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A Study of the Relation Between Post-Partum Amenorrhea'and Lactation

I. Introduction

THERE has been a great deal of discussion in recent years about the nature of relationship between post-partum amenorrhea and lactation period. The most commonly used measure for the association between lactation and PPA, in these studies, is the coefficient of correlation (Y), based on the assumption of a linear relationship between these two variables. Saxena (1969), observing the value of Y near about 0.2, argues that the relation between PPA and lactation is not exactly linear and hence the value of Y may be misleading. His argument rests on the fact that in the overwhelming majority of lactating women, generally, amenorrhea terminates before the curtailment of lactation and no sooner menstruation is returned, lactation does not affect the length of amenorrhea. However, he suggests another index Y, following Goodman and Kruskal (1954), to represent the relation between lactation and PPA.

One of the important problems in this regard is to examine the nature of the variation in PPA with prolonged breast-feeding. This paper presents some findings on the relation between post-partum amenorrhea and breast-feeding in a community where extended lactation is universal and is suspended only due to either death of infant or next pregnancy. With the data of Varanasi Survey, an account of which is given in Section II, it is shown that a second degree polynomial would explain the variation in average length of PPA better than a linear regression equation. The significance of the quadratic term has been examined in Section V. Section VII deals with the suitability of the Gompertz curve to data. Discussion of the results given in the last section.

II. Data

In order to make a comprehensive and detailed study of several demographic and socio-economic characteristics, a Demographic Survey of Varanasi (Rural) was conducted in 1969-70, under the auspices of the Demographic Research Centre, Banaras Hindu University (sponsored by the Population Council, New York). The survey covered about 2200 households scattered in 52 villages in Varanasi Tehsil. Each eligible couple was personally interviewed and detailed information regarding the duration of PPA, lactation, gestation, date of termination, age of mother etc., for each pregnancy within last seven years from the reference date of the survey (September 1969), was collected. A couple is termed as 'eligible', if both the partners are alive, female's age is less than fifty years and has not attained menopause on the reference date.

In the present study, lactation and amenorrhea periods following second last live births have been analysed. This is so, because consideration of last birth provides us most of the continuing PPA and/or lactation cases, whereas the informations following earlier births suffers more from recall lapse. Out of 2591 eligible couples in the sample, 31 have been excluded due to multiple births within last seven years. Only 1186 females have been reported with at least two pregnancies in this period. Again, in order to give full exposure to breast-feeding, 487 cases, with most of the continuing cases are not included in the study. Thus, 699 last but one pregnancies terminated three years prior to the reference date. 13 second last pregnancies, out of 699, resulted in defective terminations and for 200 cases the duration of PPA and/or the lactation period are not available. Thus excluding in all 213 (13 + 200) cases, we are able to classify 486 mothers according to different amenorrhea and breast-feeding periods.

III. Preliminary Results

In the community to which data is concerned the length of lactation extends more than a year for about 82 per cent cases. Only 18 per cent women lactate for less than a year. The early weaning is mainly contributed to two reasons, (1) death of infant within a year and (2) less breast milk to nurse the infant. The average amenorrhea and lactation period are observed as 11.08

months and 22.81 months respectively. Singh and Bhaduri (1971) also report that average PPA generally lies between 10 to 14 months for several studies conducted in India. The bivariate frequency distribution of PPA and breast-feeding yields a coefficient of correlation *(r)* equal to 0.18, which is consistent with the results obtained by Saxena (1969) and others. A low value of *r* perhaps amplifies the fact that it is not reasonable to assume a linear relationship between these two variables. Therefore, the suitability of a second degree polynomial, next to linear equation, has been examined in the following section.

IV. Fitting of a Second Degree Polynomial

In almost all communities, PPA period, following a live birth has been observed to increase as the duration of lactation extends but after some time as menstruation returns, amenorrhea period no longer is affected by lactation. Thus, it shows a constant nature for longer lactation periods. A second degree curve, therefore, may approximate the average duration of PPA, rather than a straight line. Hence, in the present section, a second degree polynomial is fitted to average lengths of amenorrhea for given breast-feeding periods.

A second degree polynomial can be written as,

$$Y = a + bX + cX^2, \quad (1)$$

where *a, b* and *c* are constants to be estimated. *X* is independent variable and *Y* depends on *X*. Assuming the average length of PPA, given in Table 1, to be dependent on the other variable—lactation period—we can write the former as *Y* and the latter one a *X*. Since the *X* values are equally spaced, the fitting can be further simplified by using a second degree orthogonal polynomial,

$$Y = A + BX_1 + CX_2, \quad (2)$$

where the coefficients of this polynomial are so chosen that

$$\Sigma X_i = 0 \quad \text{and } \Sigma X_i X_j = 0, \ (i \neq j), \ i, j = 1, 2. \quad (3)$$

The sums are over the *n* values of *X* in the sample. Equations (3) define the orthogonality of polynomials X_l and X_z.

It can be easily shown that the polynomial (2) would give the same result as (1). Polynomial (2) has superiority on (1) only for its simplicity in fitting, because the X_1 X_2 values can be directly read from any statistical table for specified values of *n*. Also, an orthogonal fitting provides us with a testing procedure to examine the significance of each term in the polynomial. If necessary, (2) can be expressed in terms of *X* and its powers utilising explicit formulas .X_1 and X_2.

TABLE 1—FITTING A SECOND DEGREE ORTHOGONAL POLYNOMIAL TO AVERAGE PPA

Duration of lactation in months (X)	*Average PPA in months (Y)*	x_1	X_2	*Estimated average PPA (Y)*
3	4.44	-3	5	4.54
9	7.94	-2	0	7.75
15	10.68	_j	-3	10.34
21	11.51	0	-4	12.31
27	13.96	1	-3	13.66
33	14.64	2	0	14.39
39	14.37	3	5	14.50
$\Sigma X_i Y$		46.47	-25.91	
λ		1	1	
ΣX_i^2		28	84	

Table 1 shows the values of X_1 and X_2 for $n = 7$. Following Snedecor and Cochran (1967) the fitting of second degree orthogonal polynomial provides the values of $\hat{A}$, $\hat{B}$, and $\hat{C}$, estimates of A, B and C as,

$$\hat{A} = 11.077, \quad \hat{B} = 1.660, \quad \hat{C} = -0.308$$

so that the orthogonal polynomial becomes,

$$\hat{Y} = 11.077 + 1.660\, X_1 - 0.308\, X_2. \qquad (4)$$

An expression of $\hat{Y}$ in the original X-variable can be obtained, using the following explicit formulas of X_1 and X_2 in terms of X.

$$X_1 = \frac{X - \overline{X}}{h},\ X_2 = \left(\frac{X - \overline{X}}{h}\right)^2 - \frac{n^2 - 1}{12},$$

where $\overline{X}$ denotes the average of X values and h denotes the equal difference between two successive values of X. In the present case, $\overline{X} = 21$ months, $h = 6$ months and $n = 7$. The substitution of X_1 and X_2 in terms of X gives the estimates of a, b and c,

$$\hat{a} = 2.7064,\ \hat{b} = 0.6379,\ \hat{c} = -0.0086,$$

which provides the quadratic equation in X,

$$\hat{Y} = 2.7064 + 0.6379X - 0.0086X^2. \qquad (5)$$

The estimated values of Y from equation (5) are presented in the last column of Table 1.

V. Testing of the Quadratic Term

The fitting of a second degree orthogonal polynomial to the data provides us with a test at each stage whether the addition of a higher power term will

TABLE 2—REDUCTION IN SUM OF SQUARES DUE TO SUCCESSIVE TERMS

Source	*Degrees of freedom*	*Sum of squares*	*Mean sum of squares*	*F*
Total : $\Sigma(Y - \overline{Y})^2$	6	86.0972		
Reduction to linear	1	77.1236		
Deviation from linear	5	8.9736	1.7947	42.97
Reduction to quadratic	1	7.9920		
Deviation from quadratic	4	0.9815	0.2453	32.58
Reduction to cubic	1	0.0004		
Deviation from cubic	3	0.9811	0.3270	0.001

resonably improve the fit. The test provides the lowest degree polynomial which can be treated as adequate. In order to examine the significance of the second degree term in the polynomial (1) above, test has been applied exactly on the same lines as given in Snedecor and Cochran (1967). Table 2 shows the calculated sum of squares for each term and corresponding *F* values. Both *F* values for linear and quadratic terms are highly significant while the cubic term shows an insignificant value of *F* at 5 per cent level of significance. Clearly, the second degree equation is suitable for the data.

VI. Weighted Regression Equation

It is worthwhile to note that average PPA periods in different lactation groups are based on unequal number of observations. The different weights are presented in Table 3. Thus, a weighted regression equation should be treated

TABLE 3-ESTIMATES OF AVERAGE PPA USING WEIGHTED REGRESSION AND GOMPERTZ CURVE

Duration of lactation in months (X)	*Average PPA in months*	*Weights*	*Estimates of Average*	*PPA using*
			Weighted second degree polynomial	*Gompertz curve*
3	4.44	54	4.68	4.44
9	7.94	34	7.75	7.16
15	10.68	77	10.35	9.61
21	11.51	76	12.33	11.51
27	13.96	116	13.68	12.87
33	14.64	49	14.40	13.78
39	14.37	80	14.50	14,37
Total		486		

as a more reasonable fit. For this purpose, the weights are accounted in the present section and the weighted second degree polynomial is fitted to the data. The least square estimates of *a, b* and *c* are obtained using three normal equations,

$$\left.\begin{aligned} \Sigma w_i y_i &= a\Sigma w_i + b\Sigma w_i x_i + c\Sigma w_i x_i^2 \\ \Sigma w_i x_i y_i &= a\Sigma w_i x_i + b\Sigma w_i x_i^2 + c\Sigma w_i x_i^3 \\ \Sigma w_i x_i^2 y_i &= a\Sigma w_i x_i^2 + b\Sigma w_i x_i^3 + c\Sigma w_i x_i^4 \end{aligned}\right\} \quad (6)$$

where *w* denotes the weight and sums extend over all *X* values.

Solving the above normal equations for a, b and c we have,

$$\hat{a} = 2.6689, \ \hat{b} = 0.6426, \ \hat{c} = -0.0087$$

so that the weighted second degree equation is,

$$Y = 2.6689 + 0.6426X - 0.0087X^2, \tag{7}$$

Incidently, the weighted regression coefficients are approximately equal to that of unweighted equation (5). The estimated Y values from (7) are presented in Table 3.

VII. Gompertz Fitting

The pattern of the length of average PPA observed in the present study, shows a constant nature while lactation extends for more than two years. Hence, it is reasonable to think for a curve with the same property. In this light, the well-known Gompertz curve has been fitted to the data in order to test its suitability for such situations. The equation of the curve may be written as,

$$Y = KA^{B^X}, \tag{8}$$

where K, A and B are three constants.

The curve approaches K as an upper limit if A is negative. Constants can be determined in such a way as to make the curve pass through any three selected points. For this purpose, the selected points are $(3, Y_3)$, $(21, Y_{21})$, and $(39, Y_{39})$, so that the whole range of observations is covered. The estimates of K, A and B calculated as,

$$\hat{K} = 15.372, \ \hat{A} = 0.205, \ \hat{B} = 0.922.$$

Making the substitution of estimated values of K, A and B in (8), we have the fitted Gompertz curve,

$$\hat{Y} = (15.372)(0.205)^{(0.922)^X}. \tag{9}$$

Clearly, the asymptote to the curve lies in the vicinity of 15 months. The estimated values of Y, using the equation (9) are plotted in the last column of Table 3.

VII. Discussion of the Results

As shown in preceding sections, a second degree parabola explains the average length of PPA for lactation periods ranging from 3 to 39 months. Though the contribution of the quadratic term for smaller breast-feeding periods is almost negligible, it plays a significant role for larger lactation periods. It should be noted that the values of average length of PPA, beyond 27 months of lactation remain almost constant upto 39 months and it is very rare to expect lactation period to exceed 40 months. For reasonable periods of breast-feeding, therefore, the second degree parabola seems to be adequate.

The method of fitting of the Gompertz curve is crude since it utilizes only three selected points out of seven. However, the fitted curve reveals that it can frequently be used to describe the variation in the length of PPA according to the duration of lactation. The asymptote to the curve is at about 15 months. This sets up an upper bound for average PPA. Several studies conducted in India, also show that average PPA hardly extends beyond 15 months.

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