BIRTH ORDER AND FAMILY SIZE: BIAS CAUSED BY CHANGES IN BIRTH RATE

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Birth Order and Family Size: Bias Caused by Changes in Birth Rate

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Introduction

In a previous paper (Price and Hare, 1969) we drew attention to some types of bias which may complicate the search for a useful association between disease and birth order. In particular, we considered biases occurring in a sample of adult patients where the patients' mothers have all passed their reproductive period and where, therefore, the sibships of the patients are complete. In such a sample, the recognized methods of searching for an association between disease and birth order are based on the assumption, that, for a null hypothesis, the sample will be randomly distributed among the birth ranks for each sibship size. But in fact the distribution may be non-random, and there are two main causes for this. These are (i) changes in the birth rate of the population, and (ii) changes in the birth rank distribution of the patients between birth and the age-range from which the sample is selected (e.g. differential rates of mortality or migration). The principal aim in the present paper is to illustrate the bias arising from the first of these causes.

Changes in the birth rate of a population may be the result of changes in the number of families started or of changes in the size of completed families. The effect of these changes on the birth-rank distribution of a sample of the population can be predicted, and the predicted effects may be summarized as follows. An increase in the number of families started will result in an over-representation of early birth ranks for every sibship size. A decrease in family size will result in an over-representation of early birth ranks in small sibships and an over-representation of late birth ranks in large sibships. Changes in the opposite direction will produce the opposite effects. During the present century, changes in birth rate have occurred in most populations and certainly in that of England and Wales and these will therefore be a cause of bias in the birth-rank distribution of patient samples. In order to make use of these predictions, however, we need to know the probable size of such bias; but in this country there is no way of calculating it from available statistics, and the only practical way of determining it is to study a large sample representative of the general population. No large random sample of the population in Great Britain has been studied for birth order, and the largest published samples of adult patients are the 2,500 psychiatric patients and the 500 medical and surgical in-patients of Norton (1952). Norton's psychiatric sample (see Gregory, 1958) does in fact show just the sort of deviation from random to be expected, on the above predictions, from the birth rate changes in this country; but he did not make an analysis by age, and as many of his patients were probably under 20 years old the bias due to birth rate changes cannot fully be separated from that due to incompleteness of sibships.

We have therefore thought it worth while to report our findings in a comparatively large sample (over 20,000) of adult psychiatric patients, classified by age, and in spite of certain deficiencies in the material as a representative sample of the general population.

Method

For each patient attending the Bethlem and Maudsley Hospitals, certain data are routinely recorded on punch-cards. Since 1958 these data have included the patients' family size and birth order. We examined the punch-cards of all cases discharged from the hospitals during the period 1958–1966. For simplicity, any patient of a twin-birth was excluded.

TABLE I

The cohorts of patients

Cohort	Years of birth	Age range at admission 1958–1966 (years)	Number of patients	
			of known family size	family size not known
1	1888–1897	61–78	992	133
2	1898–1907	51–68	2,010	269
3	1908–1917	41–58	3,341	471
4	1918–1922	36–48	2,324	297
5	1923–1927	31–43	2,567	291
6	1928–1932	26–38	2,710	280
7	1933–1937	21–33	2,614	276
8	1938–1942	16–28	2,561	280
9	1942–1947	16–23	1,891	149
All	1888–1947	16–78	21,010	2,446

Because mean family size varies with country, we aimed to exclude foreign-born patients, but were only able to do this for patients discharged after the autumn of 1959.

The sample patients. Our original aim was to compare birth-order distribution in different diagnoses. When this was done for five major diagnostic groups (each of more than 1,800 patients), the distribution for schizophrenia was notably different from that for any of the other groups, while the distributions for these other groups did not differ appreciably among themselves. (We hope to report separately on the birth-order distribution in the schizophrenic patients.) We therefore thought it reasonable to pool the non-schizophrenic diagnoses and to examine this sample on the supposition of its being fairly representative of the population from which the hospital's patients were drawn (that is, in the main, the population of south London). Arguments supporting this supposition, together with a consideration of certain deficiencies in the sample are set out in the Discussion section.

The cohorts. The pooled sample was divided into nine cohorts, according to year of birth of the patients (Table I). The particular years chosen for these cohorts were dictated partly by the need for adequate numbers in each cohort, and partly by the fact that year of birth was not punched and age at admission was not always recorded in the same way (in 1961–1963 age was recorded only in 5-year ranges). The different methods of recording age also resulted in a small number of patients (about 3 per cent.) in each cohort being born either one year before or one year after the limits assigned for years of birth.

From Table I it may be seen that almost all patients in the first six cohorts (i.e. born between 1888 and 1932) will have been aged 30 or over at the time of admission. These patients may be considered to have certainly come from completed sibships. Moreover, as only about 7 per cent. of patients have a sibship span greater than 20 years (Price and Hare, 1969), any effect due to incompleteness of sibship would certainly be very small for the sample as a whole.

Sibship size. For the routinely recorded data, sibship size was defined as the total number of children live-born to the patient's mother, and the patient's birth order (or birth rank) was his serial position among these children. Families of more than nine siblings had been coded only as "more than 9", so that data on birth order by sibship size could only be had for sibships of up to nine. This, however, is not a serious loss, as in larger sibships the data are likely to become increasingly inaccurate.

RESULTS

1. *Birth Order*

Table II gives the distribution of all patients by birth order and sibship size. It is clear that the distribution departs from random, there

TABLE II

Birth order and family size (all cohorts together)

Family size*	Birth order									Total known	Birth order not known
	1	2	3	4	5	6	7	8	9		
1	2,413									2,413	
2	2,337	1,972								4,479	170
3	1,266	1,180	1,083							3,733	204
4	662	617	623	672						2,751	177
5	372	347	359	386	460					2,047	123
6	218	244	233	242	219	299				1,588	133
7	139	130	141	158	139	159	235			1,197	96
8	98	74	76	96	97	78	96	141		826	70
9	61	61	55	54	75	65	71	52	87	632	51

* Family size greater than 9 in 1,340 patients: not known in 2,446.

being an excess of first-born over last-born in sibships of two and three, and an excess of last-born over first-born in sibships of five and over. For sibships of two, the difference between observed and expected (i.e. random) distribution gives a χ^2 of 30·92 ($p \ll 0{\cdot}001$); for sibships of three, χ^2 is 14·25 ($p < 0{\cdot}001$). If we take only the first six cohorts (where the sibships are certainly completed), we get a very similar distribution, the difference between observed and expected numbers in sibships of two giving a χ^2 value of 8·36. Other aspects of the deviation from random are shown in Tables III and IV.

TABLE III

Birth rank distribution, by sex, in sibships of four (all cohorts together)

Sex	Birth rank				Birth rank not known
	1	2	3	4	
Male ..	304	283	242	343	67
Female ..	358	334	381	329	110

$\chi^2 = 19{\cdot}53$, d.f. = 3, $p < 0{\cdot}001$

When birth order and sibship size are examined by year of birth (i.e. by cohorts), the same general picture is found for each cohort, but the extent of the deviation from random fluctuates with time. This may be illustrated by comparing, for each sibship size, the number in the top half of a sibship (the early birth ranks)

TABLE IV

Departure from random distribution in the ultimate birth ranks, by family size and year of birth: expressed as the percentage deviation of observed from expected numbers

Family size	Per cent. deviation	
	Born 1888–1932	Born 1933–1947
2	−3·0	−5·8
3	−1·3	−4·6
4	+1·8	−0·4
5	+2·8	+7·6
6	+3·5	+4·9
7	+6·9	+7·8
8	+6·1	+6·3
9	+3·5	+5·6

with that in the bottom half, the middle rank in odd-sized sibships being excluded. An alternative method, comparing the number of first-borns with last-borns, gives very similar results. Fig. 1 shows the results for two groups of sibship sizes. Within these two groups fluctuations by year of birth are essentially similar for each sibship size.

2. Sibship Size

To arrive at the distribution of sibship sizes in the population from which the sample was drawn, it is necessary to make the correction suggested by Greenwood and Yule (1914), and to divide the numbers of patients in any sibship by the number of the sibship size. The

corrected distribution of sibship sizes, by cohorts, is shown in Fig. 2.

The mean sibship sizes for cohorts one to nine were—4·1, 3·5, 3·2, 2·8, 2·7, 2·6, 2·4, 2·3, 2·2. For these calculations the mean size of sibships greater than nine was taken to be 11.

3. Birth Order by Sex

In the tables of birth order by sibship size, the only notable difference between the sexes lay in the distribution of birth ranks in sibships of four. Here the proportion of last-borns is higher for males and the proportion in the third rank is higher for females, the distribution departing very significantly from random (Table III). When the distribution in sibships of four is examined by cohort, the proportion of males in the last rank is higher than that of females for eight of the nine cohorts, and the proportion of females in the third rank is higher than that of males for all nine of the cohorts.

Discussion

1. Is the Sample Representative?

The findings can have a general value only in as far as the patients may be taken as a representative sample of the population, that is to say only in as far as we can assume that the distribution of birth order and sibling size is not materially influenced by an association of these factors with the patient's psychiatric condition. Arguments supporting this assumption are based on the results of previous studies, on our own data, and on a comparison of our sample with the population statistics of the Registrar-General.

Most of the reported findings of an association between birth rank and psychiatric disorder (excluding subnormality) have concerned schizophrenia, and patients with schizophrenia were specifically excluded from the present sample. As regards other diagnostic groups, Malzberg (1940) found no significant association with birth order in 498 cases of manic-depressive psychosis, and Gregory (1959) none in manic-depressive psychosis, neurosis or personality disorder (numbers of cases 70, 138 and 89 respectively). Gregory considered there was an over-representation of first-born in these groups, but his conclusion must be treated with reserve because (a) his numbers are relatively small, (b) he compared his Canadian cases with samples of the British population, and birth-rate changes are likely to have been different in the two countries, and (c) he did not control for age, and thus his results may be biased by the effects of incomplete sibship and of a decreasing family size in the population. Using Gregory's test, our own sample did not show any undue excess of first-born in these diagnostic groups or in the sample as a whole.

Norton (1952) found a significant over-representation of the later birth ranks in 2,500 psychiatric (mainly neurotic) patients, and no significant deviation from expectation in 500 non-psychiatric controls (medical and surgical in-patients); but the difference in significance can be attributed to the different sizes of the two groups, and the type and degree of deviation in his psychiatric sample could be adequately attributed to changes in birth rate or to incompleteness of sibships.

Tsuang (1966), using case-material which has been largely included in the present series, found an under-representation of penultimate and last-born in females with immature personality, but the numbers were small (53), and as the diagnosis of immature personality tends to be made in young patients (and particularly so, perhaps, in females) incomplete sibships might account for the findings.

We may conclude that there is no strong evidence from published work of any association between psychiatric disorder (other than schizophrenia and subnormality) and birth rank. This is supported by our own findings, which show no appreciable difference in the distribution of birth ranks between the widely different diagnostic groups which were pooled to form the present sample. Moreover, there were no differences in the distributions when the in-patients (who may be presumed the more severely ill) were compared with the out-patients.

Since 1939 the Registrar-General has presented statistics for birth order and family size in England and Wales (*Annual Statistical Reviews*, Part 2); and during the years when our two youngest cohorts were born (except for

TABLE V

Greenwood–Yule analysis of the sample (excluding sibships greater than nine)

Birth rank	Observed numbers O	Expected numbers E	(O–E)/E per cent.	$(O-E)^2/E$
1	7,566	7,331·0	+3·2	7·53
2	4,625	4,918·0	−6·0	17·46
3	2,570	2,763·5	−7·0	13·55
4	1,608	1,587·2	+1·3	0·27
5	990	943·7	+4·9	2·27
6	601	558·9	+7·5	3·17
7	402	316·4	+27·1	23·16
8	193	159·1	+21·3	7·22
9	87	64·6	+34·7	7·77
Total	18,642	18,642·4		82·40*
Eldest	5,153	4,918·0	+4·8	11·23
Youngest	4,949	4,918·0	+0·6	0·20
Penultimate	2,715	2,763·5	−1·8	0·85
Intermediate	3,412	3,629·9	−6·0	13·08
Total	16,229	16,229·4		25·36†

* $\chi^2 = 82{\cdot}40$, d.f. = 8, $p \ll 0{\cdot}001$
† $\chi^2 = 25{\cdot}36$, d.f. = 3, $p < 0{\cdot}001$

1938) these data are in the form of legitimate maternities and presented separately for Greater London. We are therefore able to compare birth order in the two youngest cohorts with that of the general population in roughly the same geographical area. The comparison is not exact: our figures include illegitimate births, whereas the Registrar-General's exclude these; our figures exclude still-births and twin-births, whereas the Registrar-General's include still-births and count multiple births as one. But these differences should not materially affect the comparison.

Tables VI and VII compare the observed distribution of birth rank in cohorts with the expected distribution derived from the Registrar-General's figures for Greater London. For the cohort of 1938–1942, the distributions show a close correspondence. For the cohort of 1943–1947, however, there is a deviation from expectation at the 2 per cent. level of probability, due mainly to an excess of patients in the first birth rank at the expense of the second and third ranks. If this is more than a chance finding, it may be due to one of several biases. Illegitimate births are, of course, more likely to be first-born, and so at least part of the deviation must be due to the exclusion of these from the Registrar-General's figures. A further contributory factor may be the higher social class of the patients (Hare, 1968), which is likely to be associated with a smaller family size, though this should give an over-all excess of early birth ranks rather than the particular pattern found here. Alternatively, the deviation may reflect an increased predisposition to mental illness in young adult first-born. This possibility is in line with the finding of one of us (Price, 1969) that in a sample of the general population the first-born are more likely than their later-born siblings to show certain traits which are probably associated with a disposition to mental illness.

Taking into account these possible sources of bias, the correspondence between observed and expected distribution of birth ranks in our series seems fairly close and supports the position that, for the present purposes, the patients may be taken as representative of the general population.

TABLE VI

Comparison of birth rank distribution in the 1938–1942 cohort of patients with that expected from the Registrar-General's figures for Greater London

Birth rank	Greater London legitimate maternities 1939–1942		Bethlem-Maudsley patients born 1938–1942			
	Number	Per cent.	Observed (O)	Expected (E)	O–E	$(O-E)^2/E$
1	202,181	49·0	1,211	1,179·2	+31·8	0·859
2	105,303	25·5	606	614·2	−8·2	0·110
3	48,367	11·7	272	282·1	−10·1	0·362
4	23,958	5·8	123	139·7	−16·7	2·003
5	13,392	3·3	91	78·2	+12·8	2·108
6	8,242	2·0	45	48·1	−3·1	0·200
7	5,200	1·3	32	30·3	+1·7	0·095
8	3,457	0·8	16	20·1	−4·1	0·836
9	2,262	0·6	9	13·1	−4·1	1·283
Total	412,362	100·0	2,405*	2,405·0		7·856

χ^2 (8 d.f.) = 7·856 (N.S.)

* Excluding 369 patients where birth rank was unknown and 67 from sibships of greater than nine.

TABLE VII

Comparison of birth rank distribution in the 1943–1947 cohort of patients with that expected from the Registrar-General's figures for Greater London

Birth rank	Greater London legitimate maternities 1943–1947		Bethlem-Maudsley patients born 1943–1947			
	Number	Per cent.	Observed (O)	Expected (E)	O–E	$(O-E)^2/E$
1	298,338	46·3	919	845·2	+73·8	6·444
2	199,238	30·9	532	564·5	−32·5	1·871
3	81,170	12·6	195	230·0	−35·0	5·326
4	32,882	5·1	90	93·1	−3·1	0·103
5	15,296	2·4	50	43·2	+6·8	1·070
6	8,130	1·3	21	23·0	−2·0	0·174
7	4,714	0·7	11	13·3	−2·3	0·398
8	2,993	0·5	5	13·5	−5·5	2·241
9	1,746	0·3	3			
Total	644,507	100·1	1,826*	1,825·8		17·627

χ^2 (7 d.f.) = 17·627, $p<0·02$

* Excluding 198 patients where birth rank was unknown and 16 from sibships of greater than nine.

2. Deficiencies of the Sample

Among 23,462 patients whose records were studied, the sibship size was unknown in 10·4 per cent. (range 7·3 per cent. to 12·4 per cent. among the cohorts), and among the 19,666 patients whose sibship size was known (sizes 1–9) the birth order was unknown in 5·5 per cent. (Table I). Lack of information was somewhat commoner in older patients and in patients attending the emergency clinic, where the circumstances might not readily conduce to the recording of all the routine data. But there is no reason to suppose any systematic bias here, other than the slight effect due to age.

Foreign-born patients discharged during the first one and three-quarter years of the nine-year period could not be excluded from the sample because country of birth was not then recorded. During this time, the proportion of foreign-born was (by extrapolation) probably about 12 per cent. Hence the number of foreign-borns not excluded is in the region of 400, or about 2 per cent. of the total sample. It seems unlikely that this could be an appreciable source of bias.

The sex distribution of the total sample (55 per cent. females) did not differ from that of the population of Greater London (Reg. Gen. 1964), but the age structure was somewhat

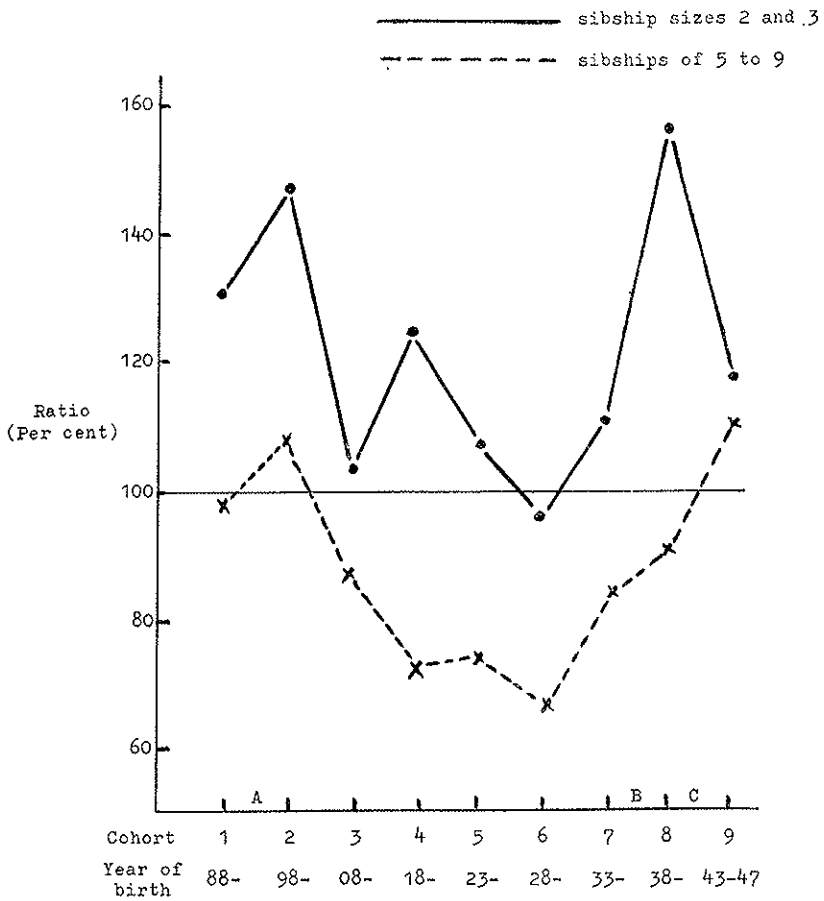

FIG. 1.—Ratio of number in top-half of sibships to number in bottom-half (excluding the mid-rank), by cohorts. A, B and C are explained in the text.

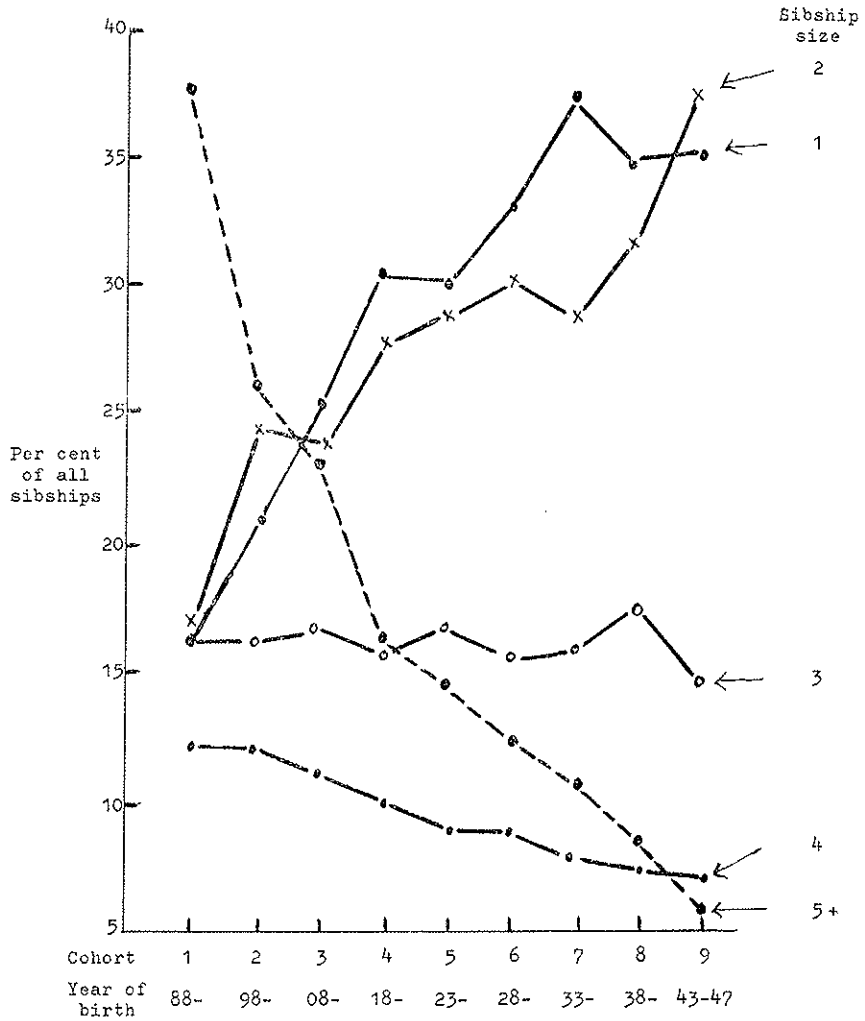

FIG. 2.—Proportional distribution of sibship size, by cohorts.

different, there being an over-representation of patients between the ages of 20 and 35, and an under-representation in ages 45 and over. However, the analysis by cohorts largely compensates for this difference.

3. Comparison of Observation with Prediction

The non-random distribution of birth ranks (Table II) is in agreement with the general theoretical prediction in showing an excess of early-born in small sibships and an excess of later-born in large sibships. This pattern is present to practically the same extent for patients aged 30 and over (cohorts 1 to 6), so that it could not be due to any incompleteness of sibships.

The non-random distribution of birth ranks by cohort (Fig. 1) may be compared with the

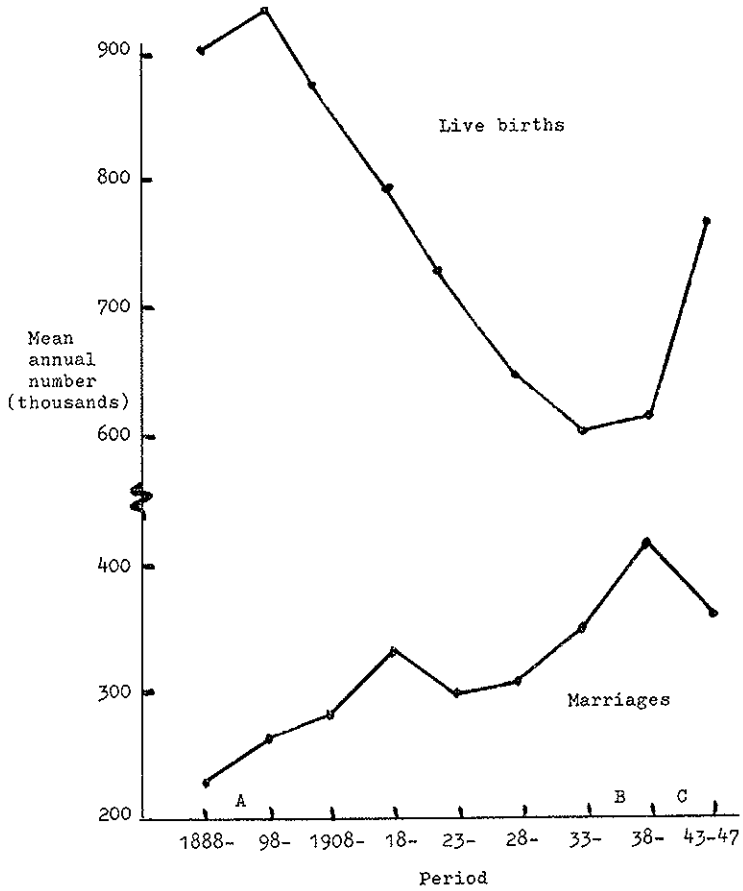

FIG. 3.—Mean annual number of live births and marriages in England and Wales, for the cohort periods.

annual marriage and birth rates for England and Wales* (Fig. 3). It is not possible to predict precisely the combined effect of the change in marriages and in live-births because there is no way of determining the relative contribution of each to the pattern of birth ranks. But if we make the not unreasonable assumption that for large families the contribution of total births is more important and that for small families the number of marriages is more important, then the fluctuations in the birth-rank pattern of the cohorts reflect with considerable accuracy the combined changes of births and marriages in the general population.

Consider, for example, the interval of time covered by the birth-years of the first and second cohorts. During this period the yearly numbers of marriages and total live births were both increasing (interval A on Figs. 1 and 3). Now the number of marriages may be taken as an index of the number of new families started (Price and Hare, 1969) and the number of births may be taken as a fair index of the mean family size (though a better index might be the number of live births less the

* The birth rank distribution for any age range depends not only on the pattern of births during the years when the patients were born but also on the pattern during the births of the older and younger siblings of the patients, i.e. for a maximum of about 20 years on either side of the range of years of birth of the patients. For the present argument, however, the data of Fig. 3 are sufficient.

number of marriages two years earlier). Bearing in mind that an increase in the number of families started leads, on theory, to an over-representation of early birth ranks in a sample of the population and that an increase in family size leads to a (relatively small) under-representation of early ranks in small families and to a (relatively large) under-representation of late ranks in large families, we can predict that the combined effect of these changes will probably lead to an over-representation of early ranks in all family sizes; and this is what is, in fact, found. The same changes in population and sample occur in the period between the seventh and eighth cohorts (interval B on Figs. 1 and 3). Again, in the period covering the births of the eighth and ninth cohorts (interval C on Figs. 1 and 3) the marriage rate was falling but the birth rate was rising. The falling marriage rate leads us to expect an under-representation of early birth ranks in all families, and the rising birth rate an over-representation of late ranks in large families. The expected combined effect is then (on the assumption made above) an under-representation of early ranks in small families and their over-representation in large families; and this, again, is what is found.

4. Implication of the Findings

With the provisos concerning the adequacy of the present sample, we may conclude that any sample of the adult population of England and Wales is likely to show a non-random distribution of birth ranks, and that the type and degree of this distribution will vary with family size and with the age structure of the sample. The extent of the departure from randomness in the present sample may be seen in Table IV. In practice, clearly, there is no simple way of correcting the distribution in any particular sample for the bias caused by fluctuations in the reproductive habits of the population. But we can say that at the present time a sample of adult patients having an age structure roughly similar to that of the present sample must show deviations from random distribution significantly different from those shown in Table IV before these can be attributed to an association between birth order and the illness. And it is clear that when the sample is large the hypothesis of random distribution in the birth ranks—the hypothesis on which all conventional methods of assessing deviations in birth order distribution are based—cannot be assumed. The standard method of Greenwood and Yule applied to the figures in Table II (for sibship sizes 1 to 9) yields a χ^2 value of 82·4 (Table V); and applied to cohorts 1 to 6 (i.e. patients aged 30 years and over) the χ^2 value is 46·6.

5. Changes in Family Size

The Registrar-General's statistics on family size concern the number of children born to women who marry in a particular year. The data on family size presented here (Fig. 2) give sibship size for persons born in particular groups of years. Gregory (1959) gave some similar data derived from schizophrenic patients in Canada.

There is, of course, no simple relation in time between mean family size as measured by the Registrar-General's method and that based (as here) on a sample of adults. The ultimate mean family size of women married in 1920 was 2·47 (Registrar-General, 1963); from the present results, this was the mean family size of persons born about 1935.

6. Relation between Birth Rank and Sex

The study of the association between birth rank and sex is beset with theoretical difficulties. Thus one might need to take into account the excess of male births, the higher mortality of young males, and any differences in the sex–age distribution of the sample. But our finding that sex differences were confined to sibships of four and that these differences held for eight of the nine cohorts simplifies the analysis. This finding—of an excess of males among the last born and a similar excess of females in the penultimate rank—is curious and is not readily attributable to an artefact. Taken at its face value, it provides limited support for the suggestion (e.g. Loxton, 1962) that last-born children might more often be males because of a parental tendency to limit the family after the birth of a son. Yet it is hard to see why, if this is the explanation, it should

apply only to families of four. Our series of 1,850 schizophrenic patients also had a (non-significant) excess of last born males in families of four but did not show an excess of females in the third rank.

Summary

1. Birth order and sibship size were studied in a series of over 20,000 psychiatric patients. Schizophrenic patients were excluded from the series because their birth order distribution did not follow the same pattern as other diagnostic groups. It is argued that the series may, with certain limitations, be accepted as a representative sample of the general population.

2. The distribution of birth ranks deviated very significantly from random, there being an over-representation of early ranks in sibships of two and three, and an over-representation of late ranks in sibships of five and larger. The extent of the deviation varied with the year of birth of the patients.

3. The type of deviation was in accord with theoretical prediction and its fluctuations were shown to follow changes in the number of marriages and of births in the population of England and Wales.

4. It is argued that in studies of the relation between illness and birth order in adults (where bias due to incomplete sibships is minimal or absent) it is necessary to take into account the bias due to reproductive changes in the population.

5. Figures are presented of the changing distribution of sibship size in the population, by birth cohorts.

6. In sibships of four there was an excess of males in the last, and of females in the penultimate, birth rank.

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