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NUTRITION AND LENGTH OF GESTATION

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ABSTRACT

This paper examines whether a food supplementation program carried out in Guatemala affected the length of gestation (n = 830 singleton births). Women who consumed more of a protein-energy or an energy supplement had significantly longer lengths of gestation. Regression slopes of energy on length of gestation were statistically significant and similar for both types of supplements, suggesting a role for energy but not for protein. The earlier calories were provided in pregnancy the greater their effect on gestation length. Women in the upper tercile of the distribution of energy intakes in the first trimester of pregnancy had a mean length of gestation 1.42 weeks longer than women in the lower tercile of the distribution. The percent of preterm deliveries (<37 weeks) was 5 percent in the upper group and 20 percent in the lower group.
KEY WORDS: gestation length, maternal nutrition, pregnancy, protein-energy malnutrition

INTRODUCTION

There are epidemiologic data which suggest that maternal nutritional status can affect the length of gestation. For instance, Vaughan (1) reported that three times as many women who had gone into premature labor had diets which were considered poor when compared with those of a control population. Low pregravid weight, inadequate weight gain during pregnancy, and poor socio-economic status have been identified as significant risk factors of a preterm delivery (2-4). Poor hematological status has also been shown to be associated with greater than expected preterm rates (5). Few reports of the results of nutrition experiments are available. Mora et al. (6) reported no effect of food supplementation during the last trimester of pregnancy on length of gestation and Rush et al. (7) observed an increased incidence of premature deliveries in women receiving a high protein supplement during pregnancy.

The present study examines whether a food supplementation program carried out in Guatemala affected the length of gestation. Previous publications have described in detail the population, experimental design, and methodology of the Guatemalan study and have reported that caloric supplementation during pregnancy improved birth weight (8), the weight of the placenta (9), and infant growth (10). This is the first publication from the Guatemala study to focus on gestation length.

MATERIALS AND METHODS

The data presented here are drawn from a longitudinal study of nutrition, physical growth, and mental development which the Institute of Nutrition of Central America and Panama (INCAP) carried out between January 1969 and

February 1977 in four small Spanish-speaking Guatemalan villages. The study population and the methods used have been described in detail elsewhare (8-10).

In 1969, INCAP began a preventive and curative medical care program and a food supplementation program. Health care was provided by auxiliary nurses under the supervision of a physician. Two types of liquid supplements were used. In two of the villages, a high protein-calorie supplement called "atole" containing 11.5 g of protein and 163 kcal per 180 ml was made available. The other two villages were provided with a fruit-flavored drink called "fresco" which contained no protein and supplied only 59 kcal per 180 ml. The supplements also contained vitamins and minerals (8). Attendance at the food supplementation centers and consumption of the supplement were free and voluntary, and as a result, a wide range of supplement intake during pregnancy was observed. The supplement was given twice daily, seven days a week. Subjects were provided with a cup containing 180 ml, and more was given if requested. Leftovers were measured and actual intake on an individual basis was recorded to the nearest 10 ml. Because dietary intake during pregnancy was more limiting in energy than in protein and because previous analyses have shown energy and not protein intake was related to pregnancy outcomes such as birth weight (8) and weight of placenta (9), supplement intake was expressed in terms of calories.

Pregnancies were identified as early as possible. At the end of the first trimester of pregnancy women were asked to recall the date of onset of the last menstrual period. From these data, length of gestation was calculated as the interval in days between the date of onset of the last menstrual period and the date of delivery.

Home dietary intakes were measured once at the end of each trimester of pregnancy using the 24-hour recall technique. Anthropometric examinations were also carried out with the same periodicity. Information about maternal morbidity during pregnancy was obtained from symptom-oriented household surveys carried out every two weeks. Other data available and used in this report were maternal age at delivery, parity, birth interval, and number of months women breast fed during pregnancy. Finally, a family socioeconomic scale was generated from information about home construction materials and number of rooms.

After delivery, children were examined periodically and data on nutrition, health, and development were collected until seven years of age. Birth weight was obtained within 24 hours after delivery by personnel using carefully standardized procedures and calibrated scales.

Between January 1, 1969 and February 28, 1977, there were 830 singleton deliveries for which length of gestation and food supplementation data were available. Four hundred and forty-one cases were from the atole villages and 389 were from the fresco villages. Birth-weight data were available for 721 of these 830 births. Mortality data were not available for 62 cases of the 830 births.

RESULTS

Means and standard deviations for some maternal characteristics during pregnancy are shown in Table 1 for atole and fresco villages. Home diet energy and protein intakes appear to be similar in atole and fresco villages. Energy intake from the supplements increased from the first to the third trimester of pregnancy and was greater in atole than in fresco villages. For all of pregnancy, average intake of calories from the supplements was significantly greater ($p < .001$) in atole villages (107 kcal/day) than in fresco villages (81 kcal/day).

Table 1

Mean and Standard Deviations for Some Maternal Characteristics During Pregnancy

	Atole villages n	Atole villages $\bar{X}$	Fresco villages n	Fresco villages $\bar{X}$	Pooled standard deviation
Home diet[+]					
Energy (kcal/day)	341	1473	275	1411	467
Protein (g/day)	341	42.3	275	42.4	13.4
Supplement (kcal/day)[++]					
First trimester	441	69	389	39	81[c]
Second trimester	441	114	389	95	102[b]
Third trimester	441	138	389	108	108[c]
Maternal and newborn characteristics					
Maternal height (cm)	437	149.0	381	149.0	5.2
Maternal head circumference (cm)	438	51.2	381	50.8	1.3[c]
Age (years)	440	28.2	389	27.9	7.3
Parity	441	4.1	389	3.5	3.2[b]
Length of gestation (weeks)	441	39.6	389	39.1	2.9[a]
Birth interval with prior delivery (months)	375	27.5	323	30.7	29.0
Birth weight (g)	387	3077	334	3027	461
Month of breastfeeding during pregnancy	346	1.7	288	1.5	1.9

[+]Average of surveys carried out at the end of the second and third trimesters of pregnancy.

[++]Each 100 kcal from the atole are accompanied by 6.1 g of protein. The fresco contained calories but not protein.

[a]$p < .05$; [b]$p < .01$; [c]$p < .001$.

The atole contributed 7.5 g of protein per day during pregnancy; the fresco did not contain protein.

Means and standard deviations for length of gestation and for a number of obstetric characteristics are also shown in Table 1. The length of gestation was longer in atole (39.6 weeks) than in fresco (39.1 weeks) villages ($p < .05$). When the sample was broken down by sex, the tendency toward greater values in atole villages was evident for male newborns (39.6 weeks and 38.8 weeks for atole and fresco males respectively, $p < .05$) but not for female newborns (39.7 weeks and 39.5 weeks for atole and fresco females respectively, N.S.). Mothers from atole villages also had larger head circumferences ($p < .001$) and greater parities ($p < .01$) as shown in Table 1.

Correlations between length of gestation and key independent variables are shown in Table 2. Energy intake from the supplements, whether accompanied by protein as in atole villages or not as in fresco villages, was significantly associated with length of gestation during the first and second, but not the third trimesters of pregnancy. Significant associations with length of gestation were also found with average intake during the entire pregnancy (i.e., all three trimesters). Other variables associated with length of gestation in circumference, birth weight, maternal age, and number of months combining pregnancy and lactation.

Slopes of regressions of supplement intake on length of gestation are shown in Table 3 for atole, fresco, and the combined sample. There were trends, none statistically significant ($p > .05$), for first trimester slopes to be larger than second trimester slopes and for values for fresco to be larger than those for atole. Regressions of third trimester intakes on length of gestation were not statistically significant ($p > .05$). In the combined sample, 10,000 kcal during the first trimester were associated with an increase in length of gestation of 4.2 days ($p < .0001$) and a similar amount during the second trimester was associated with an increase of 3.0 days ($p < .001$). Supplement intake during the first trimester of pregnancy was highly correlated with supplement intake during the second trimester of pregnancy ($r = .632$, $n = 830$, $p < .001$). Hence the slope of second trimester supplement intake on length of gestation was reduced from 3.0 ($p < .001$) to 1.1 days/10,000 kcal (N.S.) after taking into account intake in the first trimester. Each of the slopes shown in Table 3 was not appreciably changed after adjusting for the variables, other than supplement intake, which are listed in Table 3 (including those listed in the footnote to Table 3).

The range of supplement intake was arbitrarily divided into terciles for two variables: first trimester supplement intake and average intake during the entire pregnancy. The mean supplement intake as well as the mean duration of gestation for each of the terciles is shown in Table 4. The difference in mean length of gestation between third and first terciles was 1.42 weeks for first trimester supplement intake and 1.06 weeks for average intake during pregnancy. Analysis of variance showed that the mean duration of gestation varied significantly by category for both supplement variables. Similarly, the percent of newborns with short gestational age (<37 weeks) decreased signifantly from low to high categories of supplement intake as shown in Table 5. The findings in Table 5 were statistically significant in all but one comparison (i.e., for the variable "entire pregnancy" in fresco villages).

A total of 721 cases had information about length of gestation and birth weight. The percent of newborns with low birth weight (<2.5 kg) and short gestational age (<37 weeks) by tercile of supplement intake in the first trimester of pregnancy is shown in Table 6. Higher supplement intakes were clearly associated with lower rates of low birth weight and prematurity.

TABLE 2

Correlations Between Length of Gestation and Independent Variables+

Variable	Atole villages		Fresco villages		All villages	
	n	r	n	r	n	r
Supplement energy						
First trimester	441	.127[b]	389	.180[b]	830	.152[c]
Second trimester	441	.120[a]	389	.143[b]	830	.136[c]
Entire pregnancy	441	.103[a]	389	.139[b]	830	.127[c]
Maternal head circumference	438	.117[a]	381	.062	819	.102[b]
Birth weight	387	.179[c]	334	.068	721	.129[c]
Maternal age	440	-.086	389	-.054	829	-.069[a]
Months of combined pregnancy and lactation	346	.015	288	-.153[b]	634	-.056

+Only variables with at least one significant association are included. Home diet calories, home diet protein, third trimester supplement intake, maternal weight (first trimester), maternal height, maternal weight for height (first trimester), parity, birth interval with prior delivery, maternal illness during pregnancy, and family socioeconomic status were not statistically associated with the length of gestation.

[a]$p < .05$; [b]$p < .01$; [c]$p < .001$.

TABLE 3

Slopes (days per 10,000 kcal) of Regressions of Supplement Intake on Length of Gestation

	First trimester calories	Second trimester calories	Third trimester calories	Entire pregnancy
Atole villages (n = 441)	2.8[b]	2.3[a]	0.6	0.8[a]
Fresco villages (n = 389)	7.5[c]	3.6[b]	1.7	1.5[b]
All villages (n = 830)	4.2[c]	3.0[c]	1.2	1.1[c]

[a]$p < .05$; [b]$p < .01$; [c]$p < .001$.

TABLE 4

Mean Length of Gestation (weeks) by Terciles of Supplement Intake During the First Trimester of Pregnancy and During All of Pregnancy+

Tercile	Sample size	Mean supplement intake (kcal/day)	Mean length of gestation (weeks)
First trimester			
Low	271	0	38.69
Middle	275	22	39.30
High	284	138	40.11
Entire pregnancy			
Low	275	13	38.84
Middle	275	78	39.39
High	280	191	39.90

+The pooled standard deviation of length of gestation was 2.88 weeks. The mean length of gestation varied significantly by tercile of first trimester supplement intake (analysis of variance: $F = 17.62$, $p < .001$) as well as by tercile of total supplement intake during pregnancy (analysis of variance: $F = 9.61$, $p < .001$).

TABLE 5

Percent of Newborns with Short Gestational Age (<37 weeks) by Terciles of Supplement Intake in the First Trimester of Pregnancy and in the Entire Pregnancy

Tercile	Atole villages (n = 441)		Fresco villages (n = 389)		All villages (n = 830)	
	n	%	n	%	n	%
First trimester+						
Low	27/140	19.3	26/131	19.8	53/271	19.6
Middle	7/124	5.6	26/151	17.2	33/275	12.0
High	7/177	4.0	7/107	6.5	14/284	4.9
	p < .001		p < .05		p < .001	
Entire pregnancy						
Low	21/130	16.2	26/145	17.9	47/275	17.1
Middle	10/138	7.2	23/137	16.8	33/275	12.0
High	10/173	6.0	10/107	9.3	20/280	7.1
	p < .01		p > .05		p < .01	

+Terciles as defined in Table 4. Test of significance refer to χ^2, df = 2.

TABLE 6

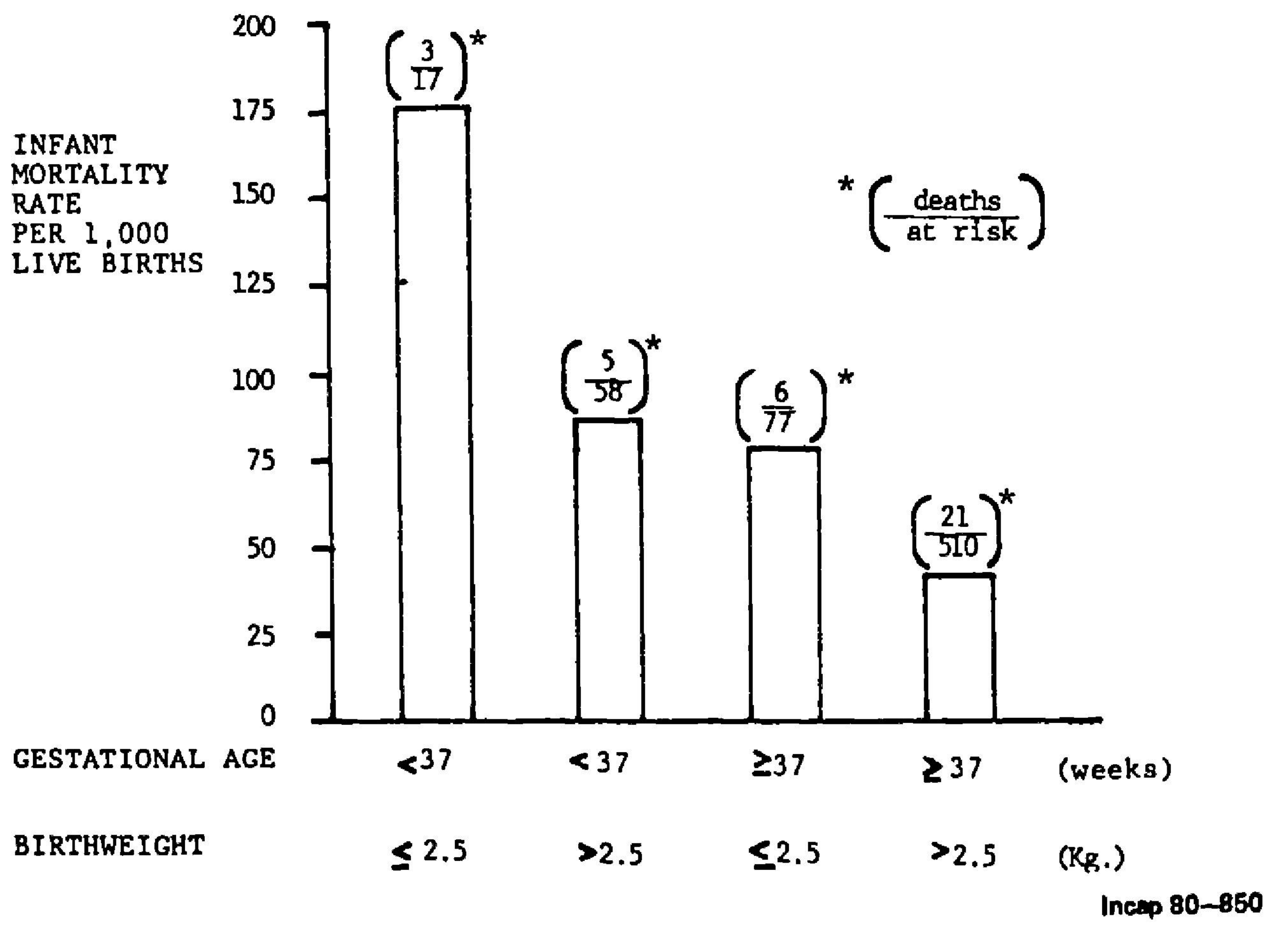
Percent of Newborns with Low Birth Weight (≤2.5 kg) and Short Gestational Age (<37 weeks) by Terciles (Low, Middle, High) of Supplement Intake During the First Trimester of Pregnancy (n = 721)

	Low		Middle		High		
	n	%	n	%	n	%	p
Low birth weight (≤2.5 kg)	38/203	18.7	25/252	9.9	34/266	12.8	<.05
Short gestation age (<37 weeks)	37/203	18.2	28/252	11.1	11/266	4.1	<.001
Low birth weight and/or short gestational age	66/203	32.5	29/252	19.4	40/266	15.0	<.001

+There were 721 cases with information about birth weight and length of gestation.

FIGURE 1

INFANT MORTALITY RATE BY CATEGORIES OF GESTATIONAL AGE AND BIRTHWEIGHT



Infant mortality data were not available for 59 of the 721 cases with both birth weight and length of gestation data. The remaining 662 cases were thus the data base for the analysis shown in Figure 1. Thirty-five of the 662 newborns died before one year of age. Those with low birth weight and short gestational age had the highest mortality (176/1000) while those with normal birth weight and gestational length had the least (41/1000).

DISCUSSION

The data presented show that the length of gestation increased as pregnant women consumed more of a protein-energy (atole) or an energy (fresco) supplement. As in earlier studies dealing with birth weight (8), weight of the placenta (9), and infant development (10), the hypothesis that the effects were due to calories rather than protein seems more plausible.

Whether the association between supplement intake and length of gestation is spurious or true is difficult to assess. The study design is quasi experimental in that villages rather than individuals were randomly assigned to treatment groups. The energy supplement was designed to be a placebo and the fact that fresco calories appear to be related to outcome variables in much the same manner as atole calories has left the study without a control group. Another problem is that the study was not preceded by a preintervention phase of data collection which would allow for "before-after" comparisons of groups.

The study did include data collection on a number of potentially confounding variables and the findings reported here indicate that the relationship between supplement intake and length of gestation remained statistically significant after adjusting for these variables. The best substitute for baseline data is the information collected during the first year of the project (i.e., 1969). The mean length of gestation in 1969 was 39.3 weeks in the atole ($n = 38$) and 39.2 weeks in the fresco villages ($n = 40$). Slightly higher values were observed for 1975-76, the last two years of the project (atole = 39.9 weeks, $n = 76$; fresco = 39.6 weeks, $n = 68$) but these were not statistically different from baseline values (pooled S.D. = 2.9, $p > .05$ for all comparisons). Though suggestive of improvement, the percent of cases with short gestational age (<37 weeks) did not change significantly ($p > .05$) from 1969-70 to 1975-76 in atole (15.8 to 6.6 percent) or fresco villages (15.0 to 10.3 percent. These analyses showing a lack of significant changes through time are biased against showing a nutritional effect in that all pregnancies occurring during the first year of the project were at least partially exposed to the supplementation program and hence not a "true" baseline.

Supplement intake was significantly associated with length of gestation but other variables indicative of maternal nutritional status were not. Home dietary energy and protein intakes as well as maternal stature and weight, were, for example, not associated with length of gestation. One explanation for the negative findings in the case of dietary variables is poor reliability and inadequate sampling of the mother's usual intake. Two interesting variables, maternal head circumference and months of combined pregnancy and lactation, did show significant associations with length of gestation. Because growth in head circumference is largely completed during the first few years of life, the data could be indicative of early nutritional status of the mother. Breast feeding during pregnancy certainly adds to the nutritional demands on the mother and would be expected to reflect negatively on pregnancy outcomes.

The mean length of gestation in the study villages ($\bar{X} = 39.4$, S.D. = 2.9. $n = 830$) was a week shorter than that reported for a California sample

($\bar{X}$ = 40.4, S.D. = 2.7, n = 198,408) (11). Also, the percent of preterm births (<37 weeks) was 11.9 in the study communities but 5.4 in the California sample (11) and 6.7 in the U.S. in 1967 (12). These differences cannot be said to be true differences because methodological nuances could account for the results. What is clear is that length of gestation, which was measured uniformly in the villages, varied with supplement intake. Women who were in the upper tercile of the distribution of supplement intake in the first trimester of pregnancy had a mean length of gestation 1.42 weeks longer than women in the lower tercile of the distribution. The percent of preterm infants was 5 percent in the upper and 20 percent in the lower tercile. Differences of these magnitudes, if true, would be of major biological significance in terms of birth weight, infant mortality, and development (13-16). The data shown in Figure 1 argue convincingly that effects of the above magnitude would be important in terms of infant mortality. Infant mortality rates were 133 per thousand for preterm infants but 46 per thousand for full term infants.

Supplement intake during the first trimester of pregnancy was more strongly related to length of gestation than intake during the rest of the pregnancy. In fact, supplement intake during the last third of the prenatal period showed no relationship at all with length of gestation. Interestingly, Mora et al. (6) improved the diets of women during the last three months of pregnancy and their results did not show modifications in the length of gestation.

In summary, the data from the Guatemalan study presented here are unique in showing consistent and biologically important associations between energy supplementation during pregnancy and length of gestation. Some alternative hypotheses were discarded by showing that the associations were independent of a number of potentially confounding variables. However, deficiencies inherent in the study design leave open many possibilities.

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REFERENCES

1. Vaughan, D. H. Some social factors in perinatal mortality. Brit. J. Prev. Soc. Med. 22:138-145, 1968.

2. Frederick, J. and Anderson, A. B. M. Factors associated with spontaneous pre-term birth. Brit. J. Obstet. Gynecol. 83:342-350, 1976.

3. Mata, L. J. The Children of Santa María Cauqué: A Prospective Field Study of Health and Growth. MIT Press, Cambridge, Mass., 1978.

4. Berkowitz, G. S. An epidemiologic study of preterm delivery. Amer. J. Epidemiology, 113:81-92, 1981.

5. Garn, S. M., Keating, M. T. and Falkner, F. Hematological status and pregnancy outcomes. Amer. J. Clin. Nutr. 34:115-117, 1981.

6. Mora, J. O., Paredes, B. de, Wagner, M., Navarro, L. de, Suescun, J., Christiansen, N. and Herrera, M. G. Nutritional supplementation and the outcome of pregnancy. I. Birthweight. Amer. J. Obstet. Gynecol. 32: 455-462, 1979.

7. Rush, D., Stein, Z. and Susser, M. Diet In Pregnancy: A Randomized Controlled Trial of Nutritional Supplements. Alan R. Liss, Inc., New York, 1980.

8. Lechtig, A., Habicht, J.-P., Delgado, H., Klein, R. E., Yarbrough, C. and Martorell, R. Effect of food supplementation during pregnancy on birthweight. Pediatrics, 56:508-520, 1975.

9. Lechtig, A., Yarbrough, D., Delgado, H., Martorell, R., Klein, R. E. and Behár, M. Effect of moderate malnutrition on the placenta. Amer. J. Obstet. Gynecol. 123:191-201, 1975.

10. Delgado, H., Lechtig, A., Yarbrough, C., Martorell, R., Klein, R. E. and Irwin, F. Maternal nutrition: its effects on infant growth and development and birthspacing. In: Nutritional Impacts on Women Throughout Life with Emphasis on Reproduction. K. Moghissi and T. N. Evans (eds.). Harper & Row Publishers, Hagerstown, Maryland, 1977, pp. 133-150.

11. Hammes, L. M. and Treloar, A. E. Gestational interval from vital records. Amer. J. Pub. Hlth. 60:1496-1505, 1970.

12. Chase, H. C. and Byrnes, M. E. Trends in "prematurity": United States, 1950-1967. Amer. J. Pub. Hlth. 60:1967-1983, 1970.

13. Van den Berg, B. and Yerushalmy, J. The relationship of the rates of intrauterine growth of infants or low birthweight to mortality, morbidity, and congenital anomalies. J. Pediat. 69:531-545, 1966.

14. Van den Berg, B. Morbidity of low birth weight and/or preterm children compared to that of the "mature." I. Methodological considerations and findings for the first two years of life. Pediatrics, 42:590-597, 1968.

15. Lilienfeld, A. M. and Pasamanick, B. Association of maternal and fetal factors with the development of epilepsy: abnormalities in prenatal and paranatal periods. JAMA, 155:719-724, 1954.

16. Clifford, S. H. High-risk pregnancy. I. Prevention of prematurity the sine qua non for reduction in mental retardation and other neurological disorders. New Engl. J. Med. 271:243-249, 1964.