Undernutrition among Bedouin Arab infants: the Bedouin Infant Feeding Study[1,2]

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ABSTRACT Two hundred seventy-four healthy Bedouin Arab newborns in 1981 were followed for 18 mo to examine the relationship between infant-feeding practices and growth during planned social change. Although wasting was not prevalent, the prevalence rate of stunting (≤ −2 SDs) increased from 12% to 19% to 32% at 6, 12, and 18 mo, respectively. After multiple-logistic-regression adjustment for covariates, the odds ratio (OR) of stunting at 6 mo was reduced among infants breast-fed only or fed with supplement compared with weaned infants. Infant-feeding practices were not associated with stunting in later infancy; however, those stunted at 6 mo had an OR of 13 of stunting at 12 mo and those stunted at 12 mo had an OR of 14 of stunting at 18 mo. In a multiple-linear-regression analysis, seasonality, duration of breast-feeding, hospitalized morbidity, and residual of height at 6 mo were negatively associated with daily average linear growth from 6 to 12 mo; these factors only explained 12% of the variation in daily linear growth. *Am J Clin Nutr* 1990;51:343–9.

KEY WORDS Infant feeding, nutritional status, growth, social change

Introduction

In communities undergoing social change, the incidence and duration of breast-feeding decrease whereas bottle and solid feeding are introduced earlier (1, 2). At the same time, modern health care may become available and challenge traditional folk medical practices and practitioners. These elements present a classical dilemma of potentially antagonistic factors that influence infant growth and development, notably increased bottle feeding under unhygienic conditions and limited maternal education with modern health care.

The Bedouin Arabs of the Negev, Israel, are undergoing a transition from a seminomadic to a sedentary lifestyle. The Bedouin Infant Feeding Study is a prospective, longitudinal cohort study, conducted from 1981 to 1984 to examine the interrelationship between infant-feeding practices and growth and morbidity in Bedouin Arab infants of the Negev. Data collection occurred during the period of planned transition to a sedentary lifestyle with expected effects on infant-feeding practices, health care, hygienic conditions, and infant growth and morbidity.

The major hypothesis of this paper is that breast-feeding is associated with constant growth during infancy after adjustment for morbidity, season, and sociodemographic covariates. Conversely early breast-milk-substitute feeding is associated with undernutrition after adjustment for covariates. The purposes of this paper are *1*) to describe the extent and severity of undernutrition in a cohort of infants born in 1981 as they were followed over time; *2*) to examine the association between infant-feeding practices, socioeconomic status (SES), hospitalized morbidity, and the percentage of stunting; and *3*) to describe the factors influencing the odds of being stunted as well as the factors influencing daily linear growth velocity over time.

Subjects and methods

Subjects

The study infants were selected from all births to Bedouin Arab women residing in the Negev in 1981. Recognizing that health status at birth, specifically low birth weight, is associated with early bottle feeding, increased morbidity, and growth retardation, we intentionally selected infants for follow-up who had a normal birth weight of ≥ 2500 g and had an average hospital stay at birth of 3d (3, 4). Four hundred six infants born between July 1, 1981, and December 31, 1981, were followed at 6, 12, and 18 mo. The following subjects were excluded from the data analysis: 32 infants born at home who did not have birth-weight information or who suffered neonatal complications; 45 infants who were missing information for the scale of SES; and 55 infants who had biased measurements (5% of all measurements) of extremely short lengths and high weights. The remaining 274 infants were included in the analysis at 6 mo; because of attrition there were 264 and 228 infants in the 12- and 18-mo analyses, respectively. The study protocol was reviewed by the Institutional Review Board at the Ben Gurion

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University (BGU) in accordance with the 1975 Helsinki Declaration.

Trained Arab female student interviewers from BGU administered a pretested questionnaire to obtain prenatal and birth information from the mother in the hospital after delivery. At each home follow-up, information on infant-feeding practices and anthropometrics were obtained. Sociodemographic data were collected at the initial interview as well as abstracted from the birth certificate.

Development of the scale of socioeconomic status

Questionnaire items for the scale of SES were selected by the anthropologist (GLH) who has > 10 y of ethnographic research experience among the Bedouin Arabs. The scale is therefore created from culture-specific socioeconomic variables. Because characteristics indicating similar SES cluster together geographically by housing type, the variables significantly associated with housing type on a univariate basis were subjected to discriminant function analysis with the dependent variable defined as tent (including tent and tent-hut dwellers), hut, and house (including house dwellers alone or in combination with any of the above type dwellings). Four variables, paternal education (0–16 y), floor type (tile, cement, or earth), cooking apparatus (electric or gas oven, primus stove, or open fire), and water source (tap, outside water pipe, cistern, or well), significantly distinguished the three housing types (5). The distribution of scores on the SES scale were trichotomized into equal units of high-, medium-, and low-SES groups.

Anthropometric data collection and analysis

Birth weights but not lengths were regularly measured by hospital nurses at delivery. For the home follow-ups, interviewers were trained to measure weights and lengths by a pediatrician at baseline, checked monthly, and periodically retrained. All training was initially conducted in the pediatric department of the Soroka Medical Center and was followed by field oversight of measurements by the supervisor. Random spot checking of anthropometrics was done in the field by the nutrition epidemiologist (MF).

Salter scales were used to measure weights and were balanced regularly. The World Health Organization (WHO) board and a locally constructed portable lightweight board with a fixed headboard were used to measure lengths to the nearest 0.1 cm. Measurements of lengths on the same subjects using both boards were not significantly different. All measurements were taken twice with the mean value included in the analysis. An effort was made to take all measurements within 2 wk of the appropriate age. When sociopolitical conditions prohibited timely measurements, age was taken into consideration in the statistical analysis.

According to the Waterlow classification, the nutritional status of infants is assessed by estimating the percentage of wasting and/or stunting (6). Wasting is a condition of low (< 80%) weight-for-height but normal (> 90%) height-for-age and stunting is a condition of low (< 90%) height-for-age but normal (> 80%) weight-for-height. The cutoff for identifying moderate to severe malnutrition is ≤ -2 SD units (SDUs) from the median value for the age and sex group of the Centers for Disease Control (CDC)–WHO reference population.

Infants were hospitalized at the Soroka Medical Center of BGU, which is the only hospital in the Negev. Medical students at BGU were trained to abstract morbidity data from pediatric hospital records and microbiology laboratory reports. All diagnoses were coded according to the ninth revision of the International Classification of Diseases (7). Because the study infants were healthy at birth and only a few had repeat hospitalizations during the first 18 mo, the age at and reason for the first hospitalization was used in the calculation of the morbidity variable. For each follow-up interval, those never hospitalized up to the infant's current age were compared with infants hospitalized for the first time with a primary diagnosis of diarrheal disease and also compared with infants diagnosed with other illnesses, the majority of which were lower-respiratory infections.

Seasonality was categorized into the hot, dry season and the cool, wet season. These two intervals include the dry months of May through October and the wet months of November through April. This dichotomization follows the Bedouin cultural perception of seasons and the dry season coincides with the peak period of hospitalizations for diarrheal disease. The percentage of days since birth that an infant spent in the dry season was used as the seasonality variable in the data analysis.

Definition of infant-feeding groups

Infant-feeding practices were categorized into five groups on the basis of maternal reporting of the infant's feeding regimen at the time of the interview. The five groups include infants who were *1*) bottle and solid fed; *2*) breast-fed and solid fed; *3*) breast-fed and bottle fed; *4*) breast-fed, bottle fed and solid fed; and *5*) exclusively breast-fed. Bottles contained powdered infant formula or powdered or fresh milk. To be classified into a solid-feeding group, an infant had to receive a solid in the 24 h before the interview or must have been introduced to a solid since the previous interview. Mothers also reported the frequency of breast-feeds and of bottle feeds from dawn to dusk and during the night in the 24 h before the interview.

Questions about feeding practices were administered as crosschecks for maternal responses to the initial feeding items. The field supervisor reviewed all questionnaires soon after the interviews and logical checks were developed to examine the consistency of the mother's response. When inconsistent responses were given, the supervisor reviewed the questionnaire with the interviewer and when appropriate recoded the initial feeding items.

Data analysis

In the first phase of the analysis, we examined the distribution of length-for-age and weight-for-length and estimated the age-specific prevalence rates of stunting and of wasting. In the second phase we estimated the approximate (crude) relative risk of stunting within strata of infant feeding practices, SES, hospitalized morbidity, and nutritional status at the previous interview and computed the 95% confidence intervals around each risk estimate.

In the third phase all variables that were significantly associated with stunting in the univariate analysis were included in a multiple-logistic-regression model and in a multiple-linear-regression model. These models were selected for their application in previous infant-feeding and growth research and for the opportunity to compare the magnitude of the odds ratio of stunting from various factors with the percentage of variation

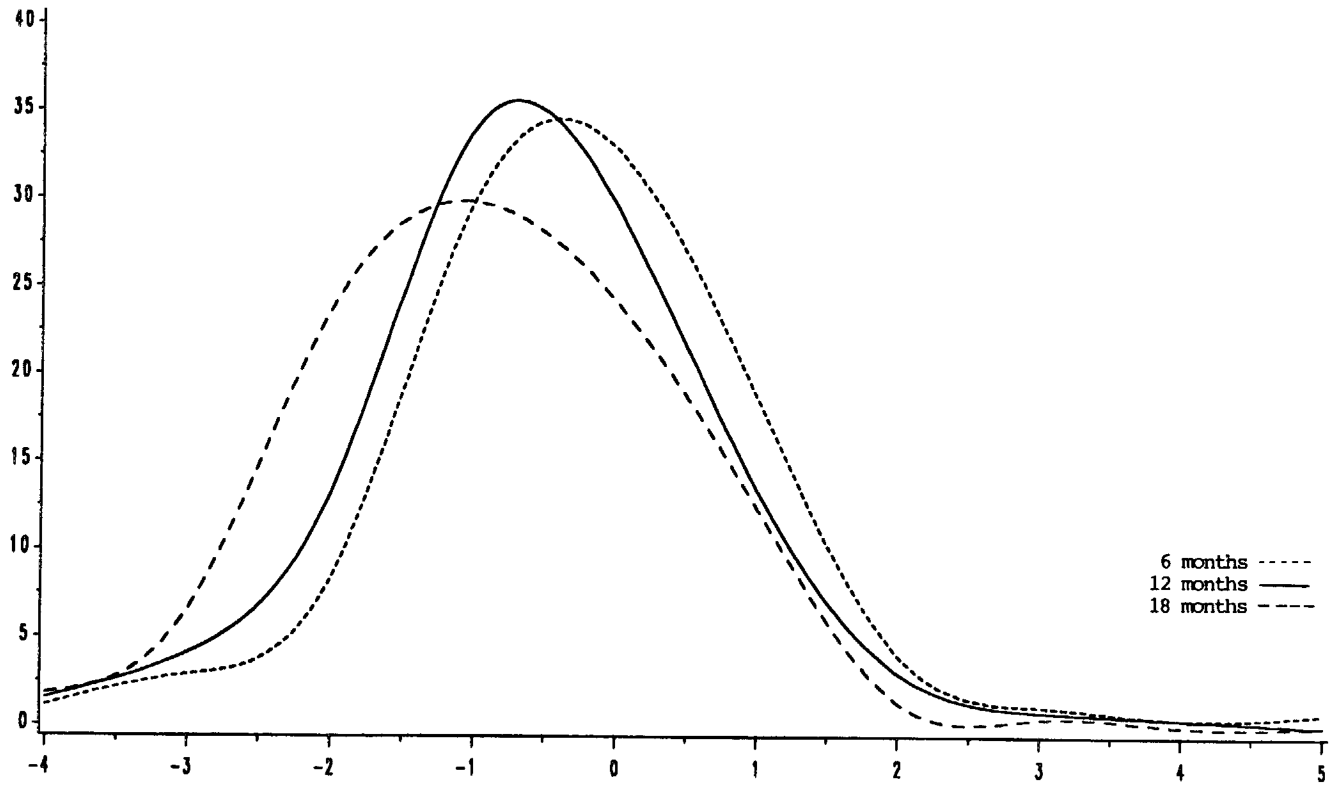

FIG 1. Height-for-age at 6, 12, and 18 mo.

in daily growth explained by the same factors (8, 9). Whereas the multiple-logistic-regression model has a dichotomous outcome of stunting (ie, ≤ −2 SDU) or normal length-for-age (ie, > −2 SDUs) based on the distribution of a reference population, the multiple-linear-regression model has a continuous outcome of the daily rate of linear growth in this population. The infant's daily rate of linear growth is calculated by subtracting the length at one interview from the length at the next divided by the number of days between interviews. Infants with daily growth velocities that were outliers (indicated by their being significantly out of the range of US linear growth velocities) were excluded from the multiple-linear-regression models (10).

The variables considered for the multiple-logistic-regression model include those with numerical values, ie, birth weight, birth order, and the percentage of days in the dry season, and those treated categorically, ie, gender, infant-feeding group, SES, hospitalized morbidity, place of residence, and nutritional status at the previous interview. The same variables were analyzed in the multiple-linear-regression model; however, infant feeding was treated continuously as two variables, the duration of breast-feeding and of solid feeding, and the numerical values of the infant's age and length at the previous interview were included.

The final models include those variables that remained after stepwise backward elimination of variables with $p = 0.15$ to remove and $p = 0.10$ to re-enter. All coefficients were estimated by the maximum likelihood method (11). Because the effect of infant feeding on growth is of primary interest, infant-feeding type was forced into the logistic regression model. The Hosmer chi-square statistic was examined for the goodness of fit of each model because most variables were categorical and some had small cells. Both the multiple-logistic and linear-regression analyses were run using the SAS procedures (*Proc Logist* and *Proc Stepwise*) (5).

Results

The distribution of length-for-age in the total follow-up cohort shifts to the left with increasing age and flattens out by 18 mo (**Fig 1**). The prevalence of stunting is ~13% at 6 mo, is ~19% by 12 mo, and increases to 32% by 18 mo. The rate of stunting increased by 42% from 6 to 12 mo and increased another 222% from 12 to 18 mo. Among infants in the high-SES group, the percentage of stunting at 6 mo was similar to the US reference population. For these infants the pattern of increasing stunting with age appears at 12 and 18 mo with 10% and 33% stunting, respectively.

The distribution of weight-for-height in the total follow-up cohort (and in the high-SES group) shifts to the left from 6 to 12 mo only to return to the 6-mo median and distribution at 18 mo (**Fig 2**). The percentage who were wasted increased from 3% to 8% between 6 and 12 mo, respectively, only to decline to < 2% at 18 mo.

The approximate relative risks of stunting at 6 mo were significantly < 1 among infants with any breast-feeding compared with those who were weaned onto the bottle and solid diet, except for the exclusively breast-fed (**Table 1**). At 6 and 12 mo

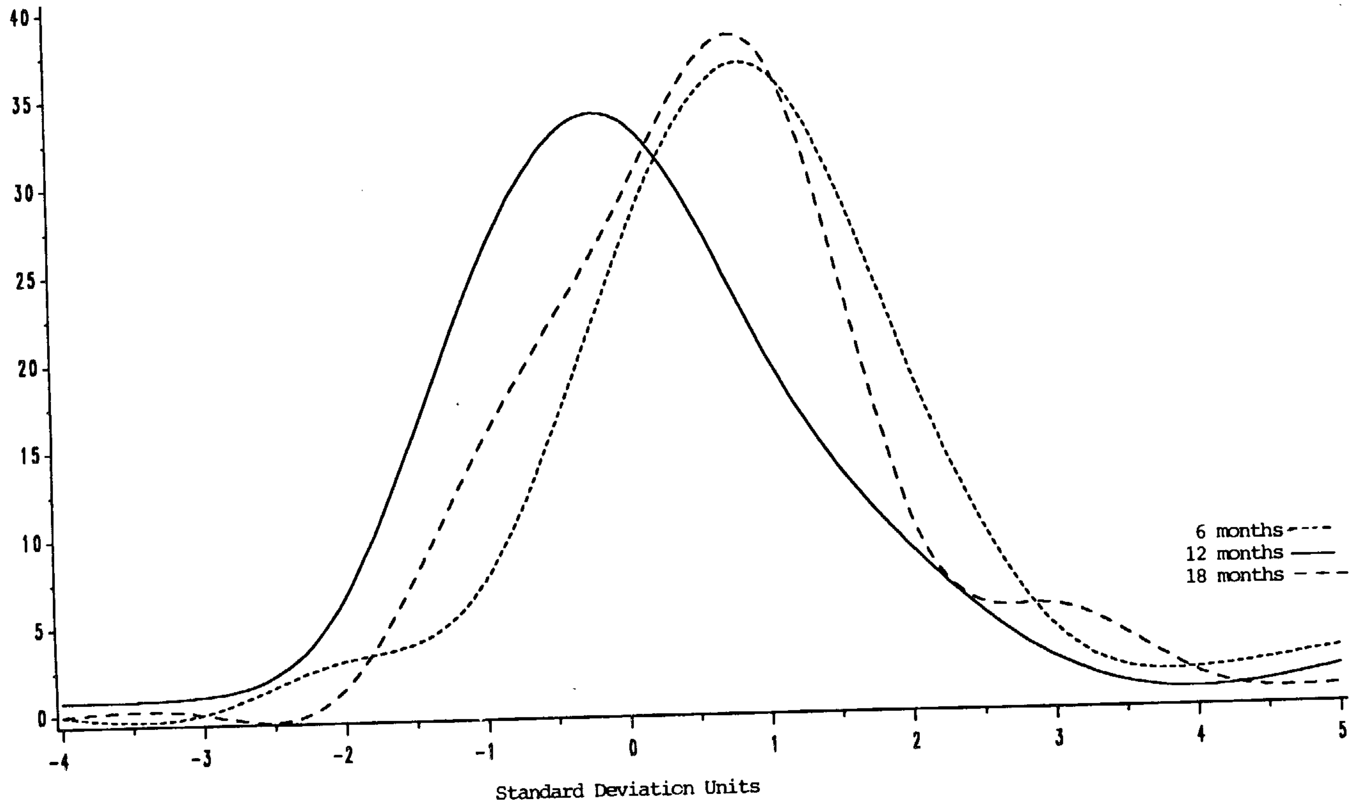

FIG 2. Weight-for-height at 6, 12, and 18 mo.

the risk of stunting consistently decreased with increasing SES and was significantly reduced for infants in families of the high-SES group. Compared with infants who were not hospitalized from birth to 6 mo, infants hospitalized for infection during the first 6 mo of life had a significantly greater risk of being stunted. Finally, those infants who were classified as stunted at the previous measurement had an almost fivefold risk of being stunted when the next measurement was taken at 12 mo and an almost fourfold risk when the next measurement was taken at 18 mo.

Multiple-logistic-regression models

Compared with infants who were bottle and solid fed at 6 mo, infants who were either exclusively breast-fed or breast-fed with bottle and/or solids had significantly reduced odds of being stunted after adjustment for SES and hospitalized morbidity (**Table 2**).

Compared with the low-SES group, infants of the middle- and high-SES groups had significantly reduced odds of being stunted after adjustment for infant-feeding practices and morbidity. Finally, compared with those who were not hospitalized from birth to 6 mo, infants hospitalized with a primary diagnosis of diarrheal disease or lower-respiratory infection had three- or fourfold odds of being stunted, respectively.

The factors influencing the odds of being stunted at 12 mo include a 13-fold risk among those who were stunted at 6 mo and the percentage of days spent in the dry season (**Table 3**). Compared with an infant without exposure to the dry season from 6 to 12 mo of age, for every day during the 6 mo that an infant spent in the dry, high-risk season for diarrheal disease, an infant experienced a 9% increase in the odds of being stunted at 12 mo. By 18 mo the only factor significantly influencing the odds of being stunted was the infant's prior nutritional status at 12 mo. Those who were stunted at 12 mo had 14-fold odds of being stunted at 18 mo.

Multiple-linear-regression models

Five variables, the percentage of days in the dry season, the duration of breast-feeding, hospitalized morbidity from 6 to 12 mo, place of residence, and residual of height at 6 mo were significantly and independently associated with the daily rate of average linear growth from 6 to 12 mo (**Table 4**). According to this model the greater the number of days in the dry season, the slower the daily growth velocity between 6 and 12 mo. In contrast the shorter the duration of breast-feeding between 6 and 12 mo, the greater the daily rate of linear growth. Moreover infants who were taller at 6 mo had a slower rate of linear growth than did infants who were shorter at 6 mo and, as expected, hospitalized morbidity decreased the growth velocity. Finally place of residence was positively associated with linear growth. All five variables explained ~12% of the variation in the mean daily linear growth.

In a cohort of healthy, normal-birth-weight infants born in 1982 with measurements of birth length who were followed at 2 and 9 mo (n = 144), the variables in a multiple-regression model of daily linear growth from 2 to 9 mo were similar to those in the 6–12-mo model of the 1981 cohort. The variables left in the model of the 1982 cohort explain 29% of the variation in mean daily linear growth.

TABLE 1
Percentage and number stunted and approximate relative risk (RR) of stunting among a cohort of Bedouin infants followed at 6, 12, and 18 mo by feeding status, SES, hospitalized morbidity, and prior nutritional status

	Age of infants								
	6 mo (n = 274)			12 mo (n = 264)			18 mo (n = 228)		
Variable	Percentage	Number	RR	Percentage	Number	RR	Percentage	Number	RR
Feeding status									
Bottle fed, solid fed	30	61	1.00	22	135	1.00	33	195	1.00
Breast-fed, bottle fed, solid fed	5	86	0.11*	12	60	0.55	23	22	0.70
Breast-fed, solid fed	4	46	0.13*	20	69	0.91	37	11	1.12
Breast-fed, bottle fed	9	47	0.30*						
Exclusively breast-fed	18	34	0.60						
SES									
Low	19	91	1.00	27	85	1.00	40	67	1.00
Middle	12	105	0.63	19	103	0.71	27	89	0.68
High	5	78	0.26*	11	76	0.41*	31	72	0.78
Hospitalized morbidity†									
Not hospitalized	10	249	1.00	18	214	1.00	31	176	1.00
Other than diarrhea	42	12	4.20*	18	28	1.00	29	28	0.94
Diarrheal disease	31	13	3.10*	32	22	1.78	46	24	1.48
Prior nutritional status									
Normal (> −2 SDU)	—	—	—	13	231	1.00	20	182	1.00
Stunted (< −2 SDU)	—	—	—	64	33	4.92*	78	46	3.90*

* 95% confidence limits exclude one.
† Hospitalized at least once during the first 6 mo or during the intervals of 6–12 or 12–18 mo; however, an infant is only counted once per interval.

The variables significantly influencing the daily growth rate from 12 to 18 mo in the 1981 cohort were the percentage of days in the dry season and age at interview (Table 4). Similar to the growth-velocity model from 6 to 12 mo, the number of days spent in the dry season was associated with a slower growth velocity. Five percent of the variation in the mean daily linear growth was explained by the variables in this model.

TABLE 2
Multiple-logistic-regression model: the odds of stunting at 6 mo*

Variable	Number	Odds ratio	95% Confidence interval
Feeding status			
Bottle fed, solid fed	61	1.00	
Breast-fed, bottle fed, solid fed	86	0.13	0.09–0.82
Breast-fed, bottle fed	47	0.23	0.08–0.75
Breast-fed, solid fed	46	0.11	0.02–0.54
Exclusively breast-fed	34	0.58	0.05–0.80
SES			
Low	91	1.00	
Middle	105	0.39	0.16–0.94
High	78	0.18	0.05–0.62
Hospitalized morbidity			
Not hospitalized	249	1.00	
Other than diarrhea†	12	4.29	1.03–17.80
Diarrheal disease	13	3.06	1.27–7.37‡

* n = 274.
† Majority are lower-respiratory disease.
‡ 90% confidence interval.

Discussion

Among healthy, normal-birth-weight, Bedouin Arab infants born in 1981 who were selected for follow-up, the prevalence and severity of stunting increased with age similarly to studies conducted in less-developed communities (MA Dempsey, unpublished observations, 1981) (9, 12–15). However, the high-SES infants had a growth pattern at 6 mo similar to the reference population, which is an indication that the growth pattern of all Bedouin Arab infants could follow the reference population. Therefore during the transition from seminomadism to a sedentary lifestyle, the growth of Bedouin Arab infants reflects the milieu of both relatively deprived and nondeprived communities.

The prevalence rates of stunting in much of the earlier research are estimated from data collected on infants of different ages at one time in contrast with the serial measurements on the same cohort in this study (13, 15). Moreover birth weights are frequently unknown and therefore prevalence estimates of stunting included the effects of the intrauterine and postnatal environments (9, 12, 14). Nevertheless the prevalence rates of 19% and 32% stunting at 12 and 18 mo, respectively, in the Bedouin Arab cohort are within the range of prevalence estimates for children aged 1–2 y and of lower SES groups (without criteria specified for SES) in the Dominican Republic, Columbia, and Pakistan (14).

The prevalence of wasting was slightly higher than expected during the diarrheal disease season at 12 mo. It shifted back to the expected ≤ 3% during the non-diarrheal-disease season.

Compared with infants who were weaned onto a bottle and solid diet, infants who were either breast-fed exclusively or in combination with bottle and solid feeding had a significantly reduced odds of stunting at 6 mo of age before and after adjustment for covariates. The approximate (crude) relative risk of stunting among the exclusively breast-fed was the only nonsignificant measure of effect, which may perhaps be due to the small numbers in this feeding group. Thus, in general, breast-feeding will maintain adequate growth up to age 6 mo in this cohort. These infants were breast-fed from 7 to 11 times per day on average as reported by the mother; however, data were not collected regarding the nutrient and energy intake from milk and other foods to determine the proportion of the infant's diet attributed to breast milk alone. Our findings are similar to the results of others (9, 16, 17) except for a Finnish study (18) in which the breast-fed infants had a slower length velocity compared with that of weaned infants after age 3 mo.

SES was inversely associated with stunting at 6 mo whereas hospitalized morbidity was positively associated with stunting. The effect of both factors on the odds of stunting was enhanced after adjustment for covariates. These findings reflect the complex of chronic poverty, unhygienic conditions, and infection associated with stunting (12).

The odds of stunting at 12 and 18 mo are predominantly influenced by the infant's prior nutritional status, notably whether an infant is in the height-deficit group by 6 and 12 mo. Therefore it appears that environmental factors with potential for intervention, such as feeding practices, unhygienic conditions, and limited resources for health care of the low-SES group, are associated with risk of early stunting, but an infant's nutritional status at 6 mo is the key to risk of stunting in late infancy.

The variables significantly influencing daily linear growth over time are similar to the set of factors remaining in the multiple-logistic-regression models; however, seasonality appears more frequently and place of residence replaces SES in the multiple-regression models. The seasonal effect on growth was documented in previous studies (19–21). Place of residence is an indicator of proximity to health clinics. Among infants of families residing in the towns, better access to care in time of illness may lead to a quicker recovery. These infants also have a better overall standard of living, with water from a tap and tile or cement floors. The variables in the multiple-linear-regression models only explain from 5% to 12% of the variation in the daily linear growth. The addition of birth length to the 1982 cohort growth-velocity model appears to contribute to a large percentage of the variation around the mean linear growth.

The array of factors with potential impact on growth that are missing from our data collection are maternal factors, such as height, postpartum diet, and morbidity; paternal height; more specific feeding data on the nutrient composition of breast milk; and minor infant morbidities not requiring hospitalizations. Preventive but not curative health-services data were collected regarding the use of the well-baby clinics.

In summary, breast-feeding alone or in combination with other foods reduces the risk of linear growth retardation during the first 6 mo of life. Poverty, severe infection, and percentage of days spent in the dry season are also associated with an increased risk of early linear-growth retardation. Beyond 6 mo the stage is already set for increased growth retardation among already nutritionally deprived infants. These factors have their strongest influence by 6 mo and, therefore, intervention programs should be targeted early. Although these factors highly influence the odds of stunting, the multiple-regression models reveal a sobering high percentage of variation left unexplained.

TABLE 3
Multiple-logistic-regression models: the odds of stunting at ages 12 and 18 mo

Variable	Number	Odds ratio	95% Confidence interval
At 12 mo (n = 264)			
Feeding status			
Bottle fed, solid fed	135	1.00	
Breast-fed, bottle fed, solid-fed	60	0.54	0.02–1.46
Breast-fed, solid fed	69	1.56	0.93–2.60
Stunted at 6 mo	33	13.27	5.64–31.23
Days in dry season (%)		1.09	1.01–1.21
At 18 mo (n = 228)			
Feeding status			
Bottle fed, solid fed	196	1.00	
Breast-fed, bottle fed, solid fed	22	0.67	0.21–2.18
Breast-fed, solid fed	11	0.98	0.22–4.40
Stunted at 12 mo	46	14	6.40–31

TABLE 4
Multiple-linear-regression model

Variable	β	p
Growth velocity from ages 6 to 12 mo (n = 240)		
Place of residence	0.021	0.130
Percentage of days in the dry season	−0.004	0.005
Duration of breast-feeding	−0.003	0.103
Hospitalized morbidity from ages 6 to 12 mo	−0.017	0.137
Height at 6 mo	−0.0009	0.0001
Multiple r	0.12	
Growth velocity from ages 12 to 18 mo (n = 220)		
Percentage of days in the dry season	−0.008	0.001
Age at 18-mo interview	0.0006	0.015
Multiple r	0.05	

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