STUDIES IN THE MEANING AND RELATIONSHIPS OF BIRTH AND DEATH RATES.

III.

The Constitution of a Death Rate.

By JOHN BROWNLEE, M.D., D.Sc.

(With 1 Chart.)

This is a particularly difficult branch of the subject to investigate. It might be thought at first sight that the death rates at different age periods might be compared, and this is often done; but when it is noted that the death rates at different age periods are organically connected, it is obvious that such a comparison is statistical or actuarial and completely neglects the biology of the subject. To illustrate the problem a diagram is given. This is constructed on a principle open to objection, but, if that is remembered, it illustrates a number of points. The healthy district life table H_2 has been taken as a standard of comparison. Now a healthy district life table labours under certain disadvantages. A district may, as the Register General says, be excluded because it contains an institution drawing its inmates from a wider district. This is not a serious objection. A more serious objection is the fact that whether deaths which might be considered to belong to the district are returned to it or not, the result is equally unsatisfactory. Everyone who has had practical experience knows many instances in which it is impossible to allocate a death to the district to which it properly belongs. When all is balanced, I think that probably on the whole the healthy districts get credit for more than their share of deaths, that is, for more deaths than would occur if there was no process of intermingling of town and country. For one death the town gets credit for, the country gets credit for another, in the one case some old person dying of a cancer in a hospital, in the other, some poor young person, who having tried city life, returns broken, to die of phthisis or some similar disease. Thus a healthy district life table is open to objection as a criterion. It is, however, for the purpose at present required, the only one at our disposal.

https://doi.org/10.1017/S0022172400006094 Published online by Cambridge University Press

TABLE I. *Showing relations of death rates at different ages in different districts to healthy districts of England,* 1891–1900.

	Death rates at different ages		Ratio of death rates in several life tables to those of H_2											
	H_2		H_1		E_3		E_4		Scotland		Salford		Manchester	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0	132·074	101·327	0·98	0·98	1·36	1·41	1·46	1·52	1·21	1·26	2·29	2·42	1·66	1·73
1	28·500	26·421	1·18	1·15	2·07	2·05	1·92	1·92	1·91	1·95	3·39	3·59	3·26	3·11
2	10·100	10·355	1·31	1·22	2·39	2·25	2·08	1·96	2·22	2·14	4·00	3·67	3·72	3·50
3	7·386	7·093	1·23	1·22	2·10	2·15	1·80	1·89	1·81	1·91	3·11	3·14	3·31	3·28
4	5·787	5·657	1·23	1·18	1·98	1·96	1·68	1·70	1·62	1·72	2·63	3·21	2·95	3·08
5	4·551	4·489	1·22	1·15	1·84	1·76	1·57	1·58	1·45	1·51	1·94	1·76	2·86	3·06
6	3·680	3·662	1·18	1·11	1·64	1·51	1·42	1·43	1·51	1·61	1·82	1·92	3·01	3·17
7	2·999	3·037	1·14	1·09	1·44	1·27	1·28	1·29	1·59	1·67	1·84	1·99	3·16	3·23
8	2·504	2·588	1·09	1·08	1·26	1·06	1·17	1·18	1·61	1·73	1·84	1·93	3·22	3·21
9	2·165	2·300	1·06	1·09	1·11	0·89	1·10	1·10	1·62	1·68	1·71	1·83	3·21	3·06
10	1·966	2·139	1·05	1·11	1·00	0·78	1·09	1·08	1·62	1·69	1·62	1·64	3·08	2·83
15	2·376	2·913	1·16	1·14	1·21	1·01	1·29	1·05	1·63	1·60	1·52	1·24	1·79	1·36
20	3·793	3·981	1·10	1·17	1·27	1·23	1·21	1·04	1·65	1·43	1·74	1·13	1·46	1·27
25	4·939	4·491	1·10	1·25	1·29	1·39	1·15	1·12	1·47	1·46	1·52	1·25	1·69	1·66
30	5·286	5·021	1·23	1·32	1·58	1·58	1·27	1·23	1·45	1·63	1·54	1·58	2·23	2·03
35	6·261	5·757	1·18	1·27	1·64	1·61	1·44	1·36	1·50	1·64	1·59	1·90	2·50	2·22
40	7·569	6·823	1·15	1·16	1·67	1·55	1·58	1·47	1·54	1·54	2·51	2·14	2·65	2·26
45	9·323	7·834	1·13	1·14	1·69	1·59	1·60	1·50	1·58	1·52	2·67	2·41	2·70	2·45
50	12·545	10·215	1·06	1·09	1·59	1·54	1·56	1·47	1·52	1·53	2·42	2·39	2·53	2·47
55	16·551	14·108	1·07	1·07	1·59	1·50	1·57	1·45	1·71	1·50	2·42	2·41	2·53	2·42
60	24·946	21·894	1·02	1·00	1·47	1·35	1·47	1·36	1·48	1·35	2·49	2·27	2·30	2·16
65	36·387	32·355	1·04	1·03	1·43	1·33	1·40	1·32	1·38	1·37	2·17	2·04	2·20	2·12
70	58·545	52·270	0·99	1·00	1·28	1·23	1·28	1·23	1·23	1·17	1·72	1·80	1·90	1·82
75	95·095	85·099	0·98	0·98	1·16	1·14	1·17	1·15	1·17	1·05	1·99	1·98	1·60	1·56
80	151·442	134·717	1·00	0·99	1·09	1·09	1·09	1·09	0·96	0·99	1·07	0·96	1·36	1·32
85	234·018	206·615	1·03	1·01	1·06	1·05	1·02	1·04	0·95	0·99	0·98	1·52	1·18	1·13
90	349·364	306·353	1·08	1·03	1·06	1·03	0·98	0·99	1·08	1·06	1·06	0·78	1·06	0·96
95	503·268	439·205												
100	694·444	608·696												

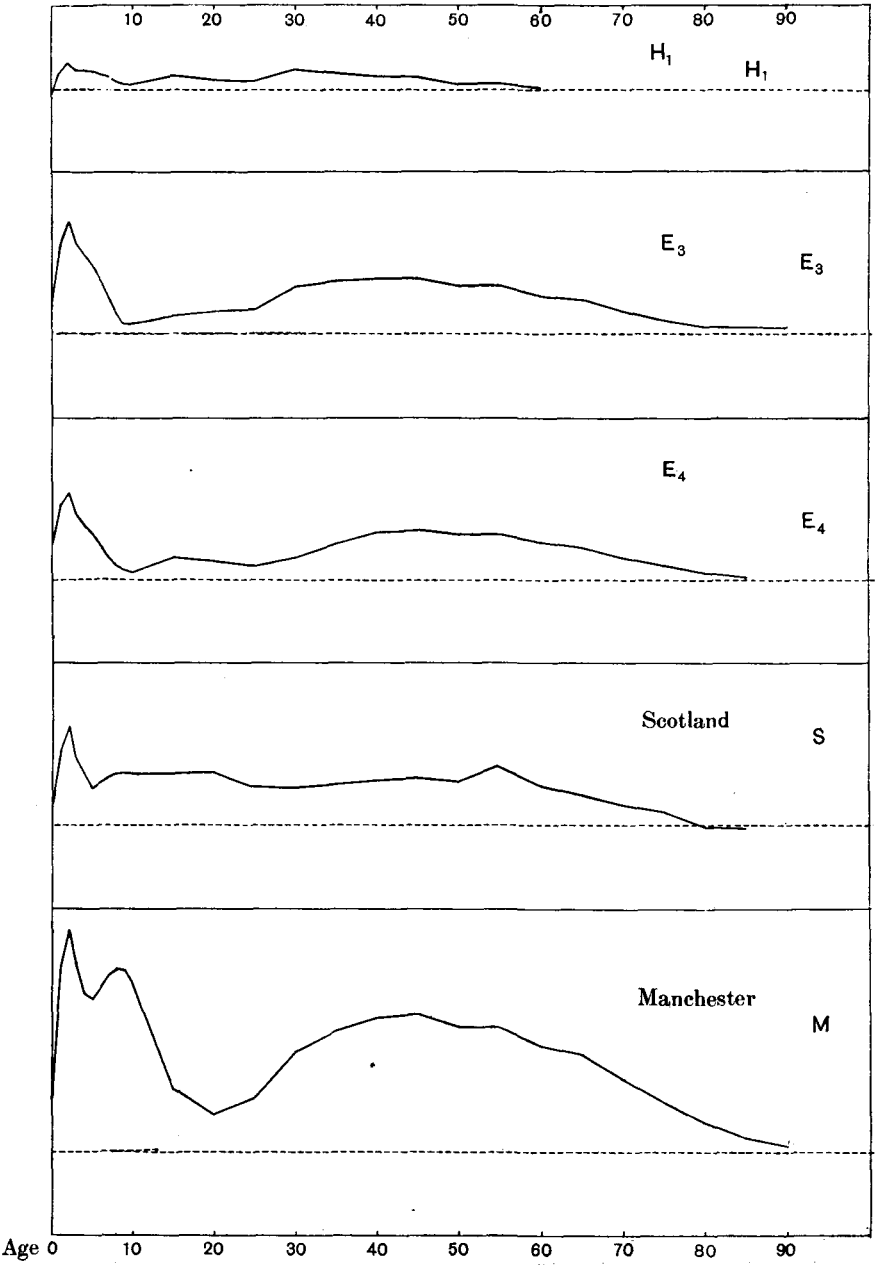

Diagram showing graphically the relationships of some of the figures given in Table I.

https://doi.org/10.1017/S0022172400006094 Published online by Cambridge University Press

The method employed is as follows: A series of life tables have been taken. The death rates have been calculated for each year of age of life from 0 to 10 and thereafter at quinquennial intervals 15, 20, 25, etc. The death rates of the life table H_2 at each age have been taken as unity and all the other tables reduced in this proportion. These comparative rates are given in Table I for the life tables H_1, E_3, E_4, Scotland, Salford and Manchester, and may be there studied at leisure. For ease of observation the values for the male sex alone have been graphically expressed in the Diagram. It will be noticed that the general form of the curves is the same. There are two maxima in each case, one between the ages of two and three years, and another about the age of forty. This is observed in every case; it is not an arbitrary phenomenon due to district. It is true that each life table has points of difference more or less special to itself, but the main features are the same. Now this clearly means that life as a whole responds in quite a definite manner to healthy or unhealthy surroundings. An excess of mortality in the first year of life is followed by a greater excess in the third, and an excess of mortality in the twentieth year is followed by a correspondingly greater excess in the fortieth. What appears a trivial increase of the death rate at the age of twenty is, however, a certain prognostic of something far from trivial when the age of forty is reached. For this low mortality in towns at twenty years of age is not due to immigration from the country. Such immigration is much less than that required to produce the defect. It is an expression of a phase in the relations of life to its surroundings, a phase not to be isolated and considered separately.

How then is it possible to form any estimate as to the extent a death rate differs from what might be expected from the general health or want of health of the district? I think it can be done to a certain extent by a process of prediction.

The tables H_2, H_1, E_4, E_3 have all been constructed by the same process, and they all are based on large populations, the two latter on the whole population of England. They represent the most definite information that can be obtained from the country at present. Taking the reciprocal of the expectation at birth, or the life table death rate (R) as the standard of comparison, the unit to which all is to be reduced, and denoting the death rate at any age x as r_x, a relationship $r_x = mR + c$ (when m and c are constants) is assumed. This assumption is justified by the results; it is only one of many other relationships of the same

kind which are found to be described almost truly by straight lines. The values obtained are given in Table II.

These values of m and c are used to predict the corresponding mortalities at all ages in four different countries and towns: Scotland, Manchester, London and Salford. In predictions like these a 10 per cent. variation might easily be observed, accounted for, firstly, by the roughness of the method, and secondly, by the processes employed in smoothing crude statistics to form life tables. In all instances

TABLE II. *Showing the values of constants* m *and* c *used for predicting death rates at different ages.*

	Males		Females	
Age	m	c	m	c
0	14·95	−155·33	15·46	−179·24
2	3·07	− 47·25	3·45	− 51·10
4	1·18	− 16·10	1·43	− 19·83
6	·459	− 4·81	·517	− 5·59
8	·123	·25	·063	1·61
10	·009	1·85	− ·091	3·89
15	·114	·39	− ·018	3·45
20	·204	·07	·100	2·46
25	·255	·27	·236	·63
30	·484	− 3·44	·473	− 2·78
35	·796	− 8·47	·727	− 6·78
40	1·17	− 14·35	·991	− 10·61
45	1·52	− 19·16	1·26	− 14·50
50	1·89	− 24·00	1·55	− 17·38
55	2·50	− 30·83	2·00	− 21·58
60	3·14	− 34·98	2·55	− 24·35
65	3·97	− 38·98	3·27	− 26·39
70	4·50	− 27·91	4·00	− 20·24
75	4·56	6·75	4·27	7·04
80	3·85	77·39	4·00	61·57
85	2·00	199·22	2·91	154·30

the average percentage error is much below this. The correspondence is in fact so close that it must be assumed that the variations of the death rates at different ages are organically connected. As regards the results it is found that for practically any age, at ages above twenty-five years, the theoretical death rate predicted by this method corresponds with the actual in the range of experimental error. Under twenty-five years certain differences make themselves apparent. If the infantile death rate predicted is found to be equal to that actually observed, the correspondence between the predicted and actual values of the death rate for the whole life is very close. Examples of this

are shown in the life tables for London and Salford for the decade 1891–1900. In London the correspondence is almost absolute, except at the age of 10. In Salford it is not nearly so absolute, but as the actual figures for Salford are not so continuous, due apparently to the small numbers on which the table is based, individual differences are larger. The special discrepancy about the age of 10 in both instances is probably due to the fact that in the neighbourhood of this age the minimum death rate exists, and in the neighbourhood of a minimum the methods of life table approximation are open to special error.

Taking the life table for Scotland, a different condition of affairs is seen. Scotland varies markedly from England in the comparative absence of summer diarrhoea, with the result that the infantile death rate predicted from the English life tables is twenty per thousand in excess of the actual infantile death rate of Scotland. For the next few years till the age of six is attained there is no appreciable difference between the actual and the predicted death rates, but this defect in the infantile death rate is balanced by the excess of the actual death rate over the theoretical between that age and the age of thirty, after which the population in Scotland shows essentially the same mortalities as the English tables, used in the manner described, predict.

Of the same phenomenon, Manchester affords a striking example, in curious distinction to the neighbouring town of Salford. In this case the predicted infantile death rate is 55 per thousand in excess of that observed. The period of life at which the compensation begins is from one to two years earlier than that in Scotland, the actual death rate at six years of age being twenty-five per cent. in excess. Matters adjust themselves also at a somewhat earlier age, since by the time twenty years is attained, the actual and theoretical death rates have come into correspondence. More especially when the township of Manchester and the outlying townships are severally examined, the same phenomena are observed, the points of difference not being sufficiently important to require special comment.

It is to be noted that the greater mortalities in Scotland and Manchester at the ages, approximately, of from six years to twenty-five years, though apparently excessive as rates in the sum correspond almost exactly to the number of deaths represented by the deficiency of the actual from the theoretical mortality at the age 0–1.

With regard to the mortalities of the adult population, it is evident from what has been said that practically the same result can be obtained

TABLE III. *Showing actual and predicted death rates, male and female, for London, Salford, Scotland and Manchester.*

	London				Salford			
	Actual		Theoretical		Actual		Theoretical	
	Male	Female	Male	Female	Male	Female	Male	Female
0	207·99	170·31	209·56	161·81	302·50	244·97	297·79	240·81
2	28·01	27·40	27·65	25·01	40·40	38·01	45·76	42·64
4	12·38	12·62	12·57	11·72	15·21	18·16	19·50	19·02
6	6·02	6·19	6·39	5·82	6·71	7·02	9·10	8·46
8	3·15	3·38	3·26	3·00	4·60	5·00	3·98	3·32
10	2·26	2·44	2·06	1·88	3·19	3·52	2·12	1·42
15	3·12	2·79	3·16	3·05	3·60	3·61	3·83	2·96
20	4·13	3·19	5·04	4·67	6·61	4·50	6·24	5·18
25	5·24	4·03	6·48	5·84	7·52	5·63	7·99	7·01
30	7·54	5·82	8·37	7·65	8·15	7·93	11·23	10·07
35	11·26	8·62	10·96	9·25	9·95	10·95	15·66	12·97
40	14·73	11·07	14·25	11·25	18·96	14·58	21·17	16·32
45	18·40	13·52	17·83	13·30	24·92	18·87	26·77	19·73
50	23·91	17·65	22·16	16·81	30·43	24·48	33·32	24·73
55	31·57	23·55	30·25	22·54	40·10	33·97	45·02	32·76
60	42·49	32·14	41·64	31·90	62·10	49·62	60·16	44·93
65	58·16	45·39	57·85	45·75	79·14	66·16	81·26	62·46
70	83·21	67·28	81·97	68·00	100·68	94·28	108·54	88·44
75	120·67	101·16	118·03	101·24	189·38	168·50	144·94	123·06
80	173·26	150·29	171·26	149·81	161·66	129·02	193·96	170·25
85	242·87	218·02	248·02	218·49	228·18	314·40	259·82	233·36

	Scotland				Manchester			
	Actual		Theoretical		Actual		Theoretical	
	Male	Female	Male	Female	Male	Female	Male	Female
0	158·97	127·89	179·05	146·35	219·44	174·97	275·51	223·03
2	22·38	22·13	21·39	21·56	37·53	36·25	41·19	38·67
4	9·39	9·75	10·17	10·29	17·09	17·44	17·75	17·38
6	5·57	5·89	5·45	5·30	11·08	11·63	8·41	7·86
8	4·03	4·47	3·00	2·94	8·07	8·30	3·80	3·25
10	3·18	3·62	2·05	1·97	6·05	6·06	2·10	1·52
15	3·86	4·66	2·93	3·07	4·26	3·97	3·66	2·98
20	6·27	5·68	4·63	4·57	5·54	5·06	5·94	5·06
25	7·27	6·57	5·96	5·60	8·36	7·47	7·61	6·77
30	7·65	8·18	7·38	7·18	11·79	10·20	10·50	9·53
35	9·38	9·45	9·34	8·53	15·64	12·76	14·47	12·14
40	11·68	10·52	11·86	10·26	20·08	15·45	19·42	15·18
45	14·72	11·93	14·73	12·04	25·22	19·22	24·51	18·29
50	19·12	15·60	18·30	15·26	31·79	25·22	30·50	22·95
55	28·33	21·23	25·15	20·54	41·80	34·12	41·29	30·46
60	36·87	29·53	35·23	28·35	57·39	47·27	55·49	42·00
65	50·40	44·20	49·75	42·48	80·12	68·58	75·34	58·70
70	71·82	61·03	72·78	64·00	111·01	94·98	101·83	83·84
75	111·59	89·04	108·73	96·97	152·36	132·37	138·14	118·15
80	145·13	133·73	163·42	145·81	206·31	178·34	188·23	165·65
85	222·09	204·16	243·94	215·58	275·28	233·10	256·84	230·02

in several different ways. On general principles, a high infantile mortality—granted similar environmental conditions—will cut off a good many children, who would otherwise perish at early ages, but the fact which is most evident from the tables given here, is that mortality is specially distributed and that life at all ages is acted on by unhealthy surroundings in a way which is very closely correlated with the sum total of the depressing influences due to the environment. The conditions which produce a high infantile death rate are exactly those conditions which depress the vitality of the whole adult population. All the evidence is against the view that a high infantile mortality produces a healthier population at adult ages. The fact that in the cases of such towns as London and Salford the death rates at all ages can practically be predicted from the knowledge of infantile death rate alone, shows the danger of such a method of reasoning. It is quite true that in certain places, such as Manchester and Scotland, the saving of infantile life is associated with higher death rates in the immediately succeeding ages. But in adult life the influence on health in the case of Manchester is just as adverse as in the case of Salford.