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Impact of the Higgins Nutrition Intervention Program on birth weight: A within-mother analysis[1]

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Abstract A study was conducted to evaluate the impact of the Higgins Nutrition Intervention Program of individual nutritional assessment and rehabilitation on pregnancy outcome in a group of urban low-income women. Developed as an adjunct to routine prenatal care, the Higgins program utilizes an individualized approach to dietary treatment that combines an assessment of the risk profile for the presenting pregnancy with the application of specific nutritional rehabilitation allowances to compensate for the negative impact of diagnosed risks. This report presents results of analyses evaluating differences in birth outcomes between 552 sibling pairs; each mother had participated in the Higgins program during the pregnancy of the second-born, but not of the first-born, member of her pair. After adjustment for parity and sex, the intervention infants weighed an average of 107 gm more than their matched siblings at birth ($p<.01$). The rate of low birth weight was 50% lower among the intervention infants than among their siblings ($p<.01$); rates of intra-uterine growth retardation and perinatal mortality were also lower in the intervention group. The high risk of poor pregnancy outcome in this group of urban low-income women was reduced by the Higgins program. *J Am Diet Assoc 89:1097-1103, 1989.*

Maternal nutrition during pregnancy is generally considered an important regulator of human fetal growth (1). More specifically, maternal undernutrition is believed to result in fetal growth retardation and consequently reduced birth weight (2-4). Low birth weight is a well-documented risk factor for infant morbidity and mortality (4,5).

Birth weight is strongly associated with social class. Infants of socially and economically disadvantaged women are 200 to 300 gm lighter at birth than those of non-disadvantaged women (6). Perhaps more important, the low birth weight rate among disadvantaged women is almost twice that among non-disadvantaged women (4,7). Although the cause of these socioeconomic differences in birth weight has been difficult to determine, it has been suggested that dietary habits and the quality of nutrition are involved (4,8,9). Support for this suggestion is provided by the fact that inadequate nutrition is itself more prevalent in socially and economically disadvantaged groups (10).

The question then arises: To what extent can pregnancy outcome among urban poor women in the developed world be improved through nutrition intervention? Nutrition intervention can be based on food supplementation, nutrition education, or a combination of the two. Four groups have conducted clinical trials to evaluate the impact of food supplements on birth outcomes (11-15); one author (16) used a non-randomized study design to evaluate an intervention program based on individualized nutrition education combined, in cases of financial need, with food supplementation. There have also been studies conducted to evaluate the impact of different state versions of the prenatal component of the Special Supplemental Food Program for Women, Infants, and Children (WIC) (17-24). Established as a service program, the primary

[1]Between 1963 and 1979, the nutrition counseling services of the Montreal Diet Dispensary were sponsored by the Federated Appeal of Greater Montreal and by Centraide. Additional funds for counseling services during this period were received from the Women's Auxiliary of the Royal Victoria Hospital, the St. George Kiwanis Club of Montreal, and Ayerst McKenna and Harrison, Inc. Financial support for data abstraction and initial data analysis was received from Health and Welfare Canada (1970-1974), the National Foundation March of Dimes (1975-1976), and the J. W. McConnell Foundation (1979).

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Table 1. The Higgins Method for classification and treatment of risks for adverse pregnancy outcome

risk	*rehabilitation allowance*
undernutrition	
Usual protein intake as determined by a diet history done at the initial assessment lower than the 1948 Canadian Dietary Standard allowance.[a,b]	Additional daily protein allowance set equal to assessed deficit in usual intake; 10 kcal added for each gram of protein in rehabilitation allowance.
underweight	
More than 5% underweight.[c]	Additional daily allowance of 20 gm protein and 200 kcal for each additional weekly pound of weight gain desired. Maximum possible additional gain set at 2 lb per week.[d]
stress condition	
Poor outcome of prior pregnancy.[e]	Additional daily allowance of 10 to 20 gm protein and 100 to 200 kcal for each stress condition. Maximum total daily rehabilitation allowance for multiple conditions set at 40 gm protein and 400 kcal.
Less than 12 months between birth of last infant and conception.	
Failure to gain 10 lb (4.5 kg) by 20th week of pregnancy.	
Pernicious vomiting (hyperemesis gravidarum).	
Serious emotional problems.	

[a]The 1948 Dietary Standard for Canada was current when the Higgins Method was formalized in 1963. Its figures have continued to be used since that time. The protein allowance for non-pregnant individuals in this standard varies according to body weight; for example 55 gm is the daily allowance for a 120-lb woman. The additional protein allowance for pregnancy is 25 gm daily during the second 20 weeks.

[b]The use of protein as a marker for the assessment of global nutrient adequacy in the Higgins Method is based on the work of Jeans et al. (38), which suggested that the level of protein intake is predictive of the level of other essential nutrients in the diet.

[c]Underweight was defined in comparison with desirable weights for adults prepared by the Metropolitan Life Insurance Company, 1960 (39).

[d]In 1972, the caloric portion of this rehabilitation allowance was changed from 200 kcal to 500 kcal.

[e]Poor outcome of prior pregnancy includes infants with birth weight below 2,500 gm and spontaneous or therapeutic abortions.

purpose of WIC is to enhance the health of expectant and lactating women as well as of newborn infants and young children who are nutritionally at risk (22).

Results of all of these evaluations suggest that nutrition interventions have positive but relatively small effects on infant birth weight (11-24). However, none of the evaluations was without problem. For example, in some of the WIC studies, it was difficult to identify a comparison group of non-WIC subjects who were as financially and nutritionally at risk as the WIC participants (25).

To help clarify the effect of nutrition intervention programs on birth outcomes, results of a sibling analysis evaluating the impact of the Higgins Nutrition Intervention Program are presented here. Because each sibling pair shares the same mother, problems of assessing program impact in the presence of inadequate matching for maternal risk factors should be reduced.

Method

The Higgins Nutrition Intervention Program

Developed as an adjunct to routine prenatal care, the Higgins Nutrition Intervention Method© is based on the application of specific nutrition rehabilitation allowances to compensate for the negative impact on pregnancy outcome of the high-risk status of many low-income pregnant women. The Higgins program consists of the systematic application of all components of the Higgins method©. The method has been described in detail elsewhere (26). Four steps are involved in its implementation:

1. Assessment of the risk profile for the presenting pregnancy (Table 1), including protein undernutrition as determined by a comparison of usual intake as quantified by a diet history (27), with the recommended nutrient intake figures in use at the time the method was developed (28).
2. Determination of an individualized nutritional rehabilitation program based on the combination of the normal needs of pregnancy (28) and additional protein and calorie rehabilitation allowances for diagnosed risks (Table 1).
3. Teaching of food consumption patterns based on individual protein and calorie requirements.
4. Regular follow-up and supervision.

Recommendations as to the kinds and amounts of food the mother should eat in order to meet her individual requirements are based on the mother's own dietary patterns and on Canada's Food Guide. Women judged unable to afford the prescribed diet by an Income Eligibility Scale (29) are provided with supplements of milk and eggs for the remainder of their pregnancies. (Oranges were also provided until 1979.) A vitamin and mineral supplement is given to every mother. Salt restriction is not recommended, and diuretics are not used.

After the initial assessment interview, each client is seen by the same dietitian at 2- to 4-week intervals for the remainder of the pregnancy. At each subsequent interview, which lasts between 30 and 45 minutes, the client is weighed, another diet history is taken, and the client is encouraged to continue positive changes in eating habits. Any serious non-nutritional problems identified during any interview are referred to appropriate agencies for further assistance and follow-up.

Study subjects

Background. Between 1963 and 1979, the Montreal Diet Dispensary carried out a study in collaboration with the Royal Victoria Hospital (RVH), a teaching hospital of McGill University. The purpose of the study was to evaluate the ability of the Higgins Nutrition Intervention Program to increase infant birth weight and improve pregnancy outcome among women attending the hospital's public maternity clinics. The study was approved by the Department of Obstetrics and Gynecology of the Royal Victoria Hospital (RVH).

Montreal Diet Dispensary dietitians provided the Higgins Nutrition Intervention Program to all women who registered at one of the hospital's public maternity clinics in 1963 and at two of the clinics from 1964 to mid-1971. The program was not provided to women attending the hospital's other public maternity clinics during that period. From mid-1971 to 1979, every second patient registering at all the hospital's maternity clinics was assigned to the Higgins Nutrition Intervention Program. There was no reason to believe that the patients assigned to the Higgins Program by these arrangements differed in any systematic way from patients not thus assigned.

The intervention program was defined as having started at the time the Montreal Diet Dispensary dietitian carried out the initial assessment interview. In most cases this occurred at or shortly after the first prenatal visit at the RVH maternity clinic. All women received the same prenatal care at the RVH clinics regardless of their participation in the Higgins program.

A total of 2,587 women met the initial eligibility criteria for participation in the Higgins program. Four hundred fifteen were subsequently excluded because they did not deliver singleton infants of known gestational age as clinic patients at the Royal Victoria Hospital. Of the remaining 2,172 eligible women, 1,980 had participated in the Higgins program, for an overall participation rate of 91%. Among the 192 (9%) non-participants, 122 were never seen for an initial assessment interview; 70 who were initially enrolled were subsequently excluded (36 of the exclusions occurred because a diet for a specific medical condition, e.g. diabetes, was ordered by clinic staff). A review of the available data for the 415 exclusions and the 122 non-participants suggests that their risk profiles for adverse pregnancy outcomes did not differ in any systematic manner from those of the 1,980 subjects who participated in the program.

Interim results evaluating this program have been reported previously. Descriptive data for intervention infants born between 1963 and 1972 were reported by Higgins in 1976 (26). In 1981, Rush (16) reported results of comparing infants born to mothers who had attended the RVH maternity clinics included in the Higgins program between 1963 and 1974 with infants born to mothers who had attended the other RVH maternity clinics during the same period.

Subjects for within-mother analysis. The 1,980 women who had participated in the Higgins program at the Royal Victoria Hospital had not done so for every infant to whom they gave birth at this hospital. Of the total of 3,866 infants born to these 1,980 mothers at the RVH, 2,310 infants were part of the Higgins program, and 1,556 infants were not. The current report presents an evaluation of the impact of the Higgins program on birth outcome utilizing a group of 552 sibling pairs drawn from these 3,866 infants. Each of the 552 mothers of these sibling pairs had participated in the Higgins program at the RVH for the first time during the pregnancy of the second-born member of her pair. Thus, in the present analyses, the "intervention infant" of each sibling pair was the first infant for whom a mother had participated in the Higgins program at the Royal Victoria Hospital; the "non-intervention infant" of the pair was born to the same mother at the same hospital prior to the birth of the intervention infant. In all cases, both infants of each pair were singleton births, born at or after 28 weeks of gestation, with birth weights greater than 999 gm. The mothers had not participated in the Higgins program during their pregnancies with the first-born member of the sibling pairs because either they had not attended public maternity clinics covered by the Higgins program (prior to mid-1971) or their clinic registration number had not indicated assignment to the Higgins program (after mid-1971).

Data collection

Data for these analyses were collected both prospectively and retrospectively. Various nutritional and demographic data were obtained for each mother at the time of her first enrollment in the program. Data on the birth outcomes for the intervention pregnancies and for all other pregnancies for which the mothers delivered at the Royal Victoria Hospital were collected after delivery of the intervention infants.

Data analysis

The impact of the Higgins program was evaluated in terms of both its effectiveness and its efficacy. For the effectiveness analyses, program participants were defined as those women who had any contact with a dietitian from the Montreal Diet Dispensary during the intervention pregnancy. For the efficacy analyses, program participants were defined as those women who had a minimum of four such dietitian contacts. The second set of analyses were undertaken because the Higgins Nutrition Intervention Program is meant to be an ongoing one, with regular contact between the mother and her dietitian during the pregnancy. Four dietitian contacts was chosen as the cutoff point to define adequate program participation for the efficacy analyses because the dietitians trained in the use of the Higgins Method believe that with less than four contacts it is very difficult to influence food consumption patterns.

Birth weight and the rates of low birth weight (LBW) (<2,500 gm), intrauterine growth retardation (IUGR), and perinatal mortality were the outcome measures used. IUGR rates were based on intrauterine growth standards developed at the Royal Victoria Hospital (30). Because of the matching system employed in the study design, the intervention infants were all of later parities than the non-intervention infants. This meant that analysis of covariance could not be used to adjust internally for the impact of increasing parity when comparing mean birth weights in the two groups. Instead, data from an external source (31) was first used to decrease individual sibling pair differences by values corresponding to the mean increase in birth weight associated with the given changes in parity; analysis of covariance (32) was then undertaken to adjust for the effect of differences in infant sex.

Odds ratios for matched pairs (33) were used to estimate the impact of the intervention program on pair differences in the incidence of low birth weight, IUGR, and perinatal mortality. Odds ratios less than one indicate a reduced risk of an adverse outcome among the intervention infants. For example, an odds ratio of 0.5 means that the odds of the intervention infants experiencing adverse outcomes is one-half that of the non-intervention infants. McNemar's test was used to determine whether the odds ratios were significantly less than one (33).

Members of the sibling pairs were often of different sexes. Rather than use conditional logistic regression to control for this fact, an estimate of the increased risk of

Table 2. Characteristics of 552 program participants at time of intervention pregnancy

age (years)	28.3 ± 6.0[a]
risk profile distribution (%)	
no risk	20
undernourished	26
underweight	6
stress conditions	15
multiple conditions including underweight	15
multiple conditions excluding underweight	18
married (%)	82
received food supplement (%)	65
dietitian contacts during pregnancy (no.)	6.0 ± 3.6

[a]Mean ± standard deviation.

low birth weight and of IUGR for female infants relative to male infants (34) was used to calculate the matched odds ratios that would be expected solely due to differences in infant sex between sibling pairs. Because the calculated values were never less than 0.99 for the risk categories in which low birth weight or IUGR occurred in either group, the null value of one was used to interpret the actual odds ratios obtained.

Data were analyzed using SAS (35,36).

Results

Basic descriptive information on the 552 mothers is provided in Table 2. These women were, on average, 28 years old and at parity four at the time of their intervention pregnancies. Only 20% of the women were assessed by the Higgins method as having no risk factors requiring nutritional rehabilitation. The women who received food supplementation because of income inadequacy were not clustered in any risk category. The risk profile distribution of this subgroup of mothers is almost identical to that of the total group of mothers who participated in the Higgins study between 1963 and 1972 (26).

Descriptive data on the outcome variables (and on confounding variables that could not be matched for in the study design [infant sex, parity]) are provided in Table 3 for the 552 sibling pairs included in the effectiveness evaluation and for the 327 pairs included in the efficacy analyses. For three of the four measures used (mean birth weight and rates of low birth weight and IUGR), outcomes for the non-intervention infants were similar in the effectiveness and efficacy groups. This suggests that for those outcomes, there was little selection bias operating in the separation of the efficacy subgroup from the total effectiveness group. Perinatal mortality, on the other hand, was lower in the efficacy subgroup than in the total effectiveness group of non-intervention infants. Even though this finding may suggest that compliance was itself an independent predictor of a lower rate of perinatal mortality, the very small numbers of deaths that actually occurred in either group suggest the need for extreme caution in making any interpretation of their significance. The unadjusted, unmatched data in these tables also show that all birth outcomes were better for the intervention infants than for the non-intervention infants.

Results from the matched analyses are presented in Table 4. In terms of the effectiveness evaluation, it can be seen that after the effects of parity and sex were controlled for, birth weights of the intervention infants averaged 107 gm higher than those of their non-intervention siblings ($p<.01$). Most of the difference remained (84 gm) when length of gestation was also controlled for in the analysis ($p<.01$). The magnitude of the program's impact on infant birth weight was not constant across risk categories. The smallest increases in mean birth weight were observed in the underweight group without other risk factors (+26 gm) and in the no-risk group (+61 gm). The largest increase was observed in the undernourished group (+146 gm). With the exception of IUGR for the undernourished group and for the multiple condition group that included underweight as a risk, a pattern suggestive of lower risk (i.e., odds ratios less than one) of low birth

Table 3. Descriptive statistics on sibling pairs[a]

sibling and evaluation[b] category	*no. of infants*	*male (%)*	*parity (no.)*	*length of gestation (week)*	*birth weight (gm)*	*low birth weight (%)*	*intrauterine growth retardation (%)*	*perinatal mortality (rate per 1,000)*
effectiveness[b] analyses								
intervention infants	552	52.5	3.9 ± 2.3[c]	39.4 ± 1.9	3,370 ± 528	4.9	1.4	9.1
non-intervention infants	552	50.4	2.7 ± 2.1	39.2 ± 2.2	3,233 ± 545	8.9	2.4	16.3
efficacy[d] analyses								
intervention infants	327	52.3	4.0 ± 2.3	39.6 ± 1.7	3,442 ± 504	2.1	0.9	6.1
non-intervention infants	327	49.5	2.7 ± 2.1	39.2 ± 2.2	3,221 ± 545	8.6	3.1	9.1

[a]There was an average of 3.6 ± 2.6 years between the births of the sibling pairs studied. Part of this time difference is related to the fact that not all of the sibling pairs were born of consecutive pregnancies (86% were consecutive; range 0 to 4 intervening births).
[b]Effectiveness was defined for these analyses as an intervention program involving any dietitian-client contact during the pregnancy. These mothers entered the program at 21 ± 8 weeks gestation.
[c]Mean ± standard deviation.
[d]Efficacy was defined for these analyses as an intervention program involving a minimum of four dietitian-client contacts during the pregnancy. These mothers entered the program at 17 ± 6 weeks gestation.

Table 4. Impact of the Higgins Nutrition Intervention Program according to risk categories

risk categories	*effectiveness[a] by risk categories*						*efficacy[b] by risk categories*					
	no. of sibling pairs	*birth weight of non-intervention infants*	*birth weight difference[c]*	*odds ratio for LBW[d,e]*	*odds ratio for IUGR[f]*	*odds ratio for perinatal mortality*	*no. of sibling pairs*	*birth weight of non-intervention infants*	*birth weight difference*	*odds ratio for LBW*	*odds ratio for IUGR*	*odds ratio for perinatal mortality*
		← (gm) →						← (gm) →				
no risk	111	3,416 ± 52[g]	61 ± 51	0.50 (0.08, 2.34)	0.33 (0.01, 4.14)	0/0	71	3,396 ± 66	81 ± 63	0.50 (0.04, 3.48)	0.33 (0.01, 4.15)	0/0
undernourished	142	3,301 ± 37	146 ± 44***	1.00 (0.19, 5.37)	1.50 (0.17, 17.87)	1.00 (0.07, 13.71)	75	3,285 ± 58	275 ± 65***	0.33 (0.01, 4.15)	0.50 (0.01, 9.64)	0/0
underweight	33	3,032 ± 86	26 ± 94	0.50 (0.01, 9.64)	0/0	0/0	23	3,137 ± 80	− 32 ± 100	0/1 (0.00, 38.8)	0/0	0/0
stress conditions	83	3,261 ± 63	107 ± 73	0.71 (0.18, 2.61)	0.25 (0.01, 2.52)	0.25 (0.01, 2.52)	53	3,164 ± 77	319 ± 74***	0/6* (0.00, 0.85)	0/3 (0.00, 2.42)	0/3 (0.00, 2.42)
multiple conditions (including underweight)	83	2,974 ± 60	106 ± 64	0.21* (0.40, 0.77)	2.0 (0.10, 124)	1.00 (0.01, 76)	48	2,982 ± 78	210 ± 78**	0.29 (0.03, 1.50)	1/0 (0.03, ∞)	1/0 (0.03, ∞)
multiple conditions (excluding underweight)	100	3,193 ± 56	119 ± 56*	0.44 (0.10, 1.59)	0.33 (0.01, 4.16)	0.50 (0.01, 9.64)	57	3,206 ± 74	167 ± 72*	0.17 (0.00, 1.38)	0/2 (0.00, 5.33)	1/0 (0.03, ∞)
overall	552	3,233 ± 23	107 ± 24**	0.48** (0.26, 0.70)	0.62 (0.22, 1.60)	0.56 (0.15, 1.85)	327	3,221 ± 30	190 ± 30***	0.22*** (0.08, 0.55)	0.30 (0.05, 1.16)	0.67 (0.06, 5.80)

[a]Effectiveness was defined for these analyses as an intervention program involving any dietitian-client contact during the pregnancy. These mothers entered the program at 21 ± 8 weeks gestation.
[b]Efficacy was defined for these analyses as an intervention program involving a minimum of four dietitian-client contacts during the pregnancy. These mothers entered the program at 17 ± 6 weeks gestation.
[c]Adjusted for parity and sex.
[d]LBW = low birth weight.
[e]Values in parentheses represent 95% confidence limits.
[f]IUGR = intrauterine growth retardation.
[g]Mean ± standard error of the mean.
*$p \leq .05$.
**$p \leq .01$.
***$p \leq .001$.

weight, IUGR, and perinatal mortality for the intervention infants can be observed. These reductions were statistically significant for the incidence of low birth weight among the total group and among the subgroup assessed as having multiple conditions, including underweight.

Results of the efficacy analyses are also presented in Table 4. After parity and sex were controlled for, the intervention infants weighed an average of 190 gm more than their matched siblings ($p<.001$). Again, the magnitude of the impact varied across risk categories: the mean birth weight of infants born to the no-risk group (+81 gm) and to the underweight group with no other risk factors (−32 gm) was not significantly different from the mean birth weight of their matched non-intervention siblings. In contrast, mean birth weight increased an average of 275 gm in the undernourished group, 319 gm in the stress group, 210 gm in the group with multiple conditions, including underweight, and 167 gm in the group with multiple conditions, excluding underweight. All of those increases are statistically significant.

Individualized prenatal nutrition intervention by the dietitian can reduce the risk of poor pregnancy outcome

The matched odds ratios for the efficacy analyses show a generally lower risk for low birth weight and for IUGR, but not for perinatal mortality, in the intervention group relative to the non-intervention group than was observed in the effectiveness analyses. Many of the calculated odds ratios reported in this table were significantly less than one. Of particular note is the threefold decrease in the odds ratios for low birth weight and for IUGR among the undernourished group when going from the effectiveness to the efficacy analyses and the absolute consistency in the two sets of analyses among the group with no diagnosed risks.

Because we did not have the necessary data available, we were unable to adjust for the effect of any change in smoking habits between pregnancies on infant birth weight. However, data from Statistics Canada (37) indicate that the percent of regular cigarette smokers among the female population of Quebec 15 years of age and older showed a slight increase (33.4% to 34.6%) between 1966 and 1979, a period similar to the period in which the entire study was conducted (1963 to 1979). If one assumes that women in this study followed a pattern similar to that of the province as a whole, there would have been about the same number of or perhaps slightly more women who started, than who stopped, smoking between their non-intervention and their intervention pregnancies. As a result, changes in smoking patterns over time are unlikely to have inflated the estimates of program impact obtained in these analyses.

Discussion

The goal of the Higgins Nutrition Intervention Program is to identify pregnant women at risk for adverse pregnancy outcomes and to intervene so as to prevent those adverse outcomes. Two sets of analyses were carried out to quantify the ability of the Higgins program to achieve this goal. Their results should represent the range in which the true program impact lies. The effectiveness analyses, which include all infants whose mothers had any dietitian contact during their intervention pregnancy, may slightly underestimate program impact because a large percentage of the women were not considered to have had adequate program participation. The efficacy analyses, on the other hand, may slightly overestimate program impact; although the minimum of four dietitian contacts needed to be included in the efficacy group could be achieved over a period of only 6 to 9 weeks, it is possible that some infants were excluded from this group because of premature delivery.

The success of the Higgins program in meeting its goal is attested to by the fact that, after adjustment for differences in infant sex and parity, those members of the sibling pairs born subsequent to any participation in the Higgins program had significantly higher birth weights and a significantly lower low-birth-weight rate than did their matched siblings. While rates of IUGR and perinatal mortality were also lower in the intervention group, the differences did not achieve statistical significance. This lack of statistical significance may be at least partially related to the small numbers of these outcome events that occurred in either group.

These results show an impact of the Higgins program on birth outcome in the same direction but of a greater magnitude than was found by Rush (16) in a retrospective matched-pairs study that utilized data collected in the Higgins Study between 1963 and 1974. They also show a greater program impact, particularly for the incidence of low birth weight, than has been observed in the evaluations of many nutrition intervention studies (11-13, 15,18-20,22-24).

Among the efficacy subgroup, the gain in mean birth weight associated with program participation was similar to the difference in mean birth weight observed between disadvantaged and non-disadvantaged groups, while the difference in the low-birth-weight rate between sibling groups was greater than that observed between disadvantaged and non-disadvantaged groups (4,6,7). Although the differences in perinatal mortality rates and rates of IUGR did not achieve statistical significance, they were indicative of a reduced risk among the infants in the intervention group.

Analyses also demonstrate that at both levels of program participation, the intervention had a greater impact on those with assessed risks for adverse pregnancy outcomes than on those without such risks. The undernourished group is of particular interest. Unlike the women who are underweight or under stress, who can be more easily detected, undernourished women will be missed as being high risk unless their usual dietary intake is assessed. Given the success of the intervention program in increasing the birth weight of infants born to women in this group, it is critically important that the women be identified and treated.

It is only possible to speculate about the reasons for the differing results in the two groups that included underweight as a risk. We suggest that less reliable estimates of effect may be possible for the underweight group without other risk conditions; the group size is small, and the women may be atypical in that there was no diagnosed undernutrition or stress condition to explain their underweight. Another possible explanation is that the extra calories and protein the underweight women with multiple conditions were taught that they needed for reasons other than their low pregravid weight were at least partially used to correct their underweight status.

This study provides one response to the recommendation made by the Committee to Study the Prevention of Low Birthweight (4, p. 15) that research should be undertaken that includes "evaluation of certain well-defined combinations of prenatal care interventions designed to meet the widely varied needs and risks among pregnant women."

Implications

The findings of this study support the central role of the dietitian as part of any multidisciplinary team approach to the prevention of adverse pregnancy outcome among low-income groups. More specifically, the findings support an individualized approach to prenatal nutrition intervention in which the dietary recommendations made by the dietitian include specific nutritional rehabilitation allowances to compensate for the negative impact of individually diagnosed risks on subsequent pregnancy outcome.

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