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A Statistical Study of Sex Ratio Data from a Sample of Students at Western Kentucky University

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A STATISTICAL STUDY OF SEX RATIO DATA FROM A SAMPLE OF STUDENTS AT WESTERN KENTUCKY UNIVERSITY

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ABSTRACT

Information on family size, sex ratio, and sex by order of birth was obtained from a sample of students at Western Kentucky University during the 1968-69 school year. Participants were white Americans coming primarily from Central Kentucky.

Data were obtained on the immediate, maternal, and paternal families from 1,018 students. Sex ratios for the immediate and parental generations were 101.2 and 103.3, respectively. The overall sex ratio for the study was 102.7. These ratios did not differ significantly from the reported secondary sex ratio of 106 in the United States.

Correlation coefficients were computed between the sexes of various children within families for the immediate generation. A significant positive correlation was found between the sex of child one and two in families of two or more children. The overall correlation between sexes in successive births was also significant. Correlation coefficients between the sexes of children separated by one, two, or three births were not significant.

For complete families of size two, a negative correlation existed between the sexes. This correlation indicated that more families stopped having children when both sexes were present in their offspring.

The observed combination of sexes within each family did not differ significantly from the expected.

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CHAPTER I

INTRODUCTION

It has been well established that the number of males exceeds the number of females at birth in the human population. The male majority fluctuates among various subsets of the population (Colombo, 1957). Less information exists on the combinations and sequences of sexes within families (Gini, 1951). Additional information is needed on the distribution of males and females within families. Objectives of this study were: 1) to determine the secondary human sex ratio of a selected sample, and 2) to study combinations and sequences of sexes within families.

CHAPTER II

REVIEW OF LITERATURE

Studies concerning human sex ratio and distributions of sexes within families have been thoroughly reviewed by Gini (1951) and Edwards (1962b). In the present review, no attempt will be made to include all the literature on human sex determinations.

Sex Ratio

It has been well established that the secondary sex ratio (number of males per 100 females at birth) is not 1:1 as would be expected with equal viability and equal functioning of X and Y bearing sperm. Although reported secondary sex ratios vary, most studies have shown an excess of males. The excess of males has varied in the different studies. Stern (1960) reported that the sex ratio at birth varied among countries, ranging from 113.2 males in Greece to 101.1 males per 100 females in the Negro population of Cuba. Rife and Snyder (1937) collected data on 1,643 Ohio families and found a secondary sex ratio of 101.97. They compared this to the sex ratio of 102.5 from the 1930 United States Census and found the two "very close." Stern (1960) reported that the most widely accepted secondary sex ratio

for the white population in the United States was 106 males per 100 females.

Colombo (1957) reviewed several factors which reportedly influence the sex ratio. These factors include: birth order, age of parents, racial differences, illegitimacy, and others. He stated that most of the factors could be due to different prenatal wastage levels. Combo cited several authors who believe that the primary sex ratio (at conception) is much higher (110 to 170 or more) than the secondary sex ratio. Ciocco (1940) reported that the sex ratio of stillborn by month of pregnancy ranged from 431.1 in month 2 to 112.4 in month 7.

Colombo (1957) illustrated mathematically how a difference in abortion and stillbirth rate could account for the various sex ratios. If the average sex ratio of stillborns is 160:100 and the primary sex ratio is 110, a loss of 10 per cent of the embryos would result in a 105.6:100 secondary sex ratio. Under similar conditions a 20 per cent loss would result in a secondary sex ratio of 100.4. Colombo, however, in his closing remarks emphasized that the exact cause of the variation in secondary sex ratio was not known. Ciocco (1938) was unwilling to accept the theory that reproductive wastage was the major factor in the variation of the sex ratio. He pointed out that there was no association between annual changes in live-births sex ratios and annual changes in either stillbirth rate or in the stillbirth sex ratio.

Correlations Between Sexes

The question as to whether there is a correlation between the sex of successive births has been debated in recent years. Schutzenberger, as cited by Edwards (1959), reported positive correlation between sexes in successive births. Edwards and Fraccaro (1960) analyzed data from 5,477 Swedish families using sexes of children separated by none, one, and two births and found no evidence of a correlation between them. The correlation coefficient between the sexes of successive children in the Swedish families was 0.0044; whereas, the r-value reported by Schutzenberger was 0.029.

Edwards (1961) used the factorial analysis to achieve a more unified analysis of the relationships between sexes of children within families. The two-factor interaction from this analysis tests the association between two births and may be divided into consecutive and non-consecutive interactions. The consecutive interaction tests the degree of association between successive births. Edwards used this analysis on Renkonen's data and found the association between consecutive births to be highly significant ($X^2 = 83.6294$ with 6 d.f.). Estimates of correlation coefficients gave a mean value for successive births of $r = 0.0261$ which was in agreement with the mean value of Schutzenberger's data. Based on these and other data, Edwards concluded that in some samples the sex of a live birth is influenced by the sex of its predecessor. He did not find any significant

association between the sex of non-consecutive two-factor interactions or any significant three- or four-factor interactions.

Beilharz (1963) suggested that the positive correlation between sexes of successive children in a family, as reported by Edwards (1962a) and others, could be due to family limitation. The sequence of sexes thus far obtained in a family coupled with Lexian variation among families in the probability of a birth being male would tend to result in a correlation. Edwards (1966), however, conducted an analysis on Renkonen's data using logarithms of the frequencies to give an analysis independent of family limitation. This analysis also provided good evidence for a positive correlation between the sexes of successive children in a family.

Family Planning

Conflicting ideas have been reported regarding the effect of birth control on the sex ratio and on the combinations of sexes in a family. Gini (1951) stated that birth control alone would not change the sex ratio, but when birth control was associated with the desire to have a child of one sex, the effects on sex combinations of families would become important. Goodman (1961) suggested that birth control could cause the sex ratio to increase, decrease, or remain unchanged depending in part upon the kind of preferences for male or female offspring and how these preferences

affect the parents decisions to have another child. Thomas (1951) presented data which indicated that the sex of the first two children did have a significant effect on the ultimate family size. In 155 families of two or more children, the first two children were of the same sex in 85 families and different in 70 families. Of the 85 families where the sex of the first two was the same, 33 families stopped and 52 families went on to have subsequent children; whereas, of the 70 families of different sex, 40 stopped and only 30 families had subsequent children. Edwards (1962a) published estimates of correlation coefficients between the sexes of various children in complete families of size two, three, four, and five or more, and found negative correlation coefficients for the last two births in families of size two, three, and four. He explains this effect as being due to birth control in that families are more likely to end with children of the opposite sex.

Binomial Distribution

Many data have been presented in the form of the binomial distribution, especially the early data reported before modern statistics were developed. Rife and Snyder (1937) compared sex distributions in 1,269 families to the expected binomial distribution and found that the two did not differ statistically. In several other works, as reported by Gini (1951), some data fit the expected while others did not. Edwards (1958) explained the deviation from

the expected binomial by assuming that the probability of a male birth varied in the population. In a later study, Edwards (1962a) stated that sex ratio data available soley in the form of binomial distribution are of little use since their analyses are difficult and interpretations are uncertain.

CHAPTER III

MATERIALS AND METHODS

During the 1968-69 school year a survey was conducted in various classes in the Ogden College of Science and Technology at Western Kentucky University. White Americans coming primarily from Central Kentucky were asked to complete the questionaire as presented in TABLE 1. A total of 1,018 students, 50 per cent males and 50 per cent females, participated in the survey. Only full sibs were included. Families having multiparous births were excluded from the study.

The number of males and females in the student's immediate family was used to obtain a secondary sex ratio for the immediate generation. The numbers of males and females in the paternal and maternal families were combined to obtain the secondary sex ratio for the parental generation. These ratios were tested against the accepted sex ratio using chi-square. Data from both generations were combined to give an overall observed secondary sex ratio which was also tested against the accepted sex ratio.

Data from the immediate generation provided information on the sex of the children by order of birth. Using these data correlations were calculated between the sexes of various children. Correlations were computed between the sexes of children of successive births (child n vs. child

TABLE 1. Questionnaire used to obtain sex data.

NAME _____ BOY _____ GIRL _____

I. For your mother's family (Include her and only her full brothers and sisters)

Total number of children ___
number of girls ___
number of boys ___

II. For your father's family (Include him and only his full brothers and sisters)

Total number of children ___
number of girls ___
number of boys ___

III. For your immediate family (Include yourself and only your full brothers and sisters)

Total number of children _____
number of girls _____
number of boys _____

Please check the following for your immediate family

(Include yourself at the appropriate place)

Child		Boy	Girl
First	(oldest)		
Second			
Third			
Fourth			
Fifth			
Sixth			
Seventh			
Eighth			
Ninth			
Tenth			
Eleventh			
Twelfth	(youngest)		

n + 1 for n = 1-4) in families of two or more children. Correlations were also computed between the sexes of children separated by one birth (child n vs. child n + 2 for n = 1-4), the sexes of children separated by two births (child n vs. child n + 3 for n = 1-4), and the sexes of children separated by three births (child n vs. child n + 4 for n = 1-3).

In complete families of size two, three, and four children, correlations were calculated between the sex of child one vs. child two. These correlations were used to study the relationship of family size and the distribution of sexes.

A 2^n factorial analysis, as described by Edwards (1961), was computed to test the effect of each of n factors and the two- and three-factor interactions in immediate families of size two, three, and four children. This analysis provided information concerning the association between consecutive births and the association between non-consecutive births.

Data for both generations were combined and grouped according to family size.[4] Each family size was divided into combinations of sexes. Through the expansion of the binomial the expected combinations of sexes for each family size was computed using both the reported and observed sex ratios. The observed and expected combinations of sexes were compared using chi-square.

CHAPTER IV

RESULTS AND DISCUSSION

Sex Ratio

The total numbers of males and females in the parental generation and immediate generation were 4,720 and 4,570, and 1,702 and 1,681, respectively. The average family size for the parental generation was 4.56 children per family, and the average family size for the immediate generation was 3.32 children per family. The secondary sex ratio in the parental generation was 103.3 (males per 100 females). The reported secondary sex ratio for white Americans most generally accepted is 106 males per 100 females, Stern (1960). The numbers of males and females in the parental generation were compared to the expected numbers by the use of chi-square and found not to differ significantly ($X^2 = 1.58$, $p = .22$). The secondary sex ratio of the immediate family was 101.2, but some bias may have been included in the ratio due to the equal number of male and female respondents; however, the observed numbers of males and females in this generation also did not differ significantly from the expected using the 106 sex ratio ($X^2 = 1.79$, $p = 0.20$).

The total numbers of males and females from the parental and immediate families were combined to obtain an

overall observed sex ratio of 102.7. This was tested and found not to differ significantly from the 106 sex ratio ($X^2 = 3.12$, $p = .08$). The overall observed sex ratio for the study is in agreement with other studies in that a majority of male births was found. The male majority was not as great as reported by Stern (1960), but this could partly be due to equal numbers of male and females respondents as mentioned previously.

Correlations Between Sexes

Correlation coefficients were calculated between sexes of various members of the immediate family, which were the only data where sex by order of birth was obtained. Correlation coefficients for the sex of successive births are presented in TABLE 2. Only one correlation--child one vs. two--was significant wheneach pair was analyzed individually, but the correlation for the combined effect of sexes of successive births was significant. This is in agreement with Schutzenberger, as cited by Edwards (1959), who reported a significant positive correlation between sexes of successive births. Edwards (1959) and Edwards and Fraccaro (1960) found no such correlation, but Edwards (1961) and (1966) using a new type of analysis did find a significant positive correlation between sexes of successive births.

A possible biological explanation has been offered to explain correlations between sexes in successive births

TABLE 2. Correlations between sexes of successive births in families of two or more children.

Child Pair	r	Degrees of Freedom
one vs. two	+0.1202**	897
two vs. three	+0.0556	612
three vs. four	+0.0494	356
four vs. five	-0.0884	203
total effect	+0.0684*	2,070

* Significant at the .05 level of probability.

** Significant at the .01 level of probability.

(Edwards, 1962b). The sex of the previous child may in some way alter the biological condition of the mother in such a way that the uterus would be less favorable for implantation of the next embryo if it were of a different sex, and thus increase the chance of abortion. This, however, has not been proven and is only one of several ideas put forward in an attempt to explain the observed significant correlation.

If some biological reason exists for a correlation between successive births, there may also be correlations between the sex of children separated by one or more births. Correlation coefficients for sexes of children separated by one birth are presented in TABLE 3. None of the correlations of sexes separated by one birth were significant. Correlations between the sexes of children separated by two or three births are reported in TABLE 4. Only one of these correlations, child two vs. six, was significant and this probably has little, if any, biological importance.

Schutzenberger, as cited by Edwards (1959), and Edwards (1961, 1962, 1966) also found no overall significant association between sexes of children separated by one or more births.

Edwards (1961) introduced the use of the factorial analysis to sex ratio data. He considered the occurrence of a male at a particular birth as corresponding to the presence of a certain factor and the occurence of a female to the absence of the factor in the 2^n factorial for n number of children. A summary of this type of analysis for the

TABLE 3. Correlations between sexes of children separated by one birth in families of three or more children

Child Pair	r	Degrees of Freedom
one vs. three	-0.0032	609
two vs. four	+0.0823	356
three vs. five	+0.1109	203
four vs. six	-0.1599	112
total effect	+0.0243	1,282

TABLE 4. Correlations between sexes of children separated by two or three births in families of four or more children.

Child Pair	r	Degrees of Freedom
one vs. four	+0.0810	357
two vs. five	+0.0576	203
three vs. six	-0.0830	110
four vs. seven	-0.00793	69
one vs. five	-0.0775	194
two vs. six	-0.2136*	111
three vs. seven	+0.0111	69
total effect	-0.0085	1,119

* Significant at the .05 level of probability.

immediate families of size two, three, and four are represented in TABLE 5. The consecutive two-factor interaction was significant in families of size three, and the total consecutive two-factor interaction resulted in a chi-square of 9.96 (6 d.f., $p = 0.14$). Edwards reported a highly significant chi-square value for the consecutive two-factor interaction.

The degree of association in non-consecutive two-factor interactions was less, $X^2 = 5.99$ with 4 degrees of freedom, $p = 0.28$. The association of three- and four-factor interactions was considerably less and as stated by Edwards (1961) "probably have no biological meaning."

Effect of Family Planning

If parents desire at least one child of each sex, then family planning could affect the correlation in families of a given size (Gini, 1951). The highly significant correlation between the sexes of child one vs. two in TABLE 2 was obtained from data using families of two or more children. Due to the age of respondents, the immediate family was considered to be complete. In families of size two only, the correlation coefficient between the sexes of child one and child two was -0.0521 with 285 degrees of freedom. The correlation coefficients for the sexes of child one vs. two in families of size three and of four were 0.0555 with 251 degrees of freedom and 0.0742 with 151 degrees of freedom, respectively. These correlations

TABLE 5. Factorial analysis of immediate families of size two, three, and four children.

Effect	Family Size							
	2		3		4		Total	
	X^2	d.f.	X^2	d.f.	X^2	d.f.	X^2	d.f.
Main effects[a]	3.93	2	0.73	3	5.97	4	10.63	9
Consecutive two-factor interactions[b]	0.90	1	7.78	2	1.29	3	9.96	6
Non-consecutive two-factor interactions[c]			0.25	1	5.73	3	5.99	4
Three- and four-factor interactions			0.57	1	2.37	5	2.94	6
Total	4.83	3	9.33	7	15.36	15	29.52	25

[a] Testing deviations of sex ratio from one-half.

[b] Testing associations between consecutive births.

[c] Testing associations between births separated by at least one other birth.

indicate that the sexes of the first two children are positively correlated in families of three or four children; whereas, they are negatively correlated in families of two children. This could be interpreted to mean that more parents are willing to stop future births after two children when they are of opposite sex. A similar trend was presented by Edwards (1962) who gave estimates of correlation coefficients between the sexes of child one and two in over 36,000 complete families of size two, three, and four children as -0.0163, 0.0387, and 0.0547, respectively. He interpreted the correlations to be due to birth control in that families are more likely to end with children of the opposite sex.

An alternative way of testing whether the sex of the first two children in a family affects the ultimate size of the family was described by Thomas (1951). She devised a test which would indicate the presence of this effect. The immediate family data for families of size two, three, and four are presented in TABLE 6. In the 350 families where the first two children were of the same sex, 38.5 per cent stopped; whereas, in the 340 families in which the sexes differed, 44.4 per cent stopped. Chi-square was used to test the hypothesis that the percentage of families who limited the family size to two children and the percentage who increased family size were the same regardless of the sex of the first two children. The resulting X^2 was 5.02 and significant. Thus both the correlation coefficients, as suggested by Edwards (1962), and the chi-square, as described

TABLE 6. Effect of sex of the first two children on ultimate family size.

First two children	Family stopped		Family increased	
	Number	Per Cent	Number	Per Cent
Same sex	135	38.5	215	61.5
Different sex	151	44.4	189	55.6

by Thomas (1951), indicate that the sex of the first two children has an effect on family size where birth control methods are used and family size can be limited.

Binomial Distribution

The data from both generations were combined to obtain the total number of families of size one through eight. The number of families of each size and the various possible combinations of sexes are presented in TABLE 7. The expected frequencies of the various combinations of sexes were computed by using the binomial expansion. Both the reported sex ratio of 106 and the observed sex ratio of 102.7 were used. Chi-square was used to compare the observed and expected number of families for each sex ratio. A summary of these chi-square are given in TABLE 8. None of the combinations of sexes differed significantly from the expected using either the reported or observed sex ratio.

TABLE 7. Sex distributions in complete families of n number of children.

Number of Males	Family Size (n)							
	1	2	3	4	5	6	7	8
8								1
7							1	3
6						3	12	16
5					9	24	35	22
4				31	64	50	54	36
3			73	110	118	79	58	26
2		139	245	150	111	43	24	13
1	138	323	206	97	49	14	16	3
0	145	146	75	30	8	0	2	0
Total	283	608	599	418	359	213	202	120

TABLE 8. Observed combinations of sexes compared with expected combinations using both the reported and observed sex ratio.

Family Size	Reported Ratio (106)		Observed Ratio (102.7)	
	X^2	p	X^2	p
1	0.90	.37	0.43	.52
2	4.26	.13	3.07	.23
3	3.22	.38	2.87	.43
4	2.52	.65	1.96	.71
5	1.97	.85	2.37	.79
6	7.39	.30	8.10	.24
7	8.88	.27	6.50	.49
8	2.00	.92	1.86	.93

CHAPTER V

SUMMARY

Data were obtained on the immediate, maternal, and paternal families of 1,018 students. Sex ratios for the immediate and parental generations were 101.2 and 103.3, respectively. The overall sex ratio for the study was 102.7. These ratios did not differ significantly from the reported secondary sex ratio of 106 in the United States.

Correlation coefficients were computed between the sexes of various children for the immediate generation. A significant positive correlation was found between the sex of child one and two in families of two or more children. The overall correlation between sexes in successive births was also significant. Correlation coefficients between the sexes of children separated by one, two, or three births were not significant.

For complete families of size two, a negative correlation existed between the sexes. This correlation indicated that more families stopped having children when both sexes were present in their offspring.

The observed combination of sexes within each family size did not differ significantly from the expected.

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