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THE INTERACTIVE EFFECTS OF MOTHER'S SCHOOLING AND UNSUPPLEMENTED BREASTFEEDING ON CHILD HEALTH

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Abstract

This paper estimates a nonlinear relationship between duration of breastfeeding and child height-for-age. For this sample of children, health benefits from unsupplemented breastfeeding differ by mother's education, with children of less educated mothers deriving the most gains. These results suggest that more educated mothers are able to provide wholesome substitutes to breastmilk without producing ill effects. Results are sensitive to the estimation technique used, with 2SLS estimates showing statistical signficance and substantial health gains compared to OLS estimates.

INTRODUCTION

Two empirical regularities in the literature on child health are: (1) more educated mothers tend to have healthier children (Cochrane, 1980), and (2) more educated mothers tend to have shortened durations of breastfeeding (Ware, 1984). Since the health benefits from breastfeeding are well established in the public health, nutrition, and medical literature (Jelliffe & Jelliffe, 1978a; Greiner & Latham, 1981; Arnold, et.al., 1981; Wray, 1978; Butz, et. al., 1984), the above phenomemon can be explained by more educated mothers being able to successfully provide healthy substitutes to breastmilk by virtue of their better health knowledge, higher incomes, and enhanced ability to change their immediate environment. The primary objective of this paper is to empirically explore the interaction of maternal schooling and her duration of unsupplemented breastfeeding as they affect child height-for-age. Duration of unsupplemented breastfeeding (in contrast to total or supplemented breatfeeding) is the focus of the study because of its nonlinear health benefits, the attainment of which depends to a large extent on the critical choices made by the mother with respect to the timing and healthful conditions surrounding the introduction of supplemental food.

Furthermore, two sub-objectives are to be achieved in the course of the empirical work: (1) an examination of the nonlinear nature of the health benefits of unsupplemented breastfeeding, and (2) a comparison of the different inferences which arise from OLS and 2SLS estimates, that is, treating breastfeeding as an exogenous or endogenous variable.

Nonlinearity

Some studies by economists on the determinants of child nutritional status commonly find a negative association, if not a statistically insignificant positive relationship, between child health and duration of breastfeeding (Blau, 1984; Wolfe & Behrman, 1982; Heller & Drake, 1979). One possible explanation is that the true underlying relationship between child health and breastfeeding may be nonlinear, that is, health benefits do not monotonically increase with duration of breastfeeding. Both short and prolonged durations of breastfeeding can cause deleterious health consequences for the child (Waterlow, 1981; Meredith, et. al.,1983). Too short or no breastfeeding at all can be harmful to the child because it deprives the infant of maternal antibodies which become even more important in view of the child's underdeveloped immune system. Besides, human milk helps stimulate the infant's own defenses (Mata, et.al., 1976; Whitehead, 1983; Haaga, 1985). A shortened duration of exclusive breastfeeding subjects the child to greater risks of exposure to germs from prepared foods and the utensils used, such as bottles (Habicht, DaVanzo & Butz, 1987). This is particularly true in poor countries where it is humid and where there is a lack of water, sanitation facilities and refrigeration. An early introduction of supplementary foods can lead to a decline in the mother´s production of milk since this is dependent on the stimulation provided by the infant´s sucking. Substitutes for breastmilk, whether infant formula or bulky food, do not have the complete array of nutrients which breastmilk has. There is also the danger of overdiluting the formula with water, either from attempts to economize or simply out of the inability to follow the manufacturer´s directions (Dwyer,1975).[1]

On the other hand, prolonged unsupplemented breastfeeding may also be harmful. Eventually, breastmilk alone is inadequate to supply the nutrient requirements of the growing child (Waterlow & Thompson, 1979; Whitehead, 1983).[2] Mata, et. al. (1976) find the duration of breastfeeding to be strongly and positively associated with the linear segment of a child´s growth but inversely related to the period of faster growth. Martorell, et. al, (1984) and Victora, et. al., (1984) find prolonged durations of exclusive breastfeeding to be associated with lower

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[1]There is also the indirect benefit of better birth spacing arising from the contraceptive role of breastfeeding.

[2]Furthermore, the nutrient content of human milk is dependent on the mother´s nutritional status (Haaga, 1985; Jelliffe & Jelliffe, 1978b). As such, the problem of prolonged unsupplemented breastfeeding, which is common in Asia and Africa, becomes further exacerbated in developing countries where mothers are often malnourished themselves. The onset of the period when breastmilk alone becomes insufficient is hastened.

stature. Wray (1978) finds unsupplemented breastfeeding to play a protective role against diarrhea only in the early months.

The key issue, then, is not merely whether to breastfeed or not, but also when supplementary foods should be introduced.[3] Waterlow (1981) describes this problem of timing as the "suckling's dilemma" where a "critical balance" (Brown, 1978) is necessary if the infant is to derive the full benefits of breastfeeding. Scrimshaw (1966) finds the age of complete weaning (severage) to be the key factor in explaining nutritional status in the 6-24 month age group. An average period of 4-6 months of age is generally accepted as the range during which supplementary foods should be introduced (Jelliffe & Jelliffe, 1978b; WHO, 1981).

If the health benefit from breastfeeding is truly nonlinear, then using a linear specification can lead to a statistically insignificant positive relationship, or even a negative association in cases where there is a significant number of children in the sample who are experiencing prolonged unsupplemented breastfeeding and whose health are consequently expected to be poor relative to those within the shorter optimal period.

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[3]When supplemented breastfeeding should cease is not clear at all. It is believed that breastmilk can be a "valuable supplementary source of 'complete' protein and of fat, calcium and vitamins" for children beyond six months of age (Jelliffe & Jelliffe, 1978b). Because of this, the focus of the paper is on unsupplemented breastfeeding alone.

Other possible explanations for the negative or insignificant association between child health and breastfeeding are data inaccuracies/inadequacies and the failure to include maternal education and breastmilk substitutes in the analysis. More educated mothers probably breastfeed less with no ill effects on child health by providing sanitary and nutritious substitutes. As such, omitting these factors from the analysis would lead to empirical results associating shorter durations of breastfeeding with better child health.

Endogeneity

One deficiency in studies dealing with breastfeeding is the use of OLS estimation techniques. This produces estimates which would be consistent and unbiased only under the assumption that breastfeeding is exogenous and is not related to child health endowment or family preferences. This assumption is inappropriate because breastfeeding is clearly a household decision related to its choice of other commodities affecting child health, and is also dependent on the child's health endowment. As a consequence, estimates of the breastfeeding health impact from these studies should be taken with caution because of a simultaneity bias (Heller & Drake, 1979; Greiner & Latham, 1981; Butz,et. al., 1984; Knowles, 1984).

This paper (1) estimates a possible nonlinear relationship between duration of unsupplemented breastfeeding and child height-for-age, (2) demonstrates the sensitivity of the results to the estimation technique used, and (3) examines how maternal education affects the health impact of breastfeeding. The next section presents the empirical specification. Section 3 presents the data and the estimation results.

2. Empirical Specification

To examine the relationship between child health and breastfeeding, the health production function of a standard household production model is estimated:

$$H = \alpha + \beta_1 M + \beta_2 BF + \beta_3 F + \beta_4 S + \varepsilon$$

where H is child nutritional status; M is maternal human capital and skills important to child rearing, such as her health, experience and education, proxied by mother's height, age and years of schooling; ε is a stochastic disturbance term. The maternal-related variables are generally accepted to be exogenous to the family, that is, they are not subject to change but are taken as given at the time the household makes its decisions affecting child health. BF, F and S are duration of breastfeeding, food consumption and sanitation, respectively.

These proximate health inputs are subject to household choice, simultaneously determined with the quality of health (H) the household chooses to provide its children. As such, they are correlated with the error term and two-stage least squares (2SLS) is used for estimation.

Two-thirds of the sample were still breastfeeding at the time of the survey, 25% of which were still breastfeeding without supplementation. This causes a censoring problem because we are unable to observe completed spells of breastfeeding. In a similar problem encountered in analyzing schooling outcomes, Lillard & King (1984) suggest the creation of an index where the child's years of schooling is divided by the average years of schooling for similar-aged children in the sample. In effect, the deviation from the "norm" is measured. This index resolves the problem of high collinearity between the child's age and duration of breastfeeding (in months) for those who were still breastfeeding at the time of the survey.[4] This procedure is adopted in this study.

This index, however, does not solve the problem of truncation. For example, mothers who were still breastfeeding at the time of the interview will be concentrated at an index value equal to the child age divided by the sample mean duration of

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[4]Both child age and duration of breastfeeding are used as regressors in the production function.

breastfeeding of similar-aged (in months) children. They cannot have values over this. Hence, the truncation occurs not only at the lower limit (because of mothers who never breastfed) but also at the upper limit (because of mothers who were still breastfeeding at the time of the interview). In estimating the household demand for breastfeeding, it is therefore necessary to use a tobit estimator with both an upper and a lower limit. The lower limit is set at zero while the upper limit is set at the ratio of the child age to the mean duration of breastfeeding for children of that age. This upper limit is a "floating" limit because it varies according to the age of the child.

The "critical balance" earlier discussed poses nonlinearities in the health effects of breastfeeding. To account for this, squared terms of the breastfeeding variables will be included as regressors.[5]

3. Data and Estimation Results

The data used are the Bicol (Philippines) Multipurpose Survey of 1978 and its Supplementary Survey of 1981.[6] The sample

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[5]Another approach is to stratify the sample into finer divisions of age groups instead of using a nonlinear specification (Chutikul, 1986). The disadvantage with this is the loss of efficiency in estimation and the small sample size in some cells.

[6]These surveys are described in Popkin, et. al. (1979) and Akin, et.al.(1985).

consists of 498 children below 25 months of age. Table 1 presents the variables used and their statistics.

Child health is measured by height-for-age (HTAGE) scores. Height-for-age is chosen because it is believed to be a long-run measure of nutritional status and because it is not subject to transitory schocks.[7] These scores are calculated by dividing the child´s length by the median length from the NCHS standards (Behrman & Vaughan,1983).[8] Breastfeeding is measured as duration (in months) of unsupplemented and supplemented breastfeeding. In the absence of individual-level food intake, food input is proxied by the household consumption of grain per male adult equivalent.[9] Sanitation input is measured as the

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[7]To illustrate, if the subject child had a bout of diarrhea prior to the survey, the measured weight of the child will be under-reported relative to what it usually is. Height (length) seemed to be the most reliable measure in the survey.

[8]Martorrell (1982, p.47) points to a minor and a major problem associated with the use of this type of specification. The minor problem is that such percentages of the median are not equivalent across age groups as in the case he cites where 95% of median height corresponds to the 8th percentile at 12 months in contrast to the 8th percentile at 48 months of age. For the age range of interest to this paper, the difference is minimal. The major problem arises when comparisons across various measures (height-for-age, weight-for-age, weight-for-height, etc.) are made. Such comparisons are not made in this paper. Furthermore, the paper does not in any way deal with measuring the extent of malnutrition in this sample.

[9]The male adult equivalent for each family is calculated using the caloric requirement by sex and age specified by FAO/WHO(1972). A male adult takes on a value of one. The calculation of this variable takes into account not only the immediate members of the family, but all of the residents in the household, including relatives and househelps, as well.

probability of having a water-sealed toilet in the household. Because of the endogeneity of these variables, predicted values of these inputs are calculated from their reduced-form equations (See Barrera, 1988a) which are then used as regressors in the production function estimation. Instruments used in this first stage are similar to those used for breastfeeding below. The reduced-form equation for the sanitation variable is estimated using a probit estimator.

The household demand for breastfeeding[10] is presented in Table 2. More educated mothers breastfeed for a shorter period. This is particularly true for unsupplemented breastfeeding. This may be attributed to two possible explanations: (1) more educated mothers have a higher opportunity cost of time for breastfeeding their children, and (2) more educated mothers are better informed about the deleterious health consequences of unduly delaying the introduction of supplemental foods, and have better perception and judgement of when breastmilk becomes insufficient to meet the child's nutrient requirements. The adequacy of breastmilk is dependent on the volume and quality of the mother's lactation and on the child's accumulated store of fat and metabolic efficiency (Waterlow & Thompson, 1979; Whitehead, 1983). As such, the

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[10]Akin, et. al., (1985) have done previous work on the determinants of various infant feeding practices using this data. They examine household choice of breastmilk, milk substitutes and supplemental foods using a multivariate logit model. Table 2 differs from their analysis in that it analyzes duration of breastfeeding.

optimal timing of supplementation for each mother/child pairing can only be made on an individual basis and is consequently dependent on the mother's perception and judgement.

Mother's age is statistically significant[11] and negatively associated with both types of breastfeeding as well as total duration. Mother's age proxies her experience in home activities such as child rearing. Older mothers should therefore be more efficient in the conduct of her domestic activities which leaves her with more time for breastfeeding. This should have led to a positive sign, assuming breastfeeding is a normal good. However, it could also lead to a negative sign because maternal experience can work just like maternal education in giving her better information and judgement as to the optimal timing of weaning.[12] Maternal age also proxies her labor market experience and hence, opportunity wage outside the family. In addition, it reflects completed or near-completed families which would mean the presence of other siblings demanding her attention and time. Moreover, if these siblings were old enough to help in caring for the infant, the ready availability of mother substitutes would make the cost of alternatives to breastfeeding much cheaper. In

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[11] Unless otherwise stated, statistical significance is set at five percent, two-tailed test, except in cases where the sign is implied by theory, in which case a one-tailed test is used.

[12] Mother's age could also signal differences in the attitude (towards breastfeeding) between younger and older mothers. One could not, however, state a priori how this would affect the duration of breastfeeding.

all these cases, the opportunity cost of time for breastfeeding the infant should be relatively higher. A negative sign in the breastfeeding demand equation would suggest that this effect outweighs the earlier hypothesized positive effect.[13]

Mother's height proxies the mother's unobserved biological endowment which is expected to affect her health and consequently, her capacity to breastfeed. Ideally, mother's weight is a better indicator of the current health status of the mother. Unfortunately, it cannot be used as an instrument because it is thought to be an endogenous variable. These results show mother's height to be statistically insignificant.

The coefficient of child age is negative for unsupplemented breastfeeding, positive for supplemented breastfeeding, and statistically significant in both cases. This is expected since other foods are fed to the breastfeeding child as she grows older. The community wage rate for women is negative in all cases but is statistically significant only for unsupplemented breastfeeding. This is not surprising since unsupplemented breastfeeding is more constraining on the time of the mother. Rice and milk are substitutes to breastmilk and their prices are expected to positively affect duration of breastfeeding. These results, however, show that they are not statistically

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[13]Blau (1984) and Wolfe & Behrman (1982) find a statistically significant positive association between maternal age and duration of breastfeeding in their Nicaraguan sample.

significant. There is no difference in duration of breastfeeding between rural and urban areas. Families with higher incomes tend to use breastmilk substitutes as seen in the statistically significant (except for unsupplemented breastfeeding) and negative coefficient of income.

Production Function

The child health production function is estimated using 2SLS and OLS techniques, and is presented in Table 3. The 2SLS estimates use the predicted values of breastfeeding from Table 2.[14] The maternal-related variables (mother's schooling, age and height) are positive and statistically significant in all equations, indicative of the importance of the mother's human capital in child health production.[15]

The 2SLS estimates of all four breastfeeding variables are jointly statistically significant at 10% with a chi-square[16] of 7.74 (d.f.=4); unsupplemented breastfeeding and its square are

[14] The squared term of the breastfeeding variable is also instrumented and the predicted values used as regressors.

[15] It should be noted that mother's height aside from proxying her unobserved biological endowments directly affecting child health, also reflects the genetic traits (such as height) passed onto the child.

[16] The Wald test is used for examining the joint statistical significance of the IV estimates. This is asymptotically equal to a chi-square, with degrees of freedom equal to the number of restrictions.

jointly significant at 5% (chi-square=5.96), while supplemented breastfeeding and its square are significant at 35% (chi-square=2.12).

Figure 1 graphically presents the pattern traced by the 2SLS estimates of unsupplemented breastfeeding.[17] It shows the hypothesized nonlinear pattern with maximum health benefits achieved at 4-5 months of unsupplemented breastfeeding, calculated at the sample mean of height-for-age score.[18]

In contrast to the 2SLS estimates, the OLS estimates of all four breastfeeding variables are not jointly statistically significant showing an F-ratio of 1.11 (35%). There is a

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[17]The equation used is

Y = ((((a/MSBFD) X (USBFD)) + ((b/MSBFD2) X (USBFD2)))/0.9)*100

where Y = percentage change in height-for-age score
a = coefficient of breastfeeding from Table 3
b = coefficient of breastfeeding-squared
MSBFD = mean duration of unsupplemented breastfeeding for children of the same age
MSBFD2 = squared term of MSBFD
USBFD = months of unsupplemented breastfeeding for the child
USBFD2 = squared term of USBFD
0.9 = average sample height-for-age score

Note that the percentage gains are calculated at the sample average height-for-age.

[18]The pattern for supplemented breastfeeding is nonlinear as well, but upward sloping. Children with longer durations of supplemented breastfeeding show better health performance because they are spared the deleterious health consequences of prolonged unsupplemented breastfeeding, while not foregoing the benefits of breastfeeding, and because it is the more educated mothers who exhibit shorter durations of unsupplemented breastfeeding (Table 2) and who provide wholesome substitutes (as will be confirmed in the next section of this paper).

substantial difference in the magnitude of the OLS and 2SLS coefficients for breastfeeding, with the 2SLS estimates showing a much larger health impact as seen in Figure 3. The 2SLS estimates give a more pronounced nonlinear relationship in contrast to the OLS estimates which show a very flat pattern with little variation in health impact.[19] The 2SLS estimates conform better to empirical results of experimental studies (Victora, et. al., 1984) and to the public health and medical literature which identify the optimal point at the 4-6 month period. The inability of OLS to capture differences in the health impact may be due to its use as regressors of observed breastfeeding behavior, not predicted, which may be correlated with unobserved factors that also explain variations in child health. This allows for many confounding effects to mask the true relationship between duration of breastfeeding and child health.[20]

Total duration of breastfeeding is alternatively run as a

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[19]The scale of the y-axis (percentage gains in height-for-age score) is intentionally magnified to highlight the sharp contrast between the 2SLS and OLS estimates. This would explain the very steep slope of the 2SLS curve.

[20]To further examine the endogeneity of breastfeeding, the Hausman (1978) specification test is run. The child health production is estimated with predicted food and sanitation inputs, uninstrumented breastfeeding variables, and the residuals of the breastfeeding reduced-form equations. The residuals show an F-ratio of 1.63 (16%). This joint statistical significance, while marginal, can still be taken as suggestive of misspecification when breastfeeding is treated as exogenous (when OLS is used), since the Hausman test is a low-power test (that is, it leans towards not picking up the presence of misspecification).

specification. It has the same nonlinear pattern exhibited by unsupplemented breastfeeding with maximum health benefits achieved at 7-8 months of age (calculated at the sample mean of height-for-age), suggestive of an optimum age for complete weaning for this sample of children.[21] Again, 2SLS estimates show child health to be more sensitive to varying levels of breastfeeding compared to OLS estimates. To examine the consequence of using a linear specification for this sample, the child health production function is reestimated without the squared terms (results are not presented). The results would suggest minimal health benefits as none of the coefficients of breastfeeding are statistically significant in any of the equations.

Maternal Education-Breastfeeding Interaction

The demand equations for breastfeeding (Table 2) show that more educated mothers breastfeed for shorter durations.[22] However, the child health production function (Table 3) shows both maternal education and breastfeeding to positively affect child health. Taken together, these results suggest that more educated mothers are able to breastfeed for shorter durations

[21]The joint significance of the two breastfeeding variables is marginal [16% for 2SLS estimates with a chi-square of 3.61 (df=2) and 16% for OLS estimates with an F-ratio of 1.81 (df=2,487)].

[22]This is a finding similar to many other studies (Ware, 1984).

without producing ill effects because of the mother's ability to provide wholesome substitutes such as better food supplements and better sanitation.[23] As such, one may pose the hypothesis that maternal education is a substitute for breastfeeding. To test this conjecture, the child health production function is reestimated in Table 4 with interactive terms between maternal education and duration of breastfeeding. The interactive terms are generally jointly significant.[24] Figure 3 graphically presents these interactions.[25] Children of less educated mothers benefit more from longer durations of unsupplemented breastfeeding. Note that the peaking of health gains occurs

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[23]DaVanzo & Habicht (1984) find that sanitation and water inputs serve as substitutes for breastfeeding. They find the health benefits of unsupplemented breastfeeding to be greater in households with poor sanitation and water facilities.

[24]All four interactive terms and maternal education are jointly significant at 9% with a chi-square of 9.43 (d.f.=5). Considering only the four interactive terms, joint significance is 13% with a chi-square of 7.06 (d.f.=4). All eight breastfeeding variables, interacted and uninteracted, are significant at 9 % with a chi-square of 13.81 (d.f.=8).

[25]The equation used in drawing Figure 3 is

$$Y = ((((a/MSBFD) \times (USBFD)) + ((b/MSBFD2) \times (USBFD2)) + ((c/MSBFD) \times (USBFD)) + ((d/MSBFD2) \times (USBFD2)))/0.9)*100$$

where Y = percentage change in height-for-age score
a = coefficient of breastfeeding from Table 4
b = coefficient of breastfeeding-squared
c = coefficient of interacted breastfeeding
d = coefficient of interacted breastfeeding-squared
MSBFD = mean duration of unsupplemented breastfeeding for children of the same age
MSBFD2 = squared term of MSBFD
USBFD = months of unsupplemented breastfeeding for the child
USBFD2 = squared term of USBFD
0.9 = sample average height-for-age score

later and is greater for children of mothers with little schooling. This is not a surprising finding because the introduction of prepared foods exposes the infant to increased risks of infection from pathogenic agents. More educated mothers (who have better health knowledge and perception, and who are presumably more disposed to hygienic practices), are in a better position to protect their children against these risks, compared to mothers with little schooling, and are therefore able to cease unsupplemented breastfeeding with little ill effects, if at all.[26] These results confirm the hypothesized substitutability between breastfeeding and maternal education (or the human capital it proxies).

Rosenzweig & Schultz (1981) show that there are efficiency and allocative effects in the way maternal education affects child health. These results are suggestive of an allocative effect in operation.

Summary and Conclusions

The use of a linear specification for breastfeeding is inappropriate and can lead to the misleading inference that health benefits from breastfeeding are minimal and/or

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[26]Barrera (1988b) finds that for this sample, more educated mothers afford better protection (especially among 0-2 year olds) against an unhealthy environment relative to mothers with little schooling.

statistically insignificant. Inferences are also sensitive to the type of estimation technique used, with 2SLS estimates showing statistical significance and substantial health gains (in contrast to OLS estimates). More educated mothers can breastfeed less without harmful consequences because of their ability to provide wholesome substitutes.

For purposes of policy formulation, these results suggest that breastfeeding promotion campaigns could be beneficially targetted to mothers with little schooling whose children seem to derive the most health gains, at least for this sample. More educated mothers seem to be able to provide healthy substitutes for breastfeeding.

BIBLIOGRAPHY

Akin, J., C. Griffin, D. Guilkey, and B. Popkin (1985a).
The Demand for Primary Health Services in the Third World
New Jersey: Rowman & Allanheld

Akin, J., C. Griffin, D. Guilkey, and B. Popkin (1985b).
Determinants of infant feeding: a household production approach
Economic Development and Cultural Change

Arnold, J.C., R.W. Engel, D. Aguillon & M.M. Caedo (1981).
Utilization of family characteristics in nutritional classification of preschool children.
American Journal of Clinical Nutrition,
Vol.34, No. 11

Barrera, Albino (1988a)
Maternal Schooling and Child Health.
Ph.D. dissertation, Yale University

Barrera, Albino (1988b)
The Role of Maternal Schooling and Its Interaction With Public Health Programs in Child Health Production.
Yale University, Economic Growth Center Discussion Paper #551

Behrman, Richard E. M.D. & Victor Vaughan III, M.D.(1983).
Textbook of Pediatrics [Nelson].
12th edition.
Philadelphia: W. B. Saunders Company

Blau, David (1984).
"A Model of Child Nutrition, Fertility and Women´s Time Allocation: The Case of Nicaragua" in T. P. Schultz & K. Wolpin (eds.) Research in Population Economics,
Vol. 5. Greenwich Connecticut: JAI Press

Brown, R.E. (1978).
Weaning foods in developing countries.
American Journal of Clinical Nutrition
Vol. 31, pp.2066-2072

Butz, W.P., J.P. Habicht, & J. DaVanzo (1984).
"Environmental factors in the relationship between breastfeeding and infant mortality: the role of water and sanitation in Malaysia" in American Journal of Epidemiology, 119, No. 4: 516-525

Chutikul, S. (1986).
Malnourished children: An economic approach to the causes and consequences in rural Thailand. Honolulu, Hawaii: East West Center Paper No. 102

Dwyer, Johanna T. (1975)
"The Demise of Breast Feeding: Sales, Sloth or Society?" in Priorities in Child Nutrition, Vol. II, Harvard: School of Public Health

FAO/WHO (1972).
Energy & Protein Requirements.
Report of a Joint FAO/WHO Expert Group. Rome: FAO

Greiner, Theodore H., & M. Latham (1981).
Factors associated with nutritional status among young children in St.Vincent. Ecology of Food & Nutrition, Vol.10, No.3, pp.135-141

Haaga, John G. (1985).
Health Consequences of Infant Feeding in Malaysia: A Review.
RAND Note, N-2146-AID

Habicht, J.P., J. DaVanzo, & W. Butz (1987)
Mother´s Milk & Sewage: Their Interactive Effects on Infant Mortality. Pediatrics

Hausman, J. A. (1978). Specification tests in econometrics
Econometrica Vol. 46, No. 6

Heckman, J. (1979).
Sample selection bias as a specification error
Econometrica

Heller, Peter S. & William D. Drake (1979)
Malnutrition, child morbidity and the family decision process
Journal of Development Economics Vol. 6, pp 203-235.

Jelliffe, D. & E.F.P. Jelliffe (1978a).
Human Milk in the Modern World.
Oxford: Oxford University Press

Jelliffe, D. & E.F.P. Jelliffe (1978b).
The volume and composition of human milk in poorly nourished communities: a review. American Journal of Clinical Nutrition, Vol. 31, pp.492-515

Knowles, J. (1984).
"Interactions between malnutrition and disease: a simultaneous equations model applied to data from a low-income area of Karachi" in Pakistan Journal of Applied Economics, Vol. III, No. 2. Karachi, Pakistan: Applied Economics Research Centre.

Lillard, L.A. & E.M. King (1984).Methods for Analyzing Schooling Choice with Household Survey Data. Rand Note, N-1963-AID July 1984

Martorrell, R., (1982).
Nutrition & Health Status Indicators: Suggestions for Surveys of the Standards of Living in Developing Countries. World Bank: LSMS Working Paper #13.

Martorell. R., J. Leslie, P. Moock (1984).
Characteristics and determinants of child nutritional status in Nepal American Journal of Clinical Nutrition Vol.39, No. 1, pp. 74-86

Mata. L., R. Kronmal, B. Garcia, W. Butler, J. Urrutia, S. Murillo (1976). "Breastfeeding, weaning and the diarrheal syndrome in a Guatemalan Indian village." in Acute Diarrhoea in Childhood Ciba Foundation Symposium 42 (new series).
New York: North Holland

Nakamura, A. & M. Nakamura (1985).
Dynamic models of the labor force behavior of married women which can be estimated using limited amounts of past information.
Journal of Econometrics, Vol. 27, No. 3; 273-298

Popkin, B. & S. Roco with P. Bragais & C. S. Callison (1979)
1978 Multipurpose Survey, Vol. 1: Survey Design & Implementation
Manila: USAID

Rosenzweig, M. & T.P.Schultz (1982)
Child Mortality & Fertility in Colombia: Individual & Community Effects. Health Policy & Education, 2, pp.305-348. Amsterdam: Elsevier Scientific Publishing.

Rosenzweig, M. & T.P.Schultz (1981)
Education and the household production of child health
Social Statistics Section, Proceedings of the American Statistical Association

Scrimshaw, N.S. (1966).
The effect of the interaction of nutrition and infection in the pre-school child. National Academy of Sciences - National Research Council, Publication 1282, Washington, D. C., pp. 63-73

Schultz, T.P. (1984).
Studying the impact of household economic and community variables on child mortality. in Child Survival. Strategies for Research. (eds.) W. Henry Mosley & Lincoln C. Chen. Population & Development Review Supplement to Vol. 10, 1984.

Victora, C., J.P. Vaughan, J. C. Martines & L. Barcelos (1984).
Is prolonged breast-feeding associated with malnutrition?
American Journal of Clinical Nutrition, Vol. 39, pp. 307-314

Waterlow, J. C. (1981).
Observations on the suckling's dilemma - a personal view.
Journal of Human Nutrition, Vol. 35, pp. 85-98

Waterlow, J. C. and A. M. Thompson (1979)
Observations on the adequacy of breastfeeding
Lancet, Vol. 2, pp. 238-242

Whitehead, R.G. (1983).
Nutritional aspects of human lactation
Lancet, January 22, 1983, pp. 167-169

Wolfe, B & Behrman, J. (1982).
Determinants of Child Mortality, Health, and Nutrition in a Developing Country. Journal of Development Economics, pp. 163-193

WHO (1981).
International code of marketing of breast-milk substitutes.
WHO Chronicle, Vol. 35, pp. 112-117

Wray, J.D. (1978)
Direct Nutrition intervention and the control of diarrheal diseases in preschool children
American Journal of Clinical Nutrition Vol.31, pp. 2073-2082

TABLE 1

LIST OF VARIABLES AND DEFINITIONS

Variable	MEAN	STD. DEV.
Endogenous Variables		
BREASTFEEDING DURATION (months)		
UNSUPPLEMENTED	4.284	3.405
SUPPLEMENTED	4.093	5.013
TOTAL DURATION	8.370	6.424
BREASTFEEDING DURATION (ratio of child's months of breastfeeding to the average for children of similar age [in months])		
UNSUPPLEMENTED	0.994	0.702
UNSUPPLEMENTED-SQUARED	1.480	1.708
SUPPLEMENTED	0.848	1.232
SUPPLEMENTED-SQUARED	2.234	11.840
HOUSEHOLD TOILET FACILITY (water-sealed=1)	0.454	0.498
QUANTITY OF GRAIN PER MALE ADULT EQUIVALENT (kg)	3.295	1.843
STANDARDIZED HEIGHT-FOR-AGE	0.894	0.064
Exogenous Variables		
CHILD AGE (months)	13.082	6.645
CHILD AGE-SQUARED	215.200	176.160
COMMUNITY WAGE RATE FOR WOMEN (pesos/hour)	1.350	0.914
FAMILY INCOME (annual)	9922.000	0.208E+5
LOCATION DUMMY (village=1; town=0)	0.860	0.347
MATERNAL EDUCATION (years)	5.990	3.347
MOTHER'S AGE (years)	37.780	9.699
MOTHER'S HEIGHT (centimeter)	126.700	72.920
PRICE OF DRUGS (pesos/illness)	16.690	39.130
PRICE OF MILK (pesos/gram)	3.619	0.208
PRICE OF RICE (pesos/kilo)	2.065	0.917E-1
PRICE OF COOKING OIL (pesos/liter)	1.548	0.470
PRICE OF KEROSENE (pesos/liter)	0.575	0.109
SEX (male=1;female=0)	0.515	0.500
SUFFICIENCY OF WATER FOR HH USES IN COMMUNITY (sufficient=1)	0.956	0.203
PREVALENT HH SOURCE OF WATER IN COMMUNITY (piped=1;zero otherwise)	0.757	0.428
PREVALENT TYPE OF TOILET IN COMMUNITY (water-sealed=1)	0.556	0.497
ABSENCE OF EXCRETA IN ENVIRONS OF COMMUNITY (none or little = 1)	0.820	0.383

TABLE 2

HOUSEHOLD DEMAND FOR BREASTFEEDING

Dependent variable:
DURATION OF BREASTFEEDING/AVERAGE FOR SAME-AGE CHILDREN

	UNSUPPLEMENTED	SUPPLEMENTED	TOTAL
CONSTANT	2.574 (1.29)	-5.098 (-1.10)	2.864 (1.11)
MOTHER'S SCHOOLING	-0.633E-01 (-3.91)	-0.442E-1 (-1.09)	-0.103 (-4.83)
MOTHER'S AGE (X10E-1)	-0.227 (-3.66)	-0.474 (-2.85)	-0.380 (-4.47)
MOTHER'S HEIGHT (X10E-2)	-0.487 (-0.59)	0.502 (0.24)	-0.589 (-0.52)
CHILD AGE (X10E-1)	-0.174 (-2.93)	1.07 (5.68)	-0.113 (-1.35)
LOCATION DUMMY (village=1)	0.489E-01 (0.29)	0.511 (1.08)	0.310E-1 (0.14)
COMMUNITY WAGE RATE FOR WOMEN	-0.918E-01 (-1.65)	-0.362E-1 (-0.23)	-0.894E-1 (-1.16)
INCOME	-0.220E-02 (-0.99)	-0.973E-2 (-1.68)	-0.568E-2 (-1.71)
PRICE OF RICE	0.116 (0.22)	1.63 (1.21)	0.422 (0.62)
PRICE OF COOKING OIL	0.127 (1.14)	0.919E-1 (0.34)	0.240 (1.57)
PRICE OF KEROSENE	-0.169 (-0.43)	1.15 (1.06)	0.196 (0.35)
PRICE OF MILK	0.912E-01 (0.46)	0.974E-1 (0.18)	0.593E-1 (0.23)
COMMUNITY SUFFICIENCY OF WATER FOR HH USES (sufficient=1)	-0.153 (-0.28)	-0.462 (-0.63)	-0.324 (-0.78)
COMMUNITY WATER SOURCE (piped=1)	-0.226E-01 (-0.20)	0.166 (0.55)	0.276E-1 (0.18)

PREDOMINANT COMMUNITY TYPE OF TOILET (water-sealed=1)	-0.178E-01 (-0.18)	-0.140E-1 (-0.05)	0.877E-2 (0.06)
ABSENCE OF VISIBLE EXCRETA (community) (none or little = 1)	0.103 (0.90)	0.382 (1.22)	0.250 (1.58)

tobit
no. of observations = 518

TABLE 3

PRODUCTION FUNCTION: CHILD HEIGHT-FOR-AGE

Dependent Variable: HEIGHT-FOR-AGE OF 0-2 YEAR OLDS

	(1) 2SLS	(2) OLS	(3) 2SLS	(4) OLS
CONSTANT	0.489 (4.21)	0.479 (5.07)	0.436 (4.03)	0.471 (4.99)
SEX (male=1)	-0.141E-2 (-0.24)	-0.847E-3 (-0.14)	0.430E-3 (0.07)	-0.595E-3 (-0.10)
CHILD AGE (months)	-0.573E-2 (-2.52)	-0.799E-2 (-3.99)	-0.915E-2 (-4.29)	-0.830E-2 (-4.18)
CHILD AGE SQUARED	0.109E-3 (1.20)	0.179E-3 (2.38)	0.207E-3 (2.67)	0.186E-3 (2.48)
MOTHER´S SCHOOLING	0.298E-2 (1.83)	0.257E-2 (1.82)	0.319E-2 (1.98)	0.264E-2 (1.87)
MOTHER´S HEIGHT	0.259E-2 (4.33)	0.290E-2 (5.19)	0.299E-2 (5.33)	0.293E-2 (5.27)
MOTHER´S AGE	0.163E-2 (2.27)	0.110E-2 (2.04)	0.143E-2 (2.22)	0.115E-2 (2.11)
QUANTITY OF GRAIN PER MALE ADULT EQUIVALENT*	-0.505E-2 (-0.49)	-0.501E-3 (-0.05)	-0.102E-2 (-0.10)	-0.455E-3 (-0.04)
HH USE OF SANITARY TOILET FACILITY* (water-sealed=1)	0.163E-2 (0.05)	0.128E-2 (0.05)	0.559E-2 (0.22)	0.165E-2 (0.06)
DURATION OF UNSUPPLEMENTED BREASTFEEDING*	0.146 (2.41)	0.217E-1 (2.01)	-	-
DURATION OF UNSUPPLEMENTED BREASTFEEDING-SQUARED*	-0.754E-1 (-2.30)	-0.800E-2 (-1.79)	-	-
DURATION OF SUPPLEMENTED BREASTFEEDING*	-0.150E-1 (-0.59)	0.797E-3 (0.18)	-	-
DURATION OF SUPPLEMENTED BREASTFEEDING-SQUARED*	0.683E-2 (1.39)	-0.670E-4 (-0.15)	-	-
TOTAL DURATION OF BREASTFEEDING*	-	-	0.113 (1.89)	0.302E-1 (1.69)

TOTAL DURATION OF BREASTFEEDING-SQUARED*	-	-	-0.609E-1 (-1.84)	-0.133E-1 (-1.36)
Number of Observations	498	498	498	498
Sum of Squared Residuals	1.993	2.006	2.009	2.009
R - Squared	-	0.188	-	0.186
F-Statistic	9.698	9.364	11.178	11.180

Note: Breastfeeding variable is the ratio of the child's breastfeeding to the average duration for children of of the same age. Numbers in parenthesis are t-statistics.

* Instruments used are location dummy, community wage rate, household income, price of rice, cooking oil, kerosene, and milk, community water and sanitation infrastructure and condition, and maternal-related variables such as schooling, age and height. In the breastfeeding variables, child age is included as an instrument. In the OLS equations, the food and sanitation variables used are the instrumented ones.

TABLE 4

BREASTFEEDING-MATERNAL EDUCATION INTERACTION

Dependent Variable: HEIGHT-FOR-AGE OF 0-2 YEAR OLDS

	(1) 2SLS	(2) 2SLS
CONSTANT	0.496 (4.25)	0.399 (3.47)
SEX (male=1)	-0.174E-2 (-0.30)	-0.864E-5 (-0.00)
CHILD AGE (months)	-0.551E-2 (-2.36)	-0.937E-2 (-4.35)
CHILD AGE SQUARED	0.805E-4 (0.87)	0.215E-3 (2.74)
MOTHER´S SCHOOLING	0.544E-2 (1.16)	0.550E-2 (1.85)
MOTHER´S HEIGHT	0.227E-2 (3.70)	0.307E-2 (5.39)
MOTHER´S AGE	0.224E-2 (2.81)	0.158E-2 (2.38)
QUANTITY OF GRAIN PER MALE ADULT EQUIVALENT*	-0.337E-3 (-0.03)	0.191E-3 (0.01)
HH USE OF SANITARY TOILET FACILITY* (water-sealed=1)	-0.122E-1 (-0.39)	0.594E-2 (0.23)
DURATION OF UNSUPPLEMENTED BREASTFEEDING*	0.118 (1.17)	-
DURATION OF UNSUPPLEMENTED BREASTFEEDING-SQUARED*	-0.481E-1 (-0.95)	-
DURATION OF SUPPLEMENTED BREASTFEEDING*	0.312E-1 (0.73)	-
DURATION OF SUPPLEMENTED BREASTFEEDING-SQUARED*	-0.128E-1 (-1.14)	-
TOTAL DURATION OF BREASTFEEDING*	-	0.141 (1.87)

TOTAL DURATION OF BREASTFEEDING-SQUARED*	-	-0.655E-1 (-1.62)
Interaction with Maternal Schooling		
DURATION OF UNSUPPLEMENTED BREASTFEEDING*	0.154E-2 (0.10)	-
DURATION OF UNSUPPLEMENTED BREASTFEEDING-SQUARED*	-0.415E-2 (-0.57)	-
DURATION OF SUPPLEMENTED BREASTFEEDING*	-0.420E-2 (-0.72)	-
DURATION OF SUPPLEMENTED BREASTFEEDING-SQUARED*	0.302E-2 (1.86)	-
TOTAL DURATION OF BREASTFEEDING*	-	-0.203E-2 (-0.26)
TOTAL DURATION OF BREASTFEEDING-SQUARED*	-	-0.735E-3 (-0.17)
Number of Observations	498	498
Sum of Squared Residuals	1.968	2.004
F-Statistic	7.682	9.402

Note: Breastfeeding variable is the ratio of the child's breastfeeding to the average duration for children of of the same age.

* Instruments used are location dummy, community wage rate, household income, price of rice, cooking oil, kerosene, and milk, community water and sanitation infrastructure and condition, and maternal-related variables such as schooling, age and height. In the breastfeeding variables, child age is included as an instrument.

FIGURE 1

BREASTFEEDING HEALTH IMPACT ON 0-24 MONTH OLD CHILDREN

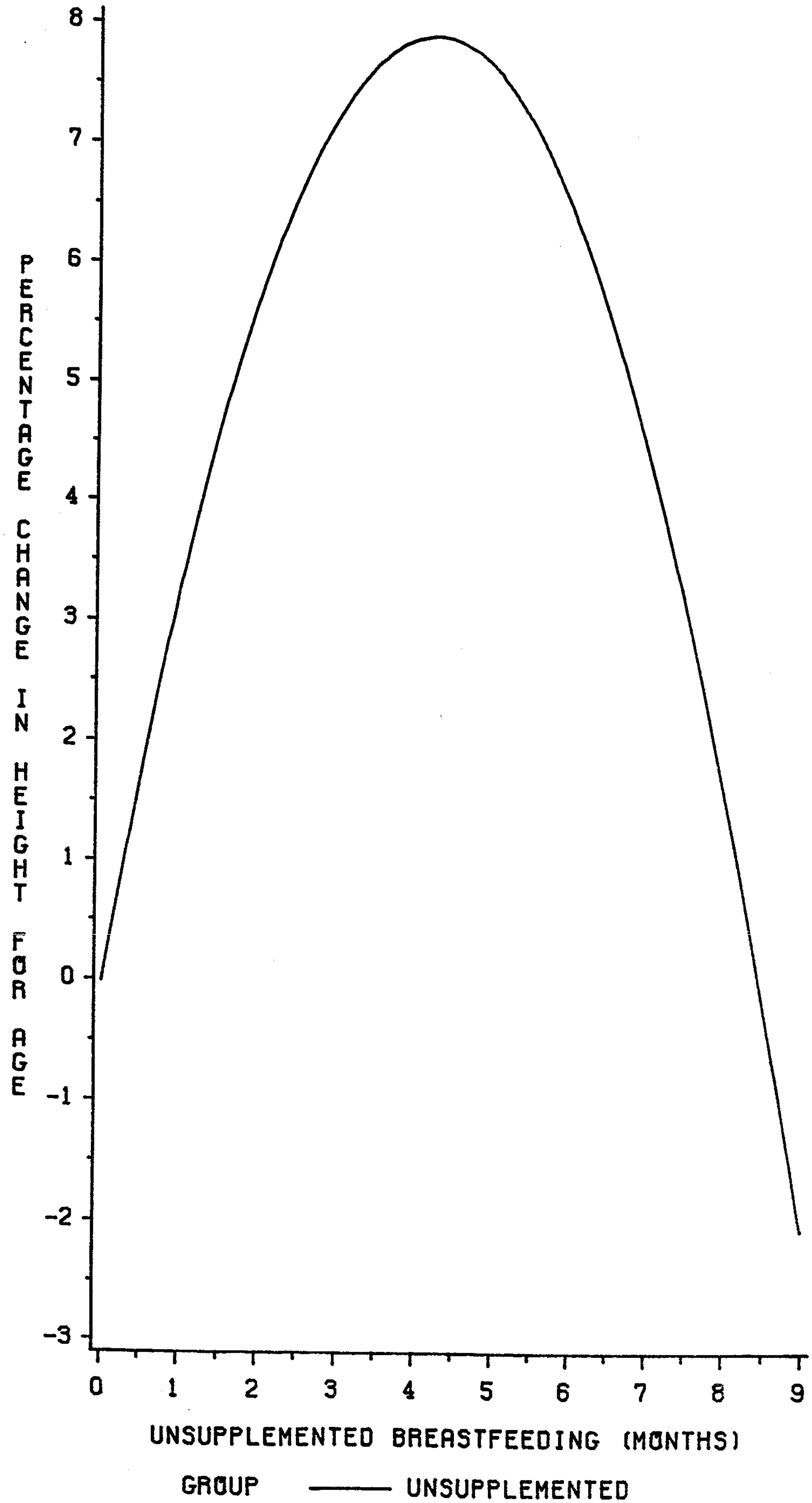

FIGURE 2

BREASTFEEDING HEALTH IMPACT OF OLS & 2SLS ESTIMATES

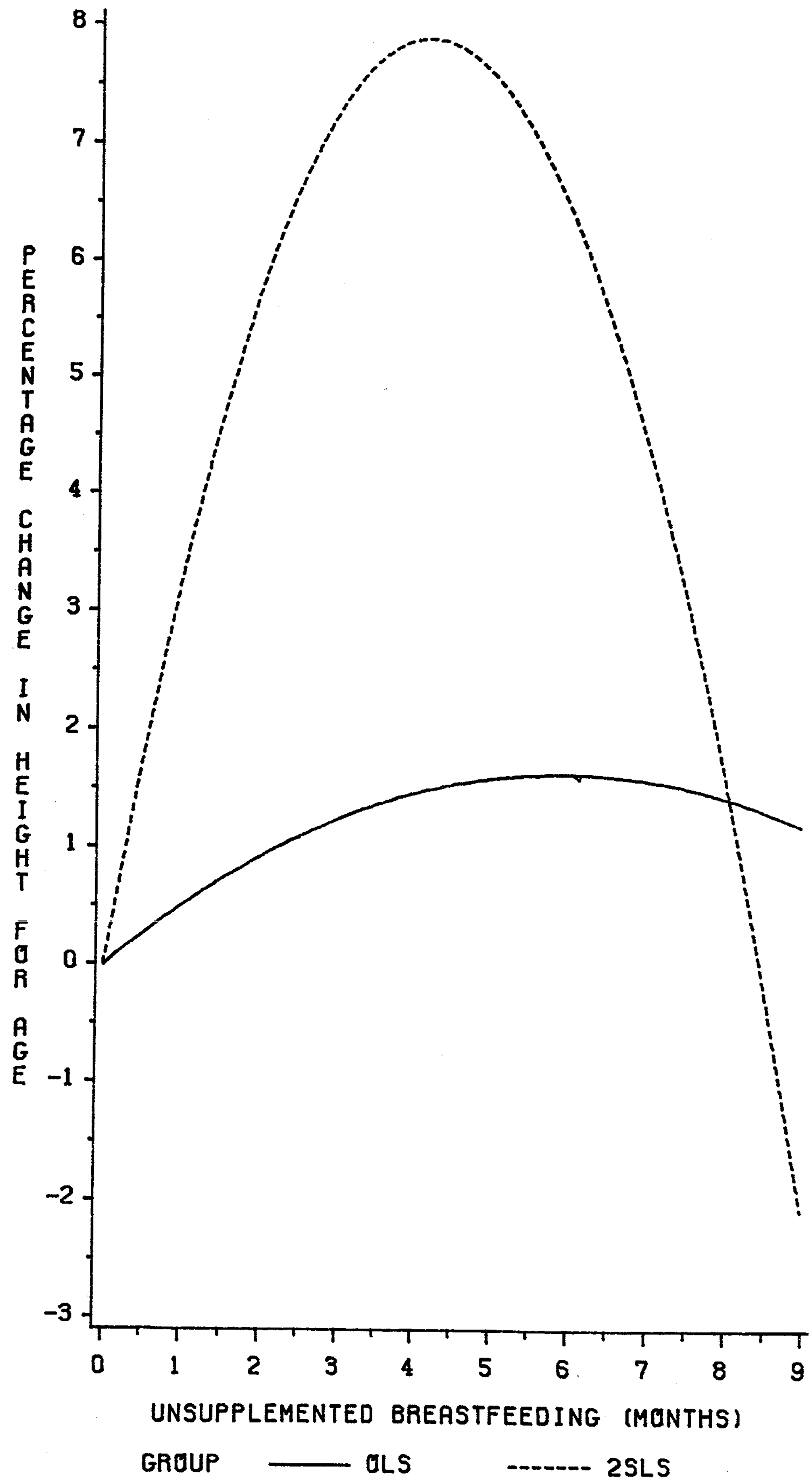

FIGURE 3
MATERNAL EDUCATION-UNSUPPLEMENTED BREASTFEEDING INTERACTION