Gestational Iron Deficiency Is Associated with Pica Behaviors in Adolescents1–3

Rachel A. Lumish,4 Sera L. Young,4 Sunmin Lee,4 Elizabeth Cooper,5 Eva Pressman,5 Ronnie Guillet,5 and Kimberly O. Brien4*

4Division of Nutritional Sciences, Cornell University, Ithaca, NY; and 5School of Medicine, University of Rochester, Rochester, NY

Abstract

A relation between pica (the craving and purposive consumption of nonfood items) during pregnancy and anemia is observed frequently. However, few studies related pica behaviors to biomarkers of iron status, and little is known about pica prevalence in U.S. pregnant adolescents. To address this, we undertook a longitudinal study examining iron status and pica behaviors among a group of 158 pregnant adolescents (aged ≤18 y). Approximately two-thirds of the participants were African American and 25% were Hispanic. Maternal iron status indicators [hemoglobin, soluble transferrin receptor, serum ferritin (SF), total body iron (TBI), and serum hepcidin] were assessed during pregnancy (18.5–37.3 wk) and at delivery. Pica behavior was assessed up to 3 times across gestation. Among the 158 adolescents, 46% reported engaging in pica behavior. Substances ingested included ice (37%), starches (8%), powders (4%), and soap (3%). During pregnancy, mean SF [geometric mean: 13.6 μg/L (95% CI: 11.0, 17.0 μg/L)], TBI (mean ± SD: 2.5 ± 4.2 mg/kg), and hepcidin [geometric mean: 19.1 μg/L (95% CI: 16.3, 22.2 μg/L)] concentrations were significantly lower (P < 0.05) in the pica group (n = 72) than values observed among the non-pica group [SF, geometric mean: 21.1 μg/L (95% CI: 18.0, 25.0 μg/L); TBI, mean ± SD: 4.3 ± 3.5 mg/kg; hepcidin, geometric mean: 27.1 μg/L (95%: 23.1, 32.1 μg/L); n = 86]. Although additional studies must address the etiology of these relations, this practice should be screened for, given its association with low iron status and because many of the substances ingested may be harmful. This trial was registered at clinicaltrials.gov as NCT01019902. J. Nutr. 144: 1533–1539, 2014.

Introduction

Pica is a general term referring to the craving and purposive consumption of nonfood items, such as earth (geophagy), raw starch (amylophagy), large quantities of ice (pagophagy), charcoal, ash, and chalk (1). It has been observed for ≥2000 y; the first known description was by Hippocrates in 400 BCE. Pica is most prevalent among pregnant women and young children (2). At points in history, it was classified as an eating disorder, in the same category as bulimia and anorexia (3). Others suggested that pica is an adaptive behavior, with potential benefits including provision of iron and detoxification of harmful dietary components (4).

As early as 30 AD, links were made between pica, pregnancy, and anemia (2). Since then, there were numerous epidemiologic studies in which an association was observed between pregnancy, iron deficiency anemia, and pica (2). Reynolds et al. (5) were the first to demonstrate a direct biochemical relation between pica and iron deficiency anemia in a group of men and women aged 15–78 y, and they were able to reverse pica in this group with iron repletion. Similar pagophagy initiation and cessation were observed in a controlled rat model of iron deficiency anemia, followed by iron repletion (6). However, most of the human studies that since examined this association classified individuals as anemic or non-anemic, using only hemoglobin or hematocrit concentrations. In addition, the majority of studies on this topic are cross-sectional, making it impossible to determine whether pica contributes to iron deficiency or whether iron deficiency is a causal factor in the development of pica (7–10).

Although the etiology of the elevated incidence of pica during pregnancy is not currently understood, 1 of the most common hypotheses is that pica is driven by an underlying nutrient deficiency (1). During pregnancy, nutritional requirements increase to support fetal and placental growth. Therefore, pregnant women are at an increased risk of nutrient deficiencies, particularly iron deficiency (11,12). Recent data from the NHANES 1999–2006 (n = 1171) suggested that 18.0% of U.S. pregnant women were iron deficient [total body iron (TBI) ≤ 0 mg/kg] (13). Similarly, adolescence is a time of higher risk for iron deficiency anemia, following by iron repletion (6).
nutrient requirements in support of adolescent growth (14). Approximately 9% of female adolescents aged 12–15 y and 11% of females aged ≥16 y who participated in the NHANES 1988–1994 were found to be iron deficient (15). This suggests that the pregnant adolescent population is particularly vulnerable to nutrient deficiencies and, therefore, under this hypothesis, might exhibit pica behavior. Few papers were published on pica behaviors among U.S. adolescents, and the majority of these reports are case studies, limiting the generalizability of these findings (16–26). To our knowledge, no studies focused on the pregnant adolescent population.

Therefore, to assess the magnitude and determinants of pica behavior in this high-risk population and its possible association with iron status, a longitudinal cohort study was undertaken in a cohort of healthy, racially diverse, urban pregnant adolescents.

**Participants and Methods**

**Population.** Pica behavior was evaluated in a cohort of 158 pregnant adolescents (aged ≥18 y) who were recruited from the Rochester Adolescent Maternity Program clinic in Rochester, New York (2006–2009). Adolescents were enrolled into 2 studies examining maternal and fetal bone health and iron status across pregnancy. Data on vitamin D and other nutrients in support of adolescent growth (14). Approximately 9% of female adolescents aged 12–15 y and 11% of females aged ≥16 y who participated in the NHANES 1988–1994 were found to be iron deficient (15). This suggests that the pregnant adolescent population is particularly vulnerable to nutrient deficiencies and, therefore, under this hypothesis, might exhibit pica behavior. Few papers were published on pica behaviors among U.S. adolescents, and the majority of these reports are case studies, limiting the generalizability of these findings (16–26). To our knowledge, no studies focused on the pregnant adolescent population.

Therefore, to assess the magnitude and determinants of pica behavior in this high-risk population and its possible association with iron status, a longitudinal cohort study was undertaken in a cohort of healthy, racially diverse, urban pregnant adolescents.

**Participants and Methods**

**Population.** Pica behavior was evaluated in a cohort of 158 pregnant adolescents (aged ≥18 y) who were recruited from the Rochester Adolescent Maternity Program clinic in Rochester, New York (2006–2009). Adolescents were enrolled into 2 studies examining maternal and fetal bone health and iron status across pregnancy. Data on vitamin D and other nutrients in support of adolescent growth (14). Approximately 9% of female adolescents aged 12–15 y and 11% of females aged ≥16 y who participated in the NHANES 1988–1994 were found to be iron deficient (15). This suggests that the pregnant adolescent population is particularly vulnerable to nutrient deficiencies and, therefore, under this hypothesis, might exhibit pica behavior. Few papers were published on pica behaviors among U.S. adolescents, and the majority of these reports are case studies, limiting the generalizability of these findings (16–26). To our knowledge, no studies focused on the pregnant adolescent population.

Therefore, to assess the magnitude and determinants of pica behavior in this high-risk population and its possible association with iron status, a longitudinal cohort study was undertaken in a cohort of healthy, racially diverse, urban pregnant adolescents.

**Participants and Methods**

**Population.** Pica behavior was evaluated in a cohort of 158 pregnant adolescents (aged ≥18 y) who were recruited from the Rochester Adolescent Maternity Program clinic in Rochester, New York (2006–2009). Adolescents were enrolled into 2 studies examining maternal and fetal bone health and iron status across pregnancy. Data on vitamin D and other nutrients in support of adolescent growth (14). Approximately 9% of female adolescents aged 12–15 y and 11% of females aged ≥16 y who participated in the NHANES 1988–1994 were found to be iron deficient (15). This suggests that the pregnant adolescent population is particularly vulnerable to nutrient deficiencies and, therefore, under this hypothesis, might exhibit pica behavior. Few papers were published on pica behaviors among U.S. adolescents, and the majority of these reports are case studies, limiting the generalizability of these findings (16–26). To our knowledge, no studies focused on the pregnant adolescent population.

Therefore, to assess the magnitude and determinants of pica behavior in this high-risk population and its possible association with iron status, a longitudinal cohort study was undertaken in a cohort of healthy, racially diverse, urban pregnant adolescents.

**Participants and Methods**

**Population.** Pica behavior was evaluated in a cohort of 158 pregnant adolescents (aged ≥18 y) who were recruited from the Rochester Adolescent Maternity Program clinic in Rochester, New York (2006–2009). Adolescents were enrolled into 2 studies examining maternal and fetal bone health and iron status across pregnancy. Data on vitamin D and other nutrients in support of adolescent growth (14). Approximately 9% of female adolescents aged 12–15 y and 11% of females aged ≥16 y who participated in the NHANES 1988–1994 were found to be iron deficient (15). This suggests that the pregnant adolescent population is particularly vulnerable to nutrient deficiencies and, therefore, under this hypothesis, might exhibit pica behavior. Few papers were published on pica behaviors among U.S. adolescents, and the majority of these reports are case studies, limiting the generalizability of these findings (16–26). To our knowledge, no studies focused on the pregnant adolescent population.

Therefore, to assess the magnitude and determinants of pica behavior in this high-risk population and its possible association with iron status, a longitudinal cohort study was undertaken in a cohort of healthy, racially diverse, urban pregnant adolescents.

Participants attended up to 3 study visits over the course of gestation timed roughly to correspond to early (12–16 wk), middle (21–25 wk), and late (31–35 wk) gestation. Of the 158 participants, 4.5% attended only 1 study visit, 28.8% were seen twice, and 66.7% attended all 3 study visits. At entry into the study, adolescents completed a health survey and self-reported information about their sociodemographic background, medical history, current medications, and cigarette, alcohol, and drug use, as reported previously (34). All of the adolescents were given either standard daily prenatal supplements, containing 27 mg of iron, or if they were unable to tolerate these supplements, additional iron supplements, as reported previously (34). At each study visit, dietary iron intake was assessed using 24-h recalls conducted by a health project coordinator. Blood samples were obtained both during pregnancy and at admission into the hospital for delivery in 122 of the 158 adolescents with pica data (77%). In the remaining group, a blood sample was obtained only during pregnancy in 25 adolescents (16%) and only at delivery in 8 adolescents (5%). Three adolescents (2%) did not provide any blood samples. Hematologic data on hemoglobin and hematocrit concentrations, which were obtained as part of standard prenatal care, were abstracted from each adolescent’s medical chart.

**Pica behavior assessment.** At each study visit, the health project coordinator asked the adolescents whether they were “craving anything other than food” while collecting information on their 24-h dietary recall. If participants reported that they were craving nonfood items, these substances were classified into 8 categories: (1) ice; (2) raw starches (flour and cornstarch); (3) powder (dust, vacuum powder from vacuum cleaner bags, and baby powder); (4) soap (soap, bar soap, laundry soap, and powdered cleansers); (5) plastic/foam (stufiing from pillows/sofas and sponges); (6) paper (writing paper, toilet paper, and tissues); (7) baking soda/powder; and (8) other (dirt and chalk). Olfactory cravings reported were not specifically inquired about and were not considered to be pica behavior, if reported, such answers were also noted. Adolescents were classified as having pica if they reported craving or eating a nonfood substance at least once during gestation.

**Statistical analysis.** Student’s t tests and Wilcoxon’s rank-sum tests were used to determine the differences in iron status between the pica and non-pica groups. Serum samples were obtained at different gestational time points; therefore, week of gestation was controlled for in logistic regression models examining the relation between pica and iron status markers. Pearson’s χ2 test was used to assess the relation between pica behaviors and categorical variables. A 2-sample test for proportions was used to evaluate the significance of the difference in pica prevalence between trimesters 2 and 3.

Logistic regression models were developed to calculate an OR for pica development by the end of pregnancy, comparing iron-deficient (SF < 12.0 µg/L) and iron-sufficient teens at mid-gestation. Variables that were associated with pica in our bivariate analyses (race, week of gestation, and gynecologic age) were included as a covariate to control for inflammation. The 28 adolescents who did not attend a study visit after their mid-gestation blood draw were excluded from this analysis. All variables associated with pica in our bivariate analyses were also incorporated into a stepwise regression to identify the most appropriate model to predict the development of pica. All statistical analyses were performed using JMP 10.0 (SAS Institute), and the results were considered statistically significant at P < 0.05.

**Results**

**Substances consumed and timing.** Eighteen different pica substances were reported as being ingested (Table 1). Based on the common characteristics of the pica substances reported, these 18 substances were classified into 8 categories: (1) ice; (2) raw starches (flour and cornstarch); (3) powder (dust, vacuum powder from vacuum cleaner bags, and baby powder); (4) soap (soap, bar soap, laundry soap, and powdered cleansers); (5) plastic/foam (stuffing from pillows/sofas and sponges); (6) paper (writing paper, toilet paper, and tissues); (7) baking soda/powder; and (8) other (dirt and chalk). Olfactory cravings reported were not specifically inquired about and were not considered to be pica behavior, if reported, such answers were also noted. Adolescents were classified as having pica if they reported craving or eating a nonfood substance at least once during gestation.
nonfood substances only, whereas 4.1% consumed nonfood substances and also reported olfactory cravings. One adolescent reported having an olfactory craving only, so she was considered to be part of the non-pica group. Only 1 of the 11 adolescents who enrolled during trimester 1 (±13 wk of gestation) reported pica behavior during trimester 1. One hundred twelve adolescents were surveyed in trimester 2 (weeks 14–26 of gestation), 21.4% of whom craved nonfood substances, and 41.8% of those surveyed in trimester 3 (n = 146) engaged in pica behavior during this trimester of pregnancy (week 27 of gestation to delivery). The prevalence of pica during trimester 3 (41.8%) was significantly greater than that in trimester 2 (21.4%) (P < 0.01).

Ice was the most frequently consumed nonfood substance, with 81.9% (59 of 72) of pica-practicing adolescents engaging in pagophagy. Of the 24 adolescents who consumed nonfood substances during trimester 2, 87.5% ingested ice. During trimester 3 of pregnancy, 82.0% of the 61 adolescents engaging in pica behavior reported consuming ice. After ice, starches were most frequently ingested, with 8.3% and 16.4% of pica-practicing adolescents reporting consumption of this substance in trimesters 2 and 3, respectively. Although most adolescents engaged in only 1 type of pica behavior, 23.6% of the pica-practicing participants reported craving >1 type of substance.

Pagophagic behavior did not appear to be influenced by season. Of the 30 adolescents who reported pagophagy only once, 11 (37%) reported this behavior during the summer months of June, July, August, and September, whereas 63% reported the behavior during winter, spring, or autumn. This 37% is not significantly higher than the expected 33% based on the fact that the summer months account for one-third of the entire year (P = 0.75). Looking at the 29 adolescents who reported pagophagy more than once during their pregnancies, only 3 adolescents reported pagophagy during the summer only.

### Study population and sociodemographic characteristics by pica behavior.

Table 2 shows the characteristics of the teen mothers who participated in the study. The majority of study participants had health insurance (90%) and were participating in the Women, Infants, and Children assistance program (73%). At enrollment in the study, 11% (n = 17) of the participants self-reported current use of cigarettes. The mean week of gestation at entry to prenatal care was 10.5 ± 4.7 wk (95% CI: 2.0–24.0 wk), and mean week of gestation at enrollment was 21.7 ± 5.5 wk. In this group of adolescents, the self-reported frequency of prenatal supplement use was as follows: 1) daily use (44%); 2) 2–5 times per week (26%); 3) once per week (19%); 4) occasionally (3%); 5) very rarely (3%); and 6) never (5%). No significant differences were observed between the pica and non-pica groups in those who self-reported >2–5 times/wk use vs. those who self-reported taking these <1 time/wk (P = 0.18).

No significant differences in terms of maternal characteristics [maternal age, P = 0.30; ethnicity, P = 0.51; gravidity, P = 0.70 (data not shown); parity, P = 0.14; pre-pregnancy BMI, P = 0.64; and gestational weight gain, P = 0.77] or sociodemographic background [health insurance coverage, P = 0.93; participation in public assistance programs, P = 0.17; level of education, P = 0.40; and history of smoking, P = 0.97 (data not shown)] were found between those who exhibited pica behavior and those who did not. No significant differences were noted between the pica and non-pica group in terms of the proportion of teens who reported taking prenatal supplements every day at each of the 3 visits (data not shown). However, participants who consumed nonfood substances had a significantly lower mean gynecologic age at conception than those who did not (4.3 ± 1.9 vs. 5.2 ± 1.7, P = 0.004). In these adolescents, pica was associated with both gynecologic age and iron status. Gynecologic age was also independently associated with iron status; therefore, iron status was a potential confounder of the pica–gynecologic age relation. Because TBI was significantly lower in the pica group than in the non-pica group (2.5 ± 4.2 vs. 4.3 ± 3.5 mg/kg, P = 0.005), mid-gestation TBI was factored into a logistic regression of pica and gynecologic age, and the relation between gynecologic age and pica remained significant (P = 0.03).

A significantly larger proportion of African-American adolescents reported pica behavior than did Caucasian teens [52% (n = 102) vs. 34% (n = 56), P = 0.03] (Table 2). To characterize the potential differences in maternal sociodemographic and iron status characteristics associated with pica behavior between these 2 groups, we looked at gynecologic age at conception, week of gestation at enrollment, anemia prevalence in each trimester, and SF at mid-gestation when week of gestation was factored into the model. No significant differences in these characteristics were found between African-American and Caucasian adolescents.

### Iron status.

Bivariate analyses indicated significant differences in iron status between those who reported pica behavior compared with those who did not report it. Specifically, SF, TBI, and hepcidin concentrations were significantly lower in the pica group than those observed among the non-pica cohort during pregnancy (Table 3). When week of gestation was controlled for, SF (P = 0.007), TBI (P = 0.02), and hepcidin

### Table 1

<table>
<thead>
<tr>
<th>Substance</th>
<th>All adolescents</th>
<th>Pica-reporting adolescents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice</td>
<td>37.3 (59)</td>
<td>81.9 (59)</td>
</tr>
<tr>
<td>Starches (flour, cornstarch)</td>
<td>7.6 (12)</td>
<td>16.7 (12)</td>
</tr>
<tr>
<td>Powders (dust, vacuum powder, baby powder)</td>
<td>3.8 (6)</td>
<td>8.3 (6)</td>
</tr>
<tr>
<td>Soap (soap, bar soap, laundry soap, powdered cleansers)</td>
<td>3.2 (5)</td>
<td>6.9 (5)</td>
</tr>
<tr>
<td>Paper (regular paper, toilet paper, tissue)</td>
<td>2.5 (4)</td>
<td>5.6 (4)</td>
</tr>
<tr>
<td>Plastic/foam (stuffing from pillow/sofas, sponges)</td>
<td>1.9 (3)</td>
<td>4.2 (3)</td>
</tr>
<tr>
<td>Baking soda/powder</td>
<td>1.3 (2)</td>
<td>2.8 (2)</td>
</tr>
<tr>
<td>Olfactory (pine-scented cleaning agents, gasoline)</td>
<td>1.9 (3)</td>
<td>4.1 (3)</td>
</tr>
<tr>
<td>Dirt, chalk</td>
<td>1.3 (2)</td>
<td>2.8 (2)</td>
</tr>
</tbody>
</table>

1 Adolescents could report ingesting >1 pica substance.

2 This percentage includes 1 adolescent who only reported olfactory cravings and, therefore, was not included in the pica group.
(P = 0.04) concentrations in the pica group remained significantly lower than those in the non-pica group. Erythropoietin concentrations at mid-gestation were higher in the pica group than in the non-pica group; the difference approached significance (P = 0.07). When week of gestation was controlled for, this difference was not significant (P = 0.12).

At delivery, TBI remained significantly lower in teens reporting pica behavior (P = 0.01). The difference in sTfR at delivery between the 2 groups was also significant, with the pica group having higher concentrations than the non-pica group (P = 0.03). The observed differences in iron status indicators did not appear to be due to variations in inflammatory status between groups, because there were no significant differences in CRP between the 2 groups.

In a logistic model of pica that incorporated race, gynecologic age at conception, week of gestation, and CRP at mid-gestation, there was no significant difference in the odds of reporting pica behavior at the last visit between adolescents who had depleted iron stores (SF < 12.0 μg/L) compared with those who were iron replete at mid-gestation [OR = 1.9 (95% CI: 0.7, 5.1), n = 100] (Supplemental Table 1). Furthermore, a bivariate analysis found no significant difference in the odds of reporting pica at the first study visit (22.2 ± 5.7 wk) between those with hemoglobin < 10.5 g/dL and those with hemoglobin ≥ 10.5 g/dL at their first prenatal visit, which occurred at 9.5 ± 2.0 wk of gestation [OR = 3.8 (95% CI: 0.7, 21.4), n = 140].

Discussion

Nearly half of the pregnant adolescents surveyed engaged in pica behavior during pregnancy, and they craved or consumed a total of 18 different nonfood substances. Pagophagy was by far the most common form of pica behavior; 82% of adolescents who reported pica behavior craved and consumed ice. Based on multiple iron status indicators, those who reported pica behavior were found to have a significantly lower iron status during pregnancy than those who did not. These data are unique and support previous findings of greater iron deficiency by pica behavior in pregnant women (10,37,38).

Although multiple studies found a relation between pica behavior and iron deficiency, few of those studies measured more than hemoglobin and/or hematocrit (10,38,39). Our study is unique in that we examined a panel of iron status indicators and obtained longitudinal data on pica behavior and iron status across gestation. Participants who exhibited pica behavior had significantly lower SF, TBI, and hepcidin during pregnancy than those who did not practice pica behavior. They also had lower TBI at delivery than did the non-pica group, and the difference in sTfR approached significance.

Although data on the prevalence of pica behavior among adolescents or pregnant women are limited, the 46% prevalence of pica behavior observed in these pregnant adolescents is within the range of previous survey data from pregnant adult women in North America. The prevalence of pica behavior in this population was reported to vary from 8.1% (in 553 African-American women attending prenatal care in Washington, DC) (37) to 76.5% (in a group of 281 pregnant women from Houston, Texas, the majority of whom were African American) (10). Our finding of greater prevalence of pica behavior among African Americans than among Caucasians (32% vs. 34%) is consistent with data from other racially diverse populations in which African Americans were more likely than Caucasians to engage in pica behavior (9,39,40). However, it is important to note that a substantial proportion of both racial groups engaged in this behavior.

Similar to the other pica studies in the United States, the most commonly consumed substance by these pregnant adolescents was ice, with 38% of all participants and 81% of those practicing pica consuming ice (9,10,37,40). The prevalence of pagophagy reported in other American pica studies ranged from 3.8% to 53.7% (9,10,37,40). Amylophagy was the second most common pica behavior, with 16.0% of pica-practicing adolescents consuming some form of raw starch. Starch ingestion was often reported in other pica studies performed in the United States, and a few studies found starch to be the most commonly consumed substance (1,41–43), which may be in part due to the accessibility of raw starches, such as flour and cornstarch, in most households.
Adolescents who engaged in pica behavior had significantly lower hemoglobin concentrations (<10.5 g/dL) at entry into prenatal care compared to those who did not engage in this behavior, even when race was controlled for (P < 0.05). This indicates that those who were iron deficient at mid-gestation were less likely to have engaged in pica behavior. Although this is not considered to be a pica behavior, Cooksey (44) reported similar cravings for gasoline and pine-scented cleaning products in a subset of the adolescents because of sample volume limitations. Our data are supportive of the hypothesis that iron deficiency is related to pica, although the specific etiology remains unclear. Adolescents who engaged in pica behavior had significantly lower iron status than those who did not practice pica. A majority of the adolescents who engaged in pica behavior consumed ice, which is not a source of iron, so our findings do not support the hypothesis that pica is an adaptive behavior practiced to restore iron status.

Cravings for the other less common substances, such as sponges, baking soda, powder, paper, and cleaning products, were reported in previous U.S. pica studies (10,44). Cravings for gasoline and pine-scented cleaning products was significantly different between those who were iron deficient vs. those who were iron replete at mid-gestation. For most of the adolescents, study visits did not occur across all 3 trimesters, so it was difficult to track the progression of pica behavior. We were also unable to collect data for every iron status indicator in every participant, because some of the assays were performed only in a subset of the adolescents because of sample volume limitations. This limited the sample size for both the longitudinal analyses and some cross-sectional bivariate analyses, potentially masking significant results. Additional studies are needed to assess the possible impact of iron, zinc, and overall micronutrient status on pica behaviors. Furthermore, we did not ask adolescents to quantify the amount of various nonfood items consumed, nor did we ask adolescents whether they had these pica behaviors before pregnancy, which would have provided additional information relevant to the onset of this behavior.

It is interesting to note that adolescents who engaged in pica behavior had, on average, significantly lower gynecologic ages than those who did not engage in this behavior, even when race and TBI were controlled for (P = 0.05). This indicates that those
who engaged in pica behavior were, on average, less biologically mature when they became pregnant, suggesting that they were more likely to still be growing and to have higher iron demands than the non-pica group.

Although iron deficiency was associated with pica in our participants, iron and zinc deficiencies frequently coexist. Zinc deficiency was also posited as an underlying cause of pica (45–49). Zinc deficiency is known to affect appetite and eating behavior (50). Several studies found that zinc deficiency is associated with an altered sense of taste and decreased taste acuity that can be reversed by zinc supplementation (51–53). Underlying zinc deficiency could be altering the adolescents’ taste perception and, therefore, could be related to their pica behaviors. Our samples were not collected in zinc-free tubes so we are not able to assess possible associations between zinc status and the outcomes measured.

Given the prevalence of pica in our study population, our findings underscore the importance of screening for pica by medical practitioners, because ingesting cleaning products, couch stuffing, vacuum powder, chalk, and sponges may be harmful. Pica behavior was also strongly associated with iron deficiency, which by itself is known to affect birth outcomes during pregnancy. Additional studies are needed to examine the mechanisms responsible for this association, and additional longitudinal studies are needed to elucidate the etiology of this behavior and interventions to prevent ingestion of possibly toxic substances during gestation.

Acknowledgments

The authors thank Tera R. Kent for general laboratory assistance. K.O.O. designed the research; K.O.O., S.L., E.C., R.G., and E.P. conducted the research; R.A.L. performed the statistical analyses; R.A.L. wrote the paper; and K.O.O. and S.L.Y. had primary responsibility for the final content. All authors read and approved the final manuscript.

References


