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EFFECT OF MORBIDITY DURING PREGNANCY ON BIRTH WEIGHT IN A RURAL GUATEMALAN POPULATION

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The high prevalence of low birth weight ($\leq$2.5 Kg) babies is a major public health problem in many poor communities. Studies in humans suggest that malnutrition during pregnancy is an important factor in accounting for this problem, but almost no information is available about the effect of common maternal diseases during pregnancy. This paper reports the effects of maternal morbidity during pregnancy on birth weight in four rural villages of Guatemala. Maternal morbidity, assessed through fortnightly interviews during pregnancy, showed a consistent inverse association with birth weight ($r = -0.149$, $n = 344$, $p<0.01$). In each village, the proportion of low birth weight babies born to mothers who were ill more than 10 percent of their pregnancy was consistently higher than the proportion of babies born to mothers who were sick 10 percent (or less) of their pregnancy ($p<0.01$). The relationship between the proportion of time ill and birth weight was basically unchanged ($r = -0.182$, $n = 334$, $p<0.01$) after controlling for maternal height, head circumference, parity, gestational age, socioeconomic status, home energy intake, energy supplementation during pregnancy and number of days surveyed during pregnancy. Moreover, a similar association was found in consecutive pregnancies of the same mother ($r = -0.197$, $n = 50$, $p = 0.16$). It was concluded that maternal morbidity during pregnancy caused a decrease in birth weight.

In addition, an inverse association was observed between the proportion of time ill during pregnancy and home energy intake ($r = -0.254$, $n = 334$, $p<0.01$). However, the amount of birth weight variance explained by morbidity during pregnancy did not decrease significantly after statistically controlling for home energy intake. Therefore, either the diet measurement is imprecise or the decrease in energy intake observed during illness was not an important mechanism.

INTRODUCTION

The high prevalence of low birth weight babies (LBW $\leq$ 2.5 Kg) found in the low socioeconomic strata of many countries, (Lechtig *et al.*, 1975b) is a major public health problem and may also be a serious obstacle to national development.

Maternal malnutrition, which is highly prevalent in low socioeconomic class groups has been identified as one of the main determinants of this problem (Lechtig *et al.*, 1975b). Similarly, maternal morbidity during pregnancy is also highly prevalent in the low socioeconomic status groups in which endemic protein calorie malnutrition, (PCM), is observed (Mata, Urrutia and Lechtig, 1971; Lechtig *et al.*, 1972b). Though a possible impact of maternal morbidity during pregnancy on birth weight has been suspected, the published literature is scanty. The most important reports have focused on the effect of maternal viral infections, particularly rubella, on fetal growth. An association was observed between maternal rubella infection and fetal growth retardation (Lundström, 1962; Siegel and Fuerst, 1966), probably due to inhibition of fetal mitotic rate (Medearis, 1964; Plotkin and Vaheri, 1967). Maternal infections produced by measles and hepatitis were associated with a higher prevalence of newborns with shorter gestational age ($\leq$ 37 weeks) but not with fetal growth retardation (Siegel and Fuerst, 1966). On the other hand, maternal infections produced by varicella and mumps have not been found to be associated with fetal growth retardation (Siegel and Fuerst, 1966).

Unfortunately, almost no report has come to our attention on the relationship between fetal growth and commonly observed symptoms during pregnancy such as upper respiratory and gastrointestinal problems. Given the relatively high prevalences of such ailments, particularly in the poor socioeconomic strata of many countries, studies on this subject should have great public health relevance.

In a preliminary report (Lechtig *et al.*, 1972b) it was found that maternal morbidity during pregnancy was inversely related to birth weight and that most of this relationship was due to decreased dietary intake. In this paper we were concerned with the effect of common illnesses known to be highly prevalent in economically poor societies and efforts were made to identify their relative importance for fetal growth. Important maternal variables capable of obscuring a relationship between maternal morbidity and birth weight were also investigated.

MATERIALS AND METHODS

Experimental Design

The data presented here are drawn from a long-term prospective study of the effect of chronic malnutrition on physical growth and mental development (Klein, Habicht and Yarbrough, 1973). This study is taking place in four rural villages of Eastern Guatemala in which chronic PCM as well as infectious diseases are endemic. Detailed descriptions of the study population have been presented in previous papers (Yarbrough *et al.*, 1975; Habicht *et al.*, 1974; Lechtig, *et al.*, 1974 and 1975c; Lechtig, *et al.*, 1972c). The experimental design and the principal examinations carried out during pregnancy are presented in Table I and have been described in a previous paper (Lechtig *et al.*, 1975c). All the villages participating in the study benefitted from preventive and curative medical care which was made available to the inhabitants.

TABLE I

Study design

Four villages: Atole[a] (2) = Protein-calorie supplement; Fresco[b] (2) = Calorie supplement

A.	*Information collected during pregnancy:*	*Frequency*
	Obstetrical history	Once initially
	Clinical examination	Quarterly
	Anthropometry	Quarterly
	Surveys: Dietary	Quarterly
	Surveys: Morbidity	Every 14 days
	Measurement of daily attendance at the feeding center and amount of supplement consumed.	
	Estimation of the socioeconomic status of the family.	
B.	*Information on delivery:* birth weight	

[a]The name of a gruel commonly made with corn.

[b]Spanish for refreshing, cool drink.

[c]The diagnosis of pregnancy was made on the basis of absence of menstruation, the status of which was determined at 14 day intervals.

Variables selected for the present analysis

The six groups of variables to be analyzed in the present article are shown in Table II. The morbidity data were gathered through surveys executed at 14 day intervals. The approach was basically symptom-oriented and used interviews of mothers in the home by four home visitors, one for each village. The home visitors were rotated periodically among the four villages to offset interviewer bias. Interviews took place Monday through Friday, the families being so divided that routinely the entire study population of each village was interviewed every two weeks. During the interview, the mother was asked to recall any symptoms she had in the last two weeks. The beginning and ending dates of a symptom were always noted. A routine quality control system was applied allowing the method to be standardized, using a supervisor, and for the purposes of validating the diagnosis, a physician (Martorell *et al.*, 1975).

TABLE II

Main variables used in the present analysis

I.	*Morbidity during pregnancy*
	—Various symptoms (Table III) including a composite indicator based on the sum of percent of time ill with diarrhea, anorexia and *cephalea* (ACD).
II	*Maternal diet during pregnancy*
	—Food supplementation during pregnancy.
	—Daily home caloric intake during the 2nd and 3rd trimester.
III.	*Maternal anthropometry during pregnancy*
	—At any time of pregnancy: height and head circumference.
	—At the end of the first trimester of pregnancy: weight.
IV.	*Obstetrical history*
	—Parity, gestational age, birth interval, age of the mother and lactation during present pregnancy.
V.	*Socioeconomic status (SES) of the family*
	—Composite indicator based on quality of housing, aspects of clothing and extent of teaching given to young children.
VI.	*Information on the newborn*
	—At birth: weight and sex.

Thus, the morbidity data used in this investigation were derived from the mother. For example, diarrhea and fever were noted on the forms when the mother referred to loose stools and to being hot; the mother's impression of fever never involved the use of a thermometer. Any symptoms of the upper and lower respiratory tracts were taken as evidence of "respiratory illnesses."

TABLE III

Definition of morbidity variables

1. *Upper respiratory infection:*	watering of the eyes and/or nasal obstruction and/or nasal secretion and/or hoarseness.
2. *Diarrhea:*	increase in frequency of bowel movements and/or change in consistency.
3. *Mastitis:*	pain and/or inflamation and/or abscess in mammary gland.
4. *Pains:*	pain in legs and/or lumbar region and/or abdomen.
5. *Cephalea:*	headache.
6. *Anorexia:*	decreased appetite and/or apathy and/or irritability.
7. *In bed:*	in bed due to illness.
8. *Fever:*	feeling of being hot or with chills.
9. *Change in diet:*	marked qualitative and/or quantitative change in diet due to illness.
10. *Healthy:*	absence of any symptom of disease; feeling of well being.
11. *ACD:*	composite indicator made up by adding percent of time with anorexia, cephalea and diarrhea.
12. *Number of days surveyed:*	absolute number of days during pregnancy covered by the morbidity surveys.

In order to simplify the analyses, the ten morbidity variables described in Table III were chosen from forty individual items. The criteria followed for selection were theoretical considerations about the variable most likely to influence fetal growth, prevalence, measurement reliability and associations found in preliminary analyses made in smaller samples (Lechtig *et al.*, 1972b).

For each of these variables, the proportion of the time ill was computed as follows: number of days with reported symptom × 100/number of days surveyed during pregnancy.

Finally, a summary variable (ACD) was built by adding percent of the time ill with diarrhea, anorexia and *cephalea.*† These items were selected because they showed the highest correlations with birth weight in the total sample.

Maternal ingestion of food during pregnancy included two variables: ingestion of supplements, and daily home dietary intake for the last two trimesters of pregnancy as estimated through 24 and 72 hour recall surveys at the end of each trimester (Lechtig *et al.*, 1972a; Lechtig *et al.* 1975c).

Maternal anthropometric examinations included height and head circumference as well as weight at the end of the first trimester of pregnancy (Lechtig *et al.*, 1975b). In addition to the obstetrical variables parity and gestational age, birth interval with the previous baby, age of the mother, and duration of lactation during the present pregnancy, were also recorded. The socioeconomic status of the family was described by a composite scale reflecting the physical conditions of the house, the mother's clothing and the reported extent of teaching various skills and tasks to preschool age children by family members (Lechtig *et al.*, 1975a). Weight of the newborn, the main dependent variable, was determined within the first 24 hours of birth to the nearest 20 grams.

Routine data collection on morbidity was carried out from June 1970 through February 1973. During this period birth weight and morbidity data were obtained from 92 percent of the sample (Lechtig *et al.*, 1975c). This high proportion was achieved for a sample size of 334 pregnancies.

RESULTS

Description of Morbidity during Pregnancy

Table IV shows that there were no significant differences in the proportion of time ill during pregnancy between the *Atole* and *Fresco* villages (see Table I for definition of *Atole* and *Fresco*). On the average, the study group was healthy only during 51 percent of the duration of their pregnancy. These values were similar to those reported in a preliminary paper (Lechtig *et al.*, 1972b) and described in a Mayan Indian village from Guatemala (Mata, Urrutia and Lechtig, 1971); on the other hand, they are much higher than those reported in a cross-sectional study of

† Moderate or violent headache.

TABLE IV

Proportion of time ill with various conditions during pregnancy (percentage[a])

	Type of village				
	Fresco villages		Atole villages		
	1 n = 72	2 n = 89	1 n = 78	2 n = 95	Total[b] n = 334
Upper respiratory disease	8.0 ± 16.0	10.6 ± 10.6	8.4 ± 12.3	7.1 ± 9.5	8.5 ± 12.1
Diarrhea	1.8 ± 6.1	0.4 ± 1.2	0.2 ± 1.2	0.2 ± 1.0	0.2 ± 1.0
Mastitis	0.0 ± 0.0	1.1 ± 10.6	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 5.4
Pains	4.4 ± 14.8	8.8 ± 21.0	6.9 ± 16.7	9.8 ± 18.9	7.7 ± 18.2
Anorexia	4.5 ± 9.4	9.7 ± 16.4	6.2 ± 11.8	6.8 ± 13.9	6.9 ± 13.4
In bed	0.3 ± 1.2	0.4 ± 1.8	0.1 ± 0.5	0.5 ± 1.9	0.3 ± 1.5
Fever	0.6 ± 1.5	2.9 ± 8.0	0.7 ± 1.8	1.1 ± 3.5	1.4 ± 4.7
Change in diet	0.0 ± 0.0	0.03 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	0.01 ± 0.2
Cephalea	1.4 ± 4.5	3.9 ± 11.4	3.9 ± 12.2	3.3 ± 8.4	3.2 ± 9.7
Healthy	51.4 ± 36.1	47.4 ± 29.7	46.0 ± 31.7	57.9 ± 32.1	50.9 ± 32.5
Composite indicator of morbidity (ACD)[c]	6.1 ± 11.1	13.9 ± 23.8	10.3 ± 21.2	10.3 ± 19.4	10.4 ± 19.8
Number of days surveyed during pregnancy	118.9 ± 72.6	191.3 ± 69.7	182.2 ± 79.5	188.4 ± 81.0	187.8 ± 75.7

[a]Days with symptom, per 100 days covered by morbidity interviews.
[b]No significant difference was observed between *Fresco* and *Atole* villages.
[c]Composite indicator built by summing the percent of time ill, with anorexia, *cephalea* and diarrhea.

TABLE V

Correlations between indicators of maternal morbidity during pregnancy and birth weight. Slope values expressed as grams of birth weight/percent of time ill, are in parentheses

Morbidity indicators[a] Percent of time ill with:	Type of village				
	Fresco village		Atole village		
	1 n = 72	2 n = 89	1 n = 78	2 n = 95	Total n = 334
Upper respiratory diseases	0.015	0.082	0.078	0.031	0.000 (0.0)
Diarrhea	—0.006	0.025	—0.222[b]	—0.137	—0.092 (—43.9)
Mastitis	0.000	—0.093	0.000	0.000	—0.052 (—4.3)
Pains	—0.006	0.002	0.068	—0.148	—0.013 (—0.5)
Anorexia	—0.074	—0.079	—0.109	—0.261[c]	—0.133[b] (—4.7)
In bed	—0.119	0.046	—0.028	—0.071	—0.025 (—7.5)
Fever	—0.099	—0.042	—0.036	—0.024	—0.038 (—3.7)
Cephalea	—0.018	—0.175	—0.153	—0.096	—0.110[b] (—5.4)
Change in diet	0.000	0.025	0.000	0.000	0.006 (18.7)
Healthy	0.056	0.065	0.114	0.072	0.087 (1.3)
Composite indicator (ACD)	—0.070	—0.137	—0.162	—0.235[c]	—0.149[c] (—3.5)

[a]Multiple correlation between morbidity indicators and birth weight: r = 0.217[c].
[b]$p < 0.05$; [c]$p < 0.01$.

a middle class American population (Sever, 1966). The proportion of time ill with diarrhea however, was strikingly low and the possible causes of this are at present being explored. One suitable explanation may be the cultural and/or biological adaptation to pathogenic strains of enteric bacteria as suggested in previous work (Urrutia *et al.*, 1975).

It should also be noted that the ten variables selected for analysis accounted for 78 percent of time ill with any symptom. The rest (22 percent of time ill) was attributable to the 30 symptoms not used in the present analysis.

Relationship between Morbidity during Pregnancy and Birth Weight

Table V presents the correlations between the morbidity indicators and birth weight. In the combined sample, nine out of the 11 single morbidity indicators (including "healthy"), plus the summary indicator (ACD) show associations with birth weight in the expected direction. Of these nine items, three and the summary variable (ACD), were associated with birth weight at a statistically significant level. The multiple correlation between the individual morbidity items and birth weight was −0.217, which is very close to the expected value (−0.228) computed on the assumption that each morbidity item made independent contributions in predicting birth weight.

The slope values provide an estimate of the impact of different morbidity symptoms on birth weight. The greatest effect on birth weight was observed with diarrhea (−43.9 g birth weight/percent of time ill); most of the other symptoms oscillated between −3 and −5 grams of birth weight percent of time ill. Of course, the rarity of reported diarrhea makes its presence a striking indicator of illness.

TABLE VI
Intercorrelations between the components of the morbidity composite indicator (ACD) (n = 334)

	Cephalea	Diarrhea	Composite indicator (ACD)
Anorexia	0.412[a]	0.225[a]	0.888[a]
Cephalea		0.272[a]	0.781[a]
Diarrhea			0.337[a]

[a]$p < 0.01$.

Table VI presents the intercorrelations between the components of ACD in the total population. Anorexia and *cephalea* were the major determinants of ACD value, and it is also apparent that some covariation exists between the three items. For this reason, the correlation between ACD and birth weight was slightly lower than the value computed if each item provided a separate contribution to birth weight prediction. Thus, in the total sample the correlation between ACD and birth weight was −0.149 while the computed value assuming independent contributions of each item was −0.195.

TABLE VII
Relationship between the composite indicator (ACD) of maternal morbidity during pregnancy and birth weight

	Correlation value (r)	Slope value (g birth weight/days ill, %)	Number of cases (n)
Atole villages	−0.196[b]	−4.8	174
Fresco villages	−0.093	−2.0	160
Four villages (atole and fresco)	−0.149[b]	−3.5	334
Four villages after controlling for type of supplement[a]	−0.149[b]	−3.5	334

[a]By multiple regression predicting birth weight in which type of supplement is forced as independent variable (fresco = 1; atole = 2).
[b]$p < 0.01$.

Table VII presents the slope values for the composite indicator (ACD) in Fresco, Atole and the total sample. It will be noted that the slope values were highly significant ($p<0.01$) in the Atole group and in the total sample, while in the Fresco villages the slope, although in the expected direction, was not statistically significant.

Figure 1 shows the proportion of low birth weight babies in the Low, and High Morbidity Groups (LMG and HMG, respectively) in each of the four villages and in the total sample. The percentage of low birth weight babies was consistently lower in the LMG than in the HMG. As Figure 2 indicates, in the total sample the proportion of LBW babies steadily increased from ten percent in the healthiest mothers up to 26 percent in the small group with more than 50 percent of the time ill with ACD.

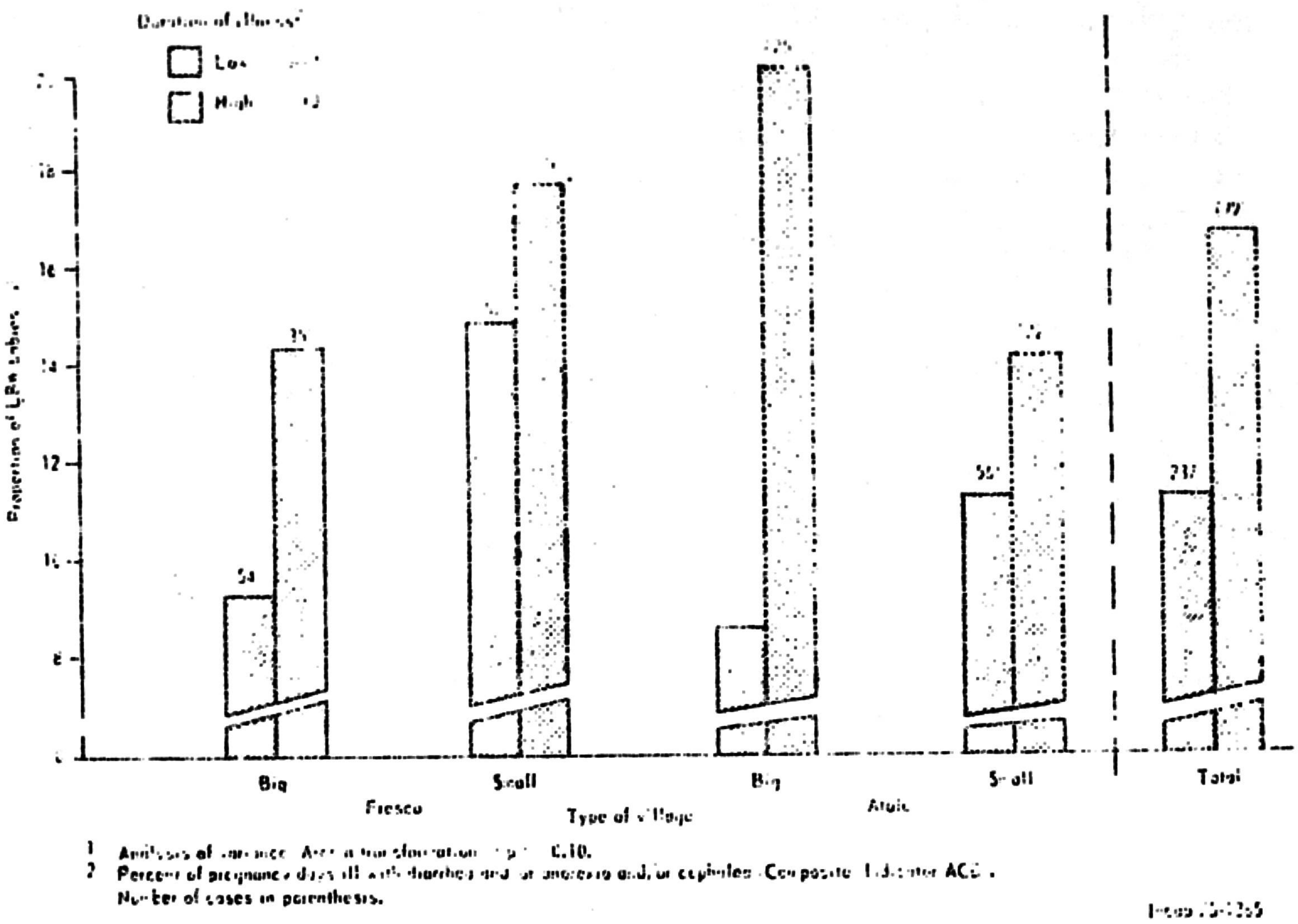

FIGURE 1 Relationship between duration of illness during pregnancy and proportion of low birth weight (LBW ≤ 2.5 kg) babies[1] by type of selected Guatemalan village. Low Morbidity Group (LMG) is designated by the oblique lines; the High Morbidity Group (HMG) by the dotted columns.

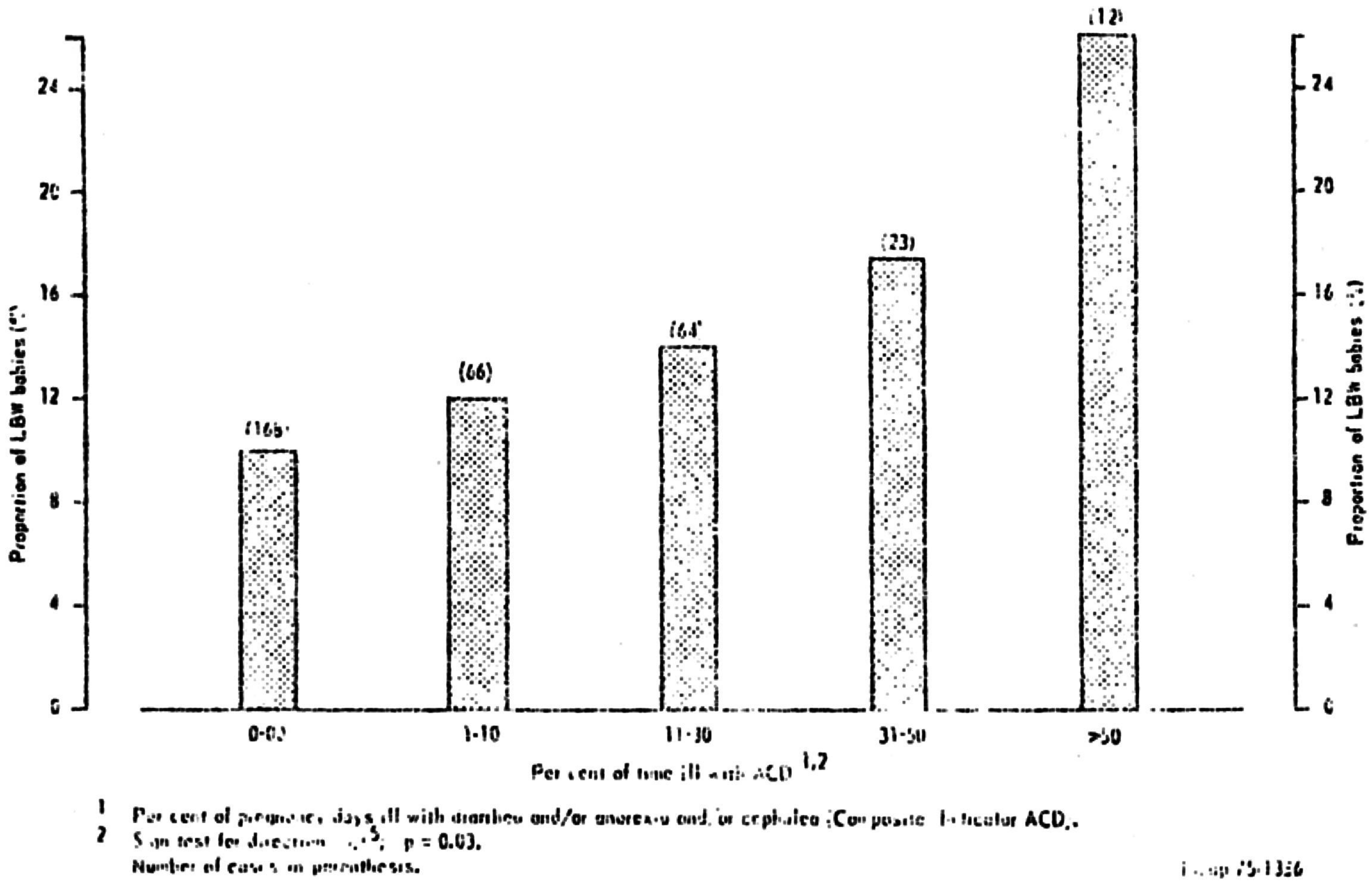

FIGURE 2 Relationship between the proportion of time ill with (ACD)[1] during pregnancy and the proportion of low birth weight (LBW ≤ 2.5 kg) babies[2] (Data for four rural Guatemalan villages, n = 334).

TABLE VIII

Maternal determinants of birth weight in four rural villages of Guatemala[a]

	Correlation coefficient with birth weight	n
A. *At conception*		
—Height	0.134[c]	399
—Head circumference	0.284[c]	363
—Age	0.116[c]	401
—Parity	0.154[c]	404
—Socioeconomic status indicator	0.219[c]	363
B. *At the end of the first trimester of pregnancy*		
—Weight at the end of first trimester	0.277[c]	221
C. *During pregnancy*		
—Gestational age	0.217[c]	395
—Morbidity composite indicator (ACD)	—0.149[c]	334
—Caloric supplementation[a]	0.135[c]	405

[a]Value for the multiple correlation predicting birth weight: r = 0.410[c].
[b]$p \leq 0.05$; [c]$p \leq 0.01$.

Effects of Potential Confounding Factors

The variables presented in Table II were investigated, first with respect to their association with birth weight, and then, with respect to their influence on the relationship between the composite indicator of maternal morbidity during pregnancy (ACD) and birth weight. Correlations between maternal characteristics and birth weight for those variables which were significantly associated with birth weight are presented in Table VIII. It will be noted that, in addition to the composite indicator of maternal morbidity during pregnancy, height, head circumference, chronological age, parity, socioeconomic status, weight at the end of the first trimester of pregnancy, gestational age and caloric supplementation were correlated with birth weight. However, all these variables together explained only 16.8 percent of the variance in birth weight.

When these maternal characteristics and the number of days surveyed during pregnancy were entered as independent variables in a multiple regression predicting birth weight, the dose-response relationship between ACD and birth weight remained almost unchanged (Table IX). Therefore, the maternal characteristics examined, either alone or combined, cannot explain the observed association between maternal morbidity and birth weight. Finally, results on the last row in Table IX indicate that the slope value of the association between changes in ACD and changes

TABLE IX

Correlations between the composite indicator (ACD) of maternal morbidity during pregnancy and birth weight. Slope values expressed as grams of birth weight/percent of time ill with ACD are in parentheses

	Type of village				
	Fresco		Atole		
	Small n = 72	Big n = 89	Small n = 78	Big n = 95	Total[a] n = 334
Before controlling for suspected confounding factors (simple regression)	—0.070 (—2.4)	—0.137 (—2.6)	—0.154 (—3.5)	—0.235[d] (—6.1)	—0.149[e] (—3.5)
After controlling for suspected confounding factors[b] (in multiple correlation)	—0.116 (—3.9)	—0.098 (—1.9)	—0.090 (—2.2)	—0.322[e] (—8.4)	—0.182[e] (—4.3)
Within siblings of same mother[c]	n = 22 —0.093 (—1.3)		n = 28 —0.260 (—4.5)		n = 50 —0.197 (—2.9)

[a]No significant difference was observed among within-village correlations.
[b]Energy supplementation during pregnancy, height, head circumference, age, parity, socioeconomic status, weight at the end of the first trimester, gestational age, birth interval, home caloric intake, amount of supplemented calories during pregnancy and number of days surveyed during pregnancy.
[c]Independent variable: differences in composite morbidity score (ACD) between the two pregnancies; dependent variable: differences in birth weight between the two siblings (the latter minus the former).
[d]$p < 0.05$; [e]$p < 0.01$.

in birth weight in consecutive pregnancies of the same mother were of similar magnitude and direction to that observed in the whole population.

In summary, the analyses presented in Tables V to IX and in Figures 1 and 2, indicate that the relationship of maternal morbidity to birth weight was consistent in both the entire populations studied and after controlling for potential confounding factors, including those constant to the mother.

DISCUSSION

Previously, it was postulated that an important mechanism associating maternal morbidity with fetal growth was the decrease in the mother's energy intake in the home (Lechtig *et al.*, 1972b). In the present study, the correlation between the home energy intake and birth weight was 0.083 ($n = 334$; $p>0.05$) while the correlation between the home energy caloric intake and the composite indicator of maternal morbidity (ACD) was -0.254 in the same sample ($n = 234$; $p<0.01$).

However, multiple regression analyses indicated that the percentage of birth weight variance "explained" by ACD decreased only 8 percent from its original value after controlling for the maternal home energy intake during pregnancy. Although the low reliability of the estimates of the energy intake in the home may be a limiting factor in this analysis, these results are not similar to those found in the preliminary study previously described (Lechtig *et al.*, 1972b). This suggests that either the observed decrement in the home dietary intake associated with common diseases may not be an important mechanism or that home dietary surveys do not measure the real consumption pattern of a given mother. Similar results were observed with energy supplementation during pregnancy (see footnote [b] in Table IX).

In observational studies such as the present one, the allocation of pregnant women to a particular category of maternal morbidity was, of course, not based upon criteria designated by the researcher. For this reason, it is necessary to interpret these findings cautiously and await confirmation of the apparently causal relationship between maternal morbidity and birth weight through further research in a variety of populations.

Nevertheless, our findings are highly suggestive. They may be summarized as follows:

Higher levels of maternal morbidity during pregnancy were associated with a significant decrease in birth weight and an increase of the proportion of low birth weight babies.

This association with birth weight held constant after important maternal variables were controlled for. Moreover, the findings were not due to missing data nor produced by undetected confounding factors related to the mother.

In consequence, the most parsimonious interpretation of these results is that maternal morbidity during pregnancy caused a decrease in birth weight in the study population.

Given the evidence of an effect of maternal morbidity on fetal growth, it is tempting to speculate on the possible mechanisms involved. Intuitively, the impact of maternal illnesses on fetal growth seems most probably mediated by decreased transfer of nutrients to the fetus. Although no direct evidence of such decreased transfer during pregnancy exists, experimental studies in human adults suggest that it may occur due to decreased food intakes resulting from the anorexia, or cultural habits, which accompany most illnesses and/or to the metabolic responses to stress brought on by infectious diseases (Beisel *et al.*, 1967; Scrimshaw, Taylor and Gordon, 1968).

The results reported above on home dietary intake may be due to the imprecision of the measurement of the diet. Alternatively it is possible that a decreased nutrient intake is not in reality the main mechanism causing the observed effects of maternal illness on fetal growth. If this last alternative is true, maternal metabolic alterations ranging from decreased maternal intestinal absorption to increased catabolic rate (Beisel *et al.*, 1967; Scrimshaw, Taylor and Gordon, 1968) would be the principal mechanisms of the effect of maternal morbidity on birth weight.

The public health implications of the observed association are obvious: The efficiency of programs aimed at decreasing infant mortality and impaired functioning could be greatly enhanced if these programs were focused on mothers at a high risk to delivering low birth weight babies. For this purpose, several instruments to predict risk, which are feasible for use in populations with inadequate health resources, have been recently proposed (Lechtig *et al.*, 1976).

In summary, these results suggest that an improvement in the health status of pregnant women will lead to a significant decrease in the prevalence of low birth weight babies in most poor communities. This may be achieved by improving sanitary conditions and health services and would help in turn to reduce the high rates of infant mortality and impaired development in these societies.

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REFERENCES

Beisel, W. R., W. D. Sawyer, E. D. Ryll and D. Crozier (1967). Metabolic effects of intracellular infections in man. *Ann. Intern. Med.* **67**, 744.

Habicht, J-P., R. Martorell, C. Yarbrough, R. M. Malina and R. E. Klein (1974). Height and weight standards for preschool children: how relevant are ethnic differences in growth potential? *Lancet* **1**, 611.

Klein, R. E., J-P. Habicht and C. Yarbrough (1973). Some methodological problems in field studies of nutrition and intelligence. In Kallen D. J. (Ed.). *Nutrition, Development and Social Behavior*. Proceedings of the Conference on the Assessment of Tests of Behavior from Studies of Nutrition in the Western Hemisphere. U.S. Government Printing Office, Washington, D.C., p. 61. (DHEW Publication No. (NIH) 73-242).

Lechtig, A., H. Delgado, R. E. Lasky, R. E. Klein, P. L. Engle, C. Yarbrough and J-P. Habicht (1975a). Maternal nutrition and fetal growth in developing societies. Socioeconomic factors. *Amer. J. Dis. Child.* **129**, 434.

Lechtig, A., H. Delgado, R. Lasky, C. Yarbrough, R. E. Klein, J-P. Habicht and M. Béhar (1975b). Maternal nutrition and fetal growth in developing countries. *Amer. J. Dis. Child* **129**, 553.

Lechtig, A., H. Delgado, C. Yarbrough, J-P. Habicht, R. Martorell and R. E Klein (1976). A simple assessment of the risk of low birth weight to select women for nutritional intervention. *Amer. J. Obstet. Gynecol.* **125**, 25.

Lechtig, A., J-P. Habicht, E. de León, G. Guzmán and M. Flores (1972a). Influencia de la nutrición materna sobre el crecimiento fetal en poblaciones rurales de Guatemala. I. Aspectos dietéticos. *Arch. Latinoamer. Nutr.* **22**, 101.

Lechtig, A., J-P. Habicht, G. Guzmán and E. de León 1972b). Morbilidad materna y crecimiento fetal en poblaciones rurales de Guatemala. *Arch. Latinoamer. Nutr.* **22**, 243.

Lechtig, A., J-P. Habicht, H. Delgado, R. E. Klein, C. Yarbrough and R. Martorell (1975c). Effect of food supplementation during pregnancy on birth weight. *Pediatrics* **56**, 508.

Lechtig, A., J-P. Habicht, G. Guzmán and E. M. Girón (1972c). Influencia de las características maternas sobre el crecimiento fetal en poblaciones rurales de Guatemala. *Arch. Latinoamer. Nutr.* **22**, 255.

Lechtig, A., L. J. Mata, J-P. Habicht, J. J. Urrutia, R. E. Klein, G. Guzmán, A. Cáceres and C. Alford (1974). Levels of immunoglobulin M (IgM) in cord blood of Latin American newborns of low socioeconomic status. *Ecology of Food and Nutrition* **3**, 171.

Lundström, R. (1962). Rubella during pregnancy: a follow-up study of children born after an epidemic of rubella in Sweden, 1951, with additional investigations on prophylaxis and treatment of maternal rubella. *Acta Paediat. Scand.* **51**, (Suppl. 133), 1.

Martorell, R., J-P. Habicht, C. Yarbrough, A. Lechtig, R. E. Klein and K. A. Western (1975). Acute morbidity and physical growth in rural Guatemalan children. *Amer. J. Dis. Child.* **129**, 1296.

Mata, L. J., J. J. Urrutia and A. Lechtig (1971). Infection and nutrition of children of a low socioeconomic rural community. *Amer. J. Clin. Nutr.* **24**, 249.

Medearis, Jr., D. N. (1964). Viral infections during pregnancy and abnormal human development. *Amer. J. Obstet. Gynecol.* **90**, 1140.

Plotkin, S. A. and A. Vaheri (1967). Human fibroblasts infected with rubella virus produce a growth inhibitor. *Science* **156**, 659.

Scrimshaw, N. S., C. E. Taylor and J. E. Gordon (1968). *Interactions of Nutrition and Infection*. World Health Organization, Geneva, p. 329. (WHO Monograph Series No. 57).

Sever, J. L. (1966). Perinatal infections affecting the developing fetus and newborn. In *The Prevention of Mental Retardation Through Control of Infectious Diseases*. U.S. Department of Health, Education and Welfare, NIH, Bethesda, Md., p. 37-68.

Siegel, M. and H. T. Fuerst (1966). Low birth weight and maternal virus diseases. A prospective study of rubella, measles, mumps, chickenpox, and hepatitis. *J. Amer. Med. Assoc.* **197**, 680.

Urrutia, J. J., L. J. Mata, F. Trent, J. R. Cruz, E. Villatoro and R. E. Alexander (1975). Infection and low birth weight in a developing country. A study in an Indian village of Guatemala. *Amer. J. Dis Child.* **129**, 558.

Yarbrough, C., J-P. Habicht, R. M. Malina, A. Lechtig and R. E. Klein (1975). Length and weight in rural Guatemalan Ladino children: birth to seven years of age. *Amer. J. Phys. Anthropol.* **42**, 439.