Intrauterine Growth Retardation, edited by Jacques Senterre. Nestlé Nutrition Workshop Series, Vol. 18. Nestec Ltd., Vevey/Raven Press, Ltd., New York © 1989.

Food Supplements During Pregnancy

Jorge Suescun* and José O. Mora**

**Department of Paediatrics, Medical School of Colombia; and **Senior Medical Nutritionist, LTS International Nutrition Unit, Bogotá, Colombia*

There is general agreement among experts in human growth on the importance of the intrauterine period and early childhood up to the age of 6 years as basic critical stages in the development of man. Indeed, it is at these stages of life that the child's body and, more specifically, his central nervous system are the most flexible. It is a well-known biological fact that the body's vulnerability to hostile environmental effects is directly related to the speed of the growth and development process.

The results of animal research on the effects of nutritional deprivation during pregnancy on the fetus have been confirmed by the findings of human "natural experiments" (1–3). Acute malnutrition of the mother during the second half of pregnancy results in a smaller body and lower weight at birth (4,5). Low weight-for-gestational-age has traditionally been considered a consequence of the mother's malnutrition and is of special importance because it is closely related to perinatal and neonatal mortality and, therefore, with the chances of survival of the newborn baby. In addition, in those who survive, there is a risk of growth and subsequent developmental disorders, which is why this factor is a crucial variable for the newborn baby's prospects (6,7). In general terms, the intrauterine period cannot escape the harm caused by poverty or by the effects of adverse environmental factors. But, although animal studies have produced conclusive proof of a close relation between nutritional deprivation during pregnancy and retardation of fetal growth, studies carried out on humans have shown contradictory results. For moral reasons, the normally used pattern of deprivation in animal research cannot be applied to humans but, on the other hand, the major differences between these two species make it impossible to generalize about the findings.

The data which are available on the human species are based on three kinds of study: (a) The so-called "natural experiments" in which calamities such as war unintentionally mimick conditions of the pattern of deprivation used in animal experiments (1–3); (b) epidemiologic studies, involving large samples of the population, on the relationship between the diet followed during pregnancy and fetal growth and development (8–12); (c) clinical studies on a small scale (13–15). Although there have been some inconsistencies in these studies, the following general conclusions have been drawn:

a. Severe nutritional deprivation during the second half of pregnancy results in delayed fetal growth and greater perinatal mortality.
b. When less energy and/or protein than recommended is consumed, there is a definite relationship between such reduced consumption and fetal growth.
c. Weight at birth, which is the most generally accepted fetal growth criterion, is clearly related to perinatal mortality and to the child's later growth and development (16–21).
d. A large energy and/or protein intake during the second half of the last trimester of pregnancy can increase the weight at birth of babies whose mothers' diets were deficient during the first half of pregnancy.

These conclusions justified the drawing up of programs to provide food supplements during pregnancy for populations at risk from malnutrition. Experimental studies have, however, in some cases failed to show that such measures are effective. The effects of prenatal food supplements on weight at birth indicate in some cases that we cannot conclude that such measures are invariably efficient in increasing fetal growth (22,23); this has led to some skepticism, which appears to be justified.

The risk of dismissing too lightly nutritional measures because of the apparent inconsistency of their results makes it necessary to consider some aspects connected with their efficiency, so that we can determine the conditions under which such measures really are effective. It should be pointed out that the apparent failure of some prenatal food supplementation programs to affect weight at birth in a major way does not imply an absence of a direct relation between maternal nutrition and fetal growth. Apart from the problems inherent in the design of such studies or relating to assessment of the programs, it is essential to consider in practice at least two very important aspects which help explain the differences between the results obtained.

INITIAL NUTRITIONAL STATUS

It is logical to assume that any nutritional measures will have effects which can be proved only if they are designed to correct deficiencies which really are found in the target population involved. Food supplementation should therefore be aimed at pregnant women whose nutritional deficiencies can be proved. Unfortunately, there are no indicators of the nutritional status of pregnant women which are sufficiently valid and reliable to be used in field conditions. The search for indicators which are sensitive and easy to apply when assessing the nutritional status of a pregnant woman and which can be used in community programs is a pressing need which should be met as a priority in nutritional research.

The variations in the effects obtained with prenatal food supplementation are partly due to the fact that the target populations have varying levels of nutritional deficiencies of an ill-defined extent. Thus, for example, discouraging effects have been recorded in industrial countries with groups with marginal or unproved nutritional deficiencies. Thus, some studies have provided supplements of specific nutrients, either without previous documentation of the presence of the respective deficiencies, or in pregnant women with generalized nutritional deficiencies, as happens in most developing countries. The type of initial deficiency would, for example, explain why some studies relate an increase of weight at birth to energy supplementation whereas others relate it to increased protein consumption.

THE REAL SUPPLEMENTATION LEVEL ACHIEVED

It is to be expected that there would be a direct relationship between the effects and the extent to which the initial deficiency is corrected. The correction level depends both on the quality and on the quantity of the supplements given, and also on their actual consumption and on the behavior of the recipients in relation to their usual diet.

a. *The quality and quantity of supplements* is important in relation to the type and extent of the deficiencies which are meant to be corrected; various studies have supplied varying quantities of supplements of varying nutritional content which are bound to have covered varying proportions of the nutritional deficiencies involved.
b. *The consumption of the supplements* may vary with their quantity and quality, the extent to which they fit into the population's eating patterns, the distribution systems and checking methods and the nutritional education imparted. It also appears to depend on the mothers' perception of their nutritional needs compared with those of the other members of their families. It is obvious that, when supplements are distributed for consumption at home, they may not be used by the intended person, but instead may be sold or exchanged, or diluted within the family. Consumption problems are reduced when the supplements are given directly at food centers but this system is not practical in programs covering large areas; problems are aggravated where the distribution systems involve coupons or vouchers.
c. *The behavior of recipients regarding their usual diets* is generally characterized by the substitution of usual foods by those given as supplements, which therefore become substitutes instead of supplements. This substitution is a genuine problem which is often underestimated and which affects the results of the programs a great deal. This means that the food supplement programs, rather than constituting a purely nutritional measure, are really transfer-of-income programs—due to the changes they bring about in the distribution of the family budget—with marginal nutritional effects.

IMPACT OF FOOD SUPPLEMENTATION DURING PREGNANCY ON MOTHER AND CHILD

The previously explained concepts have been confirmed by the results of a study of measures carried out in the marginal urban areas of Bogotá, as part of a longitudinal investigation of nutrition, stimulus, and mental development, carried out jointly by the Colombian Institute for Family Well-Being and Harvard University. The data being reported are those of the prenatal and perinatal phase of this study, for which families from the poor districts in the southern part of the city were selected according to the following criteria: (a) mothers in the first or second third of pregnancy; and (b) malnutrition found in at least 50% of children under 5 years (malnutrition was defined as less than 85% of the proper weight for age).

The population of the whole area was counted four times, at six monthly intervals; 456 families were selected and allocated at random to six experimental groups, as shown on Figs. 1 and 2. Until confinement, groups A, B, and A1 may, between them, be considered the control group who did not receive supplements, whereas groups C, D, and D1 represent the sample given supplements. All families involved in the study received a full health care program, including the free distribution of drugs prescribed by the doctors involved in the program. All families were subjected to the same assessments, regarding social class, health, physical growth, and intellectual development, for the entire duration of the study.

Food supplements were started in families from groups C, D, and D1 at the beginning of the third quarter of pregnancy. The supplements were distributed in suf-

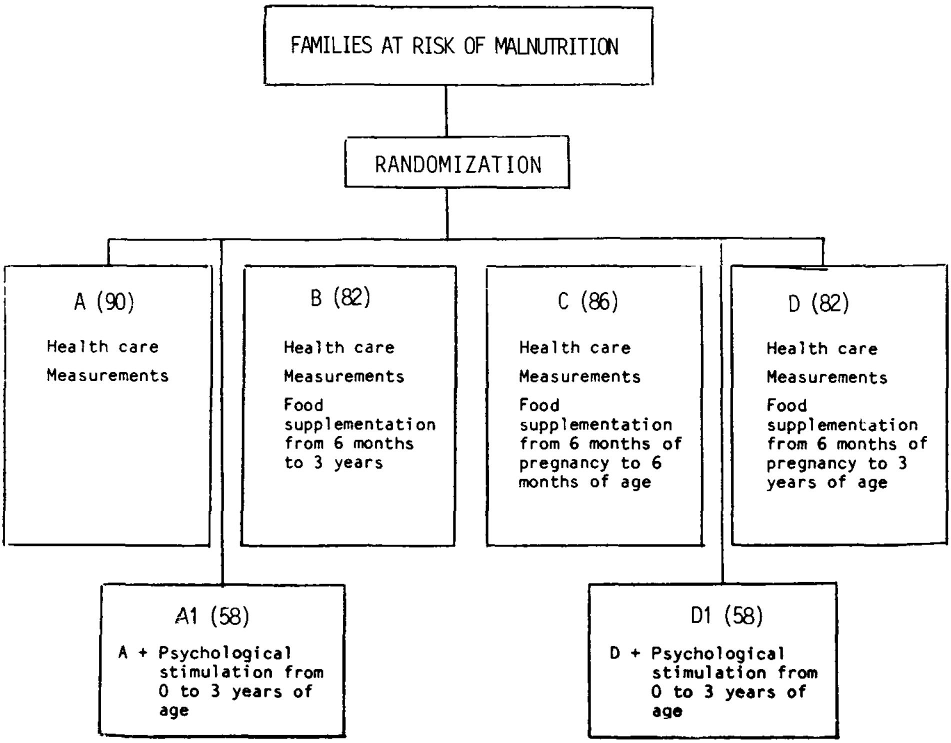

FIG. 1. Experimental design.

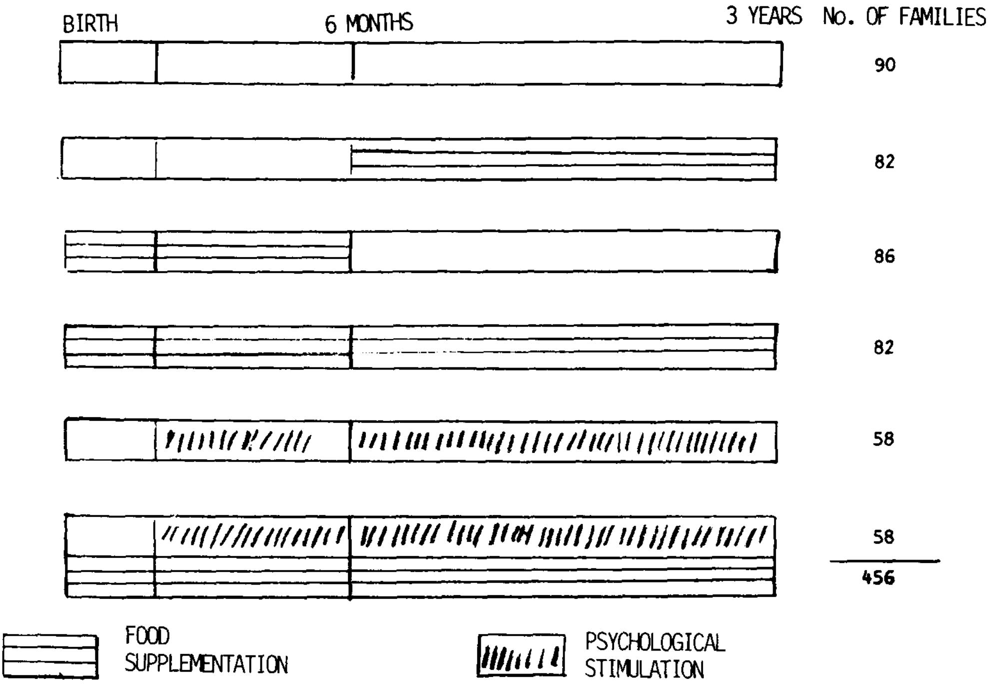

FIG. 2. Study groups according to the interventions and duration.

ficient quantities to meet a substantial part of the daily energy and nutrient intake recommended for pregnant women and other family members (Table 1). The foods were distributed weekly from premises resembling a neighborhood shop, away from the Health Center where the medical program was carried out, so as to reduce contact between the supplemented and unsupplemented groups to a minimum. The pregnant women being given supplements were instructed on the importance of continuing their usual diet as well as the supplement. As a means of checking on this, they were asked to return the empty packs when being handed the food for the following week. In addition, the correct use of the foods was checked by means of unexpected home visits by project staff. The food intake of the pregnant women was measured by means of a general survey recording consumption as recalled over 24 hr, at the beginning of the study and 2 months later.

Gestational age was calculated from the first day of the last period. In 12 cases, gestational age had to be estimated by successive measurements of uterine height, since the timing of the last period was vague. All the women were weighed at the beginning of the study, i.e., at roughly 25 weeks' gestation, and every month during pregnancy. In 117 women, the mother's weight was obtained during labor and before rupture of the membrane. The first and last measurement obtained during the study were used to estimate average weekly weight gain.

TABLE 1. *Composition of food supplements proposed for the mothers during the last trimester of pregnancy*

Food supplement	g	kcal	Protein (g)	Vitamin A (I.U.)	Iron (mg)
Skim milk powder	60	214	21.6	18	0.4
Enriched bread	150	466	16.8	6	2.6
Vegetable oil	20	176	—	—	—
Vitamin C—mineral complement	—	—	—	6,000	15.0
Total	230	856	38.4	6,024	18.0
Percentage of the recommendations	—	40	60	100	100

Quantities are per person per day.

Two-thirds of the women in the sample were delivered at the Hospital of San Juan de Dios where previously hired project staff had been instructed on how to collect information on the confinement and to take anthropometric measurements of the newborn baby. Weight at birth was determined by using a gauged balance (Toledo) with a capacity of 13,500 g and a sensitivity to 20 g. The rest of the sample had their babies in other maternity hospitals or at home, where it proved impossible to obtain the weight at birth.

Out of a total of 456 families, 7 were lost during the rest of pregnancy. There were 10 cases of stillborn babies and 6 sets of twins. We thus obtained a sample of 433 singleton births from our study. Two hundred ninety-seven babies were weighed at the hospital immediately after birth and again 25 and 31 hr after birth, and at age 15 days. One hundred ten of the remaining 136 were weighed by project staff: 13 at age 25 hr, 8 at 31 hr, and 89 when 15 days old. So as to estimate the weight at birth of these 110 babies, a regression equation was calculated with the data from the 242 babies who had complete data, i.e., at birth, at ages 25 hr, 31 hr, and 15 days. The correlation of weight at birth with the other weighings was 0.98, 0.98, and 0.87, respectively. Thus, data on the weight at birth were obtained for 407 babies, either directly or indirectly. The results of the study were not distorted when the subsample of babies of estimated weight was included.

RESULTS

Random allotment produced groups with comparable relevant socio-economic and biologic variables such as size of family, income, food expenditure, the mother's age, height, weight, and gestational age on admission, initial calorie and protein intake, number of previous pregnancies, and educational level (Table 2).

TABLE 2. *Initial comparison of relevant socioeconomic and biological variables in the groups*

Variable	Control group (n = 230)	Supplemented group (n = 226)
Size of family	5.8 ± 2.5	5.2 ± 2.0
Number of rooms in house	1.7 ± 0.9	1.6 ± 0.9
Area of house (m^2 per person)	3.2 ± 1.8	3.5 ± 1.9
Monthly family income (in US $)	50.9 ± 25.4	46.9 ± 20.5
Monthly income per capita (in US $)	9.7 ± 6.1	9.9 ± 4.8
Family expenses for food (in US $)	27.7 ± 13.4	26.2 ± 12.6
Characteristics of mother		
age (years)	26.6 ± 6.1	25.8 ± 5.4
height (cm)	149.9 ± 5.3	149.9 ± 5.5
daily consumption of energy (kcal)	1,621 ± 655	1,623 ± 635
daily consumption of protein (g)	37.0 ± 22.9	35.6 ± 19.2
number of previous pregnancies	4.2 ± 3.2	3.6 ± 2.6
number of years of education (average)	2.96	3.01

Impact on the Mothers' Diets

Tables 3 and 4 show average daily calorie and protein consumption by the pregnant women before and during the program, both in absolute quantities and in percentages of adequate quantities. Starting with a low initial consumption rate (around 1,600 kcal and 36 g protein), the reference group did not change their consumption during the program, whereas the group receiving supplements only increased their total intake by 150 kcal and 20.6 g protein, contrasting with the 856 kcal and 38.4 g protein provided. In terms of recommended quantities, the net increase was only 6% in terms of energy and 30% in terms of protein (24).

Figure 3 shows the results, with the origin of the energy and protein consumed. Real supplementation was below expectation due both to lower consumption of the supplements and to the presence of "substitution" to the normal diet; the latter was lower for proteins than for calories, showing that low-protein foods were substituted

TABLE 3. *Average daily consumption of energy and protein at the 6th and 8th month of pregnancy*

Groups	Energy (kcal)		Protein (g)	
	6 months[a]	8 months	6 months[a]	8 months
Control group	1,621 ± 655	1,573 ± 656	37.0 ± 22.9	35.5 ± 21.2
Supplemented group	1,623 ± 635	1,773 ± 568	35.6 ± 19.2	56.2 ± 22.0

[a]Before starting supplementation.

TABLE 4. *Daily intake of energy and protein in the supplemented group (percent of standard recommended intake)*

	Energy (kcal)	Protein
Before	74.8 ± 28.6	56.1 ± 30.3
After	80.9 ± 25.9	86.3 ± 34.0
Increase	6.1 ± 29.5	30.2 ± 37.7

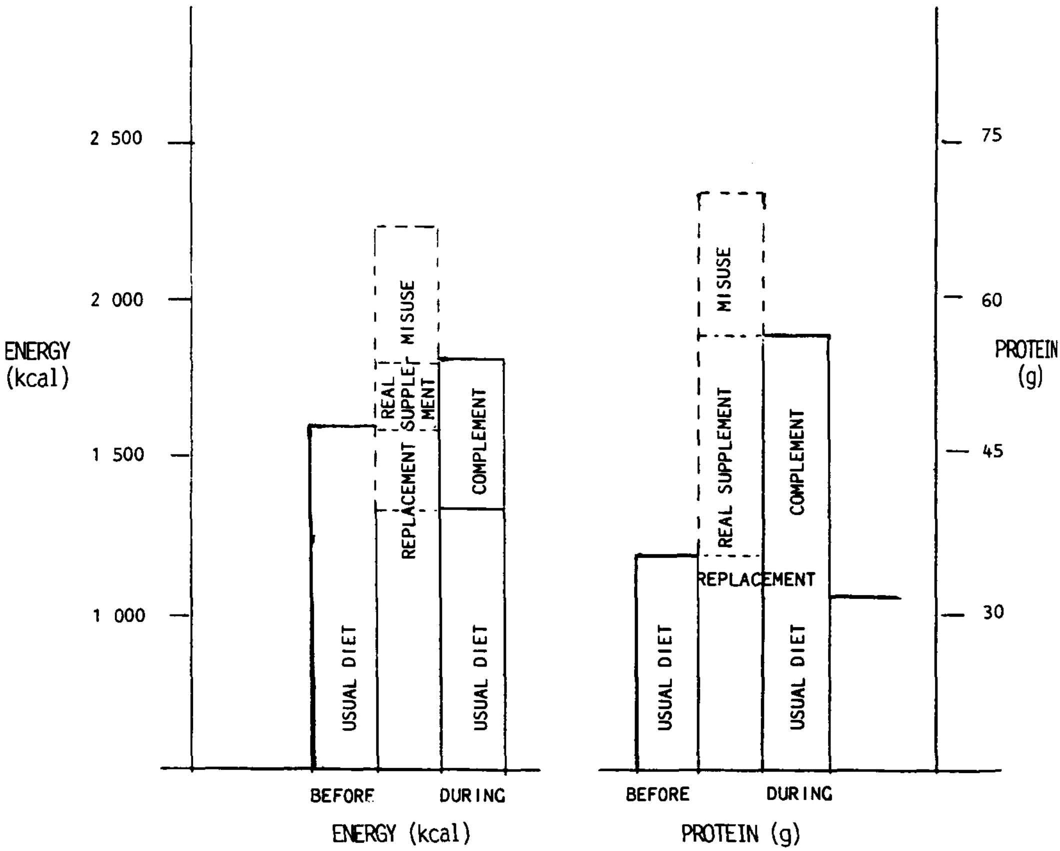

FIG. 3. Consumption of energy and protein in supplemented mothers before and during the program. Expected consumption during the supplementation period.

TABLE 5. *Weight gain during the last quarter of pregnancy by supplementation group*

Supplementation group	n	Weight gain (g)	p^a
A. Control	183	3,461 ± 1,731	—
B. Supplemented	190	4,205 ± 1,759	0.0005
< 13 weeks	75	3,940 ± 1,940	0.025
≥ 13 weeks	115	4,378 ± 1,616	0.0005
C. Total sample	373	3,840 ± 1,782	—

[a]One-tail *t*-test.

by the food supplements which were rich in proteins. In this program, the low consumption rate of supplements by the pregnant women was due more to misuse than to dilution, since they were given foods for the whole family. The substitution level was highly correlated with initial consumption in both energy ($r=0.71$, $p<0.001$) and protein ($r=0.67$, $p<0.001$).

Impact on Mothers' Weight Gain

The food supplements had a significant effect on the weight gain of mothers during the last trimester and weight gain was greater in those who took part in the program for 13 weeks or more (Table 5). On the other hand, weight gain correlated significantly with birthweight both in the control group ($r=0.18$, $p<0.001$) and in the group receiving supplements ($r=0.28$, $p<0.001$), and in the total sample ($r=0.24$, $p<0.001$). Similarly, in the group receiving supplements, the duration of supplementation significantly correlated with the mother's weight gain ($r=0.18$, $p<0.01$).

Impact on the Baby's Weight at Birth

Food supplements given for 13 or more weeks significantly affected the babies' weight at birth; the difference between the weight of the supplemented group and that of the control group was 90 g (Table 6); supplements given for less than 13 weeks did not produce significant results. The difference between the total group receiving supplements and the control group was only 63 g (25). The time during which supplements were given correlated significantly with weight at birth ($r=0.19$, $p<0.01$). The relation between quantity and response in terms of supplementary calories was about 50 g for every 10,000 kcal; this response is better than that found in a similar study carried out in Guatemala (26), which was 30 g for every 10,000 kcal, and it is within the range estimated for various ranges of energy/protein consumption (26). It should be noted that the real supplementation achieved was rel-

TABLE 6. *Birthweight in term infants by supplementation group*

Supplementation group	*n*	Birthweight (g) Mean	SD	*p*[a]
A. Control	165	2,940	318	—
B. Supplemented	177	3,003	354	< 0.05
< 13 weeks	76	2,967	344	NS
≥ 13 weeks	101	3,030	364	< 0.025
C. Total sample	342	2,973	338	—

[a]One-tail *t*-test.

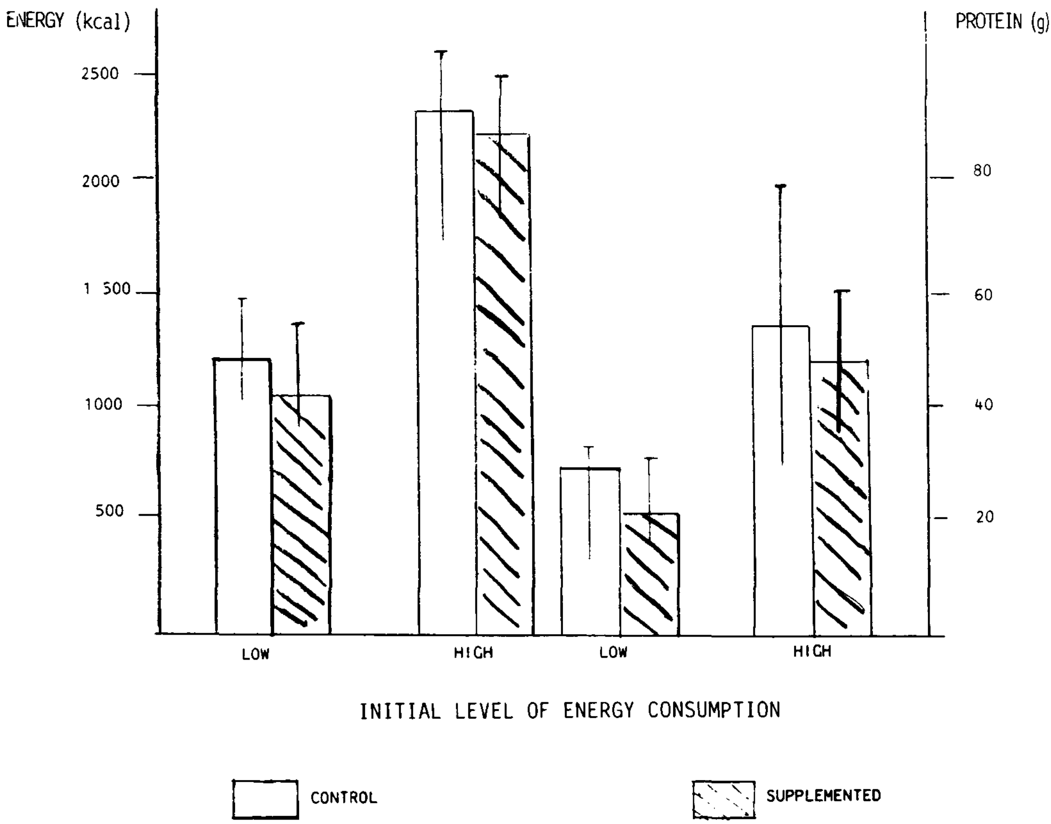

FIG. 4. Initial consumption of energy and protein by pregnant women according to consumption categories.

atively greater in terms of protein than in terms of energy in a group where protein deficiency is greater (45%) than energy deficiency (25%).

In order to study the effects of giving supplements to pregnant women with varying initial consumption levels, the sample was divided into subgroups with high and low initial consumption, using a cutoff point somewhere near the average, i.e., 1,500 kcal and 30 g protein (27). Figure 4 shows that the mean initial intakes in the low and high consumption categories did not differ between the supplemented and unsupplemented groups; the low consumption categories had an average initial intake of about 1,100 kcal and 20 g protein; the high consumption category had an intake of 2,100 kcal and 50 g protein.

The first interesting finding was the absence of differences in average consumption of supplements between the low and high initial consumption categories. Second, in the group receiving supplements, those with a low initial consumption increased their consumption considerably, taking up to 1,600 kcal and 50 g protein, whereas the large consumers increased their protein consumption (up to 60 g), but not their calorie consumption, due to a high proportion of substitution in their diet (Fig. 5).

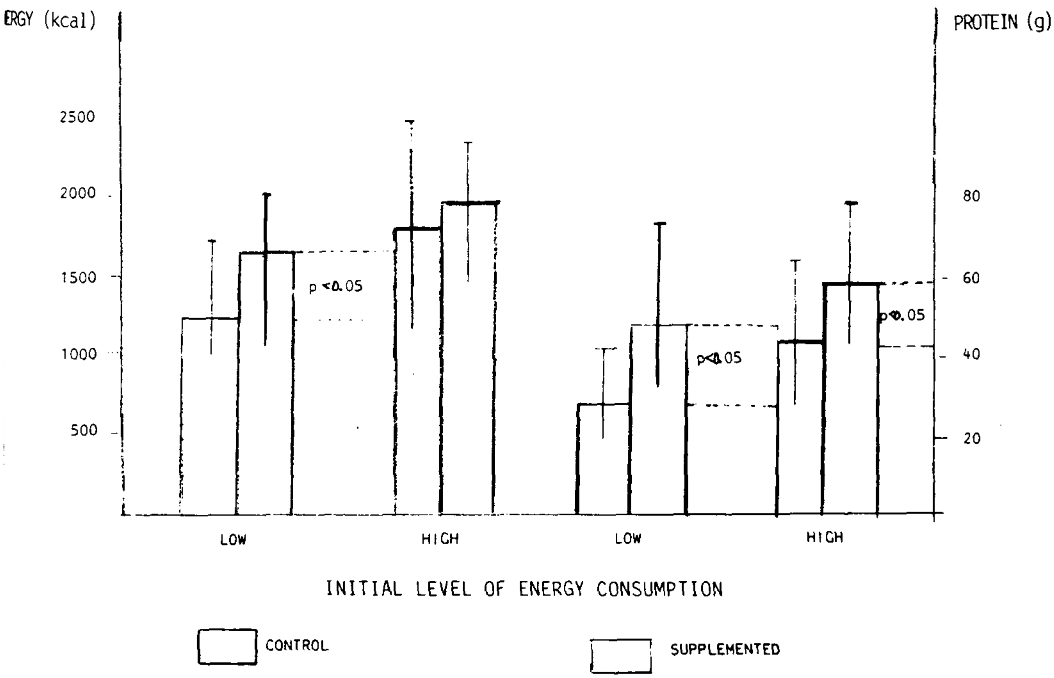

FIG. 5. Final consumption of energy and protein by pregnant women according to the consumption categories.

TABLE 7. *Birthweight by supplementation group according to initial consumption levels of energy and protein*

Initial consumption level	Control group n	Control group Mean (g)	Control group SD	Supplemented group n	Supplemented group Mean (g)	Supplemented group SD	Difference (g)	p^a
Energy (kcal)								
> 1,500	102	2,910	418	107	3,018	391	108	< 0.025
< 1,500	98	2,945	363	99	2,924	344	− 21	NS
Protein (g)								
> 30	106	2,916	410	144	3,031	362	115	< 0.025
< 30	94	2,939	371	92	2,901	371	− 38	NS

[a]One-tail *t*-test

Last, there were significant differences in weight at birth between the control group and the high category of the supplemented group, but not the group with low initial consumption (Table 7). This effect on weight at birth was specifically associated with a greater intake of protein without an increased calorie consumption, contrary to the findings of the study in Guatemala; this discrepancy can partly be attributed to the fact that the Bogotá sample had a greater initial protein deficiency (average daily consumption in Guatemala 45 g versus 36 g in the Bogotá sample), while calorie deficiencies were similar (around 1,600 kcal per day).

The absence of effects on fetal growth in the lower consumption subgroup—in spite of the fact that the supplementation achieved was greater in terms of both protein and calories—suggests the existence of a minimum or threshold level of consumption which must be exceeded if there are to be effects on fetal growth. This level could be expressed either in terms of daily consumption or in terms of duration of supplementation of the amount achieved. It should be noted that, although the mothers' weight gain was greater in the high consumption category, the differences between the control group and the group receiving supplements were significant in

TABLE 8. *Perinatal and neonatal mortality by supplementation group*

	Control group No.	Control group Rate	Supplemented group No.	Supplemented group Rate	Total No.	Total Rate
Stillbirth[a]	8	36.0	2	9.0	10	22.6
Perinatal mortality[a]	14	63.1	7	31.7	21	47.4
Neonatal mortality[b]	9	42.1	5	22.8	14	32.3

[a]Rates of stillbirths and perinatal mortality per 100 pregnancies.
[b]Rates of neonatal mortality per 1,000 live births.

both categories. This suggests that nutritional supplementation in chronically underfed pregnant women first restores the depleted reserves of the mother and *then* results in increased fetal growth.

Impact on Perinatal Mortality

The greatest differences between newborn babies whose mothers had received supplements and those who had not showed in the rates of stillbirth and perinatal and neonatal mortality (28). Indeed, all three rates were at least twice as high in the group who had not received supplements (Table 8). Both perinatal and neonatal mortality rates were generally more than ten times as high in premature babies than in those born after full gestation, while both figures were about three times lower in premature babies whose mothers had received supplements (Table 9) (29).

Impact on Duration of Breast-Feeding

As shown in Table 10, the supplementation program did not act as a brake on the mothers' milk production; on the contrary, there was a tendency to prolong breast-feeding in the group who received supplements, compared with the control group. The average duration of breast-feeding was 6 months in the control group, and 7.2 months in the group who received supplements. The fact that the food supplements also significantly increased the mother's weight gain in the last 3 months of pregnancy suggests that the difference in the duration of breast-feeding could be connected with the mothers' improved nutritional status in the group receiving supplements (30).

TABLE 9. *Perinatal and neonatal mortality in premature and term infants by supplementation group*

	Control group		Supplemented group		Total	
	No.	Rate	No.	Rate	No.	Rate
Perinatal mortality[a]						
Preterm infants	9	360.0	3	136.4	12	255.3
Term infants	5	28.6	4	21.4	9	24.9
Total	14	63.1	7	31.7	21	47.4
Neonatal mortality[b]						
Preterm infants	6	285.7	2	95.2	8	190.5
Term infants	3	15.5	3	15.2	6	15.3
Total	9	42.1	5	22.8	14	32.3

[a]Perinatal mortality rate per 100 pregnancies.
[b]Neonatal mortality rate per 1,000 live births.

TABLE 10. *Duration of breast-feeding in a sample of 1,977 mothers by supplementation group*

	Control group			Supplemented group		
	n	%	Cum %	n	%	Cum %
Duration (months)						
< 3	50	29.8	29.8	45	27.1	27.1
3–5	34	20.2	50.0	30	18.1	45.2
6–11	39	23.2	73.2	40	24.1	69.3
≥ 12	45	26.8	100.0	51	30.7	100.0
Total	168	100.0	—	166	100.0	—
Average duration		6 Months			7.2 Months	

Cum %, cumulative percentage.

SUMMARY

There appear to be few doubts about the direct connection between prenatal nutrition, expressed in terms of energy and protein consumption, and fetal growth; or about the effectiveness of suitable food supplements during pregnancy for pregnant women with nutritional deficiencies. The important practical question is to define the most efficient means by which to achieve adequate energy and protein intakes in pregnant women belonging to the large masses of marginal populations in the developing countries. The answer to this question should consider not only the possibilities of acting directly and temporarily as a palliative measure, but—and this is more important—a search for final solutions to the problem of poverty whose ultimate eradication would relegate studies such as the present one to mere academic speculation.

REFERENCES

1. Stein Z, et al. Famine and human development: The Dutch Hunger Winter of 1944/45.
2. Smith CA. Effect of maternal undernutrition upon the newborn infant in Holland (1944–1945). *J Pediatr* 1947;30:229.
3. Antonov AN. Children born during the siege of Leningrad in 1942. *J Pediatr* 1947;30:250.
4. Winick M. Malnutrition and brain development. *J Pediatr* 1969;74:667.
5. Dobbing, J. The later growth of the brain and its vulnerability. *Pediatrics* 1974;53:2.
6. Bergner L, Susser MW. Low birthweight and prenatal nutrition: an interpretative review. *Pediatrics,* 1972;46:946.
7. Lechtig A, et al. Causas de bajo peso al nacer en Latinoamerica. *Arch Latinoam Nutr* 1971;27:320.
8. Burke BS, Beal VA, Kirkwood SB, Stuart HC. The influence of nutrition during pregnancy upon the condition of the infant at birth. *J Nutr* 1943;26:569.
9. Ebbs J. The influence of prenatal diet on the mother and child. *J Nutr* 1941;22:515.
10. McGanity WR, Cannon RO, Bridgeforth EB, Martin MP, Densen PM, Darby WJ. The Vanderbilt Cooperative Study on maternal and infant nutrition. Relationships of obstetric performance to nutrition. *Am J Obstet Gynecol* 1954;67:501.

11. Sontag LW, Wines J. Relation of mothers' diets to status of their infants at birth and in infancy. *Am J Obstet Gynecol* 1947;54:994.
12. Thomson AM. Diet in pregnancy, III. Diet in relation to the course and outcome of pregnancy. *Br J Nutr* 1959;13:509.
13. Kasius RV, Randall A, Tompkins WT, Wiehl DG. Maternal and newborn studies at Philadelphia Lying-in Hospital. Newborn Studies. I. Size and growth of babies of mothers receiving nutrient supplements. In: *The promotion of maternal and newborn health*. New York: Milbank Memorial Fund, 1955:153.
14. Venkatachalam PS. Maternal nutritional status and its effect on the newly born. *Bull WHO* 1962; 26:193.
15. Iyenger L. Effects of dietary supplements late in pregnancy on the expectant mother and her newborn. *Indian J Med Res* 1967;55:85.
16. Churchill JA, Neff JW, Caldwell DF. Birth weight and intelligence. *Obstet Gynecol* 1966;28:425.
17. Wiener G, Rider RV, Oppel WC, Harper PA. Correlates of low birth weight: psychological status, at eight to ten years of age. *Pediatr Res* 1968;2:110.
18. Yerushalmy J. Relation of birth weight, gestational age, and the rate of intrauterine growth to perinatal mortality. *Pediatr Clin N Am* 1970;17:114.
19. Puffer RR, Serrano CV. Patterns of mortality in childhood. Washington D.C.: Pan American Health Organization (PAHO) Scientific. Publication No. 262, 1973.
20. Davies PA, Stewart AL. Low birth-weight infants: neurological sequelae and later intelligence. *Br Med Bull* 1975;3:85.
21. Committee on Maternal Nutrition, Food and Nutrition Board, National Research Council. Nutritional supplementation and the outcome of pregnancy. Washington, D.C.: National Academy of Sciences, 1973.
22. Blackwell RQ, Chow BF, Chinn KSK, Blackwell BN, Hsu SC. Prospective maternal nutrition study in Taiwan: rationale, study design, feasibility, and preliminary findings. *Nutr Rep Int* 1973;7:517.
23. Lechtig A, Habicht JP, Delgado H, Klein RE, Yarbrough C, Martorell R. Effect of food supplementation during pregnancy on birth weight. *Pediatrics* 1975;56:508.
24. Mora JO, de Paredes B, Wagner M, de Navarro L, Suescún J, Christiansen N, Herrera MG. Nutritional supplementation and the outcome of pregnancy. I. Birthweight. *Am J Clin Nutr* (in press).
25. Mora JO, de Navarro L, Clement J, Wagner M, de Paredes B, Herrera MG. The effect of nutritional supplementation on calorie and protein intake of pregnant women. *Nutr Rep Int* 1978;17:217.
26. Lechtig A, Yarbrough C, Delgado H, Habicht JP, Martorell R, Klein RE. Influence of maternal nutrition on birth weight. *Am J Clin Nutr* 1975;28:1223.
27. Christiansen N, Mora JO, de Navarro L, de Paredes B, Herrera MG. Effects of nutritional supplementation during pregnancy upon birth weight: the influence of pre-supplementation diet. (In preparation.)
28. Mora JO, Clement J, Christiansen N, Suescún J, Wagner M, Herrera MG. Nutritional supplementation and the outcome of pregnancy. III. Perinatal and neonatal mortality. Enviado para publicación, 1976.
29. Mora JO. Complementacion alimentaria durante el embarazo impacto sobre la madre y el nino. ICBF (Columbian Institute for Family), cuadernillo número 6.
30. Mora JO, de Navarro L, Suescún J, Wagner M, Herrera MG. Situación actual y tendencia de la lactancia materna en la zona urbana de Bogotá. ICBF, cuadernillo número 8.

DISCUSSION

Dr. Senterre: In the literature, there are very divergent findings and views on the effects of maternal food supplementation during pregnancy on birthweight. Dr. Wharton, at Sorrento Maternity Hospital, Birmingham, showed a differential effect of supplementation during pregnancy according to the nutritional state of the mothers and reviewed recent pregnancy supplemention studies (1). I would like to get his opinion about the problem of dietary supplementation in pregnancy.

Dr. Wharton: The table shows my own analysis (Table 1) of 8 trials of nutritional supple-

TABLE 1. *Summary of recent pregnancy supplementation studies*

		Supplement regimen			Results		
		Per day				Effect compared to controls	
Study design and controls	Subgroups, if any	Energy kcal	Protein (g)	Duration	Number	Birth wt	Wt for gestation
Guatemala: Prospective, not random, all mothers offered supplement. Controls: poor attenders consuming small amounts	Atole supplement	163	11	2nd, 3rd trimester	219	+ 131 g	
	Fresco supplement	59	Nil		186	+ 87 g $p < 0.01$	
Colombia: Prospective, randomized. Controls: contemporary, same program, no supplement	Boys	155	20	3rd	200	+ 107 g $p < 0.10$	
	Girls	155	20	3rd	207	− 7 g NS	
Aberdeen: Prospective. Controls: contemporary, matched mother also likely to produce light baby, no supplement		300	16	3rd	180	+ 37 NS	Increased with amount of supplement supplied $p < 0.03$
Harlem: New York Prospective randomized. Controls: contemporary, same clinic given multivitamins	Supplement	470	40	Before 30 wks	248	− 32 g NS	More preterm
	Complement	322	6		256	+ 41 g NS	

Taiwan: Prospective. Controls: contemporary, given low energy supplement. Historical comparison with mother's previous baby	Compared with contemporary controls						
	Boys	800	80	From	110	+ 55 NS	
	Girls	800	80	birth	103	+ 32 NS	
	Compared with previous births to mother			of previous baby			
	Boys	800	80		111	+ 161 $p < 0.05$	
	Girls	800	80		105	− 49 g NS	
Sorrento: Birmingham Prospective, randomized. Controls: contemporary same clinic given multivitamins	Unselected	273	8	2nd, 3rd	142	− 40 g NS	+ 0.1 SD NS
	Nutritionally at risk	425	11	3rd	45	+ 330 g $p < 0.05$	+ 0.8 SD $p < 0.01$
	Nutrionally adequate	425	11	3rd	83	− 180 g NS	− 0.03 SD NS
Gambia: Prospective, not random, all mothers given supplement. Controls: historical comparison with mothers observed in previous 4 years	Wet season	900	35	2nd, 3rd	146	+ 225 g $p < 0.01$	+ 224 g $p < 0.01$
	Dry season	900	35	2nd, 3rd	126	+ 2 g NS	− 32 g NS

Adapted from ref. 1.

mentation during pregnancy (2–9). They are divided into three groups, i.e., those where there has been a positive effect on intrauterine growth (trials 1–3), no effect (trials 4,5) or a differential effect (trials 6–8). Very recent studies of maternal nutrition have been published from Kenya (10) and India (11). The comment made earlier on the importance of considering energy balance may explain these apparently conflicting results. There is a need to select mothers for supplementation, i.e., it should be targeted. At Sorrento, supplementation enhanced fetal growth in mothers at nutritional risk but had no effect or possibly an adverse effect in the adequately nourished ones. The Gambian findings published later have similarities. In mothers supplemented during the wet season, when food was limited and work in the fields arduous (i.e., when energy balance was less satisfactory), fetal growth was enhanced compared with the historical controls. However, in mothers supplemented during the more affluent dry season, fetal growth was not enhanced—indeed, it was slightly below control levels. Like all therapeutic maneuvers, dietary supplementation should be targeted only at those who require the therapy. Increment in triceps skinfold was an effective method of selection. Probably in Guatemala, Colombia, and in Gambia during the wet season, where supplementation had a positive effect, the mothers were nutritionally at risk. The Aberdeen mothers selected for supplementation had adverse nutritional features associated with poor intrauterine growth (e.g., weight, height, and weight gain below the 25th percentile). Concerning the Taiwan results, if the safer contemporary controls are used for comparison, then supplementation had no effect, but then "before supplementation there was little evidence of gross abnormality with respect to . . . fetal growth." The New York study supplementation was aimed at mothers with a low weight, low weight gain or low dietary intake but no evidence was produced that these factors were good predictors of poor intrauterine growth in that population. We did not find poor intrauterine growth to be associated with poor nutritional status in our European population, so we did not supplement them.

Dr. Seeds: I'd like to ask Dr. Villar if there was a difference in defined IUGR between his supplemented and unsupplemented groups. Also, was there any difference in fetal distress in labor?

Dr. Villar: I do not have data on labor. With regard to IUGR, the increase in birthweight which we observed was mainly due to intrauterine growth and not to longer gestation, after allowing for maternal height and parity. The effect on gestational age was very minor—only 2 to 3 days.

Dr. Canosa: Did you make adjustments for physical work in the mothers?

Dr. Villar: The results I showed were adjusted for several confinding variables including S.E.S. We did not have specific indicators of work during pregnancy.

Dr. Canosa: From my experience in Southeast Asia, heavy work is an important variable which must be accounted for before making recommendations about norms for pregnancy weight gain and so forth. Another variable that might be worth considering is carbon monoxide (CO). Women who spend most of the day inside the house cooking may be exposed to significant levels of CO.

Dr. Belizan: We studied a rural population in Guatemala and showed an effect of CO contamination and birthweight. This was in women who lived in one-room homes where they cooked, lived, and slept (12).

Dr. Villar: The percentage of women who cook and live in the same room in Guatemala City is very small. The main contaminant in this urban population is reported to be lead. However, we did a longitudinal study of lead levels among pregnant women but found low levels. I suspect the main reason is that they have a very high calcium intake, so there is competition between calcium and lead which reduces lead absorption from the gut.

Dr. Wharton: One of the major criticisms of the Guatemala study has been that the women were self-selected for treatment. What is your comment about this, Dr. Villar?

Dr. Villar: This is always a possibility. Several pieces of evidence can be present against the self-selection effect. In the first place, the association was between total supplementation and birthweight and not with the number of visits to the clinic. Second, it was the poorest section of the population who had the highest supplementation levels. If there had been a significant number of more educated and highly motivated women in the highly supplemented population, this would certainly have had a confounding effect, because you would have expected their infants to weigh more. But that was not the case. These are the two main arguments that the results were a genuine reflection of the effects of the supplement.

Dr. Marini: How reproducible are the biometric impedance measurements? We have had some experience in growing preterm infants which seems to show that even small changes in the position of the electrodes can alter the values. Is the method reliable?

Dr. Villar: Since there are no standards, it is difficult to talk about reliability. There is good agreement between the impedance method and other methods of known accuracy. For example, the correlation between impedance and densitometry in our pregnant and post-partum women is about 0.80, and there have been several studies in non-pregnant women showing good argeement with results of body composition using deuterium. However, I think you were referring more to standardization than to reliability. I agree that the method is sensitive to electrode position, but this requires standardization of procedures just like any other method, skinfold measurement, for example. We use only one person in each clinic to do the measurements and the techniques are standardized.

REFERENCES

1. Wharton BA. Sorrento studies of birthweight. Case for international reference data. *Acta Paediatr Scand* 1985;suppl 319:170–9.
2. Lechtig A, Habicht JP, Delagodo H, Klein RE, Yarbrough C, Martorell R. Effect of food supplementation during pregnancy on birthweight. *Pediatr* 1975;56:508–19.
3. Mora JO, de Paredes B, Wagner M, de Navarro L, Suescún J, Christiansen N, Hera MB. Nutritional supplementation and the outcome of pregnancy. 1. Birthweight. *Am J Clin Nutr* 1979;31:455–62.
4. Campbell-Brown M. Protein energy supplements in primigravid women at risk of low birthweight. In: Campbell DM, Gillmer MDG, eds. *Nutrition in pregnancy*. London: Royal College of Obstetricians and Gynaecologists, 1983;85–98.
5. Rush D, Stein Z, Susser M. A randomized controlled trial of prenatal nutritional supplementation in New York City. *Pediatr* 1980;65:687–97.
6. McDonald EC, Pollitt E, Mueller W, Hsueh AM, Sherwin R. The Bacon Chow study: maternal nutritional supplementation and birthweight of offspring. *Am J Clin Nutr* 1981;34:2133–44.
7. Viegas OAC, Scott PH, Cole TJ, Mansfield HN, Wharton P, Wharton BA. Dietary protein energy supplementation of pregnant Asian mothers at Sorrento, Birmingham. I: Unselective during second and third trimesters. *Br Med J [Clin Res]* 1982;285:589–92.
8. Viegas OAC, Scott PH, Cole TJ, Eaton P, Needham PG, Wharton BA. Dietary protein energy supplementation of pregnant Asian mothers at Sorrento, Birmingham. II: Selective during third trimester only. *Br Med J [Clin Res]* 1982;285:5925.
9. Prentice AM, Whitehead RG, Watkinson M, Lamb WH, Cole TJ. Prenatal dietary supplementation of African women and birthweight. *Lancet* 1983;1:489–92.
10. Kusin JA, Jansen AA. Maternal nutrition and birthweight: selective review and some results of observations in Machakos, Kenya. *Ann Trop Paediatr* 1986;6:3–9.
11. Tyagi NK, Bhatia BD, Sur AM. Low birthweight babies in relation to nutritional status in primipara. *Indian Pediatr* 1985;22:507–14.
12. Belizan et al. *J Trop Med Hyg* 1981;84:243.