Morbidity and Growth of Infants and Young Children In a Rural Mexican Village

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Abstract: The relationship between childhood illnesses and growth increments in length and weight was investigated in a 13-month birth cohort of rural Mexican children. Increments in length and weight for each year from birth to three years were related to high and low frequencies of reported time ill during the same period. Seventy-two of the 276 children had already been characterized as exhibiting "growth failure" relative to other members of the cohorts, and this was considered as a separate factor in the study. We found that upper and lower respiratory infection did not affect incremental gain in height or weight. A high frequency of diarrheal infection was found to reduce weight gain, although gain in height was not affected. Relative to the total sample, the average child with a high frequency of diarrhea achieved only 95 per cent of expected body weight at age three; a child with both growth failure and high diarrheal frequency reached only 90 per cent of expected body weight at age three. (Am J. Public Health 67:651–656, 1977)

Introduction

Prior to adolescence, differences in growth of children among various populations may be almost completely regulated by the environment, with genetic differences being of much less importance.[1,2] It is well known that the growth of children of developing countries falls far behind the standards for the well-nourished, healthy children of developed nations. While nutritional factors are most frequently seen as the primary agents, it is a common belief that frequent illness comprises another of the environmental agents retarding growth.[3-8]

Animal studies suggest that illness can slow down growth.[9-11] The exact relationship between growth and infection in children, however, remains uncertain. Many of the studies on the growth of well-nourished and generally healthy U.S. and British children have found no effect of illness on growth.[12-16] On the other hand, Acheson and his associates in the Oxford Child Health Survey[17-20] found that children who experienced no illness between the ages of one and five years were taller than those who experienced moderate or severe illnesses during those years. Because there was no equivalent delay in skeletal maturation, they suggested that illness may affect final adult stature. Drillien, in a study on the growth of prematurely born children, found that illness was a significant factor in reduced growth, especially in homes with a less favorable environment.[21]

Studies of well-nourished and healthy U.S. and British children may not give the best indication of the potential affect of illness on growth, since the frequency, duration, and severity of illness are much less than in children in more adverse environments, and the debilitating effects of illness may be lessened by the increased care and attention that these children receive during illness. Further, when growth has been delayed by illness, a period of accelerated growth may compensate for the delay.[22]

In an environment where conditions are generally poor, nutrition inadequate, and infections more frequent and severe, illness may have more marked effects on growth. Undernutrition can greatly increase the severity of infections[23-25] and may limit the amount of "catch-up growth" following illness. Under these circumstances illness may play a significant part in retarding children's growth. Nevertheless, a clear relationship between illness frequency and amount of growth has not always been demonstrated. Guzman and his associates examined the association between physical growth and illness frequency in rural Guatemala.[26] Analysis of amount and type of disease by gains in height and weight, and of the inverse relationship, failed to give a consistent association between amount or type of illness and growth. In another sample from rural Guatemala, however, Martorell found that children who had a greater frequency of diarrheal infections displayed significantly smaller growth increments,[27, 28] and Cravioto and his associates, also in Guate-

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mala, noted that more of the infants with low weight gain had high frequencies of illness.[29] The present study is a further attempt to analyze the relationship between frequency of illness in childhood and growth.

Materials and Methods

Our sample consists of 276 children comprising over 85 per cent of a 13-month birth cohort from a rural community in southwestern Mexico, who have been monitored continuously since birth as part of a prospective study of the ecology of growth and development.[30, 31] Anthropometric measurements were made at monthly intervals (with the exception of weight, which was taken every two weeks) by pediatricians assisted by social workers. Illness histories were collected by the same team every two weeks: these included the symptoms of any sickness during the preceding period, the number of days symptoms were present, and the dates of their duration. Physical examinations and general medical assessments of health were also carried out at the same time.

Illnesses were classified into three common groups, based on the above information: diarrhea, upper respiratory tract infections, and lower respiratory tract infections. A fourth category, "other illnesses," covered a miscellany ranging from fever and vomiting to tuberculosis and hepatitis. Because of the heterogeneity of this category, and the small sample sizes available for analyses, this category was not included in the present analyses. Illness histories were grouped into three-month intervals for each category and recorded as the number of days ill during that interval. The number of days for which there were no records available was also recorded.

Categorizations of illness were made from symptoms revealed by the morbidity surveys. Data were collected and categorized by physicians who were members of the research team, following the methodology outlines in Cravioto et al.[30] Nineteen children who developed clinical protein-calorie malnutrition are not included in our sample during the period of the disease or afterwards.

Increments of growth over 12-month periods, beginning with birth, were calculated for each child. Illness was expressed as the percentage of reported time during one year that a child was ill with each of four classes of morbidity: upper respiratory, lower respiratory, and diarrheal infections, and the sum of these three morbidities; individuals with missing data amounting to three months or more were excluded from the analysis.

For each annual period children with percentages of reported time ill were ranked by percentiles and the first and fourth quartiles selected for our study. The mean percentages for these extreme quartiles are presented in Table 1, arranged by sex for each year. It is clear that there are striking differences in frequency of illness days between the most ill and the least ill children.

Four factors were related to the growth increments of the subjects comprising our sample. These factors were:

1. *Disease*—this, of course, refers to the hypothesis being investigated, viz., that higher frequencies of disease are associated with diminished growth increments. Each of the four categories of morbidity was considered separately;
2. *Age*—since children of different ages grow at different rates, this factor was analyzed so that it would not confound any effects due to disease;
3. *Sex*—any differences due to gender were accounted for;
4. *Growth failure*—in her analysis of the growth of these children, Scholl detected growth failure in 72 of the 276.[31] Growth failure was defined as a progressive decline from the expected height or weight for age, or weight for height, in conjunction with a decrease in the muscle circumference of the upper arm. Determinations were made by regression analysis. This group represents those children whose growth, from birth to age three years, was deficient relative to other members of the sample for a complex of reasons related to their environ-

TABLE 1—Mean Frequencies of High and Low Illness Quartiles, Expressed as Percentage of Reported Days Ill, by Age and Sex

Morbidity	Percentage of reported time ill: B-1 yr.		1-2 yr.		2-3 yr.	
	m	*f*	*m*	*f*	*m*	*f*
(n)[a]	(22)	(16)	(22)	(26)	(22)	(26)
			Diarrhea			
low	2.03	0.89	1.94	1.47	0.08	0.02
high	27.19	19.76	23.06	24.88	13.32	12.41
			Upper Respiratory			
low	0.26	1.23	0.79	1.55	3.98	3.92
high	22.48	33.21	32.48	39.67	39.43	46.51
			Lower Respiratory			
low	1.71	1.21	4.71	1.80	0.02	0.08
high	23.72	29.41	40.66	39.40	19.76	24.22
			Combined Illnesses[b]			
low	12.62	9.78	18.35	16.81	8.23	9.39
high	59.01	67.73	72.43	82.40	59.49	69.50

[a]number of children
[b]sum of diarrheal, upper respiratory, and lower respiratory infections

ments. Fourteen of the 19 children who developed clinical protein-calorie malnutrition came from this group.

One thousand eighty-three increments of height and weight were analyzed. A factorial design[32] was selected as the appropriate technique since it permitted the determination of the effects upon growth of illness frequency, sex, and growth failure, treated as independent variables. In addition, the interaction of the factors could be studied. The effect of age was statistically removed, by means of an analysis of variance, as a confounding factor. Thus, this three-factor design permitted the analysis of each of the above factors independently, as well as in combination with each other.

Results

Figures 1 and 2 give the mean heights and weights of the children in our sample compared to the Denver Child Research Council sample.[33] From birth through six months the average length and weight of both male and female children fall between the 10th and 50th percentiles of the Denver sample. From age six months, however, the growth of the Mexican children begins to fall below the 10th percentile of the Denver sample and continues to fall further behind as they grow older. This pattern has been noted in other studies of the growth of children in developing countries.[5, 8]

The growth increments associated with high and low fre-

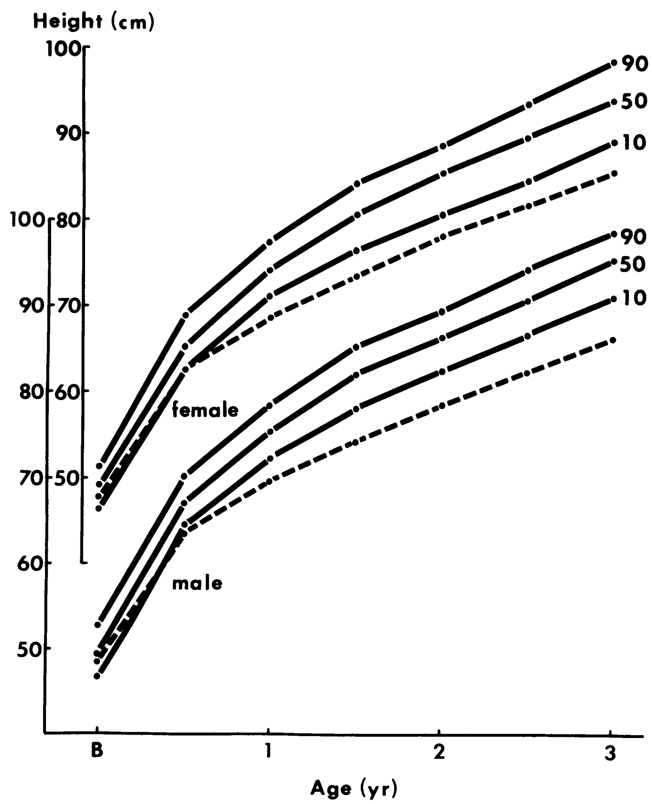

FIGURE 1—Mean Lengths (height after 2) of Mexican Children (broken lines) from Birth to Three Years Compared to the 10th, 50th and 90th Percentiles of Children of the Same Age in the Denver Child Research Council Study (solid lines).[33]

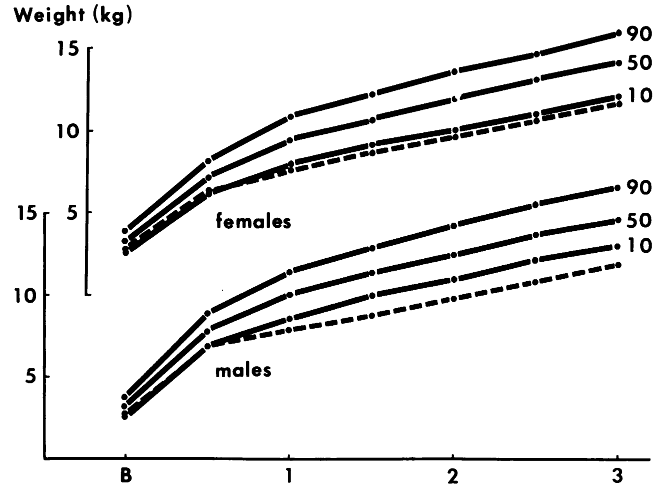

FIGURE 2—Mean Weights of Mexican Children (broken lines) from Birth to Three Years Compared to the 10th, 50th and 90th Percentiles of Children of the Same Age in the Denver Child Research Council Study (solid lines).[33]

quencies of disease were compared for height and weight in each of the four categories of disease noted above. With the two sexes, three age groups, and two categories of growth status (i.e., failing or non-failing), 12 comparisons were possible for each measurement and disease class. Table 2 shows the number of times the greater mean increment was found in the case of the high or the low disease sample. An association of disease frequency and growth increment is seen only in the case of diarrhea and weight, where children with a low frequency displayed a greater mean increment in ten of the 12 comparisons; this is significant at a probability of 0.019. The mean increments of weight in children with high and low diarrhea frequency are shown, for each of the 12 groups, in Table 3. While the differences between the average increments are usually small they are remarkably consistent.

Table 4 presents the analysis of variance of weight gain resulting from the factorial design. Age has been removed

TABLE 2—Direction of Differences between Growth Increments of Children with High and Low Disease Frequency Contrasted by Age, Sex, and Growth Status

	Height		Weight	
Morbidity	Low* Greater	High* Greater	Low* Greater	High* Greater
Diarrhea	6	6	10**	2
Upper Respiratory	6	6	5	7
Lower Respiratory	5	7	6	6
Combined Illness	6	6	5	7

*low = low disease associated with greater growth, high = high disease associated with greater growth

**p = .019, using sign test

TABLE 3—Mean Annual Weight Increment by Diarrhea Frequency and Growth Status

Growth Status	Sex	Diarrhea Frequency	Age B-1	Age 1-2	Age 2-3	Total
"Normal"	M	low	5.71	2.05	2.04	9.80
		high	5.44	2.22	1.87	9.53
	F	low	5.15	2.13	2.10	9.38
		high	4.68	1.86	1.93	8.52
"Failure"	M	low	4.50	1.53	2.58	8.61
		high	4.54	1.46	1.95	7.95
	F	low	4.83	1.92	2.21	8.96
		high	4.23	1.66	1.69	7.58
TOTAL			39.08	14.83	16.42	70.33

statistically as an effect, leaving seven "treatments" and the contribution of each of the increments of weight is indicated in the analysis by its mean square (MS). The F-ratios present the ratio of variation explained by this variable to unexplained variation (i.e., error); those F ratios not shown fall far above statistical significance.

The first three treatment variables are the effects of growth status (failing or nonfailing), disease, and sex, considered as independent variables. Obviously, growth status displays a significant effect, since the children were placed into growth status categories based upon their growth and it is included only to balance the design. There is clearly no difference in increment by sex. The effect of disease, p = .064, does not reach the usually accepted value of .05. On the other hand, this cut-off point is one of accommodation and a probability of .064 is close enough to indicate that the differences are likely to be significant.

The latter four treatment categories indicate interactions among the three independent variables, and no significant interactions are found. Thus, for example, children displaying failing growth in weight do not have higher or lower frequencies of diarrhea illness days. The effect of diarrhea is statistically independent of the long range growth deviations which form the basis of the failing/non-failing categorization.

Table 5 shows the results of the effect of diarrhea and growth failure upon weight at one, two, and three years of age. Relative to the total sample, the average child with a high frequency of diarrhea illness days has, at three years of age, achieved only 95 per cent of expected body weight, i.e., the "deficiency" is 0.59 kg. The three-year effect of growth failure is 0.72 kg. (a deficiency of 6 per cent) while a child with both growth failure and a high diarrheal frequency displays a 10 per cent (1.23 kg.) deficiency.

Discussion

This study has compared the growth, in height and weight, of children with high and low frequencies of illness days, as indicated by the presence of symptoms characterizing certain categories of disease: upper respiratory, lower respiratory, and diarrhea, as well as a fourth, composite category. A significant association was found only in the case of diarrhea and weight; a factorial design was then employed which allowed the determination of the effects of a number of factors upon growth, one being the frequency of illness days from diarrheal disease.

It is not surprising that children exhibiting growth failure would show the greatest deficits in weight gain, since a failure to gain weight was one of the criteria used in making the diagnosis of growth failure. We have included it in our analysis simply to permit the determination of the effects of another

TABLE 4—Analysis of Variance of Weight Gain by Growth Status, Diarrheal Frequency, and Sex.

Source	df	SS	MS	F
Age	2	46.003		
(Treatments	7	1.407)		
Growth Status	1	.711	.711	6.971*
Disease	1	.419	.419	4.108**
Sex	1	.088	.088	
Growth/Sex	1	.083	.083	
Growth/Disease	1	.035	.035	
Disease/Sex	1	.072	.072	
G/D/S	1	.001	.001	
Error	14	1.430	.102	

*p = .019 **p = .064

TABLE 5—Effects of Growth Failure and Diarrhea on Weight between One and Three Years

(Age)	Mean Weight in kgs. 1 yr.	2 yr.	3 yr.
Total Sample	7.81	9.72	11.80
Diarrhea	7.53	9.33	11.21
% of total sample mean	96	96	95
Growth Failure	7.34	8.98	11.08
% of total sample mean	94	92	94
Diarrhea and Growth Failure	7.19	8.75	10.57
% of total sample mean	92	90	90

factor upon growth and to allow us to analyze its interaction with illness days.

The reduced increments associated with high illness days from diarrhea approach borderline statistical significance, the probability that they are result of chance being but 6 ½/100. While this is not quite at the 5/100 level usually accepted as borderline, the sample is small and we feel the association is not a chance one.

Our data suggest that weight gain between birth and three years of age is less in children with high frequencies of illness days from diarrhea. This finding partially supports those of Martorell and his associates, who found reduced increments of weight and height associated with diarrheal disease;[27, 28] however, our study failed to show any effects on height.

Of interest is the failure of our data to indicate any interaction between diarrhea and growth failure in terms of weight gain. Children whose growth has failed may also exhibit further deficits in weight gain resulting from diarrhea, but these deficits are not different from those of children whose growth is more normal for their cohort. This is supported by the work of Scholl, who found that children with growth failure did not have frequencies of disease symptomatology significantly different from those without failure.[31] Although the concomitants of failure as we have defined it are being analyzed further, it appears that this condition is associated with the socioeconomic, demographic, and anthropometric characteristics of the parents, while disease symptoms cut across them as yet another factor inhibiting weight gain.

Our data (Table 5) indicate that, in this sample, children displaying high frequencies of illness days from diarrhea in the first three years of life may suffer deficits in weight gain of 5 per cent, relative to the total cohort. If, at the same time, their growth is affected by other factors such that they may be classed as having growth failure, the combined deficit could reach 10 per cent. Diarrhea is thus an important part of the pattern of morbidity and mortality among the young children of developing nations and contributes to their deficits in weight gain during these early years of childhood.

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