Prevalence of Accurately Reconstituted Infant Formula in the WIC population and in the non-WIC-eligible population: Exploring Maternal Knowledge, Attitudes, and Practices of Infant Formula Preparation

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Introduction

Approximately 17% of children in the United States are overweight, and this appears to be increasing (1). The first few months of life may present a critical time point for an effective intervention for preventing overweight, as infant feeding practices are thought to be a major contributor to early rapid weight gain and this gain may increase risk of childhood overweight (2-7). It has been well-established that there are significant differences between exclusively breastfed and formula-fed infants in terms of growth and intake, with formula-fed infants taking in more energy and growing at a faster rate than breastfed infants in the first year of life (8-10). Formula-fed infants are more likely to be over-fed than breastfed infants (11), and may be less able to self-regulate energy intake.

The mechanisms underlying these differences between formula-fed and exclusively breastfed infants are not well understood, though physiological responses to the composition of infant formula, behaviors inherent to bottle-feeding, or a combination of both have all been proposed as potential hypotheses (12). The hypothesis regarding composition of formula remains inconclusive (12). Behaviors inherent to bottle-feeding are likely to significantly influence these differences. Potential factors such as parental attitudes, abilities and beliefs about infant feeding could have an impact on infant rate of weight gain (13). In addition, one often over-looked behavior is that of infant formula preparation: specifically, that of powdered infant formula reconstitution.
A review by Renfrew, Ansell and Macleod, in 2003, of formula-reconstitution studies in industrialized countries, found that both over-concentration and over-dilution of formula occur (14). This review highlighted the paucity of documentation of the prevalence of these inappropriate formula reconstitution practices. Errors in reconstitution, either intentional or unintentional, may lead to increased energy intake, whether via increased offering of low-energy formula or simply offering high-energy formula. Properly reconstituted formula should provide 20 calories per ounce (15). Twenty-two calories per ounce is used to produce “catch-up” growth in preterm infants, and therefore small differences in reconstitution can have a biologically meaningful impact (15).

Should infants chronically receive over-dilute infant formula, it is conceivable that infants increase hunger cues and that mothers interpret these cues to indicate readiness for other foods or fluids. Early introduction of solid food is a risk factor for later childhood overweight (16-17). Conversely, an infant chronically exposed to a high-energy infant formula would be expected to gain weight, if unable to self-regulate intake. Developing methodology to identify mothers at risk for these behaviors, and intervening, may have a positive impact on long-term child weight outcomes. As nearly half of infants in the United States are served by the WIC program (18), and given the active changes to the WIC food package for formula-fed infants (19), the outcomes of this project are especially timely. Though the intention of the changes to the WIC food package is to equalize the value of the formula-feeding and the breastfeeding food packages, the unintentional result may be an increase in over-dilution of powdered or from-concentrate formula, with caregivers anticipating decreasing supply.
Therefore, the objective of this study was to examine the prevalence of accuracy of infant formula reconstitution and assess how maternal knowledge, practices and attitudes surrounding these behaviors are related to accurate preparation. The study was a cross-sectional, observational design with two groups of formula-feeding mothers: an income-eligible WIC-participant group and a non-WIC group (income > 185% Federal Poverty Level). These groups were chosen because of the potential for income-level to influence accurate preparation of reconstitution of infant formula, via intentional over-dilution (“stretching”), and because the WIC program serves such a large proportion of infants in the U.S (18).

Methods

Mothers of healthy, term, formula-fed infants ≤ 6 mo of age, were recruited from the WIC program in two counties in East Tennessee and from a university-housed birth registry. Approval for recruitment of the income-eligible WIC-participant group was received from Institutional Review Boards of the University of Tennessee, Knoxville and the State of Tennessee. Approval for recruitment of the non-WIC-income-eligible group was received from only the University of Tennessee, Knoxville Institutional Review Board.

Mothers recruited from WIC were approached by the WIC staff and provided a flyer indicating the infant feeding study, and encouraged mothers to contact the research lab at the university. WIC staff provided no further information to potential participants. Mothers were informed that participation in this study would in no way impact their WIC benefits. Upon calling the research lab, potential subjects were screened for eligibility by trained research staff.
Mothers recruited from the university-housed birth registry were contacted from a list generated monthly by the registry database staff. Trained research assistants contacted mothers via phone and screened them for eligibility.

Upon determination of eligibility, research assistants explained the project activities and explained consent. Those who were willing to participate were mailed a consent form and were contacted several days later and completed a telephone survey, consisting of a series of questions about formula preparation and infant feeding. A modified version of an infant feeding scale, which has been developed and validated elsewhere through an extensive process and which is currently in review for publication, was used to assess infant feeding attitudes in this project (20, personal communication). Consent forms were returned to the research lab, registered, and survey data entered into the computer. Mothers were mailed a small gift card as compensation for their time.

Mothers who qualified for the larger infant-feeding attitudes study, who also had infants ≤ 4 mo of age, and who were exclusively offering reconstituted powdered infant formula (no current breastfeeding or other foods or fluids) were invited to participate in a sub-study. This subset of mothers recorded infant intake for 24 hours and collected a 15 mL sample of infant formula from each bottle offered prior to offering the bottle to the infant. The intake forms and sample collection vials were mailed to eligible and participating mothers. Within 3 days of collection of the formula samples and intake data, research assistants scheduled the mother to meet a trained research team at either her respective WIC clinic or the research lab at the university, whichever was more convenient for the mother. These mothers were asked the same series of questions and their infants were weighed and measured. An additional small gift card was provided to
these mothers upon completion of this additional task. Collected samples were stored at -20 °C until analyzed using the loss on drying method.

*Formula sample and formula intake collection (sub-sample)*

Mothers participating in the formula-collection sub-study were given standardized forms on which to record the time and volume of each formula-feed (amount offered after decanting and amount remaining at the end of the feed, in ½ ounce increments), as well as who offered the bottle to the infant. These data were recorded for 24 hrs. Though intake of any other foods or fluids was discouraged while participating in this study, the research team recognized that this is a relatively common behavior. Therefore, forms were provided for recording these foods or fluids during the 24 h data collection period. Data was also collected for pacifier use and infant morbidity. From each intake record, the total volume of formula was calculated for the 24 h period.

*Anthropometry (sub-sample)*

Infant birth weight and length were obtained from maternal recall. Infant weight and length were measured within three days of formula sample collection, using the procedures developed for the WHO Multicentre Growth Reference Study (21). Weight was measured on a digital scale accurate to the nearest 5 g. Scales were checked daily using standard weights. Length was measured to the nearest 0.1 cm using an infantometer. The research assistants for this project were trained by the project PI, who was trained by experts for the U.S. site in the WHO Multicentre Growth Reference Study. After training and before beginning data collection, a standardization session with 10 infants was conducted to verify that each research assistant’s precision and reliability were satisfactory.
All data-collection forms (screening, infant feeding questionnaire, intake, and anthropometry) were coded and entered by two different research assistants. These files were then electronically compared and proper corrections made to the original electronic files.

**Data Analysis**

Data were analyzed using SAS for Windows (version 9.1.3). Initial analyses included descriptive characteristics of study participants. Simple t-tests, correlations, and chi-square tests were used to compare characteristics and responses of the 2 study groups. Factor analysis was used to explore factors surrounding infant feeding.

**Results/Discussion**

Ninety-three mothers were screened for this project. Of these, 53 were ineligible, with the primary reasons being breastfeeding (n=28) or infant being too old (n=17). Of the 40 mothers completing the telephone interview, average age was 30.5 years, with infants averaging 4.1 months of age. Eighteen mothers were WIC-income-eligible and the remaining 22 were above this income cut-off. Twenty one of the infants were male and 19 were female.

*Results of the infant feeding scale (n=40)*

Parental styles of feeding, described by Birch et al, in 2001, are thought to be predictive or illustrative of the interaction between parent and child and may influence overfeeding (20, 22). Using the infant feeding scale from Thompson et al, for assessment of the infant feeding behaviors in this sample, mothers were read a series of several statements and asked to respond as “Disagree” (1), “Slightly Disagree”(2), “Neutral”(3), “Slightly Agree”(4), and “Agree”(5). Four feeding-style factors were found in this
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sample (Table 1). These included *laissez-faire* (little interaction with infant during feeding, quantity and quality are of little concern), *pressuring/controlling* (parent uses food to modify infant behavior and parent is concerned about too little intake), *restrictive/controlling* (quality and quantity are controlled by parent), and *responsive* (parent is responsive to infant hunger and satiety cues) (20, 22). Results from this current project indicate similar responses to those described in the manuscript in review (20). This is a promising finding, potentially indicating common behaviors and beliefs across populations.

**Table 1. Parental Infant Feeding Factors (n=40)**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laissez-faire</td>
<td>2.3 (0.815)</td>
<td>1.0-5.0</td>
</tr>
<tr>
<td>Pressuring/controlling</td>
<td>2.09 (0.655)</td>
<td>1.1-3.5</td>
</tr>
<tr>
<td>Restrictive</td>
<td>2.5 (1.29)</td>
<td>1.0-5.0</td>
</tr>
<tr>
<td>Responsive</td>
<td>4.46 (0.571)</td>
<td>3.0-5.0</td>
</tr>
</tbody>
</table>

In addition to the questions from the infant feeding scale, mothers were read several statements regarding formula preparation and asked to respond on the same scale as described above. There were no differences by income level to the statements in Table 2. However, there was a trend in differences between infant sex and disagreement with the statement regarding “over-strong” formula, with mothers of males tending to disagree more strongly (p=0.09). Maternal age appeared to be a potential factor in formula-preparation opinions, with older mothers tending to disagree more with the statement regarding thin formula being okay (r=-0.532; p=0.0768).
Table 2. Responses by formula-feeding mothers to statements regarding formula preparation (n=40)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think it is important to be very careful when mixing up formula</td>
<td>4.8 (0.65)</td>
<td>2-5</td>
</tr>
<tr>
<td>I think formula that is a little over-strong is okay for my baby</td>
<td>1.2 (0.70)</td>
<td>1-4</td>
</tr>
<tr>
<td>I think formula that is a little thin is okay for my baby</td>
<td>1.5 (1.15)</td>
<td>1-5</td>
</tr>
<tr>
<td>I think parents learn how much formula should be added to water and don’t have to measure exactly</td>
<td>1.5 (1.18)</td>
<td>1-5</td>
</tr>
</tbody>
</table>

Sub-sample (Infant formula collection, intake collection, infant anthropometry)

Eighteen mothers provided a 24 hour sample of prepared formula, and the average infant age was 3.1 months. Infant anthropometry is shown in Table 3.

Table 3. Infant anthropometry for sub-sample (n=18)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant age (in weeks)</td>
<td>13.3 (4.18)</td>
<td>4.7-17.5</td>
</tr>
<tr>
<td>Infant weight (in grams)</td>
<td>6164.9 (1175.2)</td>
<td>3996-7805</td>
</tr>
<tr>
<td>Infant length (in centimeters)</td>
<td>59.8 (4.02)</td>
<td>51.0-65.0</td>
</tr>
</tbody>
</table>

Infant intake and energy-density are shown in Table 4. None of these 18 mothers reported offering any other foods or fluids during the 24 hr collection. “Normal” energy-density was defined as 18-22 kcal/oz. Results indicate that, though the average kcal/oz was 18.5, 26% of the mothers were consistently over-diluting the infant formula (<18 kcal/oz).
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kcal/oz); there was an overall average range of 14.5-23 kcal/oz. Only one subject over-concentrated the infant formula (kcal/ounce= 23). Contrary to our hypothesis, there were no differences by income level. However, the sample size was quite small and a larger sample size may impact results.

Table 4. Twenty-four hour formula intake and energy-density (n=18)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total ml (24hr)</td>
<td>963.3 (203.2)</td>
<td>627-1396.5</td>
</tr>
<tr>
<td>Total ounces (24hr)</td>
<td>33.8 (7.1)</td>
<td>22.0-49.0</td>
</tr>
<tr>
<td>Energy-density (calories/ounce)</td>
<td>18.5 (1.798)</td>
<td>14.8-23.0</td>
</tr>
<tr>
<td>Calorie intake per 24hrs</td>
<td>624.7 (118.9)</td>
<td>425.5-871.7</td>
</tr>
</tbody>
</table>

Energy density was significantly negatively associated with both ounces offered and ounces consumed (Spearman correlation): Ounces offered (r= -0.520: p=0.022), ounces consumed (r=-0.588: p=0.013). These negative associations indicate that there was some compensation allowed by the infant. There was no association between energy density and infant weight. However, due to the cross-sectional nature of the study it remains unknown if there is a long-term impact on infant rate of weight gain.

When exploring the aforementioned parental infant feeding factors in this sub-set of mothers supplying prepared infant formula samples some interesting findings arose. Specifically, mothers falling into the *restrictive* feeding construct were significantly more likely to supply formula samples of lower energy density (r=-0.469: p=0.049). Though the following results are only trends, it is possible that with a larger sample size, these results could become significant. For example, the more *responsive* a mother was, the
fewer ounces her infant consumed \((r=-0.351: p=0.129)\), potentially indicating infant control of feeding. Mothers who were more likely to demonstrate a *laissez-faire* or *pressuring* attitude with infant feeding tended to prepare more bottles \((r=0.302: p=0.196, 4=0.316: p=0.174, \text{respectively})\), indicating that the control may rest more with the mother. As a demonstration of *laissez-faire*, the more likely a mother was to agree with the statement, “I don’t think it is all that important to be careful when mixing up formula”, the more likely she was to have provided samples of dilute formula \((r=0.344: p=0.149)\). Importantly, in this sample, there was no significant relationship between parental infant feeding factors and infant intake, indicating that the infant may be able to maintain control of intake regardless of parental attitude. However, in light of the sample size and the theory that infant self-regulation of intake may be “trained-out” of infants over time, further research is required before drawing conclusions.

In conclusion, though the sample size was small, it appears likely that over-dilution is a potential issue in this formula-feeding population, regardless of income level, and further research should include investigating these behaviors and their potential impact on infant anthropometry. In addition, parental infant feeding factors may assist with identification of those mothers at risk for over-dilution.

**Application of the Research Results**

It is likely that all mothers reconstituting powdered infant formula should receive more education on accurate preparation. Though there is no indication here that income level is a risk factor for over-dilution of reconstituted powdered infant formula, in light of the changes proposed in the WIC food package for formula-feeding mothers, and the
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current economic climate, this research is important in terms of establishing a baseline of behaviors.
References


