above 10, even on the conservative assumption that research into congenital malformations, birth injuries, or asphyxia and atelectasis makes little useful progress.

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APPENDIX

METHOD AND THE INTERNATIONAL CLASSIFICATION

Since 1911 several major changes in the classification of cause of death in infant mortality returns (*vide infra*) have taken place. For this reason it is not possible merely to extract the mortality rates calculated annually by the Registrar General. For this communication, therefore, the number of deaths recorded for each specific cause have been extracted from the Annual Reviews, special regard being paid to changes of classification, and the rates have been calculated on a uniform basis throughout the period.

The greatest change in procedure came in 1940 when new rules for the classification of death resulting from several causes became operative. It has been possible and thought least misleading to locate this disjunction at the centre of the period, *i.e.* between 1930 and 1931. Thus with due reference to changing fashions in diagnosis, as discussed in the text, the values are strictly comparable from 1911 to 1930 and from 1931 to 1950. The break is quite unimportant for many causes of death. The exceptions to this are discussed in the text.

In 1950, when the sixth revision became operative, more changes were made. The effect of these may be summarized as in next column. The Registrar-General's

Tables give new figures back for 10 years. From these it is clear that:

Cause of Death	Change	Percentage of Previous Level
Pneumonia	higher	105
Influenza	lower	76
Bronchitis	lower	95
Premature Birth	lower	89
Congenital Malformations	lower	93
Convulsions	lower	89
Non-meningococcal Meningitis	slightly changed in definition, without great change in numbers recorded.	

Congenital Debility has been replaced by a new group (773) "Ill-defined diseases peculiar to early infancy". The reader can therefore make any requisite changes in the table of extrapolation based on the fifth classification.

In the twentieth century the International List of Causes of Death has been revised six times. Since the dates on which the revisions became operative are not the dates when the revisions were made and by which they are classified, which usually precede the operative dates by one or two years, it may help to classify the revisions as follows:

Revision	Date	When first used in England and Wales	Details Published
1st	1900	Never	—
2nd	1909	1911	Registrar-General's 74th Annual Report, 1911, p. viii.
3rd	1920	1921	Registrar-General's Stat. Review, Med., 1921, p. 482.
4th	1929	1931	Registrar-General's Stat. Review, Med., 1931, p. 401.
5th	1938	1940	Registrar-General's Stat. Review, Med., 1940, p. 321.
6th	1948	1950	Bulletin of the World Health Organization, Supplement 4, "Comparability of Statistics of Causes of Death according to the Fifth and Sixth Revisions of the International List".