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INFLUENCE OF BIRTH ORDER AND MATERNAL AGE ON THE HUMAN SEX RATIO AT BIRTH

BY

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Introduction

Lewis and Lewis (1905) and Knibbs (1917) noted that first births contained relatively more males than subsequent births. Russell (1936) and Ciocco (1938), using data from United States vital statistics, found decreasing sex ratio with increasing birth orders up to the fifth. Ciocco did not examine individual parities after the fifth, but Russell found no decrease in sex ratio after the sixth birth rank.

Examinations of association of sex ratio with parental age have also demonstrated fairly consistent trends, although there has been difference of opinion whether the association is with age of father or with age of mother. Decrease in masculinity with increasing age of one or other parent has been shown by Wicksell (1926), Russell (1936), Ciocco (1938), Martin (1943), and Lowe and McKeown (1950). From British statistics, the last authors showed that the trend with maternal age in stillbirth sex ratio was the inverse of that for live births, and that this opposite trend was due largely, if not entirely, to variation in the distribution of stillbirths by cause at different maternal ages. However, their data did not permit examination of association with birth order.

Data published since the reports of Russell and Ciocco, by the United States Bureau of the Census, and by the National Office of Vital Statistics' permit us to re-examine associations with maternal age and birth order for live births and stillbirths, but related information on cause of stillbirth is not available. In view of the observation of Ciocco that sex ratios of whites and non-whites are substantially different, these two groups are here considered separately. For the reasons given by Lowe and McKeown (1950), sex ratios are expressed as per cent. male.

White Births

Sex ratios of white live births, stillbirths, and total births in the United States are given by birth order in Table I and by maternal age in Table II. Data on stillbirths are not available by birth order for 1945, or by maternal age for 1948 and 1949. By definition, the group "stillbirths" contains no foetal death delivered before the fifth month of gestation. Since notification requirements vary from state to state with regard to duration of gestation, the group does not contain all foetal deaths delivered after this month, but there is no reason to believe that the selection is biased as regards birth order or maternal age.

TABLE I
SEX RATIO OF WHITE BIRTHS BY BIRTH ORDER, U.S.A., 1942–44 AND 1946–49

Birth Order	Live Births		Stillbirths		Total Births	
	No. of Births	Sex Ratio	No. of Births	Sex Ratio	No. of Births	Sex Ratio
1	7,397,413	51·62	139,340	54·67	7,536,753	51·68
2	5,412,077	51·45	74,176	54·37	5,486,253	51·49
3	2,769,615	51·31	48,074	54·72	2,817,689	51·37
4 and 5	2,124,443	51·26	48,618	54·68	2,173,061	51·34
6 and over	1,258,948	51·14	44,086	55·03	1,303,034	51·27
Total	19,888,699*	51·46	396,376*	54·68	20,285,075*	51·52

* Includes 926,203 live births and 42,082 stillbirths of unspecified birth order.

TABLE II
SEX RATIO OF WHITE BIRTHS BY MATERNAL AGE, U.S.A., 1942–47

Maternal Age	Live Births		Stillbirths		Total Births	
	No. of Births	Sex Ratio	No. of Births	Sex Ratio	No. of Births	Sex Ratio
19 and under	1,549,223	51·59	28,969	55·48	1,578,192	51·66
20–24	5,109,515	51·54	82,432	54·49	5,191,947	51·59
25–29	4,654,280	51·52	82,621	54·62	4,736,901	51·57
30–34	2,937,373	51·35	67,311	54·58	3,004,684	51·42
35–39	1,443,776	51·32	46,562	55·18	1,490,338	51·44
40 and over	400,888	51·14	19,537	54·60	420,425	51·31
Total	16,120,225*	51·47	338,421*	54·80	16,458,646*	51·54

* Includes 25,170 live births and 10,989 stillbirths of unspecified maternal age.

The Tables show that sex ratios of live births and total births decrease regularly both with birth order and with maternal age.

The sex ratio of total births (live- and still-born) is that of all births expelled from the uterus at a time when notification is required. Since this is the

closest direct estimate of the sex ratio at conception, separate examination of the influences of birth order and maternal age for total births would be desirable. However, the necessary data are not available for stillbirths, and the examination must be limited to live births, which in the present data do not differ greatly from total births in their overall associations. Table III gives the sex ratios of live births at different birth orders and maternal ages. It may be seen that sex ratios fall with parity for each maternal age group, but that there is no consistent association with maternal age when individual birth orders are considered. The data suggest therefore that there is little direct relationship between maternal age and the sex ratio of live births.

TABLE III

SEX RATIO OF WHITE LIVE BIRTHS BY BIRTH ORDER AND MATERNAL AGE, U.S.A., 1942–49

Maternal Age	Birth Order					Total
	1	2	3	4 and 5	6 and over	
19 and under	51·65	51·54	51·30	—	—	51·62
20–24	51·62	51·43	51·31	51·33	(51·28)	51·52
25–29	51·63	51·51	51·37	51·31	51·16	51·48
30–34	51·53	51·44	51·21	51·23	51·17	51·34
35–39	51·45	51·41	51·34	51·36	51·14	51·30
40 and over	(51·84)	51·57	51·19	51·12	50·90	51·15
Total ..	51·62	51·47	51·31	51·29	51·11	51·46

Estimates based on less than 50,000 births are given in brackets.
No estimate is given for cells containing less than 25,000 births.

Although Russell (1936) found no decrease in sex ratio for birth ranks after the fifth, the larger numbers now available indicate that the sex ratio of live births decreases steadily from 51·62 in the first birth rank to 51·03 at birth ranks "8 and over" (606,712 births). Examination of individual birth ranks after the eighth shows some irregularity, possibly due to small numbers, but suggests that sex ratios do not fall substantially after this birth rank.

For stillbirths the association of sex ratio with birth rank has not previously been examined, but Lowe and McKeown (1950) investigated the maternal age association. Our results, shown in Table II, confirm their findings of an increase in sex ratio with advancing maternal age after age 19. However, their figures did not show the presently observed high sex ratio in the age group "19 and under", for which their numbers were small. In the present series, the difference between the age groups "19 and under" and "20–24" is not likely to have arisen by chance ($0·99 \pm 0·34$). Association with birth order is similar (Table I), with decrease in sex ratio from birth rank 1 to birth rank 2 and then increase with increasing birth rank. Unfortunately, present sources do not give birth rank, sex, and maternal age simultaneously for stillbirths.

NON-WHITE BIRTHS

For non-white births, Tables IV, V, and VI give similar data to that already recorded for whites (see also Figs 1 and 2, opposite). We may note that for non-whites:

(1) In live births and total births, sex ratios are lower than in whites, but for stillbirths they are higher. The latter difference would be exaggerated if sex ratios were calculated from sex-specific stillbirth rates.

(2) As in whites, sex ratios of live births show no consistent relationship to maternal age, but display fairly

TABLE IV

SEX RATIO OF NON-WHITE BIRTHS BY BIRTH ORDER, U.S.A., 1942–44 AND 1946–49

Birth Order	Live Births		Stillbirths		Total Births	
	No. of Births	Sex Ratio	No. of Births	Sex Ratio	No. of Births	Sex Ratio
1	750,874	50·68	29,237	56·62	780,111	50·90
2	559,525	50·81	16,071	55·99	575,596	50·95
3	380,001	50·63	11,668	55·31	391,669	50·77
4 and 5	454,969	50·52	15,999	55·54	470,968	50·69
6 and over	485,477	50·50	26,045	55·67	511,522	50·76
Total	2,733,176*	50·64	108,999*	55·93	2,842,175*	50·84

* Includes 102,330 live births and 9,979 stillbirths of unspecified birth order.

TABLE V

SEX RATIO OF NON-WHITE BIRTHS BY MATERNAL AGE, U.S.A., 1942–47

Maternal Age	Live Births		Stillbirths		Total Births	
	No. of Births	Sex Ratio	No. of Births	Sex Ratio	No. of Births	Sex Ratio
19 and under	488,352	50·69	18,153	56·98	506,505	50·92
20–24	679,709	50·67	23,256	56·02	702,965	50·85
25–29	451,897	50·61	17,476	55·76	469,373	50·81
30–34	284,987	50·59	13,891	55·76	298,878	50·83
35 and over	226,395	50·37	14,725	56·19	241,120	50·72
Total	2,142,499*	50·62	90,754*	56·15	2,233,253*	50·85

* Includes 11,159 live births and 3,253 stillbirths of unspecified maternal age.

TABLE VI

SEX RATIO OF NON-WHITE LIVE BIRTHS BY BIRTH ORDER AND MATERNAL AGE, U.S.A., 1942–49

Maternal Age	Birth Order					Total
	1	2	3	4 and 5	6 and over	
19 and under	50·66	50·74	(50·64)	—	—	50·65
20–24	50·77	50·71	50·68	50·44	(50·53)	50·67
25–29	50·59	50·92	50·41	50·57	50·44	50·59
30–34	(50·50)	(51·23)	(50·92)	50·65	50·55	50·67
35 and over	—	—	—	(50·38)	50·36	50·39
Total ..	50·68	50·78	50·64	50·51	50·45	50·62

Estimates based on less than 50,000 births are given in brackets.
No estimate is given for cells containing less than 25,000 births.

consistent trends with birth rank when the association between maternal age and birth order is separated.

(3) The effect of birth rank differs from that noted for whites, in that the sex ratio first increases from birth rank 1 to birth rank 2 before decreasing with increasing birth order.

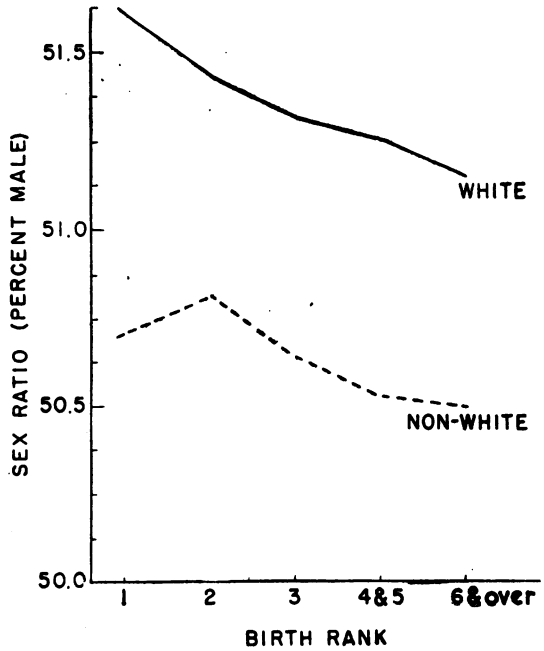

FIG. 1.—Sex ratio of live births by birth order, U.S.A., 1942–44 and 1946–49.

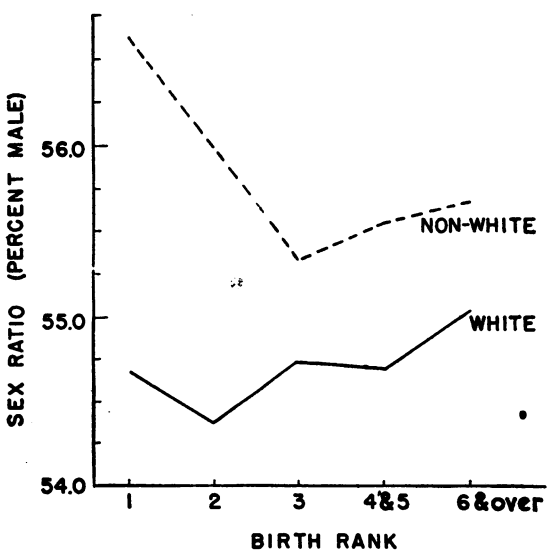

FIG. 2.—Sex ratio of stillbirths by birth order, U.S.A., 1942–44 and 1946–49.

(4) For stillbirths, trends are similar to those observed in whites, except that the lowest masculinity is seen in birth rank 3 (instead of 2), and at ages 25–34 (instead of 24 and under).

Observed difference between sex ratios of white and non-white stillbirths should be interpreted with some caution, since non-white stillbirths are reported less frequently than white, and reported births may be biased in respect of sex. In addition, at early gestational ages sex reporting may be less accurate in non-whites than in whites.

DISCUSSION

These data, based as they are on large numbers of births, enable us to say with some confidence that maternal age is not associated with the sex ratio of live births except indirectly through the interdependence of maternal age and birth order. This is surprising, since many causes of stillbirth (and also presumably of abortion) are associated with maternal age. It suggests that these latter causes of foetal death do not greatly influence the sex ratio, either because they have no pronounced sex ratio, or because they are not common in early foetal life. Observed variations in stillbirth sex ratio with age and birth order are insufficient to account for trends in the sex ratio of livebirths, and search must be made for some feature or features of early foetal death (prior to the time of notification) which might do so. If the trends noted are not due to variation in the sex ratio at conception, the data here presented indicate that cause should be sought in relatively common conditions associated with birth order. It may be pertinent to point out that anencephalus is at least one cause of foetal death which is associated with birth order but not with maternal age (Record and McKeown, 1949), a fact which almost certainly accounts for a considerable number of previable or prenotification foetal deaths, and which shows moreover a higher proportion of females in first than in subsequent birth ranks (MacMahon and McKeown, 1952). Without direct evidence, however, it would be unwise to assume that cases of anencephalus which abort in early stages of pregnancy exhibit associations similar to those of cases which come to attention in later months.

The variation in the sex ratio of live births cannot be explained by magnifying the trends seen for stillbirths on the assumption that such trends will be similar for previable foetal deaths, since, neither for whites nor for non-whites, is the trend for live births the inverse of that for stillbirths (Figs 1 and 2). Nor would it be reasonable to expect that such an

explanation would account for variations in the live birth sex ratio, since some common causes of stillbirth which have marked sex ratios (*e.g.* difficult labour) clearly do not operate in early foetal life.

The increase in sex ratio noted in many countries after the first world war and during the second has been attributed by Martin (1943) among others to a lower age at marriage with a consequent lower maternal age at delivery. Evidence already presented here suggests that this is unlikely, but indicates the possibility that variations in birth rank distribution may have been responsible. For England and Wales where the trend was noted in both wars, the Registrar-General does not give numbers of births by birth order and sex, but the numbers of legitimate maternities have been available by birth order since the latter part of 1938. Table VII gives the sex ratio of legitimate total births and the percentage of all legitimate maternities of the first birth rank in 2-year groups for 1937–48. There is no association between the secular trend in sex ratio and the proportion of first births. By applying sex ratios for individual birth orders, 1, 2, 3, 4, and 5, and 6 and over, derived from United States data for whites (Table I), to the respective number of maternities in England and Wales occurring at each birth order, we may obtain expected sex ratios during the time under consideration; the expected sex ratios (Table VII, last column) show the trend which would have occurred with observed changes in birth rank distribution if there had been no secular change in sex ratios of individual birth ranks.

TABLE VII
SECULAR CHANGES IN SEX RATIO OF TOTAL BIRTHS IN ENGLAND AND WALES, 1937–48

Years	Sex Ratio of Legitimate Births	Percentage of Legitimate Maternities Primiparous	Expected Sex Ratio*
1937–38	51·42	—	—
1939–40	51·42	42·56	51·52
1941–42	51·49	44·89	51·53
1943–44	51·60	42·46	51·53
1945–46	51·52	41·30	51·53
1947–48	51·55	43·05	51·53

* Calculated by applying to the numbers of maternities of 1st, 2nd, 3rd, 4th and 5th, and 6th and over, birth rank, the sex ratios for each birth rank shown in Table I, and totalling for each 2-year period (see text).

There is practically no variation from year to year, and, unless the association between sex ratio and birth order is much stronger in England and Wales than for white births in the United States, we may conclude that the increased sex ratio during the war years was probably not the result of changing birth rank distribution of births. This conclusion is supported by the fact that illegitimate births, for which marked changes in birth rank distribution seem less likely than for legitimate births, show the secular trend to an even greater extent than legitimate births (Fig. 3).

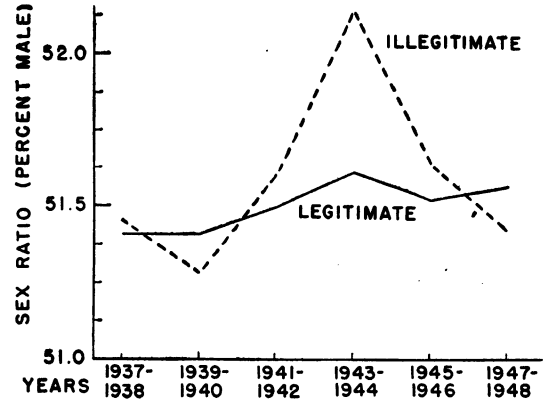

FIG. 3.—Secular change in legitimate and illegitimate total birth sex ratio, England and Wales, 1937–48.

SUMMARY

Data from the United States Bureau of the Census and from the National Office of Vital Statistics annual reports, 1942–49, are used to show that:

(*a*) For white births:

(1) Sex ratio of live births decreases both with increasing birth rank and with increasing maternal age.

(2) No consistent association with maternal age is seen when birth rank is fixed, but the downward trend with birth rank remains in each maternal age group.

(3) Sex ratio of stillbirths is high at the extremes of birth rank and maternal age. These two variables cannot be separated for stillbirths with the data available.

(*b*) For non-white births:

(1) When the association between maternal age and birth order is separated, the sex ratio of live births shows no consistent relationship to maternal age, but does show an increase from birth order 1 to birth order 2 and then a decrease with increasing birth rank.

(2) Stillbirths exhibit a U-shaped trend with both birth rank and maternal age, the base of the U being at higher birth ranks and maternal ages than for whites.

Evidence is presented which suggests that the increased sex ratio observed in England and Wales during the last war was not the result of changes either in maternal age at childbirth or in birth rank distribution of the population of births.

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