

UC Berkeley

UC Berkeley Previously Published Works

Title

Pica among Mexican women

Permalink

<https://escholarship.org/uc/item/1kf4n400>

Journal

Maternal and Child Nutrition, 11(4)

ISSN

1740-8695

Authors

Lin, Janice W
Temple, Luisa
Trujillo, Celina
et al.

Publication Date

2015-10-01

DOI

10.1111/mcn.12120

Peer reviewed

Original Article

Pica during pregnancy among Mexican-born women:
a formative study

Janice W. Lin*, Luisa Temple[†], Celina Trujillo*, Fabiola Mejia-Rodriguez[‡],
Lisa Goldman Rosas[§], Lia Fernald* and Sera L. Young^{¶1}

*School of Public Health, University of California, Berkeley, California, USA, [†]New York Medical College, Valhalla, New York, USA, [‡]Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública, Cuernavaca, Morelos, Mexico, [§]Stanford Prevention Research Center, Stanford University, Palo Alto, California, USA, and [¶]Division of Nutritional Sciences, Cornell University, Ithaca, New York, USA

Abstract

Although pica, the craving and purposive consumption of non-food substances, is common among many populations, especially during pregnancy, the health consequences are not well understood. Further, very little is known about pica among Mexican populations in the United States and Mexico. Therefore, we conducted formative research to understand pica in this understudied population. Our objectives were to identify the frequency and types of pica behaviours, to understand perceived aetiologies and consequences of pica and to ascertain if the behaviour was common enough to warrant a larger study. We held nine focus group discussions (three in the Salinas Valley, California; six in Xoxocotla, Morelos, Mexico) with 76 Mexican-born women who were currently pregnant or had delivered within the past 2 years. Earth, adobe, bean stones and ice were the most commonly reported pica substances. Twenty-eight of the 76 participants (37%) reported ever engaging in pica; 22 participants (29%) reported doing so during pregnancy. The proportion of women reporting pica in the United States and Mexico was 43% and 34%, respectively. Women attributed pica to the overwhelming organoleptic appeal of pica substances (especially smell and texture) and to micronutrient deficiencies. Perceived consequences of unfulfilled pica cravings were birthmarks or fetal loss; fulfilled pica cravings were also thought to be generally harmful to the mother or child, with several women specifying toxic lead, pesticides or 'worms'. In sum, pica among Mexican women is common enough to warrant a larger epidemiologic study of its sociodemographic correlates and physiological consequences.

Keywords: pica, geophagy, amylophagy, craving, Latina, pregnancy, Mexico, nutrition.

Correspondence: Dr Sera L. Young, Cornell University, Division of Nutritional Sciences, 113 Savage Hall, Ithaca, NY 14853, USA.
E-mail: sera.young@cornell.edu

¹<http://serayoung.org>

Introduction

Pica, the craving and purposive consumption of substances that the consumer does not define as food (Young 2010), is a phenomenon that has been documented around the world (Laufer 1930; Anell & Lagercrantz 1958; Heusinger 2006; Young *et al.* 2011). The most common types of pica are geophagy (consumption of earth), amylophagy (consumption of raw

starches such as cornstarch or uncooked rice) and pagophagy (the consumption of large quantities of ice) (Young 2010). A range of other non-food items have also been reported, including chalk, baby powder, paper and paint chips (Danford 1982; Sayetta 1986; Blinder *et al.* 1988; Loveland *et al.* 1989; Prince 1989; Horner *et al.* 1991).

Both the aetiology and health consequences of pica remain enigmatic, and as such, it is of public health

concern. On one hand, pica may be beneficial, by protecting against harmful pathogens and toxins; quelling nausea, vomiting and diarrhoea; or contributing beneficial micronutrients (Young 2010, 2011). Pica may also be harmful, by reducing the bioavailability of beneficial micronutrients, causing intestinal impaction, displacing food, introducing toxic substances such as lead or by acting as a vector for geohelminth infection (Young 2010, 2011). It is also of public health interest because it is most prevalent among two vulnerable populations: pregnant women and children (Young *et al.* 2011).

Although there are many ethnographic descriptions of pica from around the world (Laufer 1930; Anell & Lagercrantz 1958; Heusinger 2006), some of the most detailed quantitative studies of pica were conducted with pregnant women in the United States (cf. Young 2010, Supplemental Table 1). These studies indicate that pica during pregnancy is an unexpectedly common practice, especially among minority populations (Hertz 1947; Vermeer & Frate 1979; Edwards *et al.* 1994; Smulian *et al.* 1995). Indeed, in several American obstetric populations, the prevalence of pica consumption was over 50% (O'Rourke *et al.* 1967; Coles *et al.* 1995; Cooksey 1995; Rainville 1998).

Despite the fact that minority women in the United States appear to be more likely to engage in pica than White women, and that Latino populations are the largest immigrant group in the United States, only two studies have focused on Latino populations with any detail. Both of these studies were conducted among Mexican immigrant populations living in the United States. One study, conducted in 1969 among 65 migrant families of Mexican descent in California, concluded the prevalence of pica to be 58.5% among

pregnant women, 23.1% among non-pregnant women, 49.2% among children and 0% among men (Bruhn & Pangborn 1971). Items consumed included earth, ashes, clay pots, adobe and magnesium carbonate. In the second study, the prevalence of pica was assessed among 225 Mexican women, 150 of whom were living in the California in 1999 (Simpson *et al.* 2000). They found that 31% of those women in the United States reported engaging in pica during pregnancy, eating items including ice, earth, magnesium carbonate, ashes and clay.

Data on the prevalence of pica among Mexican populations in Mexico is even more scant. There are brief ethnographic descriptions of geophagy (Díaz del Castillo *et al.* 1912; Joyce & Saville 1914), including religious geophagy (Bourke 1894; Hunter & de Kleine 1984), and reports of acute lead poisoning among pregnant Mexican women and their newborns because of the ingestion of pottery with lead-based glazes (Fuortes *et al.* 1996; Klitzman *et al.* 2002; Shannon 2003; Lowry *et al.* 2004; Mýcyk & Leikin 2004; Thihalolipavan *et al.* 2013). In the sole study of prevalence among Mexican women in Mexico, conducted in Baja, the prevalence of pica among 75 women was 44%; women reported eating earth, bean stones, magnesium carbonate and ashes (Simpson *et al.* 2000).

Thus, because of the evidence suggesting that pica may be common among Mexican women, the range of potential harmful and salubrious consequences, and the large Mexican population in the United States, we embarked on a formative study of pica among Mexican women in the United States and Mexico. Our objectives included (1) identifying pica behaviours (2) determining perceived aetiologies and con-

Key messages

- Non-food cravings are common among Mexican-born women living in Mexico and the United States, especially during pregnancy. Twenty-eight of the 76 focus group discussion participants (37%) reported ever engaging in pica; 22 participants (29%) reported doing so during pregnancy.
- Earth, adobe, bean stones and ice are the most commonly craved items.
- Although it was considered dangerous to not indulge pica cravings, pica substances themselves were also thought to be harmful to the mother and child.
- Population-based research is needed to identify the sociodemographic and physiological correlates of pica, including adverse or beneficial health effects.

sequences of pica, including if it was perceived to be beneficial or harmful, and (3) ascertaining if the behaviour was common enough to warrant a larger study, and if so, how it should best be approached.

Materials and methods

This qualitative exploratory study was based on data from a total of nine focus group discussions (FGDs) with 76 participants. Three FGDs were held in Salinas Valley, central California in September 2008, with a total of 23 participants. Six FGDs were held in Xoxocotla, in the Mexican state of Morelos, in May 2009, with a total of 53 women. Salinas Valley was selected as the site in the United States because of its large Mexican population; Xoxocotla was selected because of the existing research infrastructure through the Instituto Nacional de Salud Pública (Mexican National Institute of Public Health).

Recruitment at both sites was done through a combination of fliers, clinic personnel and 'word of mouth' by women who had participated in earlier FGDs. Criteria for participation was self-identified Mexican descent and being pregnant or having delivered in the last 2 years.

FGDs were held at a community hospital primarily serving low-income, migrant populations in Salinas, and a spare room at a public health clinic in Xoxocotla. Participants were encouraged to speak the language in which they communicated most easily; all participants chose Spanish. In the United States, the FGD facilitator was bilingual and bicultural, and in Mexico, the two facilitators were both Mexican researchers affiliated with the Instituto Nacional de Salud Pública. Discussions began by asking about aversions and cravings in general during pregnancy and then moved to experiences with non-food cravings, including their personal experiences with pica as well as those of others. Each FGD lasted approximately 90 min. Participants in US FGDs received grocery store gift cards for \$16, participants in Mexico were not remunerated, per local research practice.

The FGD guide was informed by the ecological model of nutrition, in which the individual's biological and psychological needs are understood to both influence and be influenced by multiple social and

environmental factors (Jerome *et al.* 1980). This framework has been successfully applied to the study of pica, where it has been shown to be a useful heuristic device for understanding the multiple, multidirectional influences (Young & Pelto 2012). The same FGD guide was used in both settings (cf. Supporting Information Appendix S1).

All FGDs were recorded and subsequently transcribed into Spanish and translated into English by bilingual speakers. All FGDs were observed and notes were made on non-verbal reactions and tone.

The analysis steps followed the principles and procedures outlined by Charmaz (2006) for grounded theory. First, English transcripts were read by three of the researchers, and each independently identified themes. The senior author then developed a coding structure based on the initial list of themes. From our previous work (Young 2010; Young *et al.* 2010, 2011), we had expected some of the themes that appeared, e.g. 'secrecy' and 'cravings'; others were unanticipated, e.g. harm caused by unfulfilled cravings. The next step was to reread each of the transcripts, and code and extract the sentences and sections pertinent to each of the themes. The coding rubric continued to evolve as coding progressed. Thematic content was discussed among authors until agreement was reached. Tabulation of frequencies, e.g. of pica substances craved, was performed using Microsoft Excel (2009) (Microsoft Corp., Redmond, WA, USA).

The study was approved by the Institutional Review Board at the University of California, Berkeley and the Research, Ethics and Biosecurity Committees of the National Institute of Public Health, Cuernavaca, México.

Results

Study population

All 76 participants had been born in Mexico and were either pregnant or had delivered within the last 2 years. Women living in Salinas Valley were born in a number of states, mostly in central Mexico, including Jalisco, Guanajuato, Morelos and Michoacan. In contrast, most of the women interviewed in Mexico were

born in Morelos, either in Xoxocotla or neighbouring towns.

Types of non-foods consumed

Although participants were not familiar with the term 'pica', the concept of craving and eating items that were not food was immediately understood, as indicated by many nods and murmurs in each FGD. For example, when one participant in Mexico described the intensity of the cravings, explaining how her cravings were so strong that when she would see the craved item her mouth would water [MX#2pg10], other women smiled empathetically and volunteered similar experiences.

The geophagic substances that were spontaneously mentioned by participants were earth, bean stones and adobe (Table 1). Earth from near their homes as well as from further afar was craved. One woman described *chalma* earth [MX#4pg5], also known as *tierra santa*, or holy earth, from Chalma, Mexico, sold in 10 peso bags for human consumption. White earth from San Juan de Dios in Jalisco was another type of *tierra santa* purchased to be eaten [US#1pg15]. A participant in the United States shared that her family went to San Juan de Los Lagos to buy 'ready-made white earth crosses' [US#2pg16]. Others consumed earth that was found in and around their homes.

A second type of geophagic substance craved was *piedritas de frijoles*, or bean stones, the clods of earth found among uncooked beans. 'Sucking' (*chupando*),

rather than eating, was the term commonly used to describe the ingestion of bean stones [e.g. MX#5pg12]. They are typically consumed without preparation, but one participant washed them so they could be 'clean' before consumption [MX#1pg8].

The third geophagic substance consumed by participants was adobe, the clay-rich material used to build many structures. Typically, pieces of adobe were picked off from homes and eaten [MX#2pg6, MX#2pg2].

The non-geophagic pica items mentioned included ice, unripe mangoes (sometimes with lemon and chilli or salt) and magnesium carbonate (Table 1). Ice was typically obtained from the home, and only reported among women resident in the United States. The consumption of unripe mangoes would not typically be classified as pica, as it is a snack food in Mexico (and many other parts of the world), but because the respondents discussed it when listing other craved non-food substances, we have reported it here. Magnesium carbonate, known as 'terrón de magnesia' [US#1pg6] was usually purchased for consumption at a pharmacy, and came in the form of small white manufactured cubes [US#1pg2].

Frequency

Out of the 23 participants in United States, 10 (43%) indicated they had engaged in pica behaviour (Table 1). Of those 10 women that reported pica in the United States, six women (60%) reported pica behaviour while pregnant. In the FGDs in Mexico, 18 (34%) out of the 53 total participants reported pica, and 16 (89%) out of these 18 women did so while pregnant.

Pica among others

Non-food cravings among family members, friends and acquaintances were familiar to many participants in both the United States and Mexico. All of the above items were reported to be consumed by other people, as well as uncooked rice and chalk. The 23 women in US FGDs knew of 25 others who had craved and eaten non-food items; among 20 (80%) of those individuals, it occurred during pregnancy. The

Table 1. Types and frequency of non-food item consumption among 76 Mexican-born female focus group discussion participants, by country of current residence

Item	United States <i>n</i> = 23	Mexico <i>n</i> = 53
Earth	5	6
Adobe	1	5
Bean stones	0	6
Ice	2	0
Other*	3	2
Total women engaging in pica [†]	10	18

*Other: unripe mango, magnesium carbonate. [†]Frequencies do not sum to total number of pica consumers, because some participants consumed multiple substances.

53 participants in the FGDs in Mexico knew of 20 individuals who engaged in pica; 15 (75%) of whom were pregnant at the time.

Organoleptic appeal

For many participants, the taste and smell of these items was the greatest appeal. Damp earth was an important trigger for geophagy; some women reported cravings triggered by the smell of wet earth after it rained [US#1pg3], while others actually watered the earth to enjoy its smell and/or taste [MX#3pg1]. For instance, one woman now living in the United States explained, 'during the first 3 months of pregnancy, after it rained. . . my mother had to close all the doors so I wouldn't be able to smell the wet fresh earth' [US#3pg26]. A participant in Mexico explained that simply smelling the earth was enough to satisfy her craving; she would 'wet the earth and smell it' but wouldn't eat it [MX#3pg2]. One participant in Mexico said, 'I laughed because I smelled it (adobe) a couple of times when I was pregnant and I thought "should I dare or not?"' [MX#5pg6]. Several participants agreed that pregnancy makes them more open to considering non-food consumption. One participant said 'I did indeed crave wet adobe but never tried it' [MX#5pg7] and attributed this behaviour to 'being sensitive to everything when pregnant' [MX#5pg7].

Texture was the second most important organoleptic quality, discussed far less frequently than smell. 'I had a craving for small hard pieces found in the adobes. . . I loved the taste and sound it made when I chewed on it' [US#2pg13]. Another participant shared that her older sister ate uncooked rice when she was pregnant because she 'liked the feeling of biting into it' [US#1pg7].

Micronutrient deficiencies as a cause of pica

Several women discussed pica in the context of micronutrient deficiencies, often based on biomedical encounters they had had. Participants in both United States and Mexico believed that iron was a significant mineral their bodies were missing which might explain their frequent cravings for earth or adobe.

One participant explained the smell of the earth making her want to eat it, 'because the earth has iron' [MX#5pg7]. Another participant said that the earth is 'giving us vitamins' [MX#5pg8]. When discussing the cause of her craving for adobe, a woman in Mexico said, 'it was because I was missing calcium [. . .]. The gynecologist prescribed me calcium later' [MX#1pg9]. She reported that her cravings went away after taking calcium pills.

Health consequences of unfulfilled cravings

Women described a range of negative consequences of not satisfying a craving during pregnancy. Participants in FGDs in Mexico discussed at length how if a pregnant woman did not eat a craved item (either food or non-foods), the baby would have a birthmark in the shape of the desired item. For example, a participant mentioned that her cousin was born with a big apple birthmark because her aunt craved apples but did not eat them [MX#2pg7]. For this reason, many thought that it was better to indulge pica cravings [MX#3pg1].

A more dire consequence of not responding to cravings was fetal loss. One woman in Mexico recommended to her niece who craved adobe to try it because 'she could lose the baby [miscarry] because of [not satisfying] the craving' [MX#3pg1]. Another woman in Mexico stated 'we get the symptoms [cravings] from what the baby wants and you have to eat what it wants. Otherwise you can lose the baby' [MX#1pg3]. Similarly, a woman in the United States said 'I ate everything I had a craving for because if you do not, the babies are the ones who suffer' [US#3pg26]. While most women did not specify the mechanism by which fetal loss could occur, one mentioned iron deficiency [MX#6pg8].

Perceived health consequences of pica

Although it was considered dangerous to not indulge pica cravings, pica substances themselves were also thought to be dangerous. Approximately half of the participants in Mexico believed that eating pica substances was harmful for the baby and/or the mother,

while in the United States, nearly all the participants believed that pica was harmful.

A range of harmful consequences were reported in Mexico. 'When my nephew was a year old, he would dampen the earth, it would get muddy, and he would play in it and eat it. . . then when he was 3 years old, the doctor said he had kidney stones' [MX#3pg4]. Another woman believed that pica items were a vector for parasitic infections. 'My nephew was already 5 years old. . . he couldn't eat anything. He threw up a lot of small worms' [MX#3pg4]. Another woman said that a woman she knew 'who ate adobe was in pain after the delivery. . . she had parasites in the placenta' and the baby 'was very small at birth' [MX#4pg3–4].

Some women in the United States expressed similar sentiments about pica being harmful for both the mother and baby. One participant mentioned that eating non-food substances 'is a problem' because they 'do not contain nutrients' [US#1pg5]. Another participant added that 'these substances can be harmful for the mother and baby' [US#1pg5] and that the 'earth is rich in lead' [US#2pg18]. The US participants also brought up the deleterious nature of consuming earth in the United States because of pesticides. One woman in the United States believed that ingesting pica substances in the United States was worse than in Mexico for this very reason [US#1pg4–5]. In contrast, none of the women in Mexico mentioned pesticides as a reason to refrain from eating pica items.

Discussion

Our first objective study was to describe pica behaviours. Indeed, our findings suggest that pica is common during pregnancy among women of Mexican origin living in the United States and Mexico. Twenty-eight of the 76 participants (37%) reported ever engaging in pica; 22 participants (29%) reported doing so during pregnancy. By country, the proportion of women reporting pica was 43% in the United States and 34% in Mexico. Because the participants were not selected to be representative, this cannot be extrapolated as population prevalence. However, the similarities in frequency of pica among the two other studies conducted among women of Mexican origin

(Bruhn & Pangborn 1971; Simpson *et al.* 2000) suggests that pica remains a behaviour sufficiently common to merit rigorous quantitative investigation.

There were also many similarities in types of pica substances reported across the three studies. Geophagy was manifested similarly as adobe, earth and bean stones. Magnesium carbonate was also mentioned in all three studies. This was striking as it is typically considered to be a medicine, not a food; the rationale for this classification should be probed further. As in Simpson *et al.*'s (2000) study, ice was mentioned by US-based participants, but not those living in Mexico. This may be due to lesser availability of ice to Mexican participants, or because ice is more socially acceptable than other pica substances in the United States. Magnesium carbonate was also mentioned across all three studies.

Unripe mango was a pica substance that had not previously been identified in this population. Indeed, it was quite surprising that participants identified unripe mango as a craved non-food, because it is a common snack food in Mexico. Interestingly, unripe mangoes have also been described as a craved non-food in Tanzania, even though unripe mango is also considered to be a snack food there (Young *et al.* 2007, 2010). This suggests that unripe mango should be regularly inquired about as a pica substance, and the significance of this classification of mangoes bears further exploration.

This was also the first time that uncooked rice was reported as a pica substance in this population, although there have been reports of uncooked rice as a pica substance in New York (Posner *et al.* 1957; Roselle 1970), Tanzania (Nyaruhucha 2009; Young *et al.* 2010), Madagascar (Golden *et al.* 2012), Réunion (Giudicelli & Combes 1992) and France (Kettaneh *et al.* 2005). It would be worthwhile to investigate the biochemical similarities and differences between uncooked rice and other more common amylophagic substances, e.g. cornstarch. Further, these data suggest that uncooked rice should specifically be probed when inquiring about pica behaviours; it may easily be overlooked as cooked rice is indubitably a food.

Our second objective was to elucidate the perceived aetiologies and consequences of pica. Participants' discussion of these were remarkably physiological; little

was made of any symbolic properties of pica substances as has been the case elsewhere, e.g. Kenya (Geissler 2000). Although participants mentioned several types of holy earth, there was no discussion of any healing or religious properties. Instead, the appeal of pica substances was in the organoleptic features, i.e. smell, taste and/or texture. The perceived benefits of pica were also physiological, including satisfying the cravings of the baby, thereby preventing birthmarks or fetal loss, as well as providing micronutrients in which the mother might be deficient. The risks associated with pica were also health-related: they could damage the health of the consumer, e.g. through helminthic infections or toxic pesticides. In short, participants thought that not fulfilling a pica craving was harmful, but that if consumed, the pica substances themselves could be detrimental to health. Of note, none of these physiological consequences were reported to have been experienced by any participants. The overwhelmingly physiological explanations of pica may be attributable to the FGDs taking place within a medical clinic (in Mexico) or perceived affiliations of FGD facilitators with health facilities.

Our third objective was ascertaining if the behaviour was common enough to warrant a larger study, and if so, how it should best be approached. This formative study has suggested a number of insights for conducting a larger, population-based study.

1. The substances that should be queried about more systematically include the various types of earths as well as magnesium carbonate, ice, unripe mangoes and uncooked rice. Geophagic substances should be queried about using phrases including 'sucked on', which was a term that participants identified with better.
2. Individual interviews, rather than group reporting would be preferable to obtain a more accurate description of pica behaviour. Judgmental comments by some FGD participants (e.g. about the dirtiness of sucking on bean stones [MX#5pg13]) likely caused some women to refrain from discussing their own non-food cravings. In-depth interviews would also be a better methodology for developing a more nuanced understanding of pica, i.e. one that went beyond physiological causes and consequences. Such an

approach might also help to explain why unripe mangoes (typically considered a snack food) and magnesium carbonate (which is sold as a medicine) were grouped with cravings for items that were unambiguously non-foods.

3. Pica was not practiced exclusively by pregnant women, such that pica outside of pregnancy should also be queried.

4. Other useful information for understanding the consequences of pica includes biochemical analyses of the micronutrient content, bioavailability and binding capacity of pica substances. Determining the heavy metal and pesticide content of geophagic earths would also be useful for assessing the potential risks of this behaviour.

In summary, given the prevalence of pica, the large population of Mexican women, the unknown health consequences and women's own conflicted feelings about the health consequences of pica, a rigorous study of this nutritional enigma is long overdue.

Acknowledgements

We warmly thank the women who participated in the focus group discussions, both in Salinas, California and Xoxocotla, Mexico. We also gratefully acknowledge Livia González and Cynthia Jeannette for conducting the interviews in Mexico, Damaris Hernandez for assisting with translation, Jean Cox and Gretel Peltó for comments on an earlier draft, Sonia Hernandez-Cordero for research support in Cuernavaca, and Brenda Eskenazi and the CHAMACOS project for their research support in Salinas.

Source of funding

This research was funded by a UCMEXUS small grant and the Thrasher Fund. SLY was supported by K01 MH098902 from the National Institute of Mental Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Mental Health or the National Institutes of Health.

Conflict of interest

The authors declare that they have no conflicts of interest.

Contributions

FMR, LGR, LF and SLY designed the study; JWJ, CT, FMR, and LGR collected the data; JWJ, LT, and SLY analyzed the data; SLY and JWJ wrote the first draft; all authors critically reviewed the final manuscript.

References

- Anell B. & Lagercrantz S. (1958) *Geophagical Customs*. Studia Ethnographica Upsaliensia: Uppsala.
- Blinder B., Goodman S. & Henderson P. (1988) Pica: a critical review of diagnosis and treatment. In: *The Eating Disorders: Medical and Psychological Bases of Diagnosis and Treatment* (eds B. Blinder, B. Chaitin & R. Goldstein), pp. 331–344. PMA Publishing Corp: New York.
- Bourke J. (1894) Popular medicine, customs and superstitions of the rio grande. *Journal of American Folklore* **7**, 119–146.
- Bruhn C. & Pangborn R. (1971) Reported incidence of pica among migrant families. *Journal of the American Dietetic Association* **58** (5), 417–420.
- Charmaz K. (2006) *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. Sage Publications: Thousand Oaks, CA.
- Coles T., Schall J.I., Hediger M.L. & Scholl T.O. (1995) Pica during pregnancy – associations with dietary intake, serum micronutrients and pregnancy outcome. *FASEB Journal* **9** (3), A443.
- Cooksey N. (1995) Pica and olfactory craving of pregnancy: how deep are the secrets? *Birth* **22** (3), 129–137.
- Danford D. (1982) Pica and nutrition. *Pica and Nutrition* **2**, 303–322.
- Díaz del Castillo B., García G., Maudslay A. & Saville M. (1912) *The True History of the Conquest of New Spain*, Vol. 4. Hakluyt Society: London.
- Edwards C.H., Johnson A.A., Knight E.M., Oyemade U.J., Cole O.J., Westney O.E. *et al.* (1994) Pica in an urban environment. *The Journal of Nutrition* **124** (6 Suppl.), 954S–962S.
- Fuortes L.J., Weisman D., Niebyl J., Gergely R. & Reynolds S. (1996) Pregnancy, pica, pottery and Pb (lead). *Journal of the American College of Toxicology* **15** (5), 445–450.
- Geissler P. (2000) The significance of earth-eating: social and cultural aspects of geophagy among Luo children. *Africa* **70** (4), 653–682.
- Giudicelli J. & Combes J. (1992) [Pica and iron deficiency in adolescence]. *Archives françaises de pédiatrie* **49** (9), 779–783.
- Golden C.D., Rasolofoniaina B.J.R., Benjamin R. & Young S.L. (2012) Pica and amylophagy are common among Malagasy men, women and children. *PLoS ONE* **7** (10), e47129.
- Hertz H. (1947) Notes on clay and starch eating among negroes in a Southern urban community. *Social Forces* **25** (3), 343–344.
- Heusinger K., 2006. Die sogenannte Geophagie oder tropische (besser: Malaria-) Chlorose als Krankheit aller Länder und Klimate, Elibron Classics. Available at: <http://www.amazon.com/sogenannte-Geophagie-oder-tropische-besser/dp/0543911020>
- Horner R.D., Lackey C.J., Kolasa K. & Warren K. (1991) Pica practices of pregnant women. *Journal of the American Dietetic Association* **91** (1), 34–38.
- Hunter J. & de Kleine R. (1984) Geophagy in central America. *Geographical Review* **74** (2), 157–169.
- Jerome N., Kandel R. & Pelto G. (1980) An ecological approach to nutritional anthropology. In: *Nutritional Anthropology: Contemporary Approaches to Diet and Culture* (eds N. Jerome, R. Kangel & G.H. Pelto), pp. 13–45. Redgrave Publishing Company: Pleasantville, NY.
- Joyce T. & Saville M. (1914) *Mexican Archaeology: An Introduction to the Archaeology of the Mexican and Mayan Civilizations of Pre-Spanish America*. Philip Lee Warner: London.
- Kettaneh A., Eclache V., Fain O., Sontag C., Uzan M., Carbillon L. *et al.* (2005) Pica and food craving in patients with iron-deficiency anemia: a case-control study in France. *American Journal of Medicine* **118** (2), 185–188.
- Klitzman S., Sharma A., Nicaj L., Vitkevich R. & Leighton J. (2002) Lead poisoning among pregnant women in New York City: risk factors and screening practices. *Journal of Urban Health* **79** (2), 225–237.
- Laufer B. (1930) Geophagy. *Field Museum of Natural History, Publication 280* **18** (2), 99–198.
- Loveland C., Furst T. & Lauritzen G. (1989) Geophagia in human populations. *Food & Foodways* **3**, 333–356.
- Lowry L., Cherry D.C., Brady D.C., Huggins B., D'Sa A.M. & Levin J.L. (2004) An unexplained case of elevated blood lead in a Hispanic child. *Environmental Health Perspectives* **112** (2), 222–225.
- Mycyk M. & Leikin J. (2004) Combined exchange transfusion and chelation therapy for neonatal lead poisoning. *Annals of Pharmacotherapy* **38** (5), 821–824.
- Nyaruhucha C.N.M. (2009) Food cravings, aversions and pica among pregnant women in Dar es Salaam,

- Tanzania. *Tanzania Journal of Health Research* **11** (1), 29–34.
- O'Rourke D., Quinn J., Nicholson J. & Gibson H. (1967) Geophagia during pregnancy. *Obstetrics and Gynecology* **29** (4), 581–584.
- Posner L., McCottry C. & Posner A. (1957) Pregnancy craving and pica. *Obstetrics and Gynecology* **9** (3), 270–272.
- Prince I. (1989) Pica and geophagia in cross-cultural perspective. *Transcultural Psychiatric Research Review* **26**, 167–197.
- Rainville A. (1998) Pica practices of pregnant women are associated with lower maternal hemoglobin level at delivery. *Journal of the American Dietetic Association* **98** (3), 293–296.
- Roselle H. (1970) Association of laundry starch and clay ingestion with anemia in New York City. *Archives of Internal Medicine* **125** (1), 57–61.
- Sayetta R. (1986) Pica: an overview. *American Family Physician* **33** (5), 181–185.
- Shannon M. (2003) Severe lead poisoning in pregnancy. *Ambulatory Pediatrics* **3** (1), 37–39.
- Simpson E., Mull J.D., Longley E. & East J. (2000) Pica during pregnancy in low-income women born in Mexico. *Western Journal of Medicine* **173** (1), 20–24.
- Smulian J., Motiwala S. & Sigman R. (1995) Pica in a rural obstetric population. *Southern Medical Journal* **88** (12), 1236–1240.
- Thihalolipavan S., Candalla B.M. & Ehrlich J. (2013) Examining pica in NYC pregnant women with elevated blood lead levels. *Maternal and Child Health Journal* **17** (1), 49–55.
- Vermeer D. & Frate D. (1979) Geophagia in rural Mississippi: environmental and cultural contexts and nutritional implications. *American Journal of Clinical Nutrition* **32** (10), 2129–2135.
- Young S.L. (2010) Pica in pregnancy: new ideas about an old condition. *Pica and Nutrition* **30**, 403–422.
- Young S.L. (2011) *Craving Earth*. Columbia University Press: New York.
- Young S.L. & Pelto G.H. (2012) Core concepts in nutritional anthropology. In: *Nutritional Health: Strategies for Disease Prevention* (eds N. Temple *et al.*), pp. 523–537. Humana Press: Totowa, NJ. doi: 10.1007/978-1-61779-894-8_25.
- Young S.L., Goodman D., Farag T.H., Ali S.M., Khatib M.R., Khalfan S.S. *et al.* (2007) Geophagia is not associated with Trichuris or hookworm transmission in Zanzibar, Tanzania. *Transactions of the Royal Society of Tropical Medicine and Hygiene* **101** (8), 766–772.
- Young S.L., Khalfan S.S., Farag T.H., Kavle J.A., Ali S.M., Hajji H. *et al.* (2010) Association of pica with anemia and gastrointestinal distress among pregnant women in Zanzibar, Tanzania. *American Journal of Tropical Medicine and Hygiene* **83** (1), 144–151.
- Young S.L., Sherman P., Pelto G. & Lucks J.B. (2011) Why on earth do people eat dirt? A test of alternative hypotheses. *Quarterly Review of Biology* **86** (2), 97–120.

Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1. Focus group discussion guide for study on pica among Mexican-born women.