Maternal Nutrition and Fetal Growth in Developing Societies

Socioeconomic Factors

Aaron Lechtig, MD, MPH; Hernan Delgado, MD, MPH; Robert E. Lasky, PhD; Robert E. Klein, PhD; Patricia L. Engle, PhD; Charles Yarbrough, PhD; Jean-Pierre Habicht, MD, PhD

Developing societies share several common characteristics, including low gross national product per capita, heavy dependency on the export of raw materials, inefficient systems of land tenure, and deficient technology. Malnutrition and infectious disease are highly prevalent, especially during the first five to seven years of life. Such societies moreover are characterized by sharp differences between upper and lower socioeconomic status groups in terms of income and living conditions.

From the Division of Human Development, Institute of Nutrition of Central America and Panama, Guatemala City.
Reprints not available.

Figure 1 summarizes results of several studies comparing height of adult women from high and low socioeconomic groups. Women from low socioeconomic groups in rural and urban populations are shorter; those from the high socioeconomic group resemble the white urban population in the United States. With regard to height or prepregnancy weight, similar facts obtain.

In developing societies, socioeconomic status is also associated with other maternal characteristics. Dietary intake of proteins and calories[1-13] and weight gain during pregnancy[4,14-17] (L. J. Mata, ScD, unpublished data) are low in women from rural populations. Comparisons in terms of birth weight show a similar pattern. In developing countries, the proportion of infants with low birth weight is greater in rural and urban groups from low socioeconomic strata than in high socioeconomic groups from the same countries.[4,6,18-23]

In most studies, socioeconomic status has been defined exclusively by family income. There are very few reports concerning other sociocultural factors that could explain the observed differences in maternal nutrition and birth weight. Maternal malnutrition, whether secondary to dietary deficiency, increased losses, or demands due to infectious disease, is an important cause of fetal growth retardation, which is perpetuated through generations.

Study of Nutrition and Mental Development

We are exploring these interrelations in an INCAP study on nu-

trition and mental development[24] in four rural ladino villages in Guatemala. The total population of the four villages is around 3,000, half of whom are below 15 years of age. The villages have a subsistence agriculture economy, producing corn, beans, and mango. The median annual income is $200 per family, most of which is allocated to food and clothing. Sanitation is extremely poor; drinking water derives from public wells or creeks and only 6% of the houses have latrines.

We have devised a socioeconomic scale based on characteristics of the house, clothing, and education of children. As the score increases, the percentage of low-birth-weight infants decreases (Fig 2). Even in small rural villages in which almost all inhabitants are poor and illiterate, very simple sociocultural scales can identify groups of mothers with sharp differences in incidence of low-birth-weight infants.

Socioeconomic score also shows a significant association with maternal height and head circumference, third-trimester maternal weight, and indicators of maternal morbidity during pregnancy. Figure 3 shows the relationship between socioeconomic score and low birth weight of infants according to maternal height. The magnitude of this association is greater in mothers with low stature than in those with high stature. A similar pattern appears when maternal weight, head circumference, or morbidity is studied. Consequently, these maternal characteristics may explain an important part of the relationship between socioeconomic score and low birth weight.

A reasonable interpretation of this finding is that the socioeconomic score reflects economic and cultural conditions resulting in maternal malnutrition and disease, which in turn produce fetal growth retardation. There are, of course, alternative explanations for these findings. It is possible, for example, that the socioeconomic score and maternal characteristics are risk indicators not causally related to the mechanisms responsible for fetal growth retardation. This, however, is an unlikely possibility since there is evidence that improvement in maternal nutrition is associated with higher birth weight.[25] Whatever the causal relations among these variables, it is clear that the so-

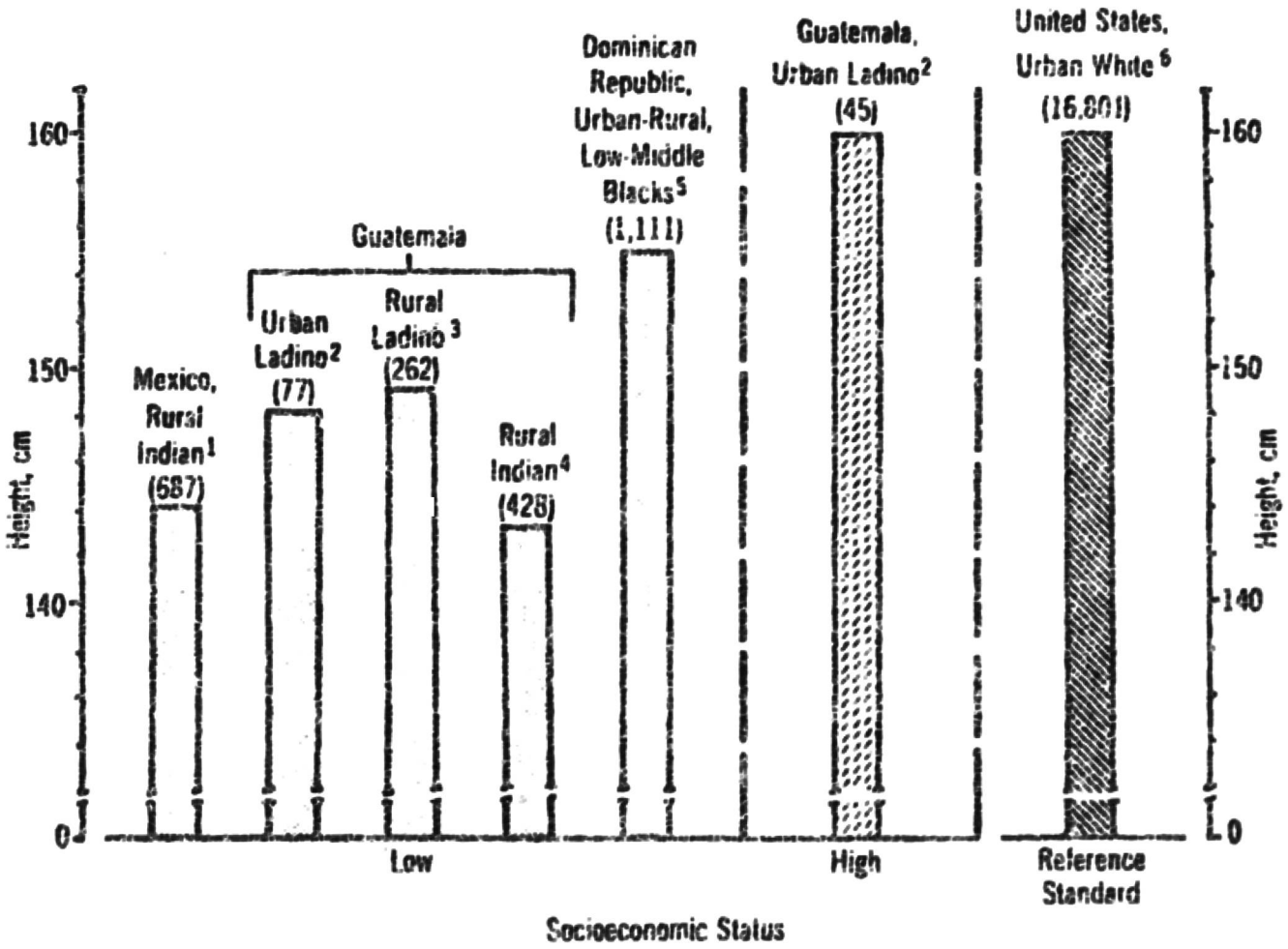


Fig 1.—Relationship between socioeconomic status and height of adult women in preindustrialized societies. Number of cases shown in parentheses. Data obtained from following sources: (1) Faulhaber[1]; (2) Arroyave et al[2] and Lechtig et al[3]; (3) Lechtig et al[4]; (4) L. J. Mata, ScD, unpublished data; (5) Sebrell et al[5]; (6) Niswander et al.[6]

Fig 2.—Relationship between socioeconomic score and proportion of children with low and high birth weights in four rural Guatemalan villages. Number of cases given in parentheses; total number is 364.

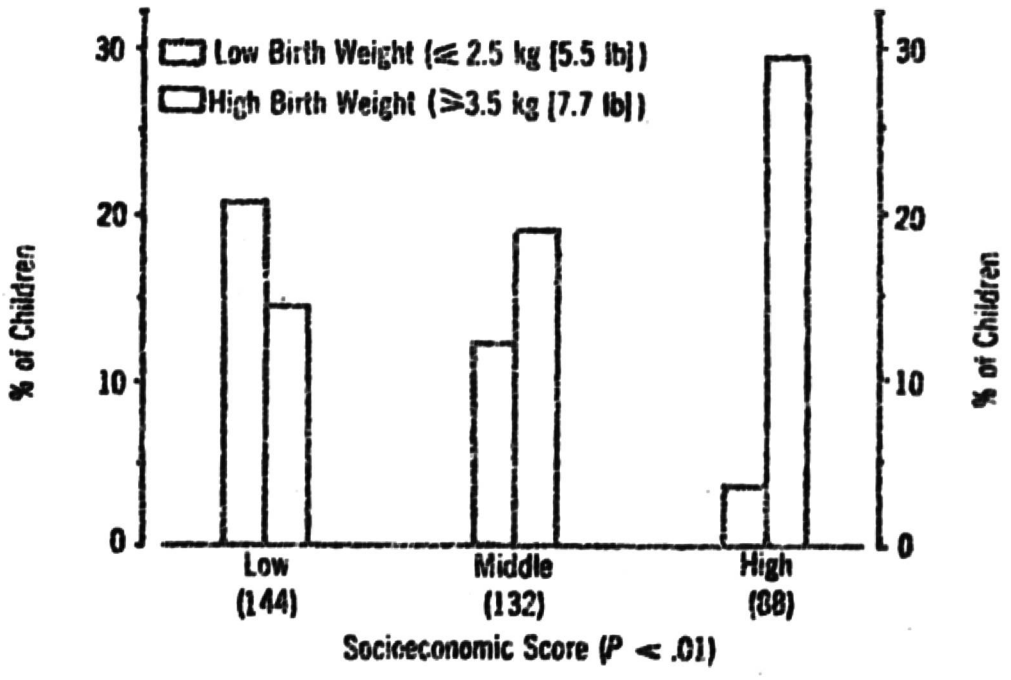
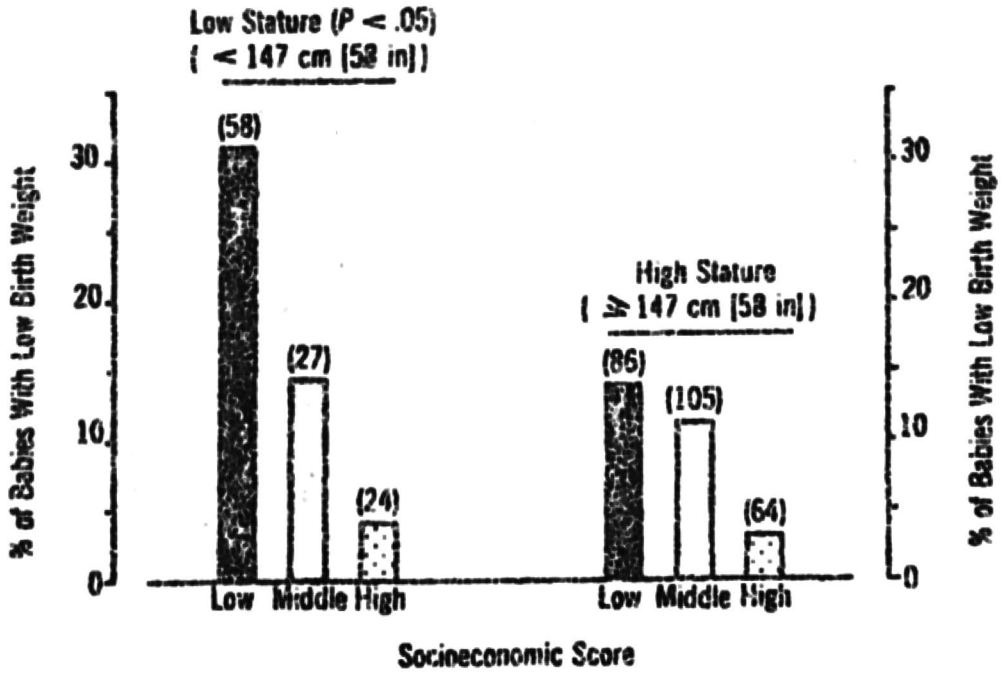


Fig 3.—Influence of maternal height on relationship between socioeconomic score and proportion of babies with low birth weight (≤ 2.5 kg [5.5 lb]). Number of cases given in parentheses.



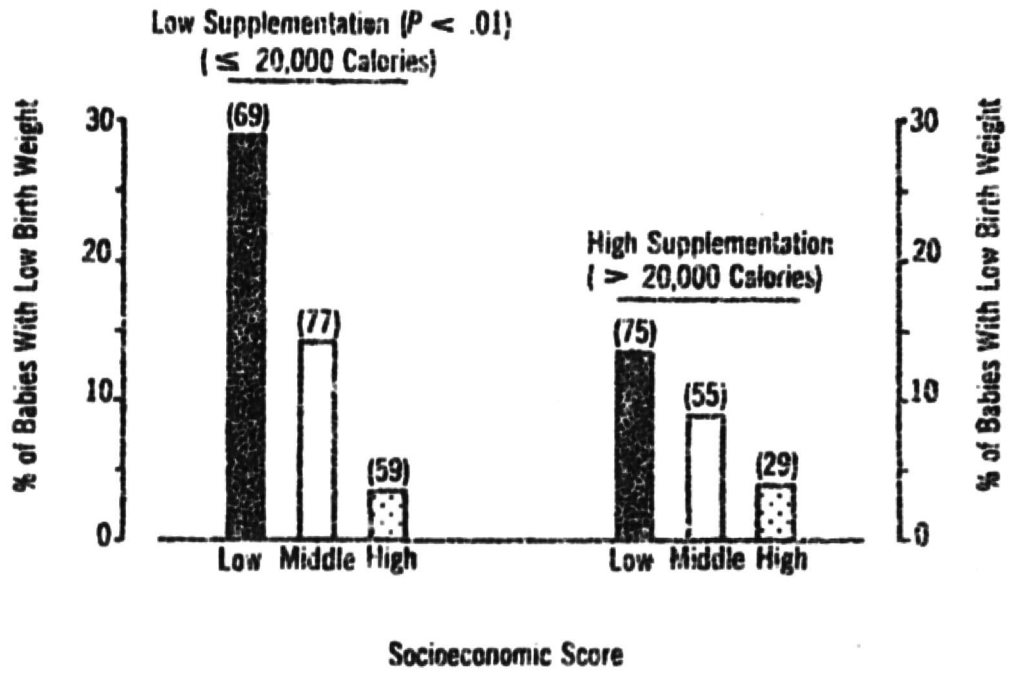


Fig 4.—Influence of caloric supplementation on relationship between socioeconomic score and proportion of babies with low birth weight. Number of cases given in parentheses.

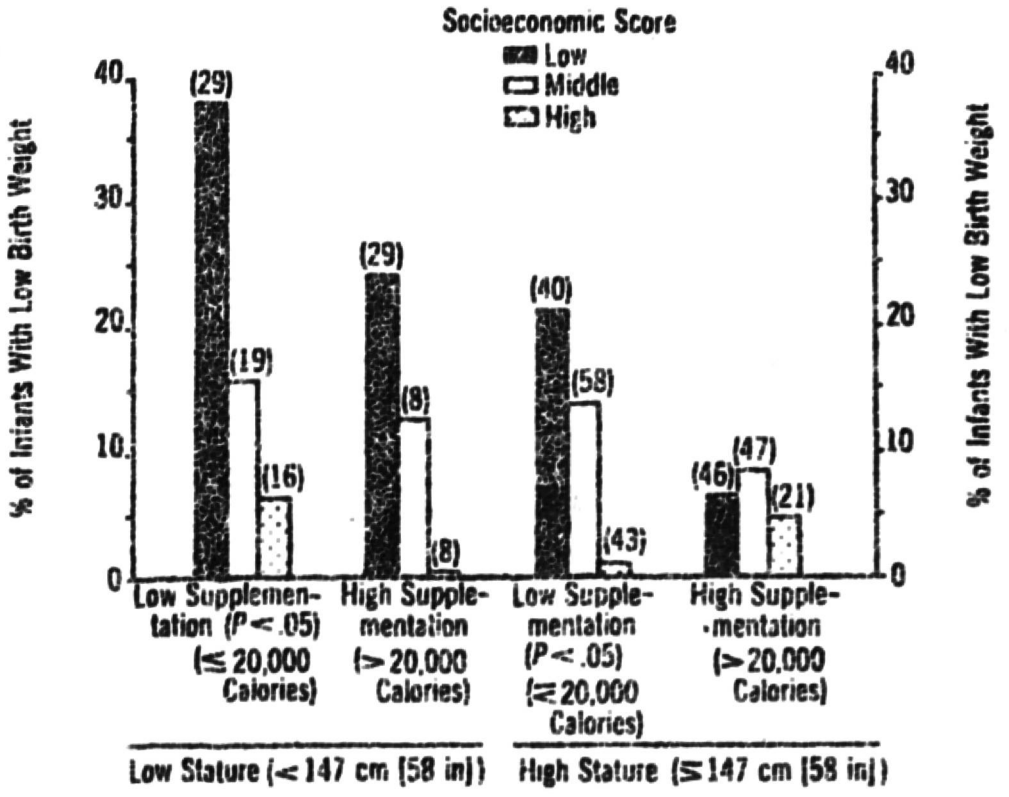


Fig 5.—Influence of maternal height and caloric supplementation during pregnancy on relationship beween socioeconomic score and proportion of infants with low birth weight. Number of cases given in parentheses.

cioeconomic score has biological importance in these villages, since the risk of low birth weight is seven times greater in mothers with a low socioeconomic score than in those with a high score.

Figure 4 shows the relationship between the socioeconomic score and low-birth-weight infants according to maternal caloric supplementation during pregnancy. The magnitude of the association is greater in mothers with low supplementation than in those with high supplementation. The group with a high socioeconomic score showed no difference in proportion of low-birth-weight infants whether supplementation was high or low. These results indicate that differences in the incidence of low birth weight according to the socioeconomic score can be reduced if mothers are well supplemented during pregnancy, and that the effects of caloric supplementation are strongest in the group with a low score.

Figure 5 presents the relationship between the socioeconomic score and proportion of low-birth-weight infants according to stature of the mother and caloric supplementation during pregnancy. The association of socioeconomic score and low birth weight is significant for short mothers with low supplementation. No association between the socioeconomic score and low birth weight is evident in tall, well-supplemented mothers. The two intermediate groups show an intermediate association.

Conclusion

Maternal height and caloric supplementation seem to have little effect on the incidence of low-birth-weight infants in mothers from high socioeconomic groups within rural ladino villages in Guatemala. On the other hand, in mothers from low socioeconomic groups, maternal height and food supplementation have a strong effect on the frequency of low-birth-weight infants. Maternal nutrition appears to be one of the intermediate steps in the causal chain between socioeconomic factors and fetal growth.

This investigation was supported by Public Health Service grant PH43-65-640 from the National Institute of Child Health and Human Development.

References

1. Faulhaber J: Anthropometry of living Indians, in Wauchope R (ed): *Handbook of Middle American Indians.* Austin, Tex, University of Texas Press, 1970, vol 9, pp 82-104.

2. Arroyave G, Hicks WH, King DL, et al: Comparación de algunos datos bioquimicos-nutricionales obtenidos de mujeres embarazadas procedentes de dos niveles socio-económicos de Guatemala. *Rev Col Med Guatemala* 11:80-85, 1960.

3. Lechtig A, Béhar M, Arroyave G, et al: Influence of maternal nutrition on the characteristics of the placenta and fetal growth. *Symposium on the Effects of Inadequate Nutrition on Human Development.* Continental Meeting on Science and Man, Mexico, DF, 1973.

4. Lechtig A, Habicht J-P, Guzmán G, et al: Influencia de las caracteristicas maternas sobre el crecimiento fetal en poblaciones rurales de Guatemala. *Arch Latinoam Nutr* 22:255-265, 1972.

5. Sebrell WH, King KW, Webb RE, et al: Nutritional status of middle and low income groups in the Dominican Republic. *Arch Latinoam Nutr* 22:1-190, 1972.

6. Niswander KR, Gordon M: *The Women and Their Pregnancies: The Collaborative Perinatal Study of the National Institute of Neurological Diseases and Stroke.* Philadelphia, WB Saunders Co, 1972.

7. Venkatachalam PS: Maternal nutritional status and its effect on the newborn. *Bull WHO* 26:193-201, 1962.

8. Pasricha S: A survey of dietary intake in a group of poor, pregnant and lactating women. *Indian J Med Res* 46:605-609, 1958.

9. Bagchi K, Bose AK: Effect of low nutrient during pregnancy on obstetrical performance and offspring. *Am J Clin Nutr* 11:586-592, 1962.

10. DeMarchi M, Isa A, Al-Saudi S, et al: Food consumption and nutritional status of pregnant women attending a maternal child health center in Baghdad. *J Fac Med Baghdad* 8:20, 1966.

11. Lechtig A, Habicht J-P, De Leon E, et al: Influencia de las caracteristicas maternas sobre el crecimiento fetal en poblaciones rurales de Guatemala. *Arch Latinoam Nutr* 22:101-115, 1972.

12. Hankin ME, Burden JK, Symonds EM: Nutrition studies in pregnancy: II. Nutrient intake and the outcome at pregnancy. *Aust NZ J Obstet Gynaecol* 4:149-155, 1964.

13. Thomson AM: Diet in pregnancy: II. Assessment of the nutrition value of diets,

especially in relation to differences between social classes. *Br J Nutr* 63:190-204, 1959.

14. Thomson AM, Billewicz WZ, Thompson B, et al: Body changes during pregnancy and lactation in rural African (Gambia) women. *J Obstet Gynaecol Br Commonw* 73:724-733, 1966.

15. Venkatachalam PS, Shanker K, Gopalan C: Changes in body weight and body composition during pregnancy. *Indian J Med Res* 48:511, 1960.

16. Girón BJJ: Valuación nutricional y hematologia materna en relación al peso del recién nacido. *Guatemala Pediatr* 5:6, 1965.

17. Stander HJ, Pastore JB: Weight changes during pregnancy and puerperium. *Am J Obstet Gynecol* 39:928-937, 1940.

18. Udani PM: Physical growth of children in different socioeconomic groups in Bombay. *Indian J Child Health* 12:593-611, 1963.

19. Shattock MF: Height and weights in a Javanese labour population of a North Sumatran rubber estate. *Trop Geogr Med* 20:147-158, 1968.

20. Cravioto J, Birch GH, De Licardie RE, et al: The ecology of infant weight gain in a preindustrial society. *Acta Paediatr Scand* 56:71-84, 1967.

21. Oberndorfer L, Mejia W, Palacios G: Anthropometric measurement of 1,650 newborns in Medellin, Colombia. *J Trop Pediatr* 11:4-13, 1965.

22. Mata LJ, Urrutia JJ, Lechtig A: Infection and nutrition of children of a low socioeconomic rural community. *Am J Clin Nutr* 24:249-259, 1971.

23. Hurtado VJJ: Estudio del crecimiento en lactantes guatemaltecos bien nutridos. *Guatemala Pediatr* 2:78,1962.

24. Klein RE, Habicht J-P, Yarbrough C: Some methodological problems in field studies of nutrition and intelligence, in Kallen DJ (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*, publication (NIH) 73-242. Dept of Health, Education and Welfare, 1973, pp 61-75.

25. Lechtig A, Arroyave G, Habicht J-P, et al: Nutrición materna y crecimiento fetal. *Arch Latinoam Nutr* 21:505-530, 1971.

Summarized Discussion of Session I

Dr. Behrman inquired whether there was an increase in mortality of infants who weigh more than 4,400 gm (10 lb) at birth, commenting that in an earlier study in the higher socioeconomic classes, heavy infants had lower intelligence quotients when tested at school age. He also wanted to know whether one could distinguish in the upper socioeconomic classes infants who weigh more than 4,400 gm at birth. Dr. Rush responded that there was indeed some increased risk at the higher birth weight. He pointed out that in infants with weights up to 3,500 gm (8 lb), there was better survival with the higher weight, followed by a plateau for about 500 gm (1 lb) and then a rise in mortality. He pointed out further than mean birth weight for Western population varied between 3,200 and 3,500 gm (7 and 8 lb), and that 4,400 gm was more than 2 standard deviations from the mean and therefore might represent, in fact, pathologic states of pregnancy. He continued that it is possible to distinguish between types of fetal gestation in upper social status, but that there was differentiation of nutrition within the upper-class mothers as well, because ability to purchase food does not necessarily assure purchase of proper nutrients. The important point is that there is a variation in nutritional status, independent of social status. However, there is an interaction between social status and effects on fetal growth. For instance, in some studies, low-birth-weight infants in an upper class incurred little or no disadvantage in eventual mental performance, whereas there was such a disadvantage among the poor. This also holds for the increase in perinatal mortality due to maternal smoking, which is greater among the poor than among the well-to-do.

Dr. Sinclair then continued the discussion, raising the issue that the correlation between pregnancy weight gain and birth weight may be somewhat spurious because one weighs the pregnant mother together with the fetus and one therefore may be measuring, at least in part, the same thing twice. Would it not be more accurate, he wondered, to subtract fetus weight from pregnancy weight gain itself. Dr. Rush responded that the proportionate component of fetal weight gain is so small as to be negligible. He continued that fetal weight of a few hundred grams is contrasted with the pregnancy weight gain of approximately 25 kg (55 lb) or so. Dr. Sinclair disagreed and stated that if one took weight gain of some 12 kg (26 lb), the fetal weight and that of the products of conception would constitute approximately one third of the total weight. Dr. Rush, on reflection, agreed and suggested that perhaps such calculations would be valid in analyzing data of pregnancy weight gain and birth weight. Dr. Ousa added that in Thailand, at least, one must account for the influence of toxemia of pregnancy on the data of weight gain during pregnancy, because in that country there are many toxemic women.

Regarding Dr. Lechtig's data, Dr. Plotkin wondered about the infection rate in mothers, for example, urinary tract infections. Dr. Lechtig responded that in their studies, infection correlated negatively with birth weight. In view of the statement by Dr. Rush that maternal smoking correlated with lower birth weight, Dr. Plotkin wondered whether there was an animal model in which this influence could be tested. Dr. Sinclair recalled that there was and referred to a Winnipeg, Canada, study by Dr. Howarth in which rats were placed in a smoke-filled box for many hours each day. The effect was a decrease of mean fetal weight, but no reduction in either length of gestation or in litter size. However, the exposed rats tended to eat less. Dr. Beisel wondered whether transplacentally transmitted glucose and other nutrients may be reduced or otherwise affected in states of infection. Dr. Behrman reported that he knew of no studies that tested this question. There then followed a discussion about the importance of placental size in relation to birth weight, and Dr. Lechtig pointed out that it has some influence on the birth weight, but that there is a large margin of safety. Dr. Rush disagreed somewhat and recalled that in the Dutch famine studies, it had been determined that the placental size depended on the size of the fetus and not the other way around.

Next, the discussion turned to maternal height as a possible determinant of birth weight of the infant, prompted by a question from Dr. Keusch. Dr. Behrman responded that in the Leningrad famine, no such correlation between height and birth weight could be made. However, Dr. Rush commented that with the available data it is not yet possible to isolate the question of height as an influence and thought that height was associated with the social status as well. Dr. Lechtig disagreed and stated his belief that there was a relationship between maternal height and birth weight. Dr. Keusch continued wondering, if height had an influence, why it was that in Dr. Lechtig's studies of caloric supplementation, the high caloric intake did eliminate the difference of birth weights between short mothers and the taller ones. Dr. Béhar then pointed out that caloric supplementation in that study affected only the pregnancy period, whereas height of the mother was really a reflection of the nutritional influences of her entire earlier life. Dr. Mata added that taller women in every society produce larger babies. Finally, Dr. Beisel added that perhaps height would be more properly defined not in some absolute, or even relative terms, but rather as achievement of optimal height level.