

AN IMPROVED METHOD OF CALCULATING BIRTH-RATES.

BY ARTHUR NEWSHOLME, M.D.,
AND T. H. C. STEVENSON, M.D.

IN the ten years 1841-50 the birth-rate of England and Wales averaged 32·6 per 1000 of population. It reached its maximum (36·3) in 1876, since which year it has steadily declined to 28·5 in 1901 and 1902, and to 27·9 in 1904.

In Scotland the highest recorded birth-rate was 35·6 in 1876, the same birth-rate being also recorded in 1860 and 1864. The lowest was 29·2 in 1902.

The highest recorded birth-rate in Ireland was 28·0 in 1871, the lowest 22·7 in 1900 and in 1901.

All parts of the United Kingdom, like many other civilized countries, show a marked and continuing decline of the birth-rate, the decline having been exceptionally great in France and in the United States.

The question arises to what extent is this decline, and it may be added the difference in the crude birth-rate of the three parts of the United Kingdom, due to a true change or difference in the fertility of married women; and to what extent to other changes in these communities? These are diminution in the proportion borne by the population at child-bearing ages to the total population, diminution in the proportion borne by the married to the total population at these ages, and postponement of marriages into the later ages of child-bearing, which may be taken as approximately 15 to 45.

It is proposed,

(*a*) to indicate the fallacies underlying the ordinary method of statement of birth-rates :

(*b*) to describe an accurate method of stating the birth-rate : and

(*c*) to discuss results obtained by employing this accurate method.

(This will be done in a subsequent paper.)

(a) *Fallacies of ordinary method of stating the birth-rate.*

The birth-rate under present conditions of life varies in accordance with the number of men and women of child-bearing ages in the community. There is no evidence that any change in the virility of men or in the potential fertility of women has occurred in the thirty or forty years for which fairly accurate birth-statistics are available: and it is therefore unnecessary in this connection to discuss Herbert Spencer's dictum that "the ability to maintain individual life and the ability to multiply vary inversely¹."

The birth-rate is usually reckoned as a rate per 1000 of the population living at all ages in the middle of the year. This is the *crude birth-rate*. It is an accurate measure of the relative fertility of two communities only when the number of married women and the ages of the married women in each of these communities in every 1000 of the total population are identical. In such a case it would be a correct statement of fertility, unless illegitimate births were so large a proportion of the total births as to introduce a serious disturbing factor into the problem.

Nor is a statement of the number of births per 1000 total women aged 15-45 an accurate measure of fertility; for in one community a large proportion of these women may be unmarried and their birth-rate be a negligible amount; while in another there may be very few unmarried women at these ages.

The statement of the number of legitimate births per 1000 of the number of married women aged 15-45 constitutes a much more accurate measure of fertility which has been seldom employed.

The following example² compares the effect of the application of the above three methods of stating the birth-rate in a concrete instance.

Legitimate Birth-rates in Kensington and Whitechapel in 1891.

	A. Birth-rate per 1000 inhabitants	B. Birth-rate per 1000 women aged 15-45	C. Birth-rate per 1000 married women aged 15-45
Kensington	21.8	61.6	215.4
Whitechapel	39.9	172.1	328.3
Percentage excess of birth-rate in Whitechapel over that in Kensington	83.0 %	179 %	53 %

¹ *A Theory of Population deduced from the General Law of Animal Fertility.* By H. Spencer, 1872.

² From Newsholme's *Elements of Vital Statistics*, p. 72, 3rd edit.

The figures in column C of the above table give a much more exact representation than the figures in columns A and B of the true fertility-rate of the two contrasted communities.

A distinction must here be drawn between birth-rate and fertility-rate. The figures in column A show the rates of increase by births in Kensington and Whitechapel in 1891 ; and from a national and economic standpoint this is the final result which is sought. They do not, however, show how much of the difference in the rates of increase by births in the two districts is owing to differences of fertility, and how much to the arithmetical causes which have been already enumerated. Before considering the true differences in fertility, and even in determining the temporary or permanent importance of changes in the crude birth-rate, these other factors must be eliminated, and we now propose to show how this can be done.

(b) *An accurate method of stating the birth-rate.*

The method of stating fertility-rates given in column C of the preceding table can only be accurately employed in comparing the corresponding figures of two or more communities when (1) of the total wives aged 15-45 the proportions at ages 20-25, 25-30, 30-35 and so on are identical in the communities compared; and when (2) there is an equal proportion in the compared communities of newly married women in each of the different age-groups. In actual communities these conditions are never fulfilled.

The first condition is necessary because of the greater fertility of young than of older married women, as exemplified by the following fertility-rates for Swedish wives in 1891¹.

Swedish Wives 1891.

Ages of Wives			Births annually per 1000 wives
15-20	...	...	518
20-25	...	...	451
25-30	...	...	375
30-35	...	...	312
35-40	...	...	250
40-45	...	...	142

The second condition is involved in the well-known fact that the fertility-rate at any given age is higher among recently married wives

¹ Quoted from a paper on "The Declining Birth-rate in Australia." By W. McLean, *Intercol. Med. Journ. of Australasia*, Mar. 20, 1904.

than among wives longer married, especially in the later years of child-bearing. The figures quoted below from the Tables of Natality published by Kőrösi¹ (based on 46,931 births in Budapest) show the influence of recent marriage in increasing the fertility-rate in a given year of married life as well as the variations in the fertility-rate according to age.

Age in years	The number of children born within a year to every 1000	
	Of women newly married	Of all married women
30—34	329	206
35—39	327	147
40—44	214	59

For errors arising from the non-fulfilment of the first condition exact correction can be made by the method to be shortly described; for the non-fulfilment of the second condition no correction appears to be practicable. The first source of error tends to understate the fertility-rate of residential when compared with industrial districts, because in the former the proportion of the total wives aged 15—45 who are at the younger child-bearing ages is smaller than in the latter. The second source of error acts in the opposite direction. The proportion of newly married women in the later age-groups is probably higher in residential districts where women marry comparatively later in life than in industrial districts where women marry at earlier ages, and the fertility-rate at the higher child-bearing ages will therefore be greater in the residential than in the industrial districts. The second possible source of error presupposes that prudential considerations diminishing fertility come into operation more particularly in later married life, which is probably the case, or that the fertility of long married women gradually becomes exhausted even though they are still technically within the child-bearing limit.

The first error is corrected by a method which is analogous to that employed by the Registrar-General in his Annual Summaries in obtaining factors of correction by means of which corrected death-rates are calculated.

The first portion of this method is shown in the following example :

¹ See *Elements of Vital Statistics*, p. 66.

BERKSHIRE, 1901.

Wives aged	No. of wives	Fertility-rate per 100 wives at each age-period. Sweden	Calculated No. of births
15—20	139	51·8	72·002
20—25	2671	45·1	1204·621
25—30	6074	37·5	2277·750
30—35	7305	31·2	2279·160
35—40	7063	25·0	1765·750
40—45	6407	14·2	909·794
	29,659		8509·077

$$\text{Standard Fertility-rate} = \frac{\text{Calculated Births} \times 1000}{\text{No. of wives aged 15—45}} = \frac{8509077}{29659} = 286·9.$$

Standard Fertility-rate of England & Wales (1901) similarly calculated = 298·55.

$$\text{Factor of Correction} = \frac{\text{Standard rate of England \& Wales}}{\text{Standard rate of Berkshire}} = \frac{298·55}{286·9} = 1·0406.$$

The standard fertility-rates for Berkshire and England given above give the total fertility of the wives of child-bearing ages in these two communities, on the supposition that the fertility-rates of these two populations were the same at each age-period as obtained in Sweden in 1891, the Swedish population representing a fairly normal population. The standard fertility-rate does not therefore represent any fact, but merely serves as a measure of the favourable or unfavourable constitution of the population of a given community for furnishing a high fertility-rate. If a large proportion of the wives are young, the standard rate is high; if only a comparatively small proportion, it is low. In the above example the wives of Berkshire were somewhat less favourably aged for child-bearing than those of England and Wales as a whole. The Berkshire recorded fertility-rate (*i.e.* the number of legitimate births per 1000 wives aged 15–45) must accordingly be increased in proportion to the difference between the two standard rates, in order to render Berkshire comparable with England and Wales.

As the standard fertility-rate is merely used as a measure of favourable or unfavourable age distribution, and as the same measure is applied to all the populations compared, any convenient fertility-rates may be employed, so long as they correctly represent the differences in fertility between the various age-periods. If in the above example the Swedish rates used were increased or decreased in any given proportion the resulting factor of correction would be unchanged, so long as the relation between the different rates remained unaltered.

McLean in the already mentioned paper employed standard fertility-rates calculated as shown above; and his comparisons are therefore restricted to comparisons of the same community at different times and can only be applied very indirectly to the task of comparing different communities.

By calculating corrected fertility-rates different communities can be made directly comparable. Thus in the example of Berkshire, 1901, taken before,

Calculated number of births (as before) = 8509·077.

Factor of correction = 1·0406.

Recorded fertility-rate = $\frac{\text{births} \times 1000}{\text{wives aged 15-45}}$ in Berkshire in 1902 = 219·7.

Corrected fertility-rate = $219\cdot7 \times 1\cdot0406 = 228\cdot6$.

Such corrected fertility-rates for different communities are strictly comparable. There are, however, several objections to them. The method of statement is unfamiliar. It is necessary to refer to the census figures relating to wives aged 15-45 for each population before the fertility-rate can be calculated, whereas the total population for each community is accessible without reference to census returns. The most important objection is that the fertility of the population as a whole depends not merely upon the ages of its married women, but also upon their number. For these reasons it is desirable to obtain a corrected birth-rate which gives the corrected number of legitimate births in terms of the entire population, and which will thus be similar to, though more accurate than, the familiar crude birth-rate. Such a birth-rate if truly corrected will include compensation for, 1st, the ages and, 2nd, the number of the wives capable of child-bearing. This compensation could be effected in the example of Berkshire taken before by (1) multiplying its crude birth-rate by the factor 1·0406, which would compensate for the higher average age of the Berkshire wives; and then (2) multiplying this result by another factor $\frac{116\cdot9}{104\cdot6}$ to remove the handicap due to its containing only 104·6 wives aged 15-45 per 1000 of its total population, as compared with 116·9 in England and Wales.

The same result is obtained more easily in one stage by the following method, in which standard birth-rates instead of standard fertility-rates are calculated:

BERKSHIRE, 1901.

Calculated no. of births (as before)	= 8509·077.
Total population at census	= 283,531.
Standard birth-rate	$= \frac{8509\cdot077 \times 1000}{283531} = 30\cdot01.$
Similarly standard birth-rate of England and Wales	= 34·91.
Factor of correction	$= \frac{34\cdot91}{30\cdot01} = 1\cdot1633.$
Recorded legitimate birth-rate of Berkshire in 1902	= 22·78.
Corrected " " " "	= 26·50.

The standard birth-rates take into account both the ages and the relative number of the wives, and the resulting factor therefore corrects for both.

For towns it has been found impracticable to calculate standard birth-rates from the Swedish fertility-rates for quinquennial age-periods, because the English census figures only give ages in decennial age-periods after the age of 25. It has therefore been necessary to use a fertility-rate for the age-period 25–35 derived from the Swedish rates for 25–30 and 30–35, and similarly for 35–45. This was obtained by adding together the calculated births at ages 25–30 and 30–35 in England and Wales, and applying the figure so obtained to the number of wives at ages 25–35, in order to obtain the fertility-rate for the whole period.

$$\frac{\text{Calculated no. of births at ages 25–35} \times 1000}{\text{No. of wives at ages 25–35}} = \text{fertility rate at ages 25–35.}$$

It became a matter of interest to ascertain whether this larger grouping of ages introduces any considerable error. This has been tested for some of the counties in which both methods are practicable, and the following table shows the standard birth-rates according as four or six age-groups are employed.

		Standard birth-rate		
		When six age-groups are employed	When four age-groups are employed	
Kent	1901	... ..	32·96	32·98
Sussex	"	... ..	30·21	30·38
Lancashire	"	... ..	36·56	36·56
Durham	"	... ..	38·04	37·89
Ireland	1881	... ..	23·57	24·06

It is only in the abnormally constituted population of Ireland that any considerable difference exists between the standard birth-rates and resulting factors of correction calculated on the two sets of figures.

In the case of Ireland where in 1901 four-group figures had to be used (the Irish census figures for 1901 not giving the ages of wives in six groups) the resultant error is one of understatement of the required correction, which, as will be seen, is already sufficiently striking. Sussex, a residential county, also with a somewhat high average age of wives, shows (a much smaller) error in the same direction. The same explanation applies in both cases. In the combined group 25-35 the proportion of wives aged 30-35 is greater in Ireland and in Sussex than it is in England and Wales, and the combined fertility-rate for the whole group should be lower. Hence the application of the combined rate deduced from the English figures somewhat overestimates the births which the Irish or Sussex wives in this age-group would furnish. Similarly for the age-groups 35-45. Except in the case of Ireland the difference is so trifling that it may be disregarded. On the other hand Durham, selected for the test on account of the large proportion of young wives in its population, shows, as might have been expected, a difference in the opposite direction. Migration as well as early marriage increases the proportion of young wives in industrial communities and has decreased the number in Ireland.

Factors of correction correcting for the proportionate number of wives aged 15-45 in a given population and taking no account of the age distribution of these wives give birth-rates corresponding to the fertility-rates illustrated in column C of the table on page 176. The following table (column B) compares the factors of correction obtained by this means for a number of English counties in 1901, with the accurate factors obtained as described on page 181 (column A).

The means by which the factors in column B have been obtained are indicated by the following example:

The percentage of married women aged 15-45 in England & Wales in 1901 = 11.69.

 " " " " Berkshire " = 10.46.

The factor of correction for Berkshire = $\frac{11.69}{10.46} = 1.1176$.

As might be expected, the difference between the two sets of factors in columns A and B when appreciable points to under-correction by the factors in column B. This arises from the fact that the average age of the wives is low in those counties in which their proportionate numbers are high. Hence factors which are high owing to a small proportion of wives (col. B) need to be still higher to correct for the high average age of the wives (col. A) and *vice versa*. Thus, contrast Sussex and Durham

in which the two sets of factors differ greatly; while Kent and Lancashire have approximately equal factors by both methods. The explanation is doubtless the same as that advanced for the differences between standard birth-rates for the same counties in the last table; the age distribution of wives in Kent and Lancashire corresponding with that of England and Wales, while the average age of wives is high in Sussex and low in Durham.

Factors of Correction for 1901.

	A. Taking into account the age distribution of wives between 15 and 45	B. Not taking into account the age distribution of wives between 15 and 45
Devonshire ...	1·1072	1·0764
Cumberland ...	1·1602	1·1427
Durham ...	·9177	·9512
Berkshire ...	1·1633	1·1176
Rutland ...	1·3381	1·2476
Kent ...	1·0592	1·0531
Sussex ...	1·1556	1·1197
Lancashire ...	·9546	·9590
Westmorland ...	1·2891	1·2177
Essex ...	·9458	·9450
Surrey ...	1·0848	1·0579
Cambridge ...	1·1382	1·1123
Cornwall ...	1·1656	1·1262
Cheshire ...	1·0268	1·0183
Derby ...	·9684	·9766

The corrections are in every instance in the same direction but the differences in their extent are in many cases so considerable as to render it well worth while to adopt the more complete method.

SUMMARY.

1. The ordinary method of calculating the birth-rate does not distinguish between the influence of fertility and of variations in conditions of the population as to age and marriage.

2. In ascertaining the true meaning of the great reduction of the birth-rate which has occurred in the last 25 years it is necessary to have means for distinguishing between the accidental and the intrinsic causes of change.

3. A step in the right direction is made when the legitimate births are stated in terms of the married women at child-bearing ages, and the illegitimate births in terms of the unmarried women of the same ages.

4. This method fails to correct for the differences of fertility of the various ages comprised in the age-period 15-45.

5. By calculating standard fertility-rates for given populations McLean overcame the above difficulty, and was thus able to compare experiences of a given community at different times with the standard.

6. In this paper it is shown that by continuing the above process and obtaining corrected fertility-rates, the fertility-rates of different communities can be made directly comparable.

7. The inconveniences of this new and unfamiliar method, and the necessity involved in it of calculating the crude as well as the corrected fertility-rate in every instance, indicate the desirability of obtaining a factor for each community which throughout an entire intercensal period can be applied to the crude birth-rate of that community.

8. The desirability of such a factor is increased by the fact that the method of corrected fertility-rates does not take into account the proportion of married women in each population.

9. In this paper a method is described of obtaining factors, which, when applied to the readily available crude birth-rates, correct completely both for the varying proportion of married women in compared populations and for the varying fertility at different periods of married life.

10. The practical bearings of these corrected birth-rates will be discussed in a later paper.

Postscript.—Since the preceding paper was sent to the printer, the 66th Annual Report of the Registrar-General of Births, Deaths etc., in England and Wales (1903) has been published; and this report on p. xvii gives a valuable official confirmation of the desirability of correcting crude birth-rates for variations relating to age and married condition. Such corrections are given for England and Wales as a whole, the method adopted being the same as is shown for Kensington and Whitechapel (1891) on p. 176. It is stated on p. xix that “the disturbing factor of changing constitution of the population is mainly, though not entirely, eliminated by calculating the proportion of births to the number of women living at child-bearing ages.” As we have seen, this method does not suffice for complete correction, and it is satisfactory to note that on p. xvii attention is also drawn to the influence of changes in the age of married women in the remark that “among married women (at 15 to 45) the proportion of those at ages under 25 years has continuously decreased.”