# Household Food Security Status Is Associated with Anemia Risk at Age 18 Months among Low-Income Infants in Massachusetts

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**ABSTRACT**

**Background** Food insecurity and anemia are prevalent among low-income families and infants. Anemia may reflect iron deficiency anemia (IDA) risk. IDA in infancy and early childhood may have long-lasting developmental effects. Few studies have examined food security status (FSS) as a risk factor for anemia.

**Objective** To examine the association between household FSS, sociodemographic and health-related variables, and anemia incidence at age 18 months among low-income infants in the Massachusetts Special Supplemental Nutrition Program for Women, Infants, and Children (MA/WIC).

**Study design** This was a longitudinal study using data from MA/WIC (August 2001 to November 2009) to assess the relationship between household FSS during the 12 months preceding the 1-year visit (age 9 to 15 months) and anemia at age 18 months.

**Participants/settings** Infants included were not anemic at age 12 months and had complete data on household FSS and the following covariates (N=17,831): race/Hispanic ethnicity, maternal education, breastfeeding duration, household size, and child age.

**Statistical analyses performed** Multiple logistic regression was used to examine the association between household FSS during the prior 12 months and anemia at 18 months, controlling for infant age, sex, and race/Hispanic ethnicity, breastfeeding, maternal education, and household size.

**Results** A majority of infants (56%) were nonwhite, and 19.9% lived in food-insecure households (4.8% in very-low food security). Of the infants who were not anemic at age 12 months, 11.7% became anemic by age 18 months. Infants living in low-food-secure households were 42% more likely (adjusted odds ratio 1.42, 95% CI, 1.27-1.60) to develop anemia at age 18 months than were their food-secure counterparts. Nonwhite race, higher household size, and lower maternal education were also associated with an elevated risk of anemia at age 18 months.

**Conclusions** Low food security appears to be associated with a significant increased risk of anemia, as do nonwhite ethnicity, lower maternal education, and larger household size. Knowledge of these risk factors can be used to design IDA-prevention interventions in this vulnerable population.
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IRON DEFICIENCY ANEMIA (IDA) IS A NUTRITION PROBlem that occurs most frequently in infants and children between the ages of 9 and 18 months, resulting in both long- and short-term negative effects on attention,[1] behavior and memory,[2,3] socioemotional development,[4] and mother–child interactions.[5] Declines in the national prevalence of IDA among toddlers (aged 1 to 2 years) has been documented through 1999-2000 using the National Health and Nutrition Examination Survey,[6] but among preschool-aged children it was fairly stable.[7] Some of the decline has been attributed to public health efforts to promote iron supplementation during pregnancy, iron-fortified formula for infants, and iron-fortified cereal to all vulnerable groups[7]; however, based on anemia prevalence as an estimate of risk of IDA, it is still fairly common among low-income children.[8] In 2010, it was estimated that 12% of low-income children aged 1 to 2 years had anemia based on the Pediatric Nutrition Surveillance System, which screens using either hemoglobin or hematocrit level.[9] One issue in the tracking of IDA prevalence in low-income populations is the fact that the large surveillance systems of these low-income populations, use hemoglobin or hematocrit level for

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screening; these can only identify anemia and not specifically IDA.[10] The National Health and Nutrition Examination Survey uses several indicators of iron status; however, it is not in a low-income population.[11] This is a distinction that is important, and without the additional biochemical indicators of IDA (ie, transferrin saturation, erythrocyte protoporphyrin level, and ferritin level), it is impossible to determine iron deficiency as the cause of anemia. However, IDA is the leading cause of anemia globally,[12] and public health programs nationally and internationally have used the indictors of hemoglobin and hematocrit as a screening tool to reflect IDA risk.[13] This includes the Pregnancy and Pediatric Surveillance Systems and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). It is important to note that those with anemia are at higher risk for IDA.[14]

WIC, a federal nutrition assistance program for low-income women and children, targets the reduction of childhood IDA by regularly screening for anemia, promoting iron-rich and vitamin C–rich foods, and counseling families about the importance of breastfeeding (or providing iron-fortified formula in the absence of breastmilk) for infants younger than age 12 months. WIC participation has been associated with reduced risk of childhood anemia.[15,16] However, nationally, among 1-year-old children who participated in WIC in 2012, 14.6% were anemic.[17] Given the detrimental consequences of even mild IDA, and the fact that anemia is a risk factor for IDA, it is important to assess the underlying social and demographic correlates that attenuate WIC's influence on anemia to provide insight as to why anemia prevalence in this population is not on par with more affluent populations.

Food insecurity could affect nutritional quality of the diet[18] and is strongly associated with income. In 2014, 14% of all households reported being food insecure (5.6% reported very-low food security); however, among households reporting incomes below the poverty level, about 39.5% of households were food insecure.[19] WIC serves low-income women, infants, and children, which is why it is likely that the prevalence of food insecurity will be elevated. Two studies have found that household or child food insecurity significantly increased the risk of IDA in young, low-income children.[15,20] One study did not find an association between food insecurity and IDA risk; however, it examined associations among children aged 3 to 5 years in the general population.[11] These existing studies relied on cross-sectional data; therefore, prevalence rather than incidence of IDA was examined. Our study uses a longitudinal design to examine the association between household food security status (FSS) during the prior 12-month period and the development of anemia at age 18 months among low-income infants participating in the Massachusetts WIC program (MA/WIC). The study hypothesized that those children living in households that report food insecurity during the year before the age 18 months WIC visit would be more likely to develop anemia than those whose households were food secure.

## METHODS

### Study Design and Sample

This longitudinal study used data (August 2001 to November 2009) from MA/WIC, which represents the entire WIC population in Massachusetts during this time period. These program data were used to examine the relationship between the development of anemia between ages 12 and 18 months and household FSS during the preceding 12 months. The sample consisted of all infants who were full term, not low birth weight, enrolled in WIC until at least age 15 months, had a WIC visit between ages 15 and 21 months, whose mother was also enrolled in WIC during pregnancy or postpartum, and who were not anemic (hemoglobin $>$11.0 g/dL) at age 12$\pm$3 months (N=32,968).

Of those in the study sample, 12,179 did not have a hemoglobin measurement at age 18$\pm$3 months, 1,798 were missing household FSS information, and 3,364 did not have complete covariate data. This yielded an analytic sample of 17,831 infants. Infants who were not anemic at age 12 months were selected for this analysis to examine development of anemia in relation to household FSS. Blood measures were not generally available at age 6 months. Moreover, when a child is anemic at age 12 months, there is likely to be some intervention so the outcome at age 18 months would be influenced by any such intervention. For these two reasons, the sample was limited to those who were not anemic at age 12 months to examine anemia development or incidence. It should be noted that infants with anemia at age 12 months (n=4,427) comprised 19.9% of the sample that met all the other criteria for inclusion (N=22,258).

Because household FSS refers to the prior 12-month period (ie, child age approximately 6 to 18 months), a second analyses of those infants whose households were food secure at their 12-month visit (using their 12-month assessment) was also conducted; thus, any food insecurity that would have developed would have done so between the 12- and 18-month visits, which is during the same time period as the anemia development. Those children born preterm or with low birth weight were excluded from the analyses because they may have lower iron stores and are at higher risk of developing IDA.[21] Moreover, food insecurity has been shown to be associated with risk of preterm or low birth weight[22]; thus, including these infants could confound the relationship between household FSS and anemia risk. Those who were Native American or Pacific Islander were also excluded because there were very few children (n=25), making adjustment for this race/ethnicity classification difficult. The study protocol was reviewed and approved by the Institutional Review Board for the Massachusetts Department of Public Health; it was also reviewed by the Simmons College Institutional Review Board and deemed exempt.

### Household FSS

A unique feature of MA/WIC is that it has assessed household FSS for all participants every 6 months since its implementation in 1999, when it received funding for a Centers for Disease Control and Prevention (CDC) demonstration project. Household FSS is based on parent/caregiver responses to a 4-question subscale of the 18-question Food Security Module developed by US Department of Agriculture (USDA) and inquires about the prior 12-month period.[23] This 4-question subscale was developed by USDA and CDC and was implemented in MA/WIC before the development of the current 6-item subscale that is widely used with the Food Security Module.[24]

The individual items and coding scheme for the 4-item subscale have been described in detail elsewhere.[23] Briefly, the four items in the subscale address the following aspects of household FSS: not having enough money to buy food for a balanced meal, adults cutting the size of or skipping meals, adults' frequency of cutting or skipping meals, and adults not eating for a whole day. Household FSS was determined by the number of positive (yes or frequently true) responses to the questions.[25] This 4-question subscale was compared with the 18-question survey in households with children with incomes <185% of the poverty level. Compared with the full 18-item scale, the 4-item scale had a sensitivity of 79%, a specificity of 97%, and a positive predictive value of 92%.[23] Based on the responses to the food security questions, household FSS was categorized as food secure, low food security, or very-low food security. For this study, household FSS data collected when the child was aged 18±3 months were used.

### Anemia Status

IDA is most common among infants and children between ages 6 months and 3 years due to the rapid growth that occurs during infancy and early childhood. Iron stores of full-term infants are adequate to meet an infant's needs up to age 6 months; therefore, depletion leading to IDA does not usually occur until age 9 months. This puts infants aged 9 to 18 months at particular risk.[14] WIC requires that infants and children be screened once for anemia between ages 9 and 12 months and once between ages 12 and 24 months.[26] Between ages 24 and 60 months screening is required annually, with a 6-month follow-up test after a low hemoglobin or hematocrit result.

Infancy screening is frequently done by the infant's pediatrician and reported to the WIC office on a Medical Referral Form, but may also be performed by WIC staff members who have the required training and oversight.[27] In cases where it is done at a doctor's office, it is either based on a venipuncture or capillary blood. In cases where it is done at the WIC program site, capillary blood via a finger prick is assessed using a HemoCue America analyzer. Based on research that indicated a nonlinear relationship between hemoglobin and hematocrit in this population,[28] hematocrit was not used. Test results at age 12±3 months and age 18±3 months were used. Anemia was defined as hemoglobin <11.0 g/dL.[8]

### Statistical Analysis

Multiple logistic regression was performed using SAS version 9.3[29] to examine the association between household FSS during the prior 12-month period and anemia status at age 18 months, controlling for the following covariates: exact age at the 18-month WIC visit, child's sex and race/Hispanic ethnicity, breastfeeding duration status (never, <3 months, 3 to <6 months, or ≥6 months), maternal education, and household size. Covariates examined, but not included in final model were birth weight, postpartum Supplemental Nutrition Assistance Program participation, and weight and length growth. These did not change the associations between household FSS and risk of anemia development nor were they directly related to anemia risk.

## RESULTS

The study sample included 17,831 infants who were not anemic at age 12 months. Fifty-six percent were nonwhite (Table 1). Almost 70% of infants were breastfed, with about 31% breastfed for at least 3 months. A majority (66.9%) of their mothers had at least a high school education. About 20% of infants lived in households that were food insecure over the prior 12-month period; 4.8% lived in households with very-low food security. Of this nonanemic cohort of infants, 11.7% became anemic by age 18 months.

Infants living in households reporting low food security were 42% more likely (adjusted odds ratio [aOR] 1.42, 95% CI 1.27 to 1.60) to develop anemia by age 18 months compared with those living in food-secure households (Table 2). No association was found with very-low food security. Similarly,

**Table 1.** Sociodemographic and hematologic characteristics of infants at age 18 months who were not anemic at age 12 months and were participating in the Massachusetts Special Supplemental Nutrition Program for Women, Infants, and Children (MA/WIC) between 2001 and 2009 (N=17,831)

| Characteristic | Result |
|---|---|
| | *Mean±standard error* |
| **Age at 18-mo visit (mo)** | 18.4±0.01 |
| **Household size** | 4.0±0.01 |
| **18-mo hemoglobin (g/dL)** | 12.0±0.01 |
| | *%* |
| **Race/ethnicity** | |
| Non-Hispanic white | 44.1 |
| Non-Hispanic black | 16.5 |
| Hispanic | 34.9 |
| Asian | 4.4 |
| **Female** | 49.2 |
| **Education of mother** | |
| Less than high school | 33.2 |
| High school | 46.6 |
| Some college | 20.3 |
| **Breastfeeding duration** | |
| Never breastfed | 30.3 |
| <3 mo | 39.4 |
| 3-<6 mo | 9.9 |
| ≥6 mo | 20.4 |
| **Household food security at age 18 mo**[a] | |
| Food secure | 80.1 |
| Low food security | 15.1 |
| Very-low food security | 4.8 |
| **Anemic at age 18 mo**[b] | 11.7 |

[a]Household food security status is based on parent/caregiver responses to a four-question subscale of the 18-question Food Security Module developed by US Department of Agriculture and inquires about the prior 12-month period.[14]
[b]Anemia at age 18 months is defined as hemoglobin <11.0 g/dL.[8]

**Table 2.** Predictors of anemia at age 18 months among infants not anemic at age 12 months who were participating in the Massachusetts Special Supplemental Nutrition Program for Women, Infants, and Children (MA/WIC) between 2001 and 2009 (N=17,831)

| Variable | Risk of anemia at age 18 mo |
|---|---|
| | *Adjusted odds ratio (95% CI)* |
| **Household food security**[a] | |
| Low food security vs food secure | 1.42 (1.27-1.60)*** |
| Very-low food security vs food secure | 0.79 (0.62-1.01) |
| **Sociodemographic and breastfeeding variables** | |
| **Age at 18-mo visit (mo)** | 1.02 (0.96-1.08) |
| **Female vs male** | 0.97 (0.88-1.06) |
| **Race/ethnicity** | |
| Non-Hispanic black vs non-Hispanic white | 1.76 (1.55-2.00)*** |
| Hispanic vs non-Hispanic white | 1.32 (1.18-1.48)*** |
| Asian vs non-Hispanic white | 1.39 (1.12-1.73)** |
| **Education of mother** | |
| High school vs some college | 1.19 (1.05-1.35)** |
| Less than high school vs some college | 1.25 (1.09-1.44)** |
| Household size | 1.05 (1.01-1.08)* |
| **Breastfeeding duration** | |
| Never breastfed vs ≥6 mo | 1.08 (0.94-1.24) |
| <3 mo vs ≥6 mo | 1.09 (0.96-1.24) |
| 3-<6 mo vs ≥6 mo | 0.98 (0.81-1.17) |

[a]Household food security status is based on parent/caregiver responses to a four-question subscale of the 18-question Food Security Module developed by US Department of Agriculture and inquires about the prior 12-month period in children aged 18 months.[14]

*Indicates statistical significance ($P<0.05$).

**Indicates statistical significance ($P<0.01$).

***Indicates statistical significance ($P<0.001$).

when the sample was limited to those nonanemic infants living in households that were food secure when they were age 12 months (n=11,076), low food security at age 18 months was associated with a 33% higher risk (data not shown) of anemia compared with food-secure households (aOR 1.33, 95% CI 1.11 to 1.58). There was no association (data not shown) between very-low food security and anemia development in this subgroup analysis (aOR 0.71, 95% CI 0.46 to 1.08).

Other predictors of anemia risk included race or ethnicity, household size, and maternal education (Table 2). Compared with non-Hispanic white infants, non-Hispanic black, Hispanic, and Asian infants were 76%, 32%, and 39% more likely, respectively, to develop anemia. A larger household size was associated with an elevated increase in risk of anemia. Infants of mothers with 12 or fewer years of education were 19% to 25% more likely to develop anemia compared with mothers with some college education. Breastfeeding initiation and duration were not associated with risk of anemia at age 18 months.

## DISCUSSION

This is the first longitudinal study to examine the association between food insecurity and anemia incidence in infants. It is also the first study to examine this question among a low-income population being served by WIC. Among the 17,831 infants included in this study, approximately 20% lived in households reporting some food insecurity while the infant was aged 6 to 18 months, and 11.7% of infants who were not anemic at age 12 months developed anemia by age 18 months. Infants living in households reporting low food security were 42% more likely to develop anemia by their 18-month visit compared with those living in food-secure households. No association was found with very-low food security.

These findings are consistent with other research conducted on this age group,[15,20] despite several differences in study design and methodology. Unlike the present study, both of these prior studies specifically examined IDA, although given their cross-sectional designs, their outcomes were IDA prevalence and not incidence. Both of these prior studies were on low-income children; however, unlike the present study, not all of them were WIC participants. These two prior study samples were also composed of a wider age range (<3 years) and were based in urban medical centers. In addition, the study by Park and colleagues[15] used child food security status (a measure of food insecurity that directly reflects the child's status) as the exposure and found that child food insecurity was associated with an elevated risk of IDA. Child food insecurity is an indicator of more severe food insecurity in the household because it is believed that adults buffer the effects of food insecurity on children.[30] Moreover, there is evidence that the sample used in the study by Park and colleagues[15] was also more disadvantaged than the MA/WIC sample because the prevalence of household food insecurity was 36% (compared with about 20% in this sample). The study by Skalicky and colleagues[20] found that very-low (but not low) food security of adults in the household was associated with an elevated risk of IDA among young children. The aforementioned design differences of these two studies may account for the somewhat different findings, being that more severe food insecurity (ie, very low in the study by Skalicky and colleagues[20] and child food security in the study by Park and colleagues[15]) but not less-severe food insecurity (ie, low food security) was associated with an elevated IDA risk.

We were surprised to find that, in the present study, very-low food security was not associated with risk of anemia; in fact, the association trended in the opposite direction. Our results may differ from other studies because all the subjects in our study were infants enrolled in WIC and these families may be receiving support and referrals to additional programs designed to ameliorate food insecurity. Despite these differences between prior research and the present study, the similarity in the results provide support for the contention that food insecurity affects risk of not only anemia but IDA given that about half of those with anemia likely have IDA.[7]

These results are also consistent with a study that included older children (aged 24 to 60 months) and examined changes in household FSS across the course of a month.[31] This study found that a worsening of household FSS was associated with a higher risk of child anemia within 12 months prior to the FSS measurement. Their findings were striking in that an increase in the number of affirmative responses (reflecting worsening food insecurity) across the course of a month was associated with a several-fold increase in risk of anemia compared with those whose household FSS did not change.[31]

All subjects in this study were enrolled in WIC and therefore were already receiving WIC packages designed to prevent anemia. Research has suggested these prevention efforts are successful. Two studies[15,16] reported that participation in WIC was associated with a reduced risk of IDA compared with those who were not WIC participants. This protective effect of WIC suggests that the associations found herein may be attenuated through WIC participation given that WIC increases access to iron-rich foods for infants and children.[32] This implies that among those WIC-eligible families who do not receive WIC benefits, household food insecurity may be associated with an even greater risk of infant anemia.

Low food security is associated with changes in quality of food that could affect the availability of nutrient-dense foods, including those with high bioavailable iron.[30] Research has shown that certain feeding behaviors are associated with higher rates of IDA in children; these include prolonged bottle feeding[33] and excessive intake of milk, both of which have been found to displace iron-rich foods.[8] In addition, a recent study of pregnant women found that women who reported food insecurity were almost 3 times as likely to have iron deficiency based on low serum ferritin level as those who were food secure.[34] Lower maternal iron stores could affect iron stores of the infant, thereby increasing risk of IDA.

Other predictors of anemia risk found herein were race/ethnicity, maternal education, and household size. Compared with non-Hispanic white infants, non-Hispanic black, Hispanic, and Asian infants were more likely to develop anemia. Nationally, among low-income infants and children aged 4 years and younger, non-Hispanic black children had the highest anemia prevalence.[9] Others have also noted race/ethnicity differences, primarily that Hispanic infants were more likely to have IDA.[16,33] The present study also suggests that more educated mothers have infants who are less likely to develop anemia compared with less-educated mothers. This is consistent with a study that found that low maternal education (<9 years) was associated with significantly lower hemoglobin levels among children.[35] Educated mothers may have more knowledge and skill in selecting more nutrient-dense foods and stretching their food dollars to access better-quality food. In addition, we found larger household size is related to a higher risk for anemia. Higher household size may put a strain on family resources, which in turn may increase the risk of anemia by limiting the amount of foods with high iron content and bioavailability, such as pureed meats. Grummer-Strawn and colleagues[36] found that cereal was typically introduced into the infants' diet quite early; however, most infants were not introduced to meat until they were about age 8 months. Because fetal iron stores are typically depleted by 6 months of age, good sources of bioavailable iron need to be among the first solid foods given to infants, and these researchers recommended early introduction of meat to provide the needed iron and zinc.[36]

Overall, breastfeeding was not associated with anemia risk in this study. This is to be expected given the fact that the majority of the infants in this sample ceased breastfeeding by age 6 months and all were on WIC, which provides supplemental foods high in iron. However, when breastfed infants were examined separately, there was a tendency for a protective effect of breastfeeding on anemia development. This is consistent with other research that found that higher breastfeeding durations were associated with higher hemoglobin levels.[28]

The American Academy of Pediatrics recommends universal screening for anemia around age 1 year.[8] CDC guidelines for at-risk populations calls for screening of all children for anemia between ages 9 and 12 months, 6 months later, and annually from ages 2 to 5 years.[14] The results from the present study affirm this schedule because a substantial proportion of children (11.7%) in this low-income WIC sample who were not anemic at age 12 months developed anemia by age 18 months. These results on anemia prevalence at 18 months are consistent with national WIC data that show that 14.2% of infants in the WIC program are anemic at age 12 months and 10.4% at age 24 months.[17]

The strengths of this study include its large longitudinal statewide dataset of low-income children of diverse backgrounds, as well as the ability to assess anemia development over a 6-month period among those who were not anemic at the first measurement. In addition, the household food security questions refer to the 12-month period before the hemoglobin measure, so that the temporal relationship is not in question. One limitation of this study is that hemoglobin is not a highly sensitive indicator of IDA[16,37] and most toddlers in the United States with iron deficiency do not have anemia.[8] In addition, low hemoglobin levels could stem from causes other than low iron stores, such as lead poisoning, sickle cell anemia, and illness, for which data were not available. Nevertheless, food insecurity increases the risk of anemia irrespective of the cause. Moreover, given that hemoglobin is widely used both in the WIC program and in pediatricians' offices to screen for anemia, this is an outcome with clinical relevance.

It is possible that the relationship reported herein is due to factors other than iron deficiency that also affect anemia risk, such as infection, other nutrient deficiencies, lead levels, or hemoglobinopathies. Because this study assessed anemia and not specifically IDA, this is a limitation; however, the fact that other cross-sectional studies have found this association using IDA as an outcome increases the likelihood that iron deficiency may be at least one of its underlying causes. In addition, this sample may not be representative of the entire WIC population of children aged 12 to 24 months, due to the inclusion criteria for this study. A large proportion of children who met the initial eligibility criteria did not have hemoglobin measures at age 18 months. This should not affect internal validity. Two other limitations are likely to have yielded underestimates of this association. First, the fact that anemia represents a later stage of iron deficiency, and second, that program data were used. These data sources have greater random error (ie, deviations from the true value that are random). Greater random error increases the likelihood of not finding a significant association even when one exists (type 2 error). Despite this larger random error, significant findings were still detected. This implies that the associations are actually stronger than those found herein.

## CONCLUSIONS

Anemia appears to develop among a substantial percentage of low-income WIC infants between ages 12 to 18 months. Low food security is a significant risk factor in the development of anemia during this time period. Nonwhite ethnicity, lower maternal education, and larger household size are also associated with greater risk. Knowledge of these risk factors can be used to target interventions to prevent IDA in this vulnerable population.

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