Seasonal Variation in Weight-for-Age in a Pediatric Emergency Room

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SYNOPSIS

Objective. The authors assess seasonal variations in the prevalence of low weight-for-age among young children visiting the pediatric emergency room of a city hospital.

Methods. We analyzed data on 11,118 children ages 6 to 24 months who visited the Boston City Hospital Pediatric Emergency Department between July 1989 and June 1992. Medical diagnoses were documented on a randomly selected subsample of 1569 children. In addition, a questionnaire about food insecurity was administered to a convenience subsample of 269 families with children under 3 years of age.

Results. The percentage of children visiting the emergency room with weight-for-age below the fifth percentile was significantly higher for the three months following the coldest months than for the remaining months of the year, controlling for year of measurement. In the subsample, gastrointestinal illness was correlated with both season of measurement and weight-for-age, but the seasonal effect remained for the entire sample after controlling for dehydration.

The questionnaire data suggested a relationship between economic stress and food insecurity that might help explain the seasonal effect. Families who were without heat or who were threatened with utility turnoff in the previous winter were twice as likely as other families to report that their children were hungry or at risk for hunger.

Conclusions. Winter and early spring constituted periods of increased nutritional risk in the in this sample of predominantly low-income children, probably because of the increased caloric associated with cold stress and infections. Further research is needed to assess whether decreased caloric availability due to high heating costs, a "heat or eat" effect, also contributes to this phenomenon.

Nutritional monitoring programs in the United States have rarely addressed seasonal effects on children's nutritional status. One study based on the second National Health and Nutrition Examination Survey (NHANES II) found the risk of obesity in children ages 6 to 11 years to be 1.5 to 2.2 times higher in the fall or winter than in midsummer, although no winter data were available from the Northeast.[1]

Table 1. Sample characteristics of children seen at the Boston City Hospital Pediatric Emergency Department, July 1989 to June 1992 (*N*=11,118 visits)

Characteristic	Percent
Age	
6–12 months	39
12–18 months	34
18–24 months	27
Sex	
Female	46
Male	54
Ethnicity	
African American	65
Hispanic	22
White	9
Asian	1
Other/unknown	4
Health insurance	
Medicaid	66
Self-pay	19
Private	8
Other/not noted	7

In contrast, the distribution of cross-sectional anthropometric measurements in young children in many developing countries has been shown to vary seasonally. This seasonal effect on growth in children in nonindustrialized settings is explained in large part by decreased availability of food and family resources for food purchase in preharvest periods, increased burden of infections during rainy seasons, and seasonal employment of mothers in the fields.[2-4] A clinical nutrition surveillance program conducted from 1989 to 1992 in the Pediatric Emergency Room at Boston City Hospital (BCH) serendipitously provided data used to address the issue of seasonal variability in nutritional status among young children in an urban area of the United States.

BCH serves a low-income, multiethnic, inner-city population. The goals of the BCH nutrition surveillance program were to design programs linking screening and clinical care for children at nutritional risk. We examined monthly anthropometric data collected over a three-year period by the nutrition surveillance team. Using these data, we were able to: *(a)* assess the impact of season of measurement on the prevalence of low weight-for-age and (*b*) explore demographic and medical factors that may be associated with low weight-for-age in an emergency room setting.

Methods

Sample selection. The sample consists of children ages 6 to 24 months who visited the Boston City Hospital Pediatric Emergency Room between July 1, 1989, and June 30, 1992. Resources limited our ability to review records and arrange clinical follow-up for children of all ages and early pilot data suggested that 6 to 24 months was the peak period for nutritional risk in our population, so we targeted this age group for the study.

Data collection. As part of a the emergency department clinical routine, triage nurses weighed all children presenting to the emergency room who were at least 6 months and less than or equal to 24 months and who were not so acutely ill or injured that they could not be measured. The children were weighed to the nearest 0.01 kg, wearing minimal clothing, using a Scale-Tronix 4800 digital pediatric scale. The scale is calibrated annually in June by the Department of Weights and Measures of the City of Boston. Each day during the study, Pediatric Nutrition Surveillance personnel reviewed the emergency room records of the previous 24 hours and entered the child's gender, date of birth, and weight into the Centers for Disease Control (CDC) anthropometric software program (CASP),[5] which provides percentiles and z-scores (standard deviation units from the mean) for weight-for-age based on the National Center for Health Statistics (NCHS) standards.[6] Because of time constraints, the emergency room triage staff could not systematically obtain lengths on all children, while weight-for-age data are available for the full sample.

In addition to gender and date of birth, the child's ethnicity and health insurance status were abstracted from the emergency department record by the Pediatric Nutrition

Table 2. Diagnoses recorded for randomized subsample of emergency room visits, December 1990 to June 1992 (*N*=1569)

Diagnosis category	Percent
Otitis, sinusitis/tonsillitis/ stomatitis/pharyngitis	37.4
Other infections	34.2
Asthma/bronchiolitis/ reactive airway disease	11.7
Trauma/ingestion/burn	11.2
Vomiting/diarrhea/gastroenteritis	11.1
Minor, nonsystemic infections	10.4
Miscellaneous	9.6
Pneumonia/meningitis/cellulitis/ sepsis/urinary tract infection	3.8
Constipation/colic/minor gastrointestinal complaints	1.3
Sickle cell anemia	1.2
Medical clearance for Department of Social Services	0.5
HIV seropositive	0.4
Not seen (left before being seen or visit not approved by health insurer)	0.8

NOTE: Each visit is coded with up to three diagnoses, so the sum is greater than 100%.

Surveillance staff. As shown in Table 1, our sample reflects the largely minority, medically indigent population receiving health care at BCH. Birth weight, gestational age, and prior medical history data were not consistently available since only the children's emergency department records could be reviewed. From this emergency department record, we coded dehydration as present or absent for each child who was weighed.

Diagnoses other than dehydration were documented and analyzed on a randomly selected subsample in the latter years of the survey. Each month from October 1990 through June 1992, five to seven 24-hour days were randomly selected (with each weekday represented at least once). During these 24-hour periods, research staff recorded diagnoses for each child seen in the emergency room. Up to three diagnoses were coded for each child. These diagnoses were coded into 13 diagnostic groupings (Table 2) that were then entered into the computerized database.

The mean daily temperature by month and year for the city of Boston were ascertained from the local records of the National Weather Service Bureau at Logan Airport.

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Questionnaire. While the large surveillance project was underway, we also administered a questionnaire[7,8] to a convenience sample of 269 families with children under three years of age visiting the BCH Pediatric Emergency Room in March and April 1992. The questionnaire was developed to assess the unmet need for multidisciplinary services for children at risk for undernutrition and to determine the relationship between service utilization, medical and nutritional status, and food insecurity, as defined by the Community Childhood Hunger Identification Project questionnaire.[9] The Project defines food insecurity as existing "whenever the availability of nutritionally adequate, safe food...is limited or uncertain."[9] Our findings with regard to housing subsidies and access to community nutrition services have been published elsewhere.[7,8]

Data analysis. To investigate the relationship between season of measurement and the likelihood of weight-for-age below the fifth percentile based on the NCHS standards, we performed chi-square tests for each year that data were collected. In addition, to obtain a summary estimate over the three years, we calculated the Mantel-Haenszel odds ratio and the corresponding chi-square statistic to adjust for potential confounding by year of data collection. Other potential confounders were evaluated in a similar manner in bivariate analyses. To control for all potential confounders simultaneously, logistic regression was employed, with the likelihood of weight-for-age below the fifth percentile as the dependent measure and season of measurement, year of data collection, and other potential confounders as the independent measures.

Results

Children 6 to 24 months of age made 13,236 visits to the BCH Pediatric Emergency Room during the three-year study period. For children with multiple visits in the same month, we selected for analysis the visit with the lowest weight-for-age z-score since we considered this the indicator of maximal health risk. After duplicate visits within any single month were excluded, 11,401 visits remained for analysis. We dropped 263 visits from the analysis because children were not weighed. As recommended by the Centers for Disease Control,[5] a further 20 visits were dropped because of weight-for-age values more than six standard deviations above or below the mean. These figures were considered a priori to represent measurement errors. Thus, the final sample consisted of 11,118 emergency room visits. Of these, 1569 visits fell on the randomly selected days during which diagnoses were recorded.

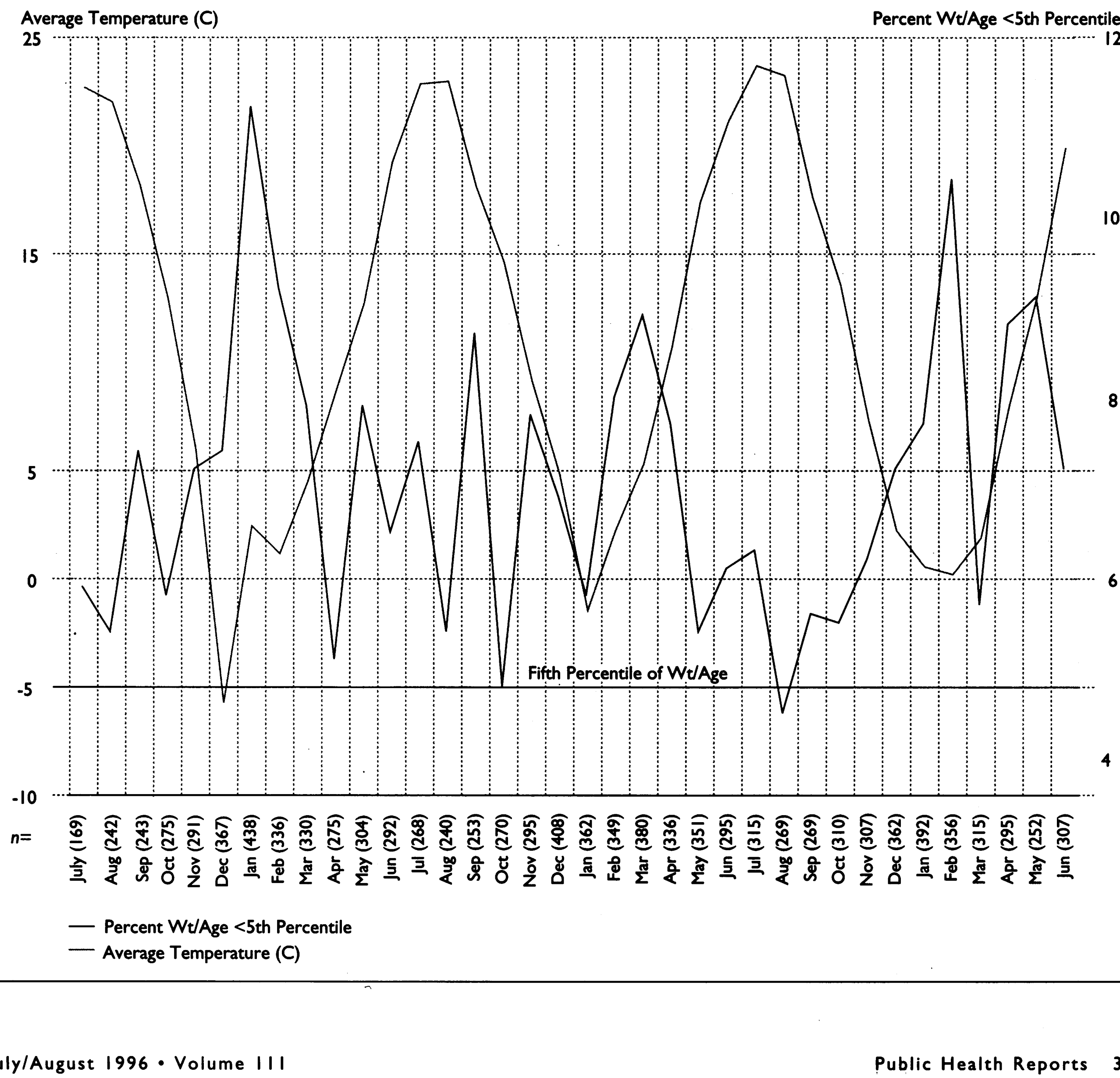
Weight-for-age and season of measurement. As the Figure shows, when point prevalence of weight-for-age was plotted month by month, an unexpected pattern emerged. With approximately one month's lag time, an increase in the prevalence of low weight-for-age followed a drop in temperature. December 1989 was the coldest month in the first study year (the mean daily temperature was 21.7°F [-5.73°C]). For the first study year (July 1989 to June 1990), the average prevalence of low weight-for-age for the three months following the coldest month was significantly higher than the average for the remaining months of the year (9.6% versus 6.6%, P=0.002).

As shown in the Figure, January was the coldest month in the second and third study years. (The mean daily temperature in January 1991 was 29.4°F [-1.45°C], and the mean daily temperature in January 1992 was 31.0°F [-0.56°C].) Although the minimum temperature was higher in the second and third years, the same time-lagged effect was seen. In spite of a peak in September 1990, the second-year prevalence of low weight-for-age was also higher in February, March, and April, the three months following the coldest month, than in all other months (8.3% versus 6.5%, P=0.049). A similar trend was found in the third year (8.4% versus 6.6%, P=0.064).

When data for all three years were combined and evaluated simultaneously using the Mantel-Haenszel odds ratio and corresponding chi-square statistic to adjust for year of measurement, this pattern was robust. The percentage of children visiting the emergency room with weight-for-age below the fifth percentile was significantly higher in the three months following the coldest month than in all others, adjusting for year of measurement (8.8% versus 6.6%, P<.001). Over the three years of data collection, the risk of a child falling below the fifth percentile in weight-for-age was 1.369 times greater in the three months following the coldest months than in the remaining months of the year, adjusting for year of measurement (95% CI, 1.176 to 1.594). There was no such effect on rates of weight-for-age above the 95th percentile adjusted for year of measurement (8.2% versus 8.9%, P=0.255).

Potentially confounding demographic variables. Gender and ethnicity did not correlate with weight-for-age. Children who were insured by Medicaid were significantly more likely than others to have a weight-for-age below the fifth percentile (8.1% versus 5.4%, P<0.001). Children younger than 18 months were more likely than those 18 to 24

Figure. Seasonal temperature variation 7/89–6/92 and low weight-for-age (N=11,118)



months to fall below the fifth percentile in weight-for-age (7.9% versus 5.3%, $P<0.001$). However, there were no seasonal differences in age or health insurance coverage between children who visited the emergency room during the three months following the coldest months and those who were seen during the rest of the year.

Potentially confounding medical variables. We reviewed the diagnoses recorded during 1569 randomly selected emergency room visits made by children ages 6 to 24 months between December 1990 and June 1992 to assess whether the children with low weight-for-age were suffering from sickle cell anemia or HIV, the two most common chronic growth-retarding illnesses treated at our hospital, or other illnesses. The demographic characteristics and rate of weight-for-age below the fifth percentile (7.2%) for this subsample were identical to that of the larger sample of 11,118. Of the 1569 visits, 19 were made by children diagnosed with sickle cell anemia and six by children diagnosed as HIV-seropositive.

In the subsample, only 4.3% of the children with weight-for-age below the fifth percentile were diagnosed with sickle cell anemia, while only 1.7% were diagnosed as HIV-seropositive. Children with sickle cell anemia or HIV did not show any seasonal pattern in their emergency room visits. Of the 14 diagnostic categories summarized in Table 2, only asthma/reactive airway disease/bronchiolitis and vomiting/diarrhea/gastroenteritis showed seasonal variability, both being more prevalent in the subsample during the three months following the coldest month than at other times of year. However, the asthma/reactive airway disease/bronchiolitis category was not significantly correlated with low weight-for-age. In contrast, the diagnostic category of vomiting/diarrhea/gastroenteritis was more prevalent in the months following the coldest months (14.4% versus 8.4%, $P<0.001$). This diagnostic category was also related to an increased prevalence of low weight-for-age (14.9% versus 6.4%, $P<0.001$) in the subsample.

The finding that vomiting/diarrhea/gastroenteritis was associated with both season and low weight-for-age in the subsample of 1569 children for whom detailed diagnoses were available led us to assess the effect of dehydration on weight-for-age in the entire sample. Only 3.3% of the children with weight-for-age below the fifth percentile were clinically diagnosed as dehydrated by the emergency room staff. When those children noted to be dehydrated were excluded, the prevalence of low weight-for-age remained significantly greater in the three months following the coldest months than in the remaining months (8.5% versus 6.4%, $P<0.001$).

Multivariate analyses. We performed logistic regression analyses to assess the effect of measurement period when potentially confounding variables were controlled statistically. Controlling for diagnosed dehydration and year of measurement did not substantially alter the increased risk of a child experiencing weight-for-age less than the fifth percentile in the three months following the coldest months (OR 1.33, 95% CI, 1.14 to 1.55). When period of measurement and dehydration were included in the analysis, no demographic variable was a significant predictor of a child experiencing weight-for-age less than the fifth percentile.

Questionnaire results. Findings from the questionnaire administered to a convenience sample of 269 families with children three years old and younger visiting the emergency room in March and April 1992 suggest that the population screened and surveyed was under economic stress, with widespread food insecurity. The ethnicity, child gender, and payment status of this sample, which have been published elsewhere[7,8] were virtually identical to those of the larger sample of 11,118 children. Not every respondent to the questionnaire answered every question. Forty-eight of 250 (19%) reported at least one day without heat in the previous three winter months, and 71 of 249 (28%) stated that they had been threatened with a utility turnoff. Those who reported being without heat were significantly more likely than other parents to report that their children were "hungry" or "at risk for hunger" (50% versus 28%, $P=0.002$), according to the criteria of the Community Childhood Hunger Identification Project.[9] Similarly, the children whose families had been threatened with a utility turnoff were more likely to be classified as "hungry" or "at risk of hunger" than children of other families (49% versus 25%, $P=0.001$).

Discussion

While surveillance data can not be used to establish unequivocal associations among risk factors and poor nutritional outcomes, convenience samples and case series such as this one can legitimately be evaluated to generate hypotheses regarding possible epidemiological relationships.[10] Our design assessed a self-referred sample of children at high health risk at a single site, on whom only limited anthropometric and medical information was available. Medical diagnoses were available on only a relatively small, randomly selected subsample, without sufficient statistical power to assess the effect of each diagnosis on weight-for-age after controlling for covariates. However, the data from this subsample suggest that the increased prevalence of low weight-for-age in this population of emergency room users is not merely an artifact of chronic illness. We do not have the data needed to address the possible contribution of prematurity and low birth weight to our findings. Since low birth weight's effects on growth parameters begins to attenuate after six to nine months of age[11,12] and there are no data to suggest that prematurity and low birth weight are seasonal in urban America—whatever their prevalence in this emergency room sample—these factors could not explain seasonal variability in low weight-for-age. Further, there were no seasonal shifts in the demographic characteristics of children visiting the emergency room that could explain our findings.

Dehydration, which was noted on the record of only 3.3% of our sample of 11,118, may have been underidentified in the clinical record. However, assuming dehydration was present in more children than documented does not alter the interpretation of our findings regarding seasonal effects. Those with marginal nutritional status whose baseline weights are lowest are most likely to present below the fifth percentile following even minimal fluid losses. Dehydration is not a pure confounder but often a concomitant of malnutrition. Poorly nourished children are more susceptible to gastrointestinal illness than well nourished children. In addition, marasmic children may clinically appear dehydrated when they are not.[13]

We conclude that winter and early spring, particularly the three months following the coldest month, may be a period of increased risk for low weight-for-age among low-income children ages 6 to 24 months in the northeast region of the United States. We did not find a corresponding increase in the prevalence of high weight-for-age in this interval, in contrast to findings previously reported for school-age children.[1]

Not all observations of increased rates of low weight-for-age in this sample occurred in the three months following the coldest months. In September 1990, for example, there was also an unexpectedly high prevalence of low weight-for-age, which was not seen in either August or October of that year. Since we were not documenting diagnoses at that time, we do not have an obvious explanation, such as an unusual infectious disease outbreak. However, it is only in the three months after the coldest month that we found increased rates of low weight-for-age sustained over three consecutive subsequent months, a pattern that was consistent year after year.

Further research will be needed to assess whether these findings can be replicated in more nationally representative samples. Future studies should also look at height-for-age and weight-for-height as well as weight-for-age to delineate possible seasonal patterns in indicators of both chronic and acute malnutrition.

Our data do not provide conclusive information about the mechanisms of this seasonal change in the prevalence of young children at nutritional risk. The increased prevalence of low weight-for-age in winter and early spring may reflect increased caloric demand produced by cold stress and acute infections,[14] particularly gastrointestinal infections. This phenomenon may be influenced by the availability of resources not traditionally considered health-related. Our questionnaire data suggest decreased caloric availability because of the increased economic stress imposed by high heating costs. The proximate causes of seasonal variation in undernutrition among low-income children in the United States may be analogous to those previously described in the developing world—infectious disease and insufficient food. In the urban northeastern United States, food availability for poor families may fluctuate not with harvest cycles but with families' economic resources. If proposed funding cuts in child nutrition services and the Low Income Home Energy Assistance Program are implemented,[15] prospective public health surveillance of large community-based pediatric samples will be essential to rule out unanticipated negative effects on the nutritional status of low-income children of this possible "heat or eat" effect.

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