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EFFECT OF MATERNAL NUTRITION ON FETAL GROWTH AND INFANT DEVELOPMENT

EFFECT OF MATERNAL NUTRITION ON FETAL GROWTH AND INFANT DEVELOPMENT [1,2]

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1. INTRODUCTION

Nearly two out of every ten children born alive in developing countries die during the first year of life. The comparable statistic for developed countries is roughly 1 in 50, making infant mortality one of the major public health problems in developing nations. Moreover, the prevalence of physical growth retardation at birth and during the first year of postnatal life is widespread in many poor communities around the world. Also, babies with early growth retardation are less likely to survive during the first year of life than babies with normal growth. Finally, babies with physical growth retardation frequently perform poorly on tests of mental development. It is widely believed that the factors which account for most of the growth failure, developmental retardation, and high mortality rates in developing countries are environmental and therefore preventable.

Maternal and child malnutrition have been implicated as one of several environmental factors contributing to these high rates of developmental retardation and infant mortality. However, in populations with chronic moderate malnutrition this assertion has been difficult to substantiate because of the imprecision involved in defining maternal and child nutritional status and because of the lack of information on the effect of important factors such as socioeconomic status and infections as alternative explanations of the detected association. Therefore, it has not been possible to date either to infer a causal association between nutrition and developmental retardation and/or infant mortality or to estimate the expected decrement on the prevalence of these conditions produced by improved nutrition.

The present paper reports the preliminary results of an experiment in which two nutritional supplements were made available to a chronically malnourished population. The food supplements were provided to pregnant and lactating women as well as to their children in four rural villages of Guatemala. Besides the outcomes of physical growth, mental development, and health, important variables, capable of obscuring postulated effects of nutrition, were also measured and investigated.

In this presentation, we will discuss the effect of food supplementation during pregnancy and lactation on the prevalence of: a) physical growth retardation; b) psychological test performance; and, c) infant mortality in the four study villages. In addition, we will also discuss some of the important factors in addition to food supplementation, that are correlated with physical growth retardation and risk of infant death.

2. MATERIAL AND METHODS

Experimental Design. The data presented here are drawn from a longitudinal study of the effects of chronic malnutrition on physical growth and mental development (Klein, et al., 1973). The experimental design and the principal examinations made during the pre and postnatal periods are presented in Table 1. Two types of food supplements are provided: atole* and fresco**. Two villages receive atole while the other two receive fresco. Attendance to the supplementation center was and is voluntary and consequently a wide range of supplement intake is observed. Table 2 presents the nutrient content for both atole and fresco. It should be stressed that the fresco contains no protein and that it provides only one third of the calories contained in an equal volume of atole. In addition, both preparations contain similar concentrations of the vitamins and minerals which are possibly limiting in the diets of this population.

Study Population. The study population is a rural population in which moderate malnutrition and infectious diseases are endemic. The villages and their inhabitants are very poor, the median family income being approximately

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* The name of a gruel, commonly made with corn.

** Spanish for refreshing, cool drink

$200 per year. The typical house is built of adobe and has no sanitary facilities. Drinking water is contaminated with enteric bacteria. Corn and beans are the principal staples of the home diet, animal protein comprising 12% of total protein intake. The average maternal height and weight of the women are low: 149 cm and 49 kg, respectively. The number of previous deliveries among the women studied ranges between 0 and 13 and the reproductive age span is from 14 to 46 years.

Variables and Sample Size. For the present analyses, ingestion of supplemented calories was selected as the criteria to assess supplement intake because the home diet appears to be more limiting in calories than in proteins (Lechtig, et al., 1975a). We stress that while calories appear to be limiting in this study population, other populations may present very different nutritional situations. The main outcome variables were the prevalence of physical growth retardation at birth and 36 months of age, psychological test performance at birth, 24 and 36 months of age and infant mortality.

Table 3 presents the sample size for each of the variables examined in the present paper. The total sample of 1083 children was made up of 671 births which occurred in the 4 villages from January 1969 through February 1973, and 412 children alive and under age 3 at the beginning of of data collection in January 1969. The analyses herein discussed report the results observed in the total sample up to 36 months of age. On May 31, 1974 the youngest child in the sample reached 15 months of age; the sample of later ages is at this moment necessarily incomplete.

3. RESULTS AND DISCUSSION

In this section we will summarize and discuss findings from previous reports and current analyses. There are three major topics of interest: physical growth retardation, psychological test performance, and infant mortality. After a resume of our results, we will then discuss briefly the implications for public health programs.

3.1 Determinants of physical growth retardation

Supplement Ingestion and Birthweight. Figure 1 shows the percentage of low birthweight babies ($\leq$ 2.5 kg) by two categories of maternal supplement ingestion. The low group consists of mothers whose total ingestion during pregnancy was less than 20,000 calories, while the high consists of mothers whose ingestion was greater than 20,000. This proportion is consistently lower in the better supplemented group in both the fresco and the atole populations. In fact, the risk of delivering low birthweight babies among high supplemented mothers is roughly half that in the low supplemented group. Home caloric intake, was however, similar in both groups, so we conclude that the supplemental calories were really additional calories to the maternal diet. In the high calorie supplementation group, this addition amounted to about 35,000 calories during all of pregnancy, or about 125 cal/day extra.

This association is not explained by other important maternal variables such as size, home diet, morbidity, obstetrical characteristics and socioeconomic status. Most importantly, this association was not produced by undetected confounding factors related to the mother (like a tendency to have bigger babies) since it was also observed within two consecutive siblings of the same mother. That is, if the same mother consumes more in one pregnancy than the other, there is a tendency for the baby of that pregnancy to be heavier at birth. We therefore conclude that caloric supplementation during pregnancy <u>caused</u> the observed decrease of the proportion of small babies in this population.

The issue of calories requires a comment. In the study population the home diet protein-calorie ratio is approximately 11%. Thus, we believe it feasible to improve the total diet of mothers by adding more calories. In other populations with different diets the situation could be quite different. The best supplement for one population need not be the best and indeed may even be harmful for another.

Supplement ingestion and growth at 36 months of age.

For these analyses we define retardation in growth, whether in weight, height, or head circumference, as being below the 30 percentile of the study population distribution. Since these limits are below the tenth percentile of Denver standards (Hansman, 1970), and since we do not believe these populations differ in genetic potential (Habicht, et al., 1974; Martorell, et al., 1975), we regard this deficit as true retardation. For weight, this limit was equivalent to 78 percent of the mean weight of the same standard.

Figure 2 shows the proportion of children with retardation in weight, height, and head circumference at 36 months of age for the low, middle and high supplemented groups. The group with low and high supplementation was formed of those children who ingested either directly or through their mothers less than 5,000 or more than 10,000 supplemented calories per quarter during at least 14 quarters. The group with middle supplementation was formed by children who did not fall in the low or high groups. It is clear that there is a strong relationship between level of supplementation and physical growth retardation.

Figure 2 has, however, two potential problems: it does not distinguish type of supplement, atole or fresco; and it mixes children who do not consume supplement for part of their life because they were born in 1966, 1967, or 1968 and children who could have consumed supplement but did not. We study these two problems in weight retardation as an example. Figure 3, based on data on only those children born into the project, makes clear that the differences noted in Figure 2 are to be found in children for whom the supplement was always available.

It is also clear, however, that the fresco villagers show a higher proportion of smaller children in the middle group than the atole villages. This raises the question of the separate effects of protein and calories in the child's consumption. We are at present exploring this issue. However, it should be stressed that within each of the four villages there was a difference by level of caloric supplementation in the proportion of children showing growth retardation. This proportion is consistently greater in the low supplemented group than in the middle or in the high group. In the total sample, the risk of growth retardation is almost three times greater in the low supplement group than in the high group.

Both in the analyses with birthweight and in these analyses of growth retardation, the association observed was replicated in analyses of variance and in regressions. Moreover, the observed associations are not explained by other variables such as maternal size, home diet, morbidity, obstetrical characteristics and socioeconomic status. Thus, at present, we consider that this relationship is causal. We estimate that the final result of food supplementation up to seven years of age will be a reduction of about 50% of the deficit in height between the low supplemented children and the Denver standards (DDH/INCAP, 1975).

Maternal Anthropometry and Birthweight. Figure 4 shows that maternal head circumference and height are associated with birthweight. Smaller mothers tend to have smaller babies. Since the bulk of the retardation in head circumference and height in the adult is a consequence of events occurring during the first few years of age, it is possible that the relation of maternal anthropometry to birthweight actually reflects the effect of early maternal nutrition on subsequent fetal nutrition. We are currently investigating other maternal anthropometric variables. Mother's arm circumference, for example is also significantly associated with birthweight. We believe that this may reflect the influence of recent maternal nutritional status on fetal growth.

Maternal Morbidity during Pregnancy and Birthweight.

Table 4 shows that a pooled indicator of morbidity during pregnancy, composed of the sum of days ill with diarrhea or anorexia and of days in bed from illness, was negatively associated with birthweight. In fact, mothers with the lowest levels of morbidity showed a proportion of low birthweight babies of only 10.5% as compared with 33.3% among the mothers with the highest levels of morbidity. Because of a tendency to lower home caloric intake in the group of mothers with high morbidity, our tentative interpretation of these results is that morbidity during pregnancy leads to low dietary intake which in turn results in fetal growth retardation (Lechtig, et al., 1972).

Cord Levels of IgM and Birthweight. There is evidence both that high cord IgM levels reflect intrauterine infection and that at least several intrauterine infections are associated with greater prevalence of low birthweight (Alford, et al., 1969). In our study population there was a negative although non-significant correlation between cord IgM levels and birthweight (Table 4). However, within the group with low IgM values ($\angle$ 20 mg %) the correlation was positive whereas in the group with high IgM values ($\geq$ 20 mg %) group the correlation was negative. These results suggest that there are at least two factors regulating the relationship between cord IgM levels and birthweight. The first is the fact that heavier babies produce greater quantities of antibodies, and the second is that intrauterine infection would produce both increased levels of IgM and fetal growth retardation (Lechtig, et al., 1974a).

Socioeconomic Factors and Birthweight. Figure 5 shows that in our study population a family socioeconomic score (SES) along with maternal height is associated with birthweight.

This association has important public health implications (Lechtig, et al., 1975b). Low birthweight babies have higher rates of infant mortality than babies with higher birthweight (Chase, 1969). This means that the efficiency of nutritional programs aimed at decreasing infant mortality could be greatly enhanced if these programs were focused on mothers at high risk of delivering low birthweight babies. Some of these maternal characteristics may be useful to build risk instruments, feasible for use in populations with inadequate health services (Lechtig, et al., 1975c).

3.2 Determinants of psychological test performance

Data on psychological test performance have been collected from birth through 36 months in sufficient quantity to allow us to address the question of the relationship between food supplementation and psychological test performance with adequate numbers of subjects.

The results presented here employ two measures of food supplementation, total food supplement ingestion by both the mother during pregnancy and lactation and by the child up until the age at which he is evaluated, and the same discrete measure of supplement ingestion used in the previous section. The principal difference between these two measures is that one reflects total ingestion across a particular period of time whereas the second is weighted and reflects the consistency of ingestion across various periods of time in the child's life.

It is important to discuss briefly the psychological tests themselves. The measures of psychological test performance presented here are measures selected from a larger battery on the basis of theoretical and statistical criteria. The psychological test battery was developed over a period of several years and its statistical and cultural appropriateness have been discussed in detail elsewhere (Klein, et al., 1972). The reliabilities for the variables discussed in this paper appeared in Table 6. It can be seen that these are high enough in most cases and allow us to speak with some precision about the relationships we encounter between psychological test performance and food supplementation.

Table 6 presents the association between mental test development and supplement ingestion at various ages.

Turning first to the results of the evaluation of the infant shortly after birth, we note that although food supplementation during gestation was associated with higher birthweight, performance on the Brazelton Neonatal Evaluation Scale was not affected. The two Brazelton variables reported here are derived from clusters of items that appeared together in factor analyses of all test items. BB1 includes the negative signs of:tonus, motor maturity, vigor, pull to sit, visual following and interest in the examiner; and trembling. BG1 is to some degree the opposite of BB1, it includes the positive signs of: vigor, visual following, social interest in the examiner, and motor maturity.

Next, Table 6 reports results for the Composite Infant Scale at 6, 15 and 24 months of age. This scale, a mixture of psychomotor items, yields 2 scores at each of the testing periods: a mental score and a motor score. At 6 months of age only the mental scale is significantly associated with supplement ingestion. By 15 months of age onward the pattern is clear: well-nourished subjects perform significantly better on mental and motor scales of the Composite Infant Scale. This is the case for both the categorical measure of supplementation as well as the measure of total supplement ingestion.

The individual test items in the Composite Infant Scale at 15 and 24 months of age were examined separately. In general, the impact of supplement ingestion seems to be more closely related to motor and manipulative skills than to language and other emerging cognitive abilities. However, the tests themselves are heavily weighted with motor and manipulative items since these are the principal behavioral characteristics which infants at 15 and 24 months of age uniformly display. For this reason performance at later ages is of particular interest since cognitive abilities begin to emerge rapidly beyond 3 years of age.

Psychological performance and its relationship to food supplement ingestion was examined at 36 months of age. At this age there is a large battery of psychometric tests tapping many and diverse skills. Table 6 presents the association of a representative set of 13 of these variables with supplement ingestion. Of the 13 test variables examined, 5 differed significantly between well and poorly supplemented children and 5 more showed trends in the expected direction. The tests for which significant differences were seen included picture naming and recognition, both estimates of the vocabulary of the children, and verbal inferences, which is a verbal reasoning task. In each case, superior performance was associated with higher level of food supplement ingestion.

Two of the tempo measures also varied inversely with food supplement intake: response time for the discrimination learning task and line velocity in the Draw a Line Slowly task. Children who had had higher levels of food supplement ingestion performed more rapidly on the discrimination learning task. In the line velocity task where the child is required to draw a line as slowly as possible, the children with higher levels of supplementation ingestion were able to do so and their velocities were significantly slower than children with low levels of supplement ingestion.

It is interesting to note that there were relatively few sex differences with respect to the impact of food supplementation on psychological test performance in this age range. In general, performance of boys and girls was quite comparable across the tests described here and, with very few exceptions, boys and girls responded similarly to food supplementation.

Table 7 presents data on the effects of the timing of supplement ingestion on psychological test performance. It presents correlations and partial correlations of CIS Mental Scores at 6, 15 and 24 months and Cognitive Composite and verbal inferences scores at 36 months with supplement ingestion. Column 1 shows the correlation between supplement ingested during pregnancy by the mother and the child's later test performance; column 2 shows the correlation between cumulative supplement ingested by the child and mother up to the time of psychological testing and the child's test performance; column 3 shows the partial correlation of cumulative supplementation with test performance when maternal gestational supplementation is controlled for by partialing; and column 4 shows the correlation of supplement ingested during pregnancy with child's test performance controlling for postnatal supplement ingestion. Not only are the correlations between gestational supplementation and later test performance significant, but once gestational supplementation is partialled out of the correlations between total cumulative supplementation and test score association, virtually no relationship remains between later cumulative supplementation and test performance. On the other hand, the effect of prenatal supplement and subsequent test performance is unaffected by controlling for later supplementation. Thus, as the previous analyses also indicated, pregnancy is the crucial period for supplementation as far as later psychological test performance is concerned.

The design of the present study like many large scale intervention studies, does not completely eliminate the possibility of confounding and subsequent misinterpretation of results. To avoid this possibility we have conducted a series of detailed analyses exploring all the interpretations of the results presented here. The first is the study of associations between supplement and psychological test performance within the same mother from child to child. As in the case of birthweight, they show statistically significant relationships. In other words, even within the same family greater maternal supplement ingestion during one pregnancy is associated with superior test performance of that child.

Among other analyses we have considered the effects of repeated testing itself on psychological test performance, the morbidity of the children and general level of parental cooperation with the project, as well as differences among the villages themselves. We have also been concerned with the possible impact of attendance to the supplementation centers _per se_ on mental development as well as the general problem of differences in social and economic characteristics among the families of the children in the study. In general, these variables do not provide a reasonable alternative explanation for the relationship between food supplement ingestion and psychological test performance. In fact, there seems to be a tendency by 36 months of age for family socioeconomic status to interact with food supplement ingestion in important ways. There was a tendency for less well supplemented children to have higher family socioeconomic status scores than well supplemented children. This tendency was not statistically significant in the total sample, although in some individual villages it was significant. Given the negative relationship between supplementation and SES, the superior performance of the well supplemented children is even more striking, since we expect that if supplementation has no effect, the higher SES children will score higher. Therefore, the comparison of the test scores of these three nutritional groups, not considering SES, is a conservative test of the hypothesis.

A pattern similar to that of the SES variable was observed for home diet; least well supplemented children had a tendency to have more adequate home diets than better supplemented children. For calories in the home diet, this effect was not significant; for proteins in the home diet, at all ages the least well supplemented children had better diets than the more supplemented children.

We suspected from these findings that the effects of the nutritional supplement would vary by level of socioeconomic status particularly at the older age of 36 months. Analyses of the effects of nutritional status within levels of socio-eonomic status (high or low) indicated that at 36 months there was greater effect of nutrition on test performance among the more socially and economically deprived children than among the less deprived children. For boys, four measures (Embedded

Figures Sum of Correct Responses and Embedded Figures Test Adaptability; Vocabulary Recognition Score; Reversal Discrimination Learning Time) displayed the pattern described above and for girls two tests (Embedded Figures Adaptability and Reversal Discrimination Learning Time) had patterns of this type.

In public health terms, one great concern is for children scoring in the lowest percentiles on tests of mental development. These children are probably less likely to be independent, self-sufficient members of the community than children scoring in the higher ranges. Consequently, we examined a child's relative risk of being in the lowest decile on our overall measure of mental development according to his level of nutrition. This analysis is reported in Table 8 for the 36 month composite test score as our best representative measure of overall cognitive performance at this age.

If there were no effects of nutritional supplementation on the risk of low test performance, we would expect that a child in the lowest decile would be equally likely to fall into each nutritional status category. However, as Table 8 indicates, a low decile child is twice as likely to have been poorly supplemented as to have been well supplemented (6/13%). A similar analysis was performed for the highest decile, or best performing children; here we see that the high decile child is twice as likely to have been well-supplemented as to have been poorly supplemented (7/16%). Further, a well supplemented child is almost three times as likely to have been in the highest decile as in the lowest decile (6/16%) and a poorly supplemented child is almost twice as likely to have been in the lowest decile as (7/13%) the highest. When all children are included (that is, the middle 80% of children are also considered) the effect of nutritional supplement on test performance category (lowest 10%, middle 80%, highest 10%) is significant.

These analyses were repeated within SES levels (high and low) to see whether the relative risk of being in the lowest versus highest decile if a child were poorly supplemented would be identical within each SES level. As Table 8 indicates, a high SES, poorly supplemented child is about equally likely to have been in the highest or lowest decile (11/12%); however, in the low SES group, a poorly supplemented child is more than 6 times as likely to be in the lowest rather than the highest decile (2/13%). When all children are included, the effect of nutritional status on test performance category is greater in the low SES group than the high SES group.

In summary, our data analyses to date suggest that food supplementation does affect psychological test performance. The effects can be seen reasonably clearly by 15 months of age and continue to be apparent at 24 and 36 months of age. Moreover, food supplementation during pregnancy appears to have a greater impact on psychological test performance than does later food supplementation. The findings are consistent with findings reported earlier for this project (Klein, et al., 1974). Finally, a range of possibly confounding variables do not provide reasonable alternative explanations for the results reported here. However, the variable of socioeconomic status does appear to interact with effects of supplementations; at 36 months, children from low SES families in our study population were more affected by supplementation than were children from higher SES families.

3.3 Determinants of infant mortality

Figure 6 reports the association between caloric supplementation and stillbirths and infant deaths during the first, second, third and fourth quarters of the first year of life. It is clear that in all five comparisons made, the proportion of deaths in the lower supplement group was greater than in the higher group. The magnitude of the differences is such that the risk of dying during the first year of life in the high supplemented group is half of that observed in the low supplemented group.

The observation that improved nutrition during pregnancy and lactation decreases infant mortality by nearly half deserves consideration. Intervention programs designed to reduce infant mortality have generally focused on the control of infectious diseases through adequate health services and paid little attention to nutrition. These results demonstrate that nutritional interventions may be important in reducing infant mortality in poor rural populations.

Other variables were also associated with infant mortality: low socioeconomic status, low maternal height, low gestational age, severe hypoxia at birth and low birthweight (Lechtig, et al., 1974b). These five variables, either alone or combined, can be useful as early indicators of children who need special attention in public health programs.

4. CONCLUSIONS

In these rural populations with whom we have worked, improved nutrition since conception is associated with an important decrease of the prevalence of physical growth retardation up to 36 months of age and of infant mortality. Nutrition also appears to be associated with psychological test performance. Maternal height, head circumference, arm perimeter and a family socioeconomic status score predict risk of delivering low birthweight babies. Therefore their use to select women at higher risk would greatly enhance the efficiency of nutritional programs to decrease growth retardation and infant mortality.

5. FINAL REMARKS

It should be emphasized that the technique of food supplementation was implemented as a research manipulation and that programs of this type are inappropriate for large populations over long periods of time. In many pre-industrial societies, the elimination of poverty itself will be the most effective way of improving nutritional status and reducing developmental retardation and infant mortality.

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TABLE 1

EXPERIMENTAL DESIGN

Four Villages - Two Villages: Atole[1] = Protein-Calorie Supplement

- Two Villages: Fresco[2] = Calorie Supplement

A. MATERNAL AND CHILD INFORMATION COLLECTED

1. INDEPENDENT VARIABLE:

   Measurement of subject's attendance to feeding center and amount of supplement ingested.

2. DEPENDENT VARIABLES:

   Assessment of physical growth

   Assessment of mental development

3. ADDITIONAL VARIABLES:

   Obstetrical history[3]

   Information on delivery

   Clinical examination

   Dietary survey

   Morbidity survey

   Socioeconomic survey of the family

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

[2] Spanish for refreshing, cool drink.

[3] Diagnosis of pregnancy by absence of menstruation.

TABLE 2

NUTRIENT CONTENT PER CUP*

(180 ml)

	Atole	Fresco
Total Calories (Kcal)	163	59
Protein (g)	11	--
Fats (g)	.7	--
Carbohydrates (g)	27	15.3
Ascorbic Acid (mg)	4.0	4.0
Calcium (g)	.4	--
Phosphorus (g)	.3	--
Thiamine (mg)	1.1	1.1
Riboflavin (mg)	1.5	1.5
Niacin (mg)	18.5	18.5
Vitamin A (mg)	1.2	1.2
Iron (mg)	5.4	5.0
Fluor (mg)	.2	.2

* Review date: October 11, 1973; figures rounded to the nearest tenth.

TABLE 3

SAMPLE SIZE[1]

Variable	Number of Children Born Into Sample	Total Number of Children Observed
Children Available	671	1083
Physical Growth:		
At birth	405	405
At 36 months	330[1]	581[1]
Mental Development:		
At birth	157	157
At 6 months	472	472
At 15 months	452	460
At 24 months	453[1]	480[1]
At 36 months	329[1]	565[1]
Infant Mortality:		
(First 12 months of age)	661	821

[1] Up to November 30, 1974.

TABLE 4

RELATIONSHIP BETWEEN MATERNAL MORBIDITY DURING PREGNANCY AND BIRTHWEIGHT

	Correlation Value	Number of Cases	Probability Value ≤
Composite Scale			
(Diarrhea, Anorexia and Bed)	- .15	249	.05
Cord IgM Levels	- .10	170	.10

TABLE 5

TEST-RETEST AND INTEROBSERVER RELIABILITY OF PSYCHOLOGICAL TEST MEASURES

Variable	Test-retest	N	Inter-observer	N
Brazelton Neonatal Assessment				
BB1	.61	20	.93	20
BG1	.67	20	.97	20
Composite Infant Scale				
6 months mental	.88	20	.82	15
6 months motor	.92	20	.82	15
15 months mental	.88	20	.87	15
15 months motor	.87	20	.87	15
24 months mental	.86	20	N.A.[a]	--
24 months motor	.44	20	N.A.	--
Preschool Battery (36 months)				
Cognitive Composite	.87	40	--[b]	--
Embedded Figures Test Sum	.81	20	.99	140
Embedded Figures Test Time	.63	20	.99	140
Embedded Figures Test Adaptability	.63	20	--[b]	--
Digit Memory	.65	20	.99	140
Memory for Sentences	.60	20	.99	140
Reversal Discrimination Learning Sum	.60	40	--[b]	--
Reversal Discrimination Learning Time	.17	20	N.A.	--
Naming	.86	20	1.00	140
Recognition	.91	20	.99	140
Verbal Inferences	.62	20	N.A.	--
Line Velocity	.65	20	.99	140
Rompecabezas	.45	20	.97	140

[a] Not available.

[b] Not appropriate; score is constructed, not observed.

TABLE 6

THE ASSOCIATION OF PSYCHOLOGICAL TEST PERFORMANCE WITH SUPPLEMENT INGESTION

Psychological Test Score		S.D. (Approx.)	Level of Supplement Ingestion[1] Low	Med.	High	F	Corr. with Total Ingestion	N[2]
Brazelton Neonatal Assessment								
BB1	X̄	12.2	39.69	40.00	39.54	.02	-.032	(157)
	N		42	32	83			
BG1	X̄	13.5	38.83	36.00	39.05	.66	-.042	(157)
	N		42	32	83			
Composite Infant Scale								
6 Months								
Mental	X̄	13.8	73.8	76.3	77.8	2.87*	.030	(472)
	N		150	221	101			
Motor	X̄	14.8	70.0	70.6	72.7	1.13	-.017	(472)
	N		150	221	101			
15 Months								
Mental	X̄	12.5	62.9	67.8	72.3	4.65**	.130**	(460)
	N		140	243	77			
Motor	X̄	15.0	73.8	77.2	82.6	6.25**	.134**	(460)
	N		140	248	77			
24 Months								
Mental	X̄	12.3	61.6	65.5	68.1	8.45**	.161	(480)
	N		206	192	82			
Motor	X̄	18.5	67.5	74.4	78.9	11.61**	.221**	(480)
	N		206	192	82			
36 Months								
Cognitive Composite	X̄	280.3	-5.28	48.97	54.20	2.75	.060	(565)
	N		278	237	50			
Embedded Figures Test Sum	X̄	3.4	9.43	10.03	9.70	1.91	.069*	(552)
	N		270	232	50			
Embedded Figures Test Time	X̄	11.4	31.5	30.1	28.9	1.58	-.079*	(552)
	N		270	232	50			
Embedded Figures Test Adaptability	X̄	24.0	9.42	12.71	72.40	1.48	.023	(552)
	N		270	232	50			
Digit Memory	X̄	8.3	10.11	10.87	12.92	2.22	.073	(465
			224	197	44			

TABLE 6 (CONT.)

THE ASSOCIATION OF PSYCHOLOGICAL TEST PERFORMANCE WITH SUPPLEMENT INGESTION

Psychological Test Score		S.D. (Approx.)	Level of Supplement Ingestion[1] Low	Med.	High	F	Corr. with Total Ingestion	N[2]
Memory for Sentences	$\bar{X}$	12.8	12.06	14.22	14.60	1.85	.076	(486)
	N		228	210	48			
Reversal Discrim. Learning Sum	$\bar{X}$	20.5	23.18	23.83	20.93	.38	-.061	(497)
	N		232	220	45			
Reversal Discrim. Learning Time	$\bar{X}$	11.0	23.4	20.7	18.3	5.13**	-.176**	(497)
	N		232	220	45			
Naming	$\bar{X}$	4.3	6.44	7.44	8.06	5.07**	.117**	(539)
	N		262	227	50			
Recognition	$\bar{X}$	5.6	19.40	20.62	20.70	2.83*	.060	(539)
	N		262	227	50			
Verbal Inferences	$\bar{X}$	1.2	1.25	1.52	2.08	3.28*	.157**	(238)
	N		120	106	12			
Line Velocity	$\bar{X}$	45.0	105.9	93.4	94.4	4.84**	-.121**	(520)
	N		250	220	50			
Rompecabezas	$\bar{X}$	5.4	5.98	5.86	6.46	.25	.0002	(476)
	N		203	223	50			

* P / .05
** P / .01
1 See text (Section 3.1) for definition
2 Sample complete through November 30, 1974.

TABLE 7

THE ASSOCIATION OF PSYCHOLOGICAL TEST PERFORMANCE WITH SUPPLEMENT INGESTION

Test	I With suppl. ingested during pregnancy	II With total supplement ingested to time of testing	III With total supplement ingested to time of testing (II), controlling for supplem. ingested during pregnancy (I)	IV With supplement ingested during pregnancy (I), controlling for post-natal supplement ingested to time of testing (II)
BOYS				
Composite Infant Scale - 6 Mos. Mental Scale	.11	.04	-.07	.13*
Composite Infant Scale - 15 Mos. Mental Scale	.09	.14*	.11	.01
Composite Infant Scale - 24 Mos. Mental Scale	.20**	.19**	.11	.12*
36 Mo. Cognitive Composite	.09	.04	.00	.12*
36 Mo. Verbal Inferences	.36**	.20**	.04	.33**
GIRLS				
Composite Infant Scale - 6 Mos. Mental Scale	.13*	.01	-.18**	.15*
Composite Infant Scale - 15 Mos. Mental Scale	.24**	.12*	-.07	.22**
Composite Infant Scale - 24 Mos. Mental Scale	.15*	.13*	.04	.09
36 Mo. Cognitive Composite	.11	.10	.04	.05
36 Mo. Verbal Inferences	.25**	.12*	-.03	.23**

n = Approx. 250 for all tests except Verbal Inferences. * P / .05
n = Approx. 120 for Verbal Inferences. ** P / .01

TABLE 8

RELATIVE RISK OF FALLING INTO EXTREME DECILES OF COGNITIVE COMPOSITE (36 MONTHS) BY NUTRITIONAL CODE AND SOCIOECONOMIC STATUS

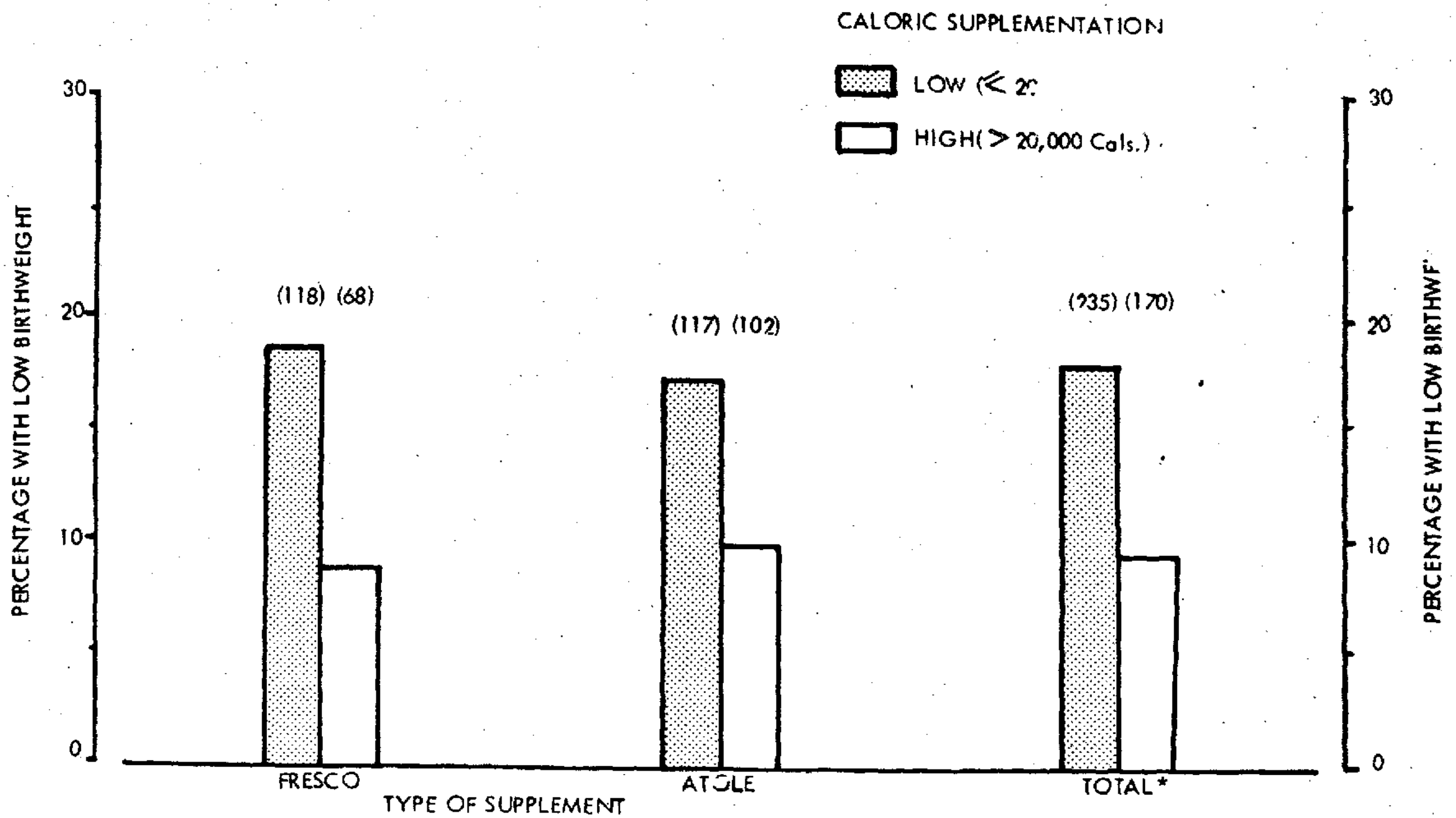
Supplement Ingestion Category	SAMPLE SIZE (N's)				PERCENTAGES				CHI SQUARE		
Total Sample	Lowest Decile	Middle Deciles	Highest Decile	Total	Lowest Decile	Middle Deciles	Highest Decile	Total	X^2	d.f.	P
Low Suppl.	35	224	19	278	13	80	7	100	9.4	4	/.05
Med. Suppl.	19	185	29	237	8	80	12	100			
High Suppl.	3	39	8	50	6	78	16	100			
Total	57	452	56	565	10	80	10	100			
Low SES											
Low Suppl.	16	104	3	123	13	85	2	100	9.3	4	/.10
Med. Suppl.	13	94	13	120	11	78	11	100			
High Suppl.	2	19	4	25	8	76	6	100			
Total	31	217	20	268	12	81	7	100			
High SES											
Low Suppl.	18	116	16	150	12	77	11	100	5.0	4	N.
Med. Suppl.	6	95	15	116	5	82	13	100			
High Suppl.	1	20	4	25	4	80	16	100			
Total	25	231	35	291	9	79	12	100			

Note: For 6 children information on family SES not available.

FIGURE 1

RELATIONSHIP BETWEEN SUPPLEMENTED CALORIES DURING PREGNANCY AND PROPORTION OF LOW BIRTHWEIGHT

($\leq$ 2.5 kg)



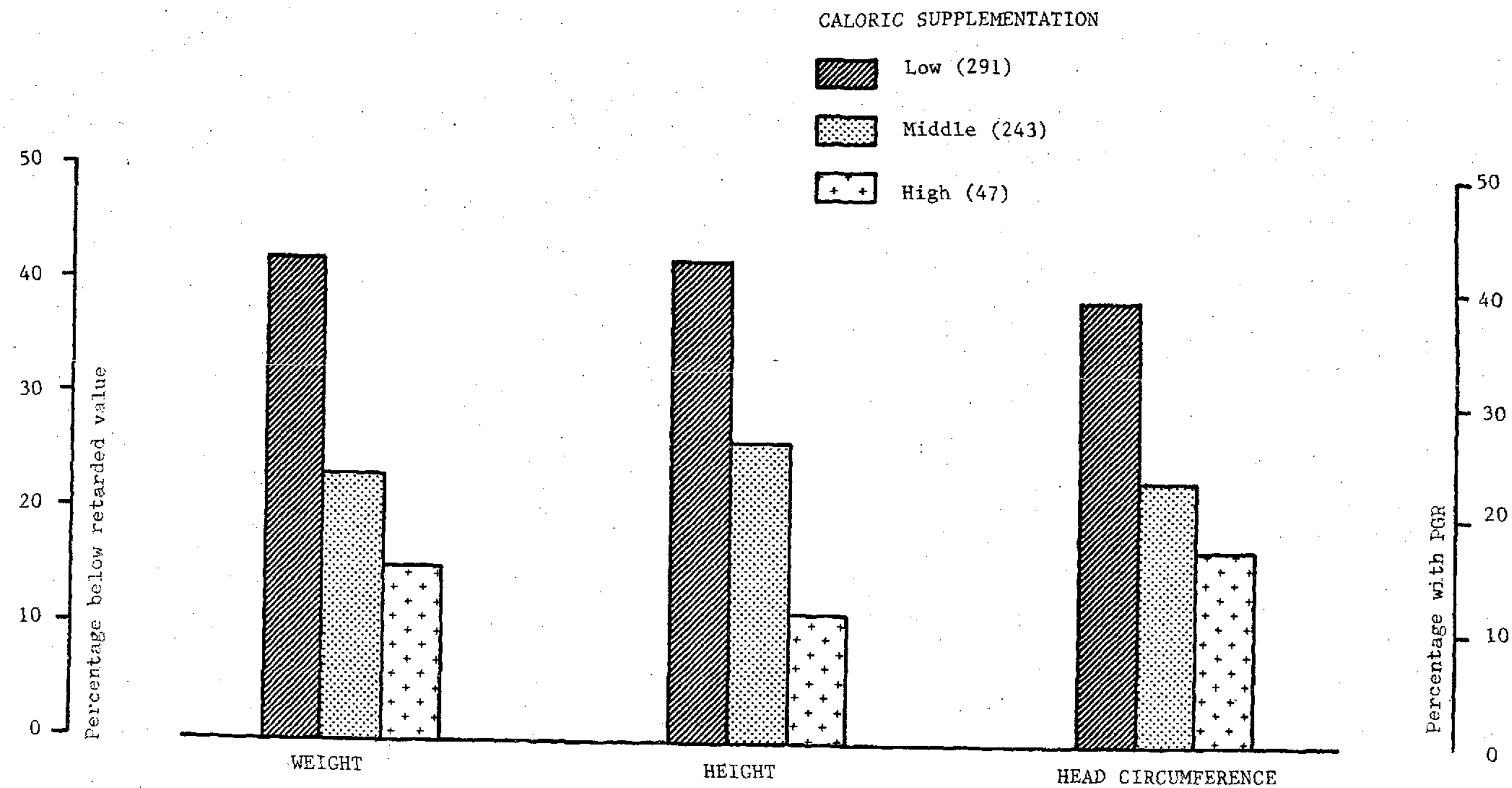
In parenthesis number of cases: * $p < .05$

Incap 74-55

FIGURE 2

RELATIONSHIP BETWEEN CATEGORY OF CALORIC SUPPLEMENTATION SINCE CONCEPTION AND PREVALENCE OF GROWTH RETARDATION*IN WEIGHT, HEIGHT AND HEAD CIRCUMFERENCE AT 36 MONTHS OF AGE

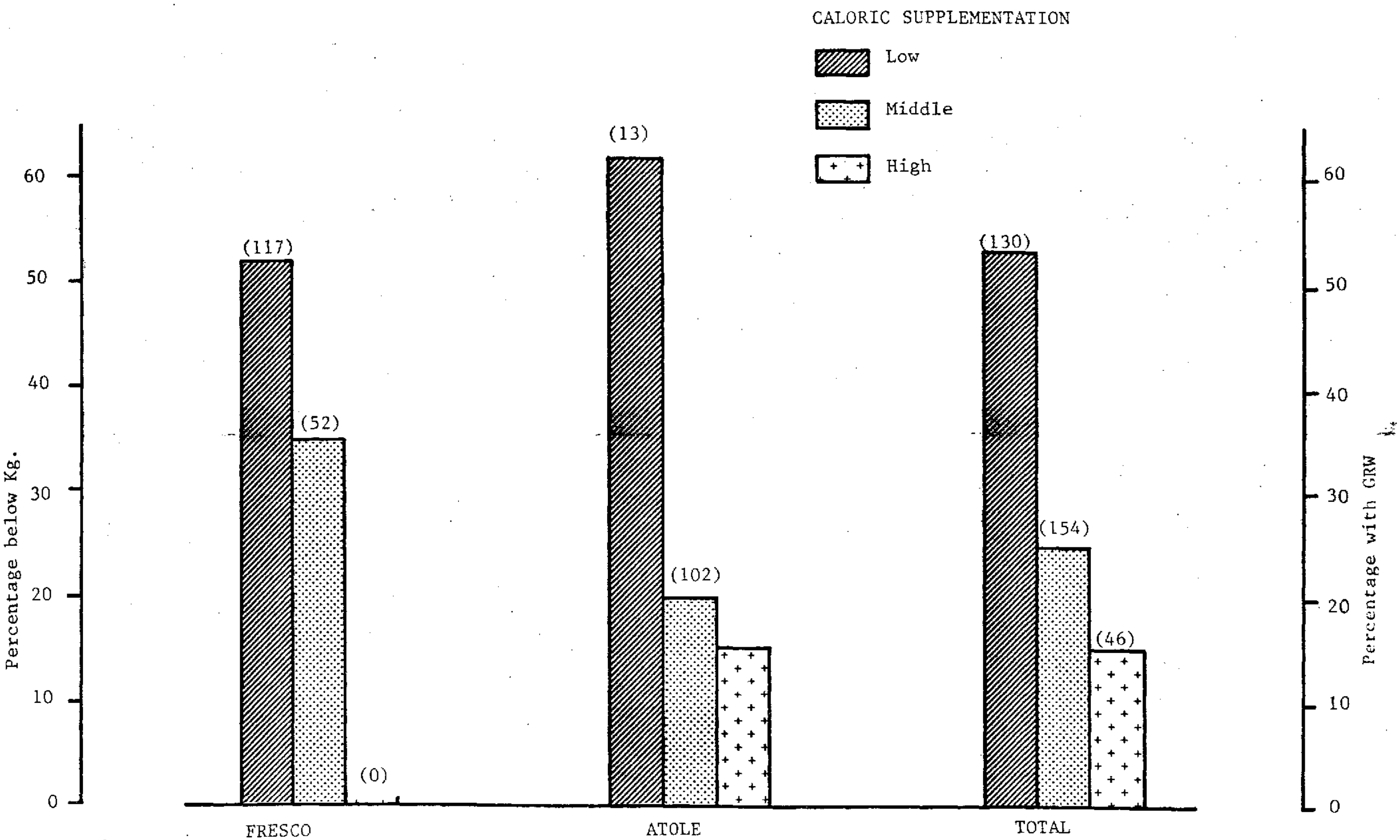
(n = 581, Fresco and Atole combined)



In parenthesis: Number of cases
*See text for definition of growth retardation.

FIGURE 3

RELATIONSHIP BETWEEN CATEGORIES OF CALORIC SUPPLEMENTATION SINCE CONCEPTION AND THE PROPORTION OF CHILDREN WITH GROWTH RETARDATION* IN WEIGHT AT 36 MONTHS OF AGE



In parenthesis: Number of cases.
* See text for definition of growth retardation.

FIGURE 4

PROPORTION OF LOW BIRTHWEIGHT BABIES PER CATEGORY OF MATERNAL HEIGHT, AND HEAD CIRCUMFERENCE

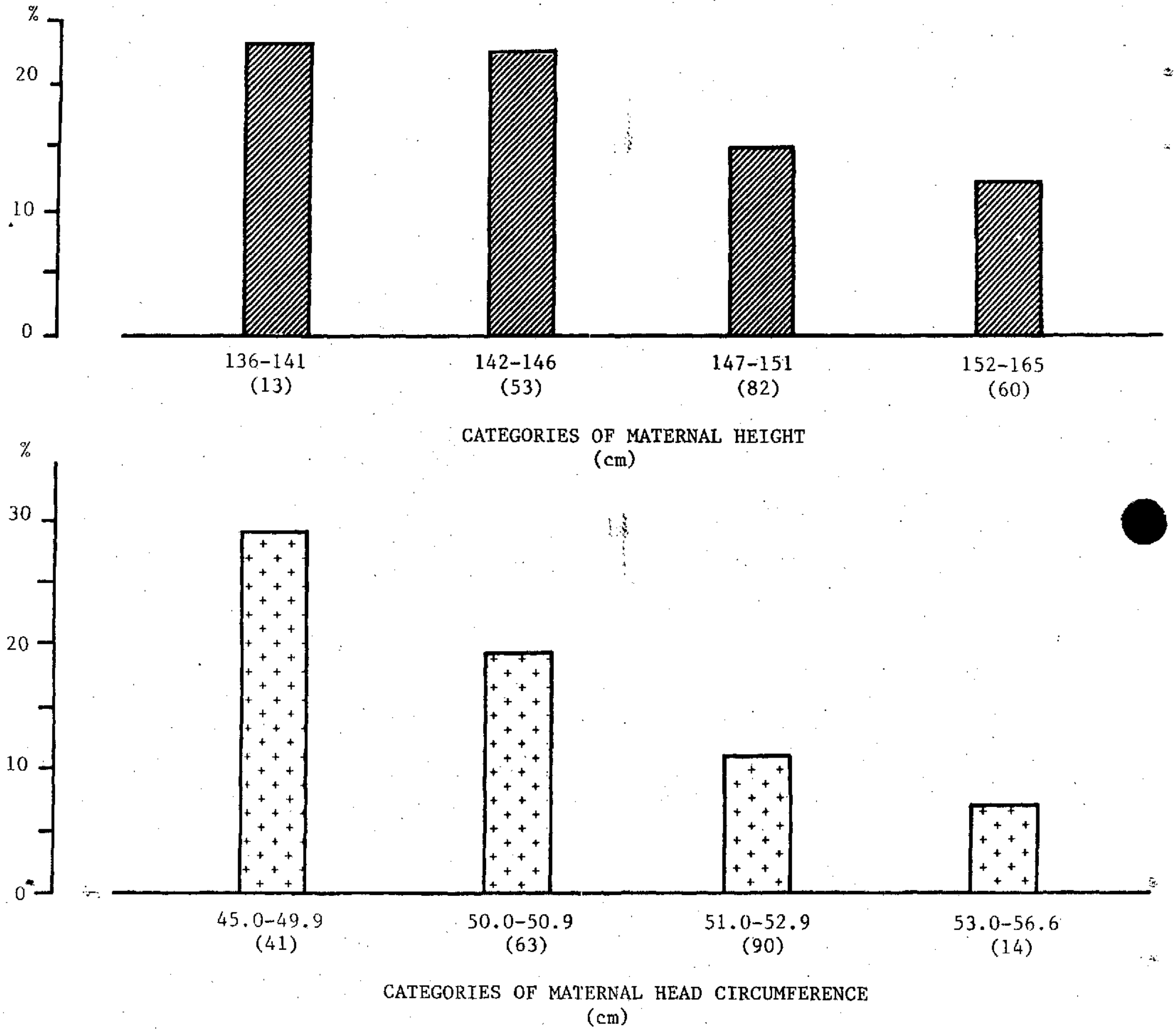
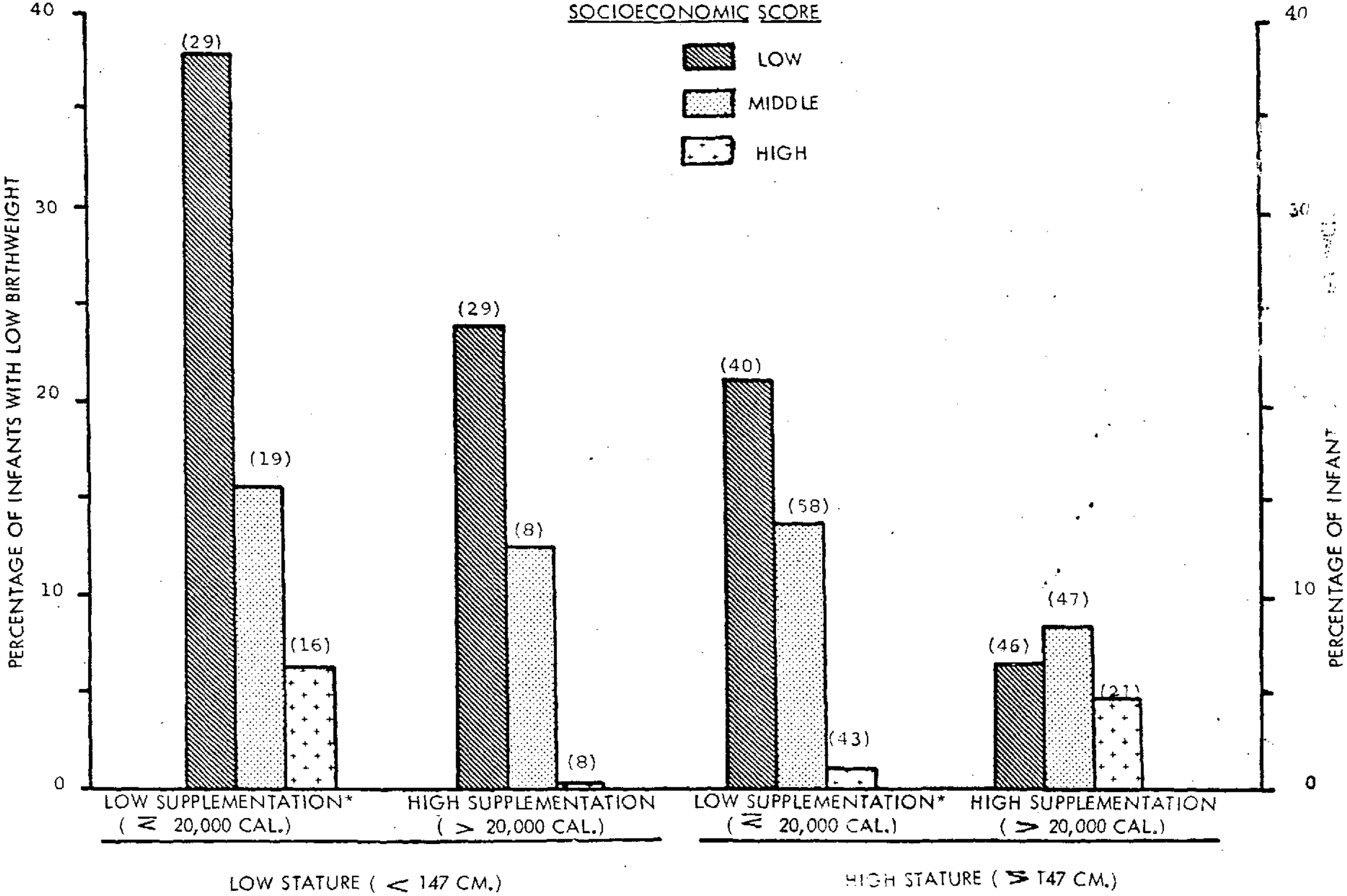


FIGURE 5

INFLUENCE OF MATERNAL HEIGHT AND CALORIC SUPPLEMENTATION DURING PREGNANCY ON THE RELATIONSHIP BETWEEN SOCIOECONOMIC SCORE AND THE PROPORTION OF INFANTS WITH LOW BIRTHWEIGHT

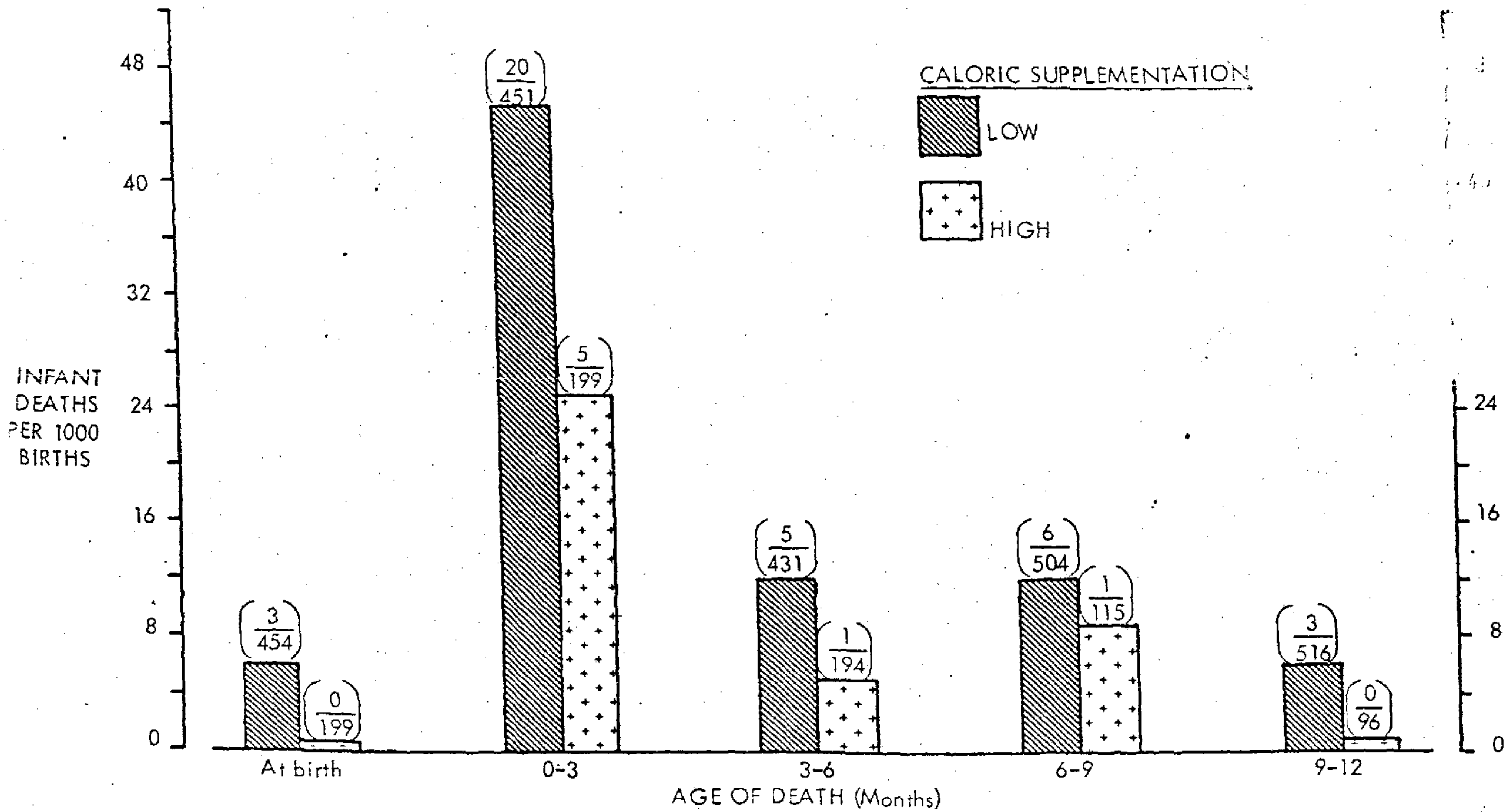


IN PARENTHESIS: NUMBER OF CASES; * P < .05

Incap 74-50

FIGURE 6

EFFECT OF CALORIC SUPPLEMENTATION DURING PREGNANCY AND LACTATION ON INFANT DEATHS[1]



In parenthesis the numerator is number of deaths and the denominator population at risk.

1. P value = .06