COMPARISON OF INFANT FEEDING PRACTICES, NUTRIENT INTAKE AND BODY WEIGHTS BY CHILDCARE USE

BY

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DISSERTATION

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ABSTRACT

The child care setting represents a crucial environment for infants and children to establish healthy feeding practices in order to prevent overweight and obesity [7]. The objective of this research was to investigate the association between parental care (PC) and child care (CC) on infant feeding practices, food consumption, nutrient intake and growth in infants receiving Special Supplemental Nutrition Program for Women Infants and Children (WIC) assistance. Our hypothesis was that unhealthy feeding practices would be more common in CC compared to PC thus leading to greater weight for length (WFL) and weight for age (WFA) z-score at 1 year of age for infants in CC. This study sampled 105 infants aged 2 to 8 months of age from the Champaign Urbana WIC office from October 2009-August 2011. Mothers completed a 3-day food record and survey at the time of recruitment to assess their infant's feeding practices, nutrient intake, health status, and demographic characteristics. Baseline and follow-up weight and length for these children within the first year of age were collected from the WIC office.

The major differences in demographic characteristics of the study sample included child care hours per week, maternal employment, household income, and single parent home by CC use. Infants in CC had an average of 29 hours of care per week compared to the 0.64 hours in the PC group ($p<0.01$). A larger ($p<0.01$) percentage of mothers were employed in the CC group (73.9%) compared to the PC group (22%). However, the household income was greater ($p<0.01$) in the PC group ($15,986 ± $10,284 PC vs $9,967± $7,489.5 CC). In addition, there was a higher ($p=0.04$) percentage of single parents in the CC group (30.5 % PC vs. 50% CC).

Breastfeeding duration and age of solid food introduction did not differ between care type. Breastfeeding duration was on average 2.3 months while average solid food introduction was 4.4 months. No differences were observed between PC and CC infants in the rates of

formula introduction. When comparing food consumption at the time of recruitment, there were no differences in the number of servings per day of food groups, but the CC group showed lower consumption of formula ($p=0.03$) and breast milk ($p=0.18$) compared to PC.

Energy intake did not differ between care type after adjusting for feeding practices and child, maternal and household characteristics. However, there was a pattern of greater energy intake in the PC group. Child age ($\beta=34.8$, $p<0.01$) and number of servings of infant formula ($\beta=86.0$, $p<0.01$) were the strongest predictors of energy intake. There was greater ($p=0.05$) calcium intake in the CC group (788 mg CC vs. 742 mg PC). Otherwise, there were no differences in macro or micronutrient intakes between CC and PC.

For growth measures, infants in PC had a significantly greater change in WFL ($\beta=2.06$, $p=0.05$) and WFA ($\beta=1.69$, $p=0.01$) z-score and a greater follow-up z-score, after adjusting for feeding practices and child, maternal and household characteristics. There were no differences by care type in the length for age (LFA) z-score over the first year of life.

The strongest predictors of the change in WFL z-score were PC use ($\beta=2.06$, $p=0.05$), maternal pre-pregnancy BMI ($\beta=0.14$, $p<0.01$), birth order ($\beta=1.63$, $p<0.05$), maternal age ($\beta=-0.34$, $p<0.01$), birth weight ($\beta=-1.77$, $p=0.06$), non-Black/African American ($\beta=3.09$, $p=0.02$) and male gender ($\beta=-2.12$, $p=0.06$). Change in WFA z-score was significantly affected by CC use ($\beta=1.69$, $p=0.01$), lower birth weight ($\beta=-1.74$, $p<0.01$), greater pre-pregnancy BMI ($\beta=0.09$, $p<0.01$), and less servings of infant formula ($\beta=-0.53$, $p=0.05$). Change in LFA was unaffected by CC use ($\beta=1.69$, $p=0.11$), but significantly affected by lower pre-pregnancy BMI ($\beta=-0.04$, $p=0.04$) and black race ($\beta=-2.54$, $p=0.05$).

Thus, we concluded that CC use did not affect feeding practices, overall nutrient intake or LFA z-scores for infants receiving WIC assistance. There was significantly greater calcium

intake in the CC group. CC use also showed a trend of less formula and breast milk. Infants in PC had a statistically greater change in WFL and WFA compared to those in CC. The main finding in this study is that CC use may have influenced differences in the change in WFL and WFA z-scores, but not overall infant feeding practices, nutrient intake and LFA z-score. Future longitudinal studies are warranted to explore the role of CC use on feeding practices, nutrient intake and growth.

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Chapter 1:

Introduction

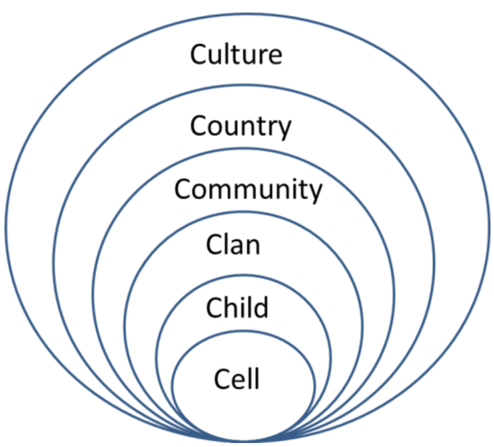
Childhood obesity has become a national health concern both in prevalence and severity [1]. An estimated 10% of children less than 2 years of age have been classified as having high weight for length (WFL) in the United States (U.S.) [2]. In 2010, the World Health Organization approximated that 42 million children were classified as overweight under the age of five, with an estimated 35 million of these children in developing countries [1]. In the U.S., 16.9% of children and adolescents were classified as obese in 2009-2010 [2]. Infants who gain weight rapidly during the first 2 years of life are more likely to be overweight later in childhood, posing serious health consequences [3, 4].

The threat of childhood overweight and obesity can lead to devastating health problems. Overweight children have an increased risk for medical problems early in life such as asthma, high blood pressure, hyperlipidemia, type 2 diabetes mellitus, asthma, and sleep apnea [5-11]. In addition, there is greater psychological and social stress as well as lower self-esteem in overweight children [12-14]. Because of these serious medical, psychological and social consequences, it is important to address this public health challenge and understand the causes of rapid weight gain in infancy and children [15].

A. Ecological Framework: Theoretical foundation for the study-Six C's Model

This study has contributed to the current literature by providing further understanding of early determinants of childhood obesity in infants using the ecological framework (Six C's Model) presented in Figure 1.1 [16]. Based on the Six C's model, a child's weight status is determined by their intake and expenditure patterns. Yet, these patterns are part of a larger ecology of the child's family, community and demographic characteristics. The Six-C's model classifies six spheres of influence determining a child's weight status. There is one sphere of genetic influence (**cell**) and five spheres of environmental influence (**child, clan, community, country, culture**) [16]. The cell sphere identifies genetic predispositions to body structure and other biological factors. The child sphere identifies personal and behavioral characteristics mostly within the child's control. The clan sphere identifies family characteristics. The community sphere encompasses factors concerning the child's social world beyond the home, such as peers, schools and other institutional factors, and community factors. The country sphere identifies state- and national-level institutions affecting citizens' priorities and opportunities. Finally, the culture sphere includes factors related to society such as culture-specific norms, myths, and biases that guide citizens' and policy makers' fundamental assumptions about eating, exercise, health, and the body [16]. This study focused on the **community** sphere of the Six-C's model – the impact of child care use in shaping infant's feeding practices, nutrient intake, and growth status during the early childhood period.

Figure 1.1. Six C's ecological model [16]



In the U.S. society, there has been an increase in non-parental child care use due to the doubling in maternal employment rates over the past 30 years [17-19]. As a result, a majority of infants in the U.S. raised in these households spend a large amount of time in child care settings outside of their home [18-20]. The U.S. Department of Education and Census Bureau approximate that 12 million of children 5 years of age and younger attend some form of child care. There are more hours spent in child care for infants compared with other places besides their home [19, 21]. Thus, the child care setting represents a crucial environment for infants and children to establish healthy eating and physical activity in order to prevent obesity [5].

Child care providers can strongly influence food consumption patterns and affect eating habits of infants [22]. The child care environment has been shown to negatively impact early weight gain in children less than 2 years of age because of unfavorable feeding practices and greater infant weight gain during the first year of life [23]. The difference between parents and child care is that parents have a greater tendency to support positive nutrition and physical activity behaviors compared with child care providers [24, 25]. It has been reported that more hours in child care during the first 6 months of life were associated with increased WFL z-score at 1 year of age and increased BMI z-score at 3 years of age in the U.S. [15]. Use of child care has also been shown to be positively associated with BMI z-score at 2 years of age as well as a larger change in BMI z-score between 1 and 2 years of age [5]. In addition, infants who use relative care were more likely to gain weight during the first 9 months of life compared to parental care [23]. However, there is limited information about the use of child care on weight status during the first year of life.

Previous research has not fully examined the nutritional practices in child care settings as compared to parental care. In addition, there has yet to be a complete assessment of the infant weaning diet specifically such as the frequency, amount, and type of solid foods consumed by infants in all types of child care. As a result, feeding practices have not yet been completely determined to be a risk factor for infant weight gain in child care.

Several studies have examined the association of child care use with dietary intake and weight status in toddlers and preschoolers [5, 26-29]. While the data are not conclusive, early introduction of solid foods prior to 4 months of age has been associated with obesity during the first year of life [30-32]. Infant feeding practices in child care have not yet been completely determined to be a risk factor for fast weight gain during infancy [30-32]. Thus, further studies are needed to understand the associations of child care and dietary intake and the mechanisms associated with childhood overweight. Thus, feeding practices, dietary intake, and growth during the first year of life are addressed in this study dissertation.

B. Objective and Study Aims

This research study helped provide new evidence about the relationship between early nutrition between infants in child care (CC) and parental care (PC) and growth status later at 12 months of age in the WIC population. The **overall objective** was to investigate infant feeding practices, food consumption, nutrient intake and growth by CC and PC use between infants receiving WIC assistance.

Specific Aims

Aim 1: Assess the differences in feeding practices of infants in child care and parental care.

The objective of this study was to assess infant feeding practices specifically in breastfeeding, formula feeding, and the introduction and type of solid foods consumed between infants in CC and PC. Our hypothesis was that unhealthy feeding practices would be more common in CC compared to PC. We expected a decreased rate of breastfeeding and early introduction of fruit juice and complementary solid foods in infants enrolled in CC.

Aim 2: Assess the differences in nutrient intake of infants in child care and parental care.

The objective was to analyze the nutrient intake of infants' diet. Our hypothesis was that all infants would meet or exceed the current Adequate Intake (AI) reference values for macro and micro nutrients with greater intake in the CC group.

Aim 3: Determine the impact of child care use on growth at 12 months age.

The objective was to investigate how CC use affects measures of weight status, specifically in the WFL, weight for age (WFA) and length for age (LFA) z-scores at 1 year of age. Our hypothesis was that unhealthy feeding practices would be more common for infants in CC leading to a higher WFL and WFA at 1 year of age.

The following chapter, Chapter 2, provides a literature review about the WIC population, infant feeding guidelines, current infant feeding practices in the U.S., nutrient intake of infants and factors impacting growth in childhood. Next, the results of this research study are detailed in the following chapters of this dissertation. Chapter 3 examines differences in infant feeding practices by CC use. Chapter 4 provides an assessment of nutrient intake in infants in CC compared to PC. Chapter 5 discusses the impact of CC use, feeding practices and demographic characteristics on WFL, WFA and LFA z-score at 12 months of age. Finally, Chapter 6 provides an overall summary and future directions.

Chapter 2:

Literature Review

A. Description of WIC program and its population.

The Special Supplemental Nutrition Program for Women, Infants and Children (WIC) population was selected for this study because WIC children have a greater risk for less breastfeeding and becoming overweight [33]. Thus, this population was identified as a target of this research study. WIC is a federal grant program provided from the U.S. Department of Agriculture (USDA) Food and Nutrition Service (FNS). This program is intended for low income populations who are at a higher nutrition risk by offering supplemental nutrition, nutrition education, and screening and referrals to other social services. Financial eligibility to WIC is defined as a household income of <185% of the poverty level or are actively partaking in the Food Stamp program, cash welfare or Medicaid program [33]. The most common income source for WIC families is Temporary Assistance for Needy Families (TANF) [33].

WIC focuses on serving pregnant women, infants and children less than 5 years old. As of 2010, WIC serves approximately 9.17 million people monthly through their program [34,35]. Cole and Fox characterized national demographic information for women, infants and children participating in WIC compared to non-WIC users [33]. The average age of women participating in WIC are 18 to 34 years old [33]. The percentage of mothers who were enrolled in WIC is 51%. Demographic information shows that 30% of WIC women and mothers have not completed high school education, while 15% of mothers are enrolled in college part time or full time [33]. Twenty eight percent of WIC mothers are employed [33]. It has been reported that the highest employment rate among WIC women is found in pregnant women enrolled in WIC at 32% [33]. WIC women were significantly less likely than higher income women to have health insurance, more likely to receive Medicaid benefits but equally as likely to have a regular source of health care. Compared to women not enrolled in WIC, there is a greater percentage of teenage mothers and Hispanic and black mothers participating in WIC [36]. In addition, this population of WIC mothers was characterized as less likely to be married, and have a greater likelihood of residing in a rural area compared urban areas [36].

Average household size of WIC families nationally is 4 people, living in primarily single family households with a small percentage residing in multi-family households with extended family [33]. Fifty eight percent of WIC participants reside with at least one other family member who is enrolled in WIC [33]. The likelihood of sibling participation in the WIC program decreases as the sibling increases in age [37]. Approximately 94% of siblings of WIC children that are less than 12 months are enrolled in WIC, while only 70% of siblings of WIC children participate in WIC by the time they are 4 years old [37].

Cole and Fox also characterized the lifestyle habits nationally for women, infants and children participating in WIC compared to non-WIC users [33]. The lifestyle habits of WIC participants, including physical activity, smoking, alcohol consumption and general health status, differed from the non-WIC participants. In terms of physical activity level, pregnant and postpartum women participating in WIC are less active compared to non-WIC participants of higher income, but equally as active as other low income non-WIC participants [33]. Some form of physical activity was done by 27% of WIC women three times a week and 15% women at least five times a week, which differs from the 45 % and 34% reported in higher income women respectively. WIC women were not significantly different in smoking prevalence compared to higher income non-WIC participants. Yet, WIC women did begin smoking earlier in age compared to high income women. In addition, WIC women were more likely to be smoking at the time of infant's birth compared to higher income counterparts (27% vs. 17%). The likelihood of exposure to second hand smoke was greater for WIC infants (47% vs. 23%) and children (44% vs. 29%) compared to higher income counterparts. Alcohol was less likely to be consumed by WIC women compared to high income non participants in their lifetime (72% vs 85%) and in the past year prior to pregnancy (21% vs. 46%). Of those WIC women who drank within the past year, the average number of alcoholic drinks per day consumed was higher in WIC population compared to higher income populations (3.7 vs. 2.1 drinks/day). The general health status of 97% of the WIC population was rated as good, very good or excellent health based on physician assessment [33].

Birth and breastfeeding information based on a Food Assistance and Nutrition Research report by Cole and Fox revealed that the average number of live births in WIC women in the U.S. (1.6) was higher compared to higher income women (1.1) [33]. Also in comparison to higher income populations, WIC women were significantly younger in age during the time of the first birth (24.1 years vs. 28.9), and more likely to have been teenagers at the time of the births (23% vs. 3%) [33]. There was a greater number of low birth weight among WIC infants compared to higher income counterparts (12% vs 4%)[33]. Low birth weight is used as a nutritional risk criteria for infants that provides them eligibility to WIC program [33]. However, WIC children and non WIC children of higher income families have similar prevalence of underweight status of weight for height less than 5^{th} percentile [33]. The prevalence of growth retardation was significantly higher in WIC children compared to higher income children (9% vs. 2%) [33]. WIC children aged 1-4 years old were more likely to be overweight (at or above 85^{th} percentile for weight for height growth charts) compared to higher income children (7% vs. 4%) [33]. However, for WIC children and higher income children, there were no significant differences in their risk of overweight, defined as weight for height between 85^{th}-95^{th} percentiles, because it was 10-15% in both groups [38]. Furthermore, the percentage of infants ever breast-fed was lower in WIC participants (39%) compared to higher income infants (71%) [33]. WIC infants are significantly less likely to have been breast-fed for 6 months both in percentage and in duration of months [33].

A majority of WIC participants are characterized as having more than one nutrition risk at the time of enrollment [33]. Fifteen percent of WIC women have a single risk factor, while 42 percent of women have four or more risks [33]. Of infants, 44% of infants and children have a single risk factor and 13% have four or more risk factors [33]. The most common risk for women and infants is dietary related, while others include overweight/obesity, anemia, or short stature (infants only) [33].

Figure 2.1 was created based on data from the WIC-Infant Feeding Practice Study (IFPS) [37]. This figure describes the percentage of infants cared for by somebody other than their mother.

B. Infant feeding Practices

During the first year of life, there is a gradual diversification of the infant's diet from breast milk or formula to the slow transition to solid foods and non- milk based liquids [39, 40]. Other factors affecting feeding practices related to parents will also be identified. Due to differences in the feeding environment between home and child care (CC), a set of national feeding guidelines for CC have been included and used as a standard of healthy infant feeding practices.

i**. Infant feeding guidelines in the United States**

There are several guidelines for infant feeding provided by the American Academy of Pediatrics (AAP), Academy of Nutrition and Dietetics (AND), Surgeon General, and the World Health Assembly. In addition, there have been some concluding feeding recommendations based on the findings of the Feeding Infants and Toddlers Study (FITS). These recommendations provide a framework for parents, clinicians, and nutrition educators to use as a reference.

A summary of infant feeding recommendations are provided in Table 2.1. A detailed list of these guidelines is provided in Appendix A. Briefly, it is recommended by the AND, Surgeon General, and the AAP Working Group on Breastfeeding that infants should be breast-fed exclusively for six months following birth [41, 42, 43]. Similarly, the World Health Assembly provides guidelines for infants to be breast-fed for 6 months exclusively, followed by a slow introduction of complementary foods after 6 months of age [44]. Breastfeeding exclusively without any supplemental liquids or solids, for the first 6 months of age is recommended by the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) [43]. WHO and UNICEF further recommend breastfeeding until at least 2 years of age or longer [43]. Breastfeeding duration has been associated with a reduced obesity risk during adolescence and adulthood by 7% and 24%, respectively [43]. Furthermore, every additional month that an infant is breast-fed, there is a 4% reduced risk of becoming overweight in adulthood [43].

ii. Characterizations of current breastfeeding patterns in the U.S.

Based on Table 2.1, there is a general consensus from the AAP, AND, and WHO that an infant should be exclusively breast fed without any additional food for the first 6 months of the child's life [45]. Breastfeeding improves cognitive development, and decreases the incidence of overweight and obesity. It has also shown to reduce the incidence and severity of infectious diseases such as bacterial meningitis, bacteremia, diarrhea, respiratory tract infection, necrotizing enterocolitis, otitis media, urinary tract infection, and late-onset sepsis in preterm infants, causing a reduction in postneonatal infant mortality rates [42]. Furthermore, there is a reduction in the rates of sudden infant death syndrome, as well as a reduction in the incidence of type 1 and type 2 diabetes mellitus, lymphoma, leukemia, and Hodgkin disease, hypercholesterolemia, and asthma [42].

In a study characterizing infant feeding patterns in the U.S. during the first year of life by Grummer-Strawn et al., the incidence of breastfeeding was 83% immediately after birth in the hospital but dropped to 50% by 6 months of age and 24% by 1 year of age [46]. However, of the 83% breast fed infants, 42% of these infants were also receiving formula while in the hospital then declined to 34% by 3 and 9 months of age [46]. Briefel et al. (2004) reported similar breastfeeding results of 76% children in the U.S. being completely breast fed or mixed feeding at birth, with an average time of 5.5 months for breastfeeding [41]. Breastfeeding rates were 30% and 16% at 6 and 12 months, respectively [41]. By 10.5 months, formula feeding accounted for the majority of milk-related feedings [46].

Due to the low rate of breastfeeding in the U.S., Healthy People 2020 has set out an objective specifically pertaining to infant and toddler feeding to "increase the proportion of mothers who ever breastfeed their babies to 81.9% in the early postpartum period, 60.6% at 6 months, and 34.1% at 12 months. Exclusive breastfeeding goals are to increase the proportion to 46.2% at 3 months and 25.5% at 6 months."

Infant feeding practices, in particular, may be an important contributor to obesity risk and may be a good target for intervention [47]. The next section will outline infant feeding patterns related to the introduction of complementary foods.

iii. Characterizations of current food consumption patterns among U.S. infants

It is important to characterize existing feeding practices during the first year of life in order to understand patterns and identify areas of improvement. Some important feeding practices include breastfeeding and formula feeding, timing and type of solid food introduction, as well as timing and type of non-milk beverages. Infants greater than 4 to 6 months should be fed a variety of complementary foods such as fruits, vegetables, whole grains, and naturally iron-rich foods by caregivers [48]. These foods help to support growth and development of the infant and foster lifelong healthy dietary choices [48]. This section will discuss the percentage of infants with early introduction of complementary foods, types of solid foods offered, reasons for the early introduction of solid foods, and the percentage of infants with early introduction of non-milk beverages.

National representative data showed that 73% and 95% of infants who were 4 to 12 months of age consumed commercial baby foods [41]. On average, infants 4 to 12 months of age have seven feeding times per day [49]. For the first 6 months of life, infants rely on formula or breast milk primarily for energy, providing 84% of total energy, with more complementary foods becoming a part of their diet at 7 to 8 months of age [49, 50]. Meal patterns, breakfast, lunch and dinner plus snacks, begin by 7 to 8 months and become more consistent by 9 to 11 months of age [49]. For breakfast, lunch and dinner, the percentage of total energy was accounted for by 13-18%, 11-17%, and 12-17%, respectively in 4 to 11 month old infants [49]. Snacks accounted for 15-20% of energy, and other (formula/breast milk) was 28-49% in 4 to 11 months old infants [49]. One fifth of infants drank 100% fruit juice at 4 to 6 months of age, 45.6% at 7 to 8 months of age and 55.3% at 9 to 11 months of age [50]. Water was consumed by

33.7% of infants at 4 to 6 months of age, 56.1% at 7 to 8 months of age, and 66.9% at 9 to 11 months of age [50].

One third of infants have been reported to consume foods earlier than the recommended 4 to 6 month age period by the AAP [41]. This recommendation is based on evidence that infants may not be developmentally ready to support complementary feeding based on their neuromuscular skills before 4 months of age thus placing them at an increased risk for feeding disorders later [51]. Furthermore, introduction of foods earlier than 4 months can increase an infants' risk of enteric infections, allergic reactions, and choking [52]. For juice, the AAP does not recommend fruit juice before 6 months of age and has no specific recommendations in fruit drinks or carbonated beverages [50, 53]. Thus, the recommendations by the AAP are based on the development, health, and safety of the infant.

In the U.S. and Europe, early introduction of solid foods and fruit juice has been associated with lower quality infant feeding practices, such as fruit juice displacing milk in the diet [46, 50, 54]. Infants who started eating solid foods at 4 months were more likely to have discontinued breastfeeding by 6 months of age and were fed fatty, sugary food and sweetened drinks by 1 year of age [46]. In the U.S., introduction of solid foods between 3 to 6 months was associated with a significant decrease in milk intake in breast-fed infants but not in formula-fed infants [55]. For U.S. infants at 4 months of age, the type of solid food consumed was 40% infant cereal, 17% fruits and vegetables, and less than 1% meat products [46]. However, unlike formula-fed infants, complementary food introduction did not lead to an increase in energy intake in breast-fed infants, as the calories from food displaced some of the breast milk calories [55]. Yet, there are unhealthy feeding practices associated with early introduction of complementary foods.

Besides early introduction of solid foods, there is evidence of premature introduction of other non-milk beverages. Water was consumed by 10% of infants by 1 month of age [46]. Juice and cow's milk was introduced to 17% and 22% of infants before the recommended 6 and 12 month age, respectively [41]. In addition, fried foods and sweetened beverages were consumed by approximately 10% infants aged 9 to 11 months [41].

In summary, early introduction of complementary foods and drinks prior to 4 months has been related to poor feeding practices such as earlier discontinuation of breastfeeding. The timing of complementary foods and drinks is a critical part of an infant's development, feeding patterns and weight status. There is an area for improvement among parents/caregivers in complementary food introduction, improving rates of breastfeeding, and decreasing fruit juice/fruit drinks.

iv. Infant feeding practices in the WIC population

a. Feeding practices in WIC populations

The WIC food package was revised on December 6, 2007 in accordance with the 2005 Dietary Guidelines for Americans and infant feeding recommendations by the AAP. All state agencies were required to implement the new package by Oct 1, 2009. See appendix B for description of the WIC food packages.

The WIC program is an ideal setting to examine early dietary behaviors, because it provides food, nutrition counseling and health referrals to low income pregnant and postpartum women, infants and children up to 5 years of age [34]. In addition, approximately 2.2 million infants benefit from WIC assistance per month [34,56]. The modified WIC package reflects recommendations by the AAP to encourage and support establishment and longer breastfeeding, to delay introduction of complementary foods, and to offer a more diverse variety of foods.

Jacknowitz et al. and Ponza et al. described the feeding practices of WIC infants by age (months) compared to non-WIC infants using nationally representative data sets [35, 57]. This data is summarized in Table 2.2 and Figure 2.2.

b. Breastfeeding in the WIC population

Breastfeeding incidence was characterized in two thirds of WIC infants as ever having been breast-fed [57]. Extensive research has demonstrated that WIC participants are less prone to breastfeed, with or without formula supplementation, compared to non-WIC participants [57-67]. WIC infants were also less likely to have ever been breast-fed compared to higher income infants (39% vs. 71%) and less likely to have been breast-fed for 6 months (31% vs. 42%) [33]. As shown in Table 2.2, there are a lower percentage of WIC participating infants who are exclusively breast-fed during the first 6 months of infancy compared to non-participants. In addition, Table 2.2 shows that there was a lower percentage of current and ever breastfeeding in WIC participants [57]. However, some WIC clinics, which have participated in creative approaches to promote breastfeeding, have increased rates of breastfeeding among WIC infants [68, 69].

The National Survey of WIC Participants indicated 50% of WIC children and 56% of WIC infants had been ever breast-fed [37]. Figure 2.2 indicates the median duration of breastfeeding was 4 months for WIC and 5.5 months for non-WIC [37]. Eighty percent of WIC infants were breast-fed for at least one month [37]. There was a 5.9% point decrease in probability of exclusive breastfeeding in WIC eligible population for ≥ 4 months and 1.9% point decrease in the chance of exclusive breastfeeding for ≥6 months [35]. When comparing CC type, Shim et al. demonstrated that WIC participants using relative care had a greater risk of short breastfeeding duration compared to PC users. However, non-WIC participants using relative care or center based care had a greater risk for short breastfeeding duration compared to PC users [70].

c. Formula feeding in the WIC population

There is a greater consumption of infant formula in WIC infants. Table 2.2 shows a greater percentage of WIC infants consuming infant formula compared to non WIC infants. There was an 8.5% point decrease in probability complying with AAP recommendations in delaying infant formula introduction until 6 months of age in WIC eligible population.

Figure 2.2 indicates that the average age of infant formula introduction was earlier in WIC participants (1.7 months) compared to non-participants (2.6 months) [35]. By 4 to 6 months of age, 95% of WIC infants are fed infant formula and 96% at 7 to 11 months of age [57]. There is greater consumption of iron in WIC infants due to the use of iron-fortified infant formula [35]. Compared to higher income infants, WIC infants were more likely to be fed supplemental infant formula (91% WIC vs. 78% high income) and at a younger age (6.6 weeks WIC vs. 9.1 weeks high income) [33].

d. Introduction of solid foods in the WIC population

There is conflicting information about the differences in solid food introduction in WIC and non-WIC participants. Table 2.2 shows a higher percentage of WIC infants were introduced to solid foods at every month in the first year of life. Yet, there were more non-WIC infants introduced to cow's milk before age 1. Figure 2.2 indicates no differences in the age of solid food introduction between infants who participated and did not participate in WIC, which is based on the 2002 FITS study [33, 35, 57, 71]. WIC infants were reported to be older in age at the time of introduction to solid foods compared to higher income infants (6.3 months WIC vs. 5.5 months high income) and equal likelihood between both groups to be offered foods before 4 months of age [33]. Table 2.2 reports data from the Early Childhood Longitudinal Study-Birth Cohort and shows a larger proportion of WIC infants who were introduced to solid foods before the recommended 4 to 6 month guidelines [35]. Jacknowitz et al. reported that WIC participants were 4.5% units less likely to postpone solid food introduction until their child was 4 months of age or older compared to non-WIC, low income WIC eligible participants [35].

In a study by Hurley et al. examining feeding practices of infants receiving WIC assistance in Maryland, all of the infants in their study population had begun on complementary foods by 3 to 5 months [72]. There were 98% of WIC infants that consumed complementary foods between the ages of 6 to 12 months mostly in the form of commercial baby foods, with average daily consumption of 1.5 servings of fruit and vegetables [72]. Approximately 70% of these infants had at least one vegetable and 86% at least one fruit or 100% fruit juice. Within this population, the consumption of vegetables increases from the period of 3 to 8 months, with 34% of WIC infants consuming vegetables at 3 to 5 months, 70% at 6 to 8 months and 69.6% at 9 to 12 months. A similar trend was found with fruits (excluding fruit juice), where the consumption increases from the period of 3 to 8 months with 41.5 % of infants consuming fruits at 3 to 5 months, 65.4% at 6 to 8 months and 64% at 9 to 12 months. Fruit juice was found in 9.1% infants at 0 to 2 months, followed by 24.5% at 3 to 5 months, 49.7% at 6 to 8 months and 67.2% at 9 to 12 months [72]. The increased consumption of fruit juice among WIC in comparison to non WIC infants is likely due to the inclusion of 100% fruit juice in the 2004-2005 WIC food package, which was recently changed to replace 100% fruit juice with commercial baby fruits and vegetables [72]. Regardless, fruit juice was introduced significantly earlier than the 6 month recommendation by the AAP.

Jacknowitz et al. described that the timing of infant cereal, pureed baby foods and cow's milk introduction was not different between WIC participants and non-WIC participants at 4.4 to 4.6 months, 5.2 to 5.5 months, and 11.6 to 11.8 months respectively [35]. As shown in Table 2.2, there is greater adherence by mothers of WIC infants compared to mothers of low income non-WIC infants to not offer cow's milk during the first 6 months of infancy [56]. Approximately one fifth of WIC infants were reported to consume cow's milk at 7 to 11 months of age [56]. WIC eligible mothers were more likely (by 2.5% units) to postpone cow's milk introduction until their infant was 8 months of age. There is lower intake of cow's milk by infants participating in WIC compared to eligible non-participants of WIC [35], except for one study by Ponza et al. that reported no difference in the introduction of cow's milk in 7 to 11 months of age [57]. Similarly, early introduction of cow's milk before 12 months of age was less common in WIC infants (11%) compared to higher-income infants (18%) [33]. Regardless, further nutrition education is necessary for WIC mothers to delay the use of cow's milk until the infant is 12 months of age.

The solid food consumption patterns of infants participating in WIC were described by Ponza et al. [57]. Baby cereals are consumed by 82% of WIC infants at 4 to 6 months of age and 97% at 7 to 11 months of age. Similar consumption patterns were found in non-participants of baby cereals. There was 71% and 98% of WIC infants fed pureed foods at 4 to 6 months and 7 to 11 months of age, respectively. Non-participants were fed pureed foods at 63% and 98% at 4 to 6 months and 7 to 11 months, respectively. Non-infant cereals that were unsweetened were more common by 7 months of age. Baby food vegetables were consumed by 40.2% and 69.8% of WIC infants at 4 to 6 months and 7 to 11 months of age, respectively. A majority ate baby food vegetables and less home cooked vegetables at 4 to 6 months. By 7 to 11 months, there were an equal proportion of WIC infants consuming both preparations of vegetables. Compared to non-WIC infants, fruit intake was higher in WIC infants 4 to 6 months but lower at 7 to 11 months of age for WIC infants. WIC infants consumed higher percentages of sweetened juice, sweets and desserts, and eggs at both 4 to 6 months and 7 to 11 months compared to non-WIC infants. Mothers receiving WIC assistance tend to engage in unfavorable infant feeding practices, which can be of concern since it increases the infants' risk of becoming overweight. Despite being informed about recommended feeding practices by their health care providers and the WIC staff, some women still choose not to follow these guidelines. There is area for improvement in the introduction of solid foods in WIC participants. Thus, the following section will discuss barriers and factors affecting a mother's decision to not follow appropriate feeding practices.

v. Influencing factors affecting low income mothers decision to not comply with infant feeding recommendations

Using a focus group approach, WIC women were interviewed to understand the reasons behind their feeding decisions [73, 74]. The goal was to understand the reasons driving their undesirable infant feeding practices such as formula feeding, early timing of solid foods, and excess juice/fruit drink use.

The first major topic explored reasons why a mother chooses to formula feed rather than breastfeed. Mothers reported choosing formula feeding instead of breastfeeding due to their concerns about adequate breast milk supply, postpartum medications, problems with infant latching onto the breast, milk intolerance, delayed lactogenesis, or concerns about mothers returning back to work or school soon [73]. In addition, these women believed that using formula can allow the mother to control the feeding schedule thus allowing them to modify their infants crying, waking and hunger so that the child would feel satiated [73, 74].

Even though health care providers provided positive encouragement for mothers to breastfeed, these women felt powerlessness to breastfeed exclusively leading to a rejection of the health care provider advice [73]. Furthermore, these women expressed the lack of family, friend, and day care provider support to breastfeed their infant and found it to be not socially acceptable to breastfeed in public [73]. Some young WIC mothers are adolescent mothers and live with their own families. Thus, grandmothers of the WIC infants have significant influence on the feeding decisions of the infant, in addition to great grandmothers, aunts and cousins of the WIC infants [73, 74]. It was reported that some family, friends and health care providers made some infant feeding decisions without the consent of the mother such as offering formula or different foods [73]. Thus, mothers perceived that people other than the parents were guiding the feeding decisions for their infants.

The next major issue addressed to these WIC mothers was a discussion about early introduction of solid foods to their infants. There was a misunderstanding among these women about the definition of solid foods; solid foods were considered to be table food rather than baby food [74]. There was a concern, however, about the risk of allergies, asthma and diabetes with early timing of complementary foods [74]. Yet, mothers expressed uncertainty about the frequency of infant feeding, and they were able to recognize hunger cues from crying or lip smacking. There was an expressed stress and strong emotional response about the perception that their infant could possibly not be getting enough nourishment, thus further supporting their decision to formula feed as well as giving extra formula, putting cereal in the bottle and/or feeding extra baby food to ensure that the baby is “full” and will have prolonged sleep [73, 74].

They were not concerned about the possible effects of obesity later in life if solid foods were introduced too early before 4 months of age [74]. In addition, these women were not concerned about how the feeding environment affects the development of the child, such as feeding the infant with the television on and feeding in several rooms of the home. The important issues in the timing of solid food introduction related to the satiety and health concerns of the infant.

vi. Parental factors affecting infant feeding practices

Understanding an infant's feeding cues by both parents and CC teachers is important for optimizing feeding practices. This section will discuss reasons for early introduction of solid foods and explain differences in the regulation of intake between breast-fed and formula-fed infants. In addition, there will be an assessment of maternal diet, educational level, nutritional status on infant feeding practices, as well as how birth order affects parental compliance with feeding guidelines.

Parents in the U.S. reported reasons for early introduction of solid foods were due to "infant interest, appropriate age, hunger, physician advice, infant not sleeping through the night" [55]. In a study examining the contributions of maternal characteristics and behaviors in predicting infant weight gain in the first year of life, weight gain from 6 to 12 months was predicted by the number of feedings and lessened maternal sensitivity to infant cues, suggesting an inability of the infant to self-regulate their formula and breast milk intake [75]. An infant's lack of self-regulation can be attributed to the mother failing to slow the pace of feeding or stopping a feeding when an infant shows cues of satiation [75]. Evidently, maternal sensitivity to feeding cues can have a significant impact on dietary intake and weight status for infants.

A mother's decision to breastfeed or formula feeding can significantly affect the infant feeding patterns and their level of dietary restriction towards their child. Mothers, who fed breast milk early in infancy and for a longer duration, had opinions and behaviors on child feeding that were less restrictive at 1 year old children [76]. Compared to exclusive formula feeding mothers, breastfeeding mothers were less likely to restrict food intake of their 1 year child [76]. In addition, every additional month of breastfeeding was related to the mothers not pressuring food intake of the child [76]. Mothers who breast-fed their infants throughout the first year of life showed lower levels of control in feeding and their toddlers had higher energy intake at 18 months of age [77]. Thus, breastfeeding allows multiple chances for the mother to interact with her child and allow the child to regulate their intake and share control of their food intake with their parents [77]. Additional counseling to expectant mothers should be implemented to increase their sensitivity to hunger and satiety when feeding their infants [76].

Besides maternal sensitivity to infant cues for satiety, the quality of the maternal diet and level of maternal education also has a significant impact on an infant's diet at 6 and 12 months of age [54]. Mothers with a more prudent diet consisting of fruits, vegetables, whole meal bread, rice and pasta are more likely to offer these foods to their infants [54]. White women who were more educated, married, older, nonsmoking and from a higher household income were found to be more likely to breastfeed and comply with the recommendations for the introduction of complementary foods by the AAP [78]. Women enrolled in WIC were least likely to breastfeed and follow the AAP recommendations on solid food introduction [78]. Obese women were more likely to breastfeed compared to non-obese women [78]. Exclusive breastfeeding for 3 months was correlated with higher infant birth weight and greater weight gain in the first 6 months of infancy. Prenatal weight status of the mother was also correlated to infant growth [79]. Yet, despite the higher fat concentrations in the breast milk of obese mothers in North Africa, the pattern of growth is not different in breast-fed infants with mothers of lower body weight [79].

Breast-fed infants are more likely to control their milk volume intake, depending on the calories and fat concentrations in the milk [79].

Maternal education has shown to determine the extent of unhealthful infant feeding practices and rate of infant weight gain. In a study examining the association between maternal education and unhealthy infant feeding practices such as timing of complementary foods, diet quality, responses to infant cues and commercial baby food use in the U.S., there were greater number of unhealthy infant feeding practices by mothers with a high school education or less [80]. These unhealthy feeding practices include introducing complementary foods prior to 4 months infants age, pre-masticating food for their infant, offering restaurant food instead of baby food, offering juice prior to 6 months of infants age, and introducing cow's milk prior to 10.5 months of infant's age [80]. However, level of maternal education was unrelated to timing of introducing new foods, number of times an infant was fed per day and use of commercial baby foods [80]. In addition, infants are also more likely to begin a healthy complementary food pattern if their mother has a higher educational level, lower BMI, less television watching, and are older in age [54]. Consequently, maternal education was shown to have a stronger impact on the quality of the infant's diet, rather than the timing and frequency of feedings.

In addition to maternal education, parents have demonstrated changes in dietary patterns and feeding practices based on the birth order of their infants in the United Kingdom [54]. First-born children were more likely to have a higher quality diet that complies with recommended feeding guidelines and not characterized as being high in calories and low in nutrients [54]. However, regardless of parental behaviors, CC providers continues to also have a significant impact on infant feeding practices due to the large percentage of infants that spend time in a CC environment [81-83].

In conclusion, parental behaviors, perceptions, education level and diet impact their infant’s diet and can differentiate the quality of their infant’s feeding practices. Early complementary food introduction has been associated with parental perceptions of appropriate infant age, infant not eating enough, not sleeping adequately, or child demonstrating ‘interest.’ Yet, parent/caregiver may be missing their child’s cues for satiation, and may be pressuring their child to feed rather than allowing the infant to regulate their own appetite. Several studies have shown that maternal education and maternal diet can significantly impact the rate of infant weight gain and compliance to the AAP recommendations, such as breastfeeding duration, timing of solid food introduction, and the quality of the infant complementary foods.

vii. Child care center feeding guidelines

There is a national guideline for CC centers provided in the Caring for Our Children-National Health and Safety Performance Standards: Guidelines for Out of Home Child Care Programs (CFOC) [84]. The AND also released guidelines for CC centers to promote a healthy nutritious CC environment that supports growth and development for infants and children [85]. These guidelines are detailed in Appendix C.

While the CFOC provides good recommendations for promoting healthy feeding practices, federal and state laws do not require compliance to these standards [84]. In a review of CC centers and home based centers, infant feeding regulations were evaluated across all 50 states in the U.S. and compared against the 11 specific feeding standards outlined in CFOC [86]. Many states have incomplete infant feeding regulations in CC centers and home based care and need to be encouraged to comply with the standards of best practice for infant feeding [86]. Although none of the states followed all of the standards, the state of Delaware included 10 of the standards in their regulations [86]. Another state, Ohio, had 5 standards included in their law for home based centers [86]. In addition, the highest average number of regulations for both CC centers and home based centers were in the Southern states while the Western States had the least [86].

Illinois, in particular, currently has regulations for 4 out of 11 standards, which are listed below [86].

- Infants are fed on demand.
- Infants are held while feeding.
- Infants cannot carry or sleep with a bottle.
- No solid food is fed in a bottle.

Illinois is lacking regulations that prevent introduction of solid foods before 6 months of age, prevent introduction of cow's milk before 12 months of age, promote breastfeeding in the CC centers, and require whole cow's milk from 1 to 2 years of age [86].

The USDA Child and Adult Care Food Program (CACFP) provide a detailed CC infant meal pattern that is required for participating CC providers. These regulations are detailed in Appendix D. While CACFP provide structured requirements, the meal pattern should be consistent with the infant's eating habits [87]. During the first year of life, infants should be served breast milk or iron-fortified infant formula [87]. Infants should be fed a minimum amount of breast milk, or formula and foods specified by age in the meal pattern table outlined in Appendix D. Breast-fed infants should be offered breast milk when they show cues for hunger, especially if they regularly drink breast milk less than the minimum amount outlined in the meal pattern guidelines [87]. Foods should be developmentally appropriate in terms of its texture and consistency [87]. Thus, parents should communicate with CC providers on the appropriate foods to be served for their child [87]. In addition, foods should be offered one at a time [87]. Fruit juice should not be served to infants until 6 months of age or when the infant is able to drink from a cup to prevent dental caries [87].

Thus, there is an opportunity for the states to increase their regulations and comply with these CC feeding standards in order to promote healthy weight gain and feeding practices [86]. As such, public policies need to be changed to address the rising obesity problem in the U.S. [88]. The next section will describe the feeding patterns of infants reported in CC settings.

viii. Infant feeding patterns in childcare

Currently in society, there are many dual career households. As a result, a majority of infants in the U.S. raised in these households spend a large amount of time in CC settings outside of their home. There are more hours spent in CC for infants compared with other places besides their home. Approximately 60% of children less than 6 years of age spend a minimum of 29 hours per week in child care [81-83]. In the U.S., more hours of care in someone else's home during the first 6 months of life were positively associated with increased WFL z-score at 1 year of age and increased BMI z-score at 3 years of age [15]. Yet, there were no reported differences in adiposity between parental care (PC) and center-based care. Regardless, CC providers can influence the food consumption patterns of infants.

Kim and Peterson reported a study of infants cared for by relatives compared to those in PC [23]. Infants cared for by a relative or CC in the U.S. were associated with an introduction of solid foods before 4 months of age and increased infant weight gain at 9 months of age, compared to infants in PC [23]. Relative care was associated with lower breastfeeding initiation rates and higher rate of early introduction of solid foods, compared to infants in PC. There was also a decreased duration of breastfeeding, introduction of solid foods earlier than recommended and increased weight gain in infants receiving CC when compared to those receiving PC. For those infants who began CC less than 3 months of age, they were less likely to have ever been breastfeed and more likely to have an early introduction to solid foods. In addition, infants attending part time CC or care by relatives had a greater weight gain over the first 9 months when compared to infants under PC.

Child care providers who had some form of college education showed positive role modeling by sitting and eating with the children [89]. This positive role modeling was less likely to be found in Hispanic CC providers [89]. Approximately 46% of CC providers cooked foods they knew children liked, a behavior more likely found in Hispanic ethnicity [89]. Family-based providers were more likely than center-based care providers to offer new foods only three to five times [90] even though it is suggested to offer new foods to a child at least 10 times [91-93]. In addition, it was found that an estimated 59% of CC providers forced children to finish their meal prior to having dessert, regardless of ethnicity, education or type of CC provider [89]. This behavior can put a child at risk for later obesity as it promotes overeating and prevents a child to respond to their own satiety cues [89].

Evidently, it appears home-based care by relatives or care in someone else's home provides a greater risk for poor infant feeding practices and increased weight gain in comparison to center-based care and parental care. Home-based care has been associated with decreased breastfeeding, early introduction of complementary foods, and decreased offerings of new foods.

C. Nutrient intake during infancy

Several nutrients are important for the proper growth and development of infants during the first year of life. Yet, it is unknown if there are differences in nutrient intake for the infant population between CC as compared to PC. In children greater than one year of age, it has been reported that they do not consume the recommended dietary intake during their hours in CC [5]. This section will provide a review of nutrient intake patterns of a national representative sample of infants in the United States. In addition, a comparison of nutrient intake will be provided for children enrolled in CC. There will also be a discussion on the nutrient consumption of infants participating in WIC.

i. Nutrient intake patterns of infants in the U.S.

An evaluation of appropriate dietary intake is based on the adequacy of each nutrient in the diet. Key nutrients in the diets of infants include carbohydrates, protein, fat, vitamin D, vitamin A, vitamin E, vitamin C, vitamin B-12, folate, vitamin B-6, thiamin, riboflavin, calcium, iron, zinc, fluoride, sodium, and water [94]. Major sources of energy, macronutrients and micronutrients are accounted for by infant formula and breast milk in diets of infants. There is a gradual transition to baby foods and table foods within the first year of life. Several foods are fortified and play a major role in the diet of infants and toddlers. This is important in the prevention of several nutrient deficiencies.

The Feeding Infants and Toddler Study (FITS) study examined dietary sources in the diets of infants as identified from national representative sample of children 4 to 24 months old [48]. This cross-sectional survey was conducted in 2002 and 2008. Nutrient intake from the 2008 FITS are presented in Appendix E [95]. Breast milk and formula were the major contributors of energy, and macronutrients for all infants. They accounted for 88% of energy at 4 to 5 months of age then drops significantly between 4 to 5 months and 6 to 8 months of age with the gradual introduction of complementary foods. By 12 to 24 months of age, formula and breast milk and milk provided only 24% of energy in the diet [48]. Other major sources of energy for infants 6 to 11 months of age included infant cereal, 100% juice, commercial baby food dinners, bananas, cookies, apples/applesauce, and commercial baby food desserts.

Infant formula/breast milk provided as much as 65% of protein to the diet of 4 to 5 month old and 40% for 6 to 11 month old infants. Protein intake other than milk/formula was derived primarily from infant cereal during the ages of 4 to 11 months. For infants 6 to 11 months of age, baby food dinners and chicken/turkey baby food meats provide a small contribution of protein to the diet. There was a larger percentage of fat provided by infant formula/breast milk and cow, goat or soy milk (79-98%) compared to other dietary fat sources. Other sources of fat included infant cereal, butter/oil/margarine, baby food dinners, cheese, cookies, and crackers/pretzels/rice cakes. Dietary carbohydrates in the form of infant cereal and breast milk provided 27.2-51.5% in 4 to 5 month old and as much as 33.7% in 6 to11 month old infants. Non-milk sources of carbohydrates in the diet of 4 to 11 month old infants included 100% juice, bananas, apples/applesauce, baby food desserts, cookies, pears, peaches, bread/rolls/biscuits/bagels/tortillas, crackers/pretzels/rice cakes, yogurt, pasta, sweetened beverages, sweet potatoes, and white potatoes.

Skinner et al. also measured the macronutrient distributions of meals and snacks for infants 7 to 11 months of age [49]. The distribution of protein, fat, and carbohydrate was 8-10%, 27-28% and 64-65% of total energy for breakfast, respectively. However, there were slightly greater protein and lower carbohydrate distributions at lunch and dinner for this age group. Lunch consisted of 10-12%, 28-29%, 61-64% and dinner 11-14%, 27-28%, 59-63% of total energy for protein, fat and carbohydrate, respectively. For snacks, the distribution of protein, fat and carbohydrate for the morning snack was 8%, 36-42%, and 51-58% of total energy while afternoon snack was 9%, 34-37%, and 57-58% of total energy, respectively. Evening snack was similar with 8-10% protein, 40-41% fat, and 51-52% carbohydrates.

For all infants throughout the first year of life, infant formula was the primary source of vitamins and minerals in the U.S., followed by breast milk [48]. There were several non-milk foods such as 100% juice, baby fruits, carrots, sweet potatoes, winter squash and fortified infant and non/infant cereal that contribute additional amounts of vitamins and minerals during 6 to 11 months of age [48]. Infant cereal provided the second or third largest source of thiamin, riboflavin, niacin, vitamin B-6, calcium, iron, zinc, magnesium, potassium and phosphorus and third or fourth largest source of vitamin C and E for infants [48]. Juice provided a large source of vitamins and minerals due to its high consumption rates [48]. There was a high consumption of vitamin A- and potassium-containing baby foods during the introduction of complementary foods such as carrots, sweet potatoes, and winter squash [48]. There was a decreased consumption of vitamin A and folate when infants transitioned from baby food at 9 to 11 months to table food from at 12 to 24 months [49]. Finally, dietary supplements contributed a small percentage of vitamins and minerals to infants 4 to 11 months old [48]. They supplied 4-5% of total vitamin and mineral intake in 4 to 5 month old, and 14% of total vitamin and mineral intake in 6 to 11 month old infants [48]. Thus, there was a slow introduction of macro and micronutrients from complementary foods throughout the first year of life. The following section will discuss nutrient intake of children enrolled in CC, which represents a growing subset of the population in the U.S.

ii. Nutrient comparison of children enrolled in child care

There is limited information about the nutrient intake of infants enrolled in CC [23]. It has been researched mostly in children greater than 3 years of age [26, 28]. Thus, further studies are necessary in infant populations during the first year of life.

The AND recommends that a child receives one half to two-thirds of RDA from CC when a child spends 8 hours or more in CC [96]. In a study comparing the nutrient intake of half-day to full-day preschool children at Head Start, children met one-third of RDA while in CC for energy, calcium, iron, zinc, and vitamin E if they attended CC 5 to 6 hours/day [26]. Energy intake was reported to be 1,482 calories/day for morning only preschool, 1,393 calories/day for afternoon only preschool, and 1,477 calories/day for full-day preschool. The caloric intakes of the afternoon only preschool children were reported to consume fewer calories, although not statistically different [26]. There was more daily calcium, vitamins A, C and B-12 consumed by children in the full-day Head Start program, compared to the half-day children [26]. However, all groups of children exceeded the recommendations for saturated fat, and the percentage of calories from fat and cholesterol were exceeded in the morning only and full-day groups [26]. The ratio of calories from protein, carbohydrate and fat was similar for all 3 groups of children, representing approximately 15%, 54% and 31% respectively. [26]. Similarly, in a comparison of nutrient adequacy in preschool children aged 3 to 6 years old enrolled in CC centers in Texas, it was noted that vitamin C, vitamin A, niacin, riboflavin, thiamin and calcium RDA requirements were met or exceeded [27]. Yet, there was inadequate consumption of energy, iron and zinc by greater than 15% of those children [27]. There was, however, an excessive sodium intake beyond the recommended range of 325 to 1,350 mg/day for this age group [27]. The percentage of protein, carbohydrate and fat was 15%, 52%, and 33%, respectively, based on a 3-day dietary intake [27]. Thus, there is an area for improvement for children in their intake of energy and some of their micronutrient requirements during their hours in CC.

It is encouraged to plan CC menus in accordance with the Dietary Guidelines for Americans [87]. A menu review of CC centers in Texas who participated in CACFP revealed adequate amounts of protein, vitamins A, C, B-12, and folate [97]. The nutrient content of menus in Mississippi CC centers participating in CACFP reported that the percentage of calories from protein and fat were higher in CACFP participating centers but total energy and saturated fat calories did not exceed recommendations [98]. This study revealed that some centers went above the recommendation for no more than 30% of calories from fat [98]. In addition, approximately 80% of both CACFP-participating and non-participating centers had excess amounts of sodium in the menus [98]. The CACFP centers offered higher amounts of calcium-containing foods and drinks [98]. However, a majority of centers met one third of protein, vitamin D, vitamin K, and potassium needs [98].

On the other hand, a menu review of CC centers in Texas who participated in CACFP reported inadequate total calories, niacin, vitamin B-6, iron and zinc, and excessive distribution of calories from fat [97]. In comparison, the nutrient content of menus in Mississippi CC centers participating in CACFP has been characterized as being significantly less in calories, protein, total carbohydrate, polyunsaturated fats, cholesterol, vitamin A, thiamin, niacin, vitamin B-6, pantothenic acid, vitamin E and zinc compared to non-participating centers [98]. A majority of the CC centers did not meet the one-third requirement of the RDA for energy, calcium, vitamin E, vitamin B-12, zinc, and iron, regardless of whether they participated in CACFP or not [98]. Evidently, it appears that participation in CACFP and recommendations to follow the Dietary

Guidelines for Americans did not guarantee that children would be offered adequate quantities of energy, as well as macro and micronutrients on the food menu.

The nutrient content of the menus was found to be significantly different when planned by a nutrition coordinator, school food service administrator or a registered dietitian [98]. Nutrition coordinators were reported to plan menus that were characterized as low in carbohydrates, pantothenic acid, and zinc, yet high in sodium and percentage of calories from fat [98]. The school food service administrators planned menus that were high in calories and a majority of vitamins and minerals, with the percentage of energy from carbohydrate, protein, and fat being 50%, 19% and 32%, that closely resembles the Dietary Guidelines for Americans [98]. Registered dietitians planned menus that were lowest in calories and total fat, but not in the percentage of total calories from fat [98]. Thus, menus planned by different food service staff can play a major role in the variability of the nutrient content in CC centers.

For infants, it is unknown if there would be a higher consumption of vitamins and minerals due to an earlier introduction of complementary foods and juice. However, we might expect a large percentage of carbohydrate, protein and fat sources to come from infant formula, breast milk and infant cereal, which is similar to the national population of infants [48]. This study has helped to identify whether differences exist in nutrient intake between infants enrolled in CC and PC.

iii. Nutrient intake of infants participating in WIC

One of the primary missions of the WIC program is to promote healthy growth of low-income infants who are at nutrition risk by providing nutrient-rich foods. Thus, WIC participation has played a significant role in improving the nutrient intake of low-income infants, specifically iron and zinc, which has led to a reduction in the anemia rates [61, 99, 100].

Compared to low-income infants not participating in WIC, there was a greater intake of iron (by 23%), zinc (by 8%), vitamin C (by 43%), thiamin (by 19%), niacin (by 13%) and vitamin B-6 (by 11%) in WIC infants [61, 99, 101, 102]. WIC infants 7 to 11 months of age consumed above the adequate intake (AI) for calcium, vitamin A, vitamin C, iron and protein, which are key nutrients specifically emphasized in the WIC food package [57]. There was a greater intake of energy beyond the recommended estimated requirements by approximately 237 kcal/day [57]. WIC infants and toddlers consumed greater amounts of energy and the WIC targeted micronutrients compared to non-WIC participants as well as exceeded the AI and the estimated average requirements (EAR) [57].

These trends in nutrient intake among WIC infants were similar to the national representative trends of infants in the U.S. from the FITS study. One study showed that all nutrients exceeded the AI for infants less than 12 months of age [103]. Energy intake was exceeded by 10% and 23% for infants in the 4 to 6 and 7 to 12 months age range, respectively [103]. Healthy, white infants from middle to upper socioeconomic status have been reported to meet or exceed energy and nutrient requirements based on the AI, except for Vitamin D and zinc which were below the recommended levels at 2, 4 and 6 months [104, 105]. Despite the adequacy of dairy product consumption, there was appropriate calcium intake but inadequate vitamin D intake in that population [105]. Fat intake changed from 42% during the first 6 months to 32% by 12 months, while protein increased from 9% to 14% at 6 to 12 months, respectively [105]. During the same time period (from 6 to 12 months), energy, carbohydrate and protein intake was shown to at least double, increasing from 690 to 1173 kcal/day, 88 to 161g carbohydrate/day and 15 to 42g protein/day [105]. Fiber was usually consumed in small quantities during the first year, with an average of 2g/day in 4-6 month old infants and 6g/day in 7-11 month old infants [103].

Based on these studies, it appears that the WIC program has succeeded in improving the nutrient consumption of infants from low income families, allowing the benefits of adequate nutrient intake comparable to the national representative sample of infants. Table 2.3 summarizes consumption patterns of the key nutrients emphasized in the WIC food package. This table highlights that the WIC population has a greater average intake of energy, protein, calcium, vitamin A, vitamin C and iron compared to the non-WIC population.

D. Factors impacting growth in childhood

Research has demonstrated that dietary patterns throughout life are often created from early food experiences [103, 106, 107]. It has been suggested that early childhood obesity can be explained by these dietary consumption patterns during infancy [72]. However, no clear relationship or evidence exists between the age of introducing complementary foods and its impact on infant weight gain based on a systematic review of literature by Baird et al. [44]. There is inconclusive evidence that early introduction of solid foods leads to a larger overall size in infancy [44]. Some reports have shown that an early introduction of complementary foods prior to the recommended 4 to 6 months of age can lead to rapid weight gain as early as infancy [108, 109]. On the other hand, some studies have found that early introduction of solid foods slows growth [110], while others showed it did not support faster weight gain after weaning [111, 112]. Therefore, it is be important to further investigate the causes of weight gain in infants.

This section will provide a review of information about feeding practices during the first 12 months of infancy that impact the rate of weight gain, followed by a review of child and familial factors impacting rate of infant weight gain and a discussion of the rapid weight gain in the first 12 months of life on weight status in childhood. Next, there will be a review on the reported relationship between WIC participation and measures of adiposity in infants.

i. Early infant feeding practices impacting the rate of weight gain in the first 12 months of age

As shown in Table 2.1 of this chapter and Appendix A, there are several recommendations for feeding practices, of which parents and caregivers choose to comply with some guidelines and deviate from others. This section will discuss the extent in which infant feeding practices affect the rate of weight gain and overall weight status later in childhood. In addition, other early risk factors impacting children's weight status will be identified and discussed.

There are several feeding practices during infancy and early childhood that have been described as predictive factors of obesity. These feeding practices include initial method of infant feeding, feeding transitions from milk-based to solid diet, infant temperament and its effect of feeding behavior, physical activity levels and environmental factors in the home [88]. Other factors include timing of solid food introduction, parenting feeding style, maternal insensitivity to infant feeding and satiety cues, bottle feeding behaviors, frequency of feeding, cereal added to the bottles, and food and beverage portion sizes [75, 113, 114]. In addition, maternal concern about infant overeating or becoming overweight in the future has shown to be significantly related to their child's fat mass at 5 years of age [78]. Among formula feeding mothers in the WIC population, however, educational interventions has proven to be ineffective at improving sensitivity to infant satiety cues and changing bottle feeding behaviors, such as discouraging more than 6 ounces before 4 months of age [115]. Thus, a variety of early feeding patterns, maternal influences, physical activity, and environment can play a role in a child's weight status.

In a study from Germany, there are also reported differences in suckling patterns between formula and breast-fed infants which affect milk intake and weight status. Formula-fed infants have a different suckling pattern, and less frequent meals that are larger in size compared to breast-fed infants [116]. Breast-fed infants, in particular, have a higher suckling occurrence and pressure [47]. Formula-fed infants consumed 20-30% greater fluid volume with a lower total number of meals and meals at night at 6 weeks and 4 months of age [47]. These differences may suggest more milk volume output from the bottle with similar or lesser amount of suckling for formula-fed infants compared to breast-fed infants.

There is some conflicting evidence about the long-term protective effects of breastfeeding in preventing overweight and obesity later in childhood. Prolonged breastfeeding has been shown to significantly reduce a child's risk of obesity, with a significant dose response relationship occurring between the length of breastfeeding and the incidence of overweight and obesity [31, 47]. For every month that an infant is breast-fed up to 9 months, the risk of later obesity decreases by 4% [114]. Breastfeeding throughout the first year of life was associated with taller and leaner children at 18 months of age [77]. In addition, total months of breastfeeding during the first year of life, is negatively associated with overweight and obesity in children at school-entry, based on a study from Germany [47]. Another study showed that exclusive formula feeding for the first 6 months created higher growth rates in weight, length and skinfold thickness compared to breast-fed infants [44]. Breastfeeding intensity, which is defined as the amount of milk feedings in which breast milk is fed per day, impacts the risk of excess weight in the second half of infancy from 6 to 12 months [114]. Compared to infants fed more than 80% breast milk at high intensity, there is twice the risk for excess weight in infants fed low- or medium-breastfeeding intensity, which are defined as less than 20% and 20-80%, respectively [114]. This study of breastfeeding intensity suggests a protective effect of excess weight gain with the greater amount of breast milk feedings per day.

Similarly, Butte et al. showed that formula-fed infants had a greater weight gain at 3 to 6 months compared to breast-fed infants [117]. Formula-fed infants had an earlier introduction of solids (2 to 4 months) compared to the breast-fed infants (4 to 6 months). Using dual-energy x-ray absorptiometry (DXA), there was lower fat-free mass (defined as body water, protein, glycogen, bone mineral content, and non-osseous mineral) and greater fat mass in breast-fed infants at 3, 6 and 9 months of age despite the reduced energy and macronutrient intake compared to formula-fed infants. Interestingly, the age of solid food introduction or cow milk and the length of formula feeding did not contribute to the body size and composition in formula-fed infants. On the other hand, the breast-fed infants were shown to have a negative association between body weight at 6 and 24 months and fat-free mass at 6 to 9 months with the age of formula introduction. The average age of formula introduction was 5.7 months for breast-fed infants [117]. A positive association was observed between body weight at 12 and 18 months and the duration of formula feeding in breast-fed infants. Similarly, Dewey et al. reported significant differences in WFL measurements between breast-fed and formula-fed infants at 12 months of age, with 15% and 7% of formula-fed and breast-fed infants being greater than the 90th percentile, respectively, although differences in body fat measurements were also evident between 9 to 15 months of age [118]. Another review from the U.S. and European countries reported the difference in weight between breast-fed and formula-fed infants at 12 months of age, with a weight difference of 400 grams by 9 months and 600-650 grams at 12 months [116]. Based on this information, breastfeeding may provide short-term benefits by affecting weight status within the first two years of life.

In contrast, longer term benefits of breastfeeding have not been found in other studies. In large randomized trials performed in Belarus with children 6.5 years old and Australia with 10 year old children, longer breastfeeding, both in duration and exclusivity, were not related to BMI [119, 120]. The 1993 Pelotas (Brazil) birth cohort study researched the effects of total breastfeeding duration, predominant breastfeeding duration, and introduction of solid or semi-solid food before four months of age on overweight and obesity at the age of 11 in children [121]. At 11 years of age, 23.2% and 11.6% of the children were overweight and obese, respectively, with the lowest prevalence among those breast-fed for one to three months compared to formula-fed infants [121]. There was no significant association between indicators of breastfeeding and anthropometric measurements at 11 years of age, despite adjustment for the other confounding variables [121]. While a majority of studies show a positive long-term effect of breastfeeding, some studies suggest that the intensity and duration of breastfeeding does not affect the long-term risk of obesity, including late childhood and early adulthood.

There is conflicting evidence about the effects of solid food introduction on adiposity later in life. Van Rossem et al. showed that the WFL did not differ by 24 months of age among infants introduced to solids very early at 0 to 3 months, early at 3 to 6 months or normal after 6 months [122]. They concluded that the differences in WFL during childhood were not an effect of solid food introduction in infancy [122]. Infants are able to regulate their total energy intake; thus, solid foods displaced the calories from formula or breast milk [123, 124]. It has been suggested that the differences in weight gain and body composition between formula and breast-fed infants are more apparent in the first 6 months, with the two groups becoming more similar after supplementary foods and drinks are introduced into the diet [117]. Mehta et al. showed that there were no differences in body composition, gain in weight, gain in length or gain in head circumference despite an early introduction of solid foods at 3 to 4 months compared to a later introduction at 6 months [123]. Similarly, there were no differences in weight, length or head circumference at 3, 6, or 12 months of infant age [123]. In a related study, duration of breastfeeding and timing of complementary food introduction (e.g. before or after 4 months of age) did not affect adiposity at 5 years of age when measured by DXA [30], which was also found in the BMI of children 7 years of age [125]. However, these studies included mostly white infants with mothers of higher educational level and were not representative of a diverse group as would be found in the WIC population. Another similar study, the DARLING study, revealed that breast-fed infants introduced to foods at either 16 to 23 weeks (4 to 5 months) compared to > 23 weeks (> 6 months) did not show distinctive weight or length differences by 12 months of age [118]. An international comparison of infants in China, India, Nigeria, Chile, Guatemala, Sweden and Australia showed minimal differences in weight and length velocity over a 16 week study period when comparing differences in timing of introduction of solid foods between 4 to 6 months of age in breast-fed infants [126]. Based on this information, the timing of complementary food introduction is not related to the long-term weight status of children.

On the other hand, some reports have shown that complementary food introduction does impact long-term weight status. Wilson et al. showed that infants introduced to food before 15 weeks (< 4 months) had a greater weight status and body fat percentage by 7 years of age compared to those who started foods after 4 months [127]. Similarly, in a large cohort study, the average age of 21 weeks of complementary food introduction was associated with a healthy BMI while introduction at 19 weeks was shown to be related to an above healthy BMI for children at 10 years of age, without an interaction effect from duration or exclusivity of breastfeeding [120]. Some reasons why parents or caregivers may offer foods, such as cereals to infants, early is to minimize spitting up, fussiness, constipation, crying, wakefulness, or perceptions of inadequate milk production, thus causing excess energy consumption and rapid weight gain [73, 74, 115, 128]. However, it may be more than the timing of complementary food introduction, rather the type of infant diet, which affects weight status.

In order to better understand the impact of weaning infant diet variations and its impact on body composition in childhood, Robinson et al. reported that a longer duration of breastfeeding (breast-fed 12 months or more) in the United Kingdom was strongly associated with a lower fat mass at 4 years of age, but not BMI [129]. In addition, regardless of duration of breastfeeding, infants fed a diet consistent with the infant guidelines dietary pattern had a higher lean mass at 4 years. No associations were found between variations in the infant weaning diet and mean BMI at 4 years in the United Kingdom, yet overweight and obese 4 year old children were breast-fed for a shorter period of time. Similarly, a diet characterized with home-prepared foods, fruits and vegetables and compliant with infant feeding guidelines was associated with greater weight gain from 6 to 12 months compared to an 'adult' diet characterized by breads and processed foods [44]. Thus, the quality of an infant weaning diet may be predictive of the child's diet quality later in life and a higher infant guidelines score is indicative of other behavioral differences such as physical activity levels and dietary intake [129]. Still, the balance of energy in and energy out will better predict the change in infant body size and composition

[130]. The following section will describe other behavioral and environment factors related to the child and parents/caregivers that can impact a child's weight status.

ii. Additional child and familial factors impacting the rate of infant weight gain

There are many different variations in personalities and family environments that can impact an infant's feeding practices and the rate of weight gain in the first year of life. It is important to understand next whether these other variables play a role in adiposity later in life. This section will review the child- and family-related factors that impact weight status in childhood.

An infant's temperament and sleep patterns can have a significant impact on their early feeding patterns, which may affect the child's long term dietary habits and weight status. The temperament of an infant, specifically a high level of distress to limitations (DTL), has been associated with higher levels of body fat in infants, as well as a greater rate of weight gain in the first 6 months of life [130]. Higher DTL was scored by a questionnaire measuring an infant's level of fussiness, crying, and visible signs of distress [130]. Infants with higher DTL likely have a greater body weight due to the parent/caregiver's practice of feeding their infant to decrease distress [130]. Wells et al. reported that infants with higher DTL expended greater amounts of energy but was not associated with body weight [131]. Thus, increased fussiness and crying could potentially lead to higher levels of energy expenditure and greater energy intake [130]. Besides the degree of fussiness and crying, an infant's sleep duration per day was associated with greater risk of childhood overweight by age 3 [132]. In particular, infants who slept less than 12 hours/day had a higher BMI and greater body fat, as measured by skin fold thickness, thus increased their odds of being overweight at 3 years of age [132]. Shortened sleep duration was more likely found in households of lower income, single or divorced parents, lower maternal education, higher amounts of television viewing, and black and Hispanic ethnicities [132]. Evidently, a child's weight status can depend on their individual temperament and sleep patterns.

Socioeconomic status and food security of the family can also affect the availability of food in the home, adequacy of dietary intake, and long-term weight status. Specifically, parental education ≥ 13 years is related to a lower incidence of overweight and obesity in children [133]. An additional household characteristic of infants with greater body weight includes those with food insecurity [134]. Less food security has been negatively associated with positive parenting behaviors, such as greater parent/child interactions, subsequently affecting healthy infant feeding practices and the risk of increased adiposity [134]. Thus, there is an indirect relationship between food insecurity and overweight because parents who wish to delay hunger might engage in less than positive parenting and feeding practices [134]. In a cohort of Hispanic, fifth grade children, Matheson et al. reported an opposite relationship between food insecure households and children's BMI [135]. Children living in a food secure household had higher BMI compared to children in food insecure household [135]. There was significantly less consumption of meat products in food insecure households compared to food secure households [135]. Furthermore, total energy and meat consumption significantly decreased at times just prior to payday in food insecure households, likely affecting the children's body weight [135]. Consequently, parental education and socioeconomic status has significant implications on their child's weight status. The next section will discuss the effect of rapid weight gain during infancy and birth weight on body weight later in life.

iii. Impact of rapid weight gain in first 12 months of life on weight status in childhood

There are many different variations in feeding practices that can affect the rate of weight gain in the first year of life. It is important to understand next whether this early weight gain has any effect later in life. This section will review the effects of rapid weight gain in infancy on weight status in childhood and adulthood.

In a study by Worobey et al. examining the contributions of maternal characteristics and behaviors in predicting infant weight gain in the first year of life, results showed no prediction of weight gain for infants from birth to 3 months or 3 to 6 months based on the assessment of infant feeding behavior, infant diet, and maternal sensitivity to infant feeding behavior in the U.S. [75]. Similarly, Taveras et al. sought to provide further information about the currently accepted finding that higher birth weight was associated with a higher BMI in childhood and adulthood [136]. Following adjustment for confounding variables and birth WFL z-score, results showed that every increment in 6 month WFL z-score in the U.S. was found to be associated with a higher BMI z-score, higher sums of subscapular and triceps skinfold thickness and increased odds of obesity at age 3 [136]. Predicted obesity prevalence for children at the highest quartiles of both birth and 6-month WFL z-scores was 40%, as compared to the 1% of children in the lowest quartiles for WFL [136]. The authors noted that obesity at 3 years of age did not predict obesity later in childhood or adulthood, but can predict health problems later in childhood [136]. A review tracking childhood overweight into adulthood reported that children ages 1 to 2 years had an odds ratio (OR) of 1.3 of obesity at 21-29 years and relative risk of 2.7 of overweight at the age of 20 [137]. Children aged 3 with BMI >75th percentile had an OR of 1.5 and those with a BMI >95th percentile had an OR of 2.0 of being obese at the age of 35 years old [137]. Thus, there has been some prediction of overweight children developing into overweight adults [75], [134, 137].

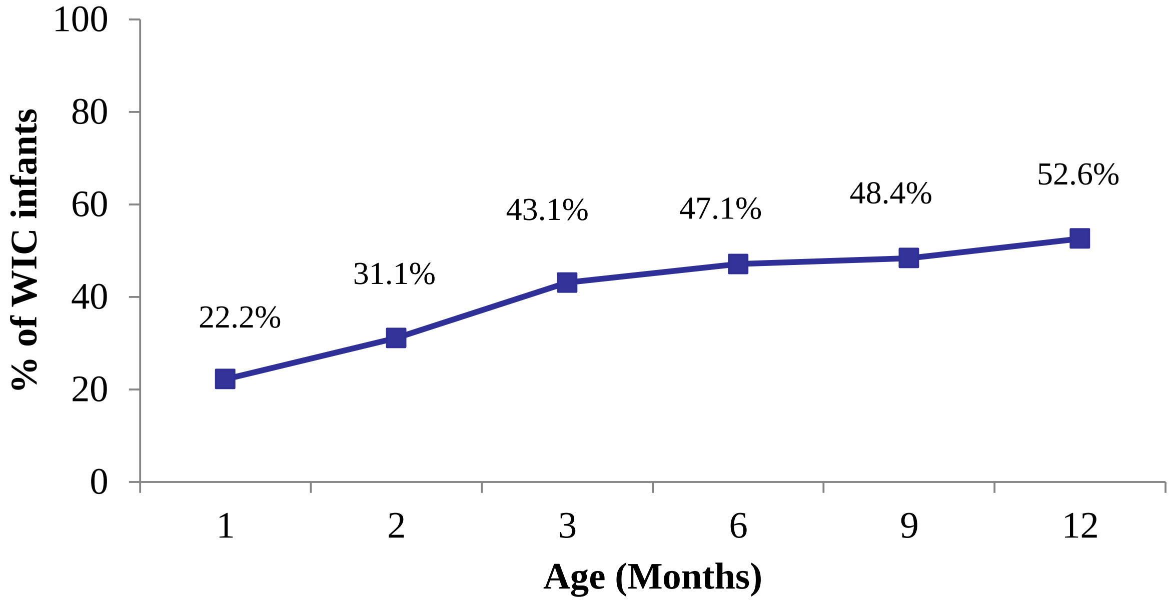
Body size and rate of weight gain in infancy has a significant impact on obesity risk in childhood and adulthood [138]. Infants across many countries, with a large WFL and plotted on the higher distribution of the growth curve, have a greater probability to be obese in childhood, adolescence and adulthood [138]. On the other hand, an infant born with a low birth weight is at risk for obesity and obesity related diseases such as cardiovascular disease, type 2 diabetes, and metabolic syndrome [117, 133]. Rapid weight gain in the first 2 years provides a significant marker of predicting obesity later in life [47]. Rapid weight gain during the first year of life has been found to increase a child's risk of obesity and extreme obesity at 24 to 38 months by 9.2 and 31.2 times, respectively [113]. The reasons for this rapid weight gain can be explained in two ways: 1) some children are predisposed genetically to be overweight or obese; 2) environmental factors (i.e. a child placed in an obesogenic environment) can promote excessive weight gain or if a child does not receive enough nourishment in utero and is exposed to poor nutrition after birth, there is an increased risk of being underweight in childhood [113]. Manios et al. reported results from a cross-sectional study in Greece of children 1 to 5 years old [139]. They reported that each unit increase in both paternal and maternal BMI as well as a rapid weight gain during the period of infancy increased the odds that the child will become overweight or obese [139]. Thus, early weight gain can be affected by many variables and has significant implications in measures of adiposity later in life. The final section will focus on long-term measures of adiposity for infants specifically in the WIC population.

iv. Relationship between WIC participation and measures of adiposity in infants

WIC participation has significantly improved the feeding practices and birth weight of low-income infants in the first year of life. Yet, it is important to consider whether participation in WIC increases a child's risk of adiposity. This section will describe patterns of birth weight and rate of weight gain during the first year of life in the WIC population.

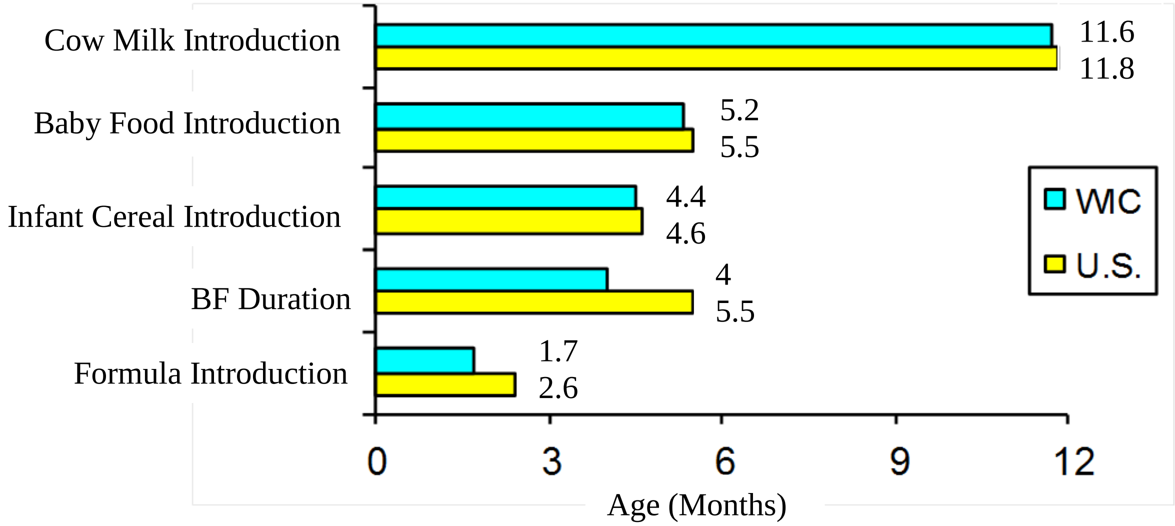
Prenatally, WIC participation has been demonstrated to decrease the prevalence of low birth weight infants and prematurity. Postnatally, WIC participation has been shown to promote greater weight gain in infants compared to non-WIC participants [140]. More recently, a multisite surveillance study indicated that infants receiving WIC assistance followed growth patterns consistent with the national normative rates both in WFA and LFA [109]. However, for infants who are from a low-income family and not receiving WIC assistance, the growth patterns fall below the national normative patterns [109]. In comparison of obesity rates, there were no differences in percentage of overweight infants of those receiving WIC assistance (9%) compared to infants from higher income families (7%) and infants from low income families not receiving WIC assistance (8%) [109]. Thus, it appears that WIC participation has not been shown to increase a child's risk of adiposity, but rather enable WIC infants to grow similarly to the national rates.

Figure 2.1: Percentage of WIC infants cared for by non-maternal caregiver



Source [37]

Figure 2.2: Age of breastfeeding duration, infant formula, solid food and cow milk introduction in the U.S. and WIC population



Source: [57]

Table 2.1. Summary of infant feeding recommendations

	AAP [41, 45, 141]	AND [43]	WHO/UNICEF [142]	FITS [41]
Breastfeeding	1) Breastfeed for the first 6 months without solid foods, continue breastfeeding until 12 months in addition to introduction of solid foods. (AAP Working Group on Breastfeeding) 2) Introduce solid foods at 4- 6 months of age. (AAP Committee on Nutrition) 3) Give supplemental iron to breast-fed infants after 4-6 months. 4) Offer iron-fortified infant formula when breastfeeding is not an option.	1)Breastfeed for the first 6 months of life without offering solid foods 2)Breastfeed with introduction of complementary foods at 6 months and continue breastfeeding until at least 12 months of age.	1)Breastfeed for the first 6 months of age without any supplemental liquids or solids, introduce complementary foods at 6 months of age. 2)Breastfeeding with complementary foods until at least 2 years of age or longer.	Breastfeed as long as possible throughout the first year.
Solid foods	Offer solid foods around 4-6 months of age or when the infant is developmentally ready.	Introduce complementary foods after 6 months of age.	------	1) Introduce solid foods (iron-fortified infant cereals, meats) when the infant shows signs developmental readiness.

Table 2.1 (Cont)	AAP [41, 45, 141]	AND [43]	WHO/UNICEF [142]	FITS [41]
				2) Offer healthy foods such as soft fruits, cooked veg, soft cheeses, fortified grain products instead of high calorie, low micronutrient items.
Juice	Offer 100% juice after 6 months of age, limit juice to 4-6 ounces daily.			
Cow's milk	Do not offer cow's milk until 1 year of age; Offer only whole milk until 2 yrs of age.	-------	-------	------

Table 2.2 Infant feeding practices by age in WIC participants and non–WIC participants

	Proportion, %											
	Breast-fed Exclusively[1,2]		Ever Breast-fed[2]		Currently Breast-fed[2]		Introduced Infant Formula[1]		Introduced Cow's Milk[1]		Introduced Solid Foods[1]	
Infant Age (months)	WIC	Non-WIC	WIC	Non-WIC	WIC	Non-WIC	WIC	Non-WIC	WIC	Non-WIC	WIC	Non-WIC
1	43.6	59.2					56.4	40.6	0.0	0.3	0.0	0.0
2	29.7	46.4					67.4	51.7	0.3	0.7	4.5	3.4
3	22.5	38.0					75.2	59.1	0.4	0.9	10.8	6.7
4	14.8[1]/4.0[2]	29.6[1]/17[2]					81.0/95[2]	64.9/77.0[2]	0.5/4.0[2]	1.0[1,2]	27.6	20.3
5	7.9	15.6	69.0	84.0	21.0	84.0	85.4	69.2	0.7	1.3	57.8	53.4
6	4.7	9.9					87.8	72.0	0.9	1.7	72.6	70.4
7	1.4[1]/0[2]	1.9[1]/0[2]					90.3	76.5	2.1	3.6	92.0	91.4
8	0.4	0.8					91.4	78.1	3.1	5.2	96.1	95.0
9			68.0	83.0	16.0	26.0						
10												
11												

[1] Data represented each individual month of age. Source: [35]

[2] Data represented as 4-6 months of age and 7-11 months of age. Source: [57]

Table 2.3 Mean intake of nutrients of WIC and non-WIC participants aged 7 to 11 months [1,2]

	Dietary Reference Intake			
	AI[3]	EAR[3]	WIC	Non-WIC
EER[3] (kcal/day)			751	733
Mean energy intake (kcal/day)			988 ± 249	874 ± 177
Protein (g/day)		0.88 g/kg	24.8 ± 8.6	22.2 ± 8.5
Calcium (mg/day)	270		662 ± 195	618 ± 219
Vitamin A (µg/day, RAE[3])	500		805 ± 248	763 ± 225
Vitamin C (mg/day)	50		127 ± 41	94 ± 31
Iron (mg/day)		6.9	18.5 ± 6.1	14.8 ± 6.8

[1]Adapted from the 2002 Feeding Infants and Toddlers Study (FITS) [57]
[2]Data expressed as mean ± standard deviation.
[3]EER=Estimated energy requirements; AI= adequate intake; EAR=estimated average requirements; RAE=retinol activity equivalents.

Chapter 3:

Comparison of Infant Feeding Practices by Child Care Use

Abstract

The child care setting represents a crucial environment for infants and children to establish healthy feeding practices in order to prevent overweight and obesity [7]. The objective of this research was to investigate the association between parental care (PC) and child care (CC) on infant feeding practices and food consumption in infants receiving the Special Supplemental Nutrition Program for Women Infants and Children (WIC) assistance. This study sampled 105 infants 2 to 8 months of age from the Champaign Urbana WIC office from October 2009-August 2011. Mothers completed a 3-day food record, and survey at the time of recruitment to assess their infant's feeding practices, and demographic characteristics. Child care was defined as infants receiving 10 hours or more per week of care from a non-parental caregiver.

Infants in CC had an average of 29 hours of care per week compared to the 0.64 hours in the PC group ($p<0.01$). A larger ($p<0.01$) percentage of mothers were employed in the CC group (73.9%) compared to the PC group (22%). However, the household income was greater ($p<0.01$) in the PC group ($15,986 ± $10,284 PC vs $9,967± $7,489.5 CC) but no differences in household size. In addition, there was a higher ($p=0.04$) percentage of single parents in the CC group compared to PC (30.5 % PC vs. 50% CC). There were no differences in child birth weight, length, gestation, gender, race/ethnicity or age at recruitment, as well as maternal age, education, race/ethnicity, or BMI status by care type.

Breastfeeding duration and age of solid food introduction did not differ between care type. Mean breastfeeding duration was 2.3 months, while average solid food introduction was 4.4 months. No differences were seen between PC and CC infants in the rate of formula

introduction. When comparing food groups, there were no significant differences in the number of servings, but the CC group showed lower consumption of formula (p=0.03) and breast milk (p=0.18) compared to PC. Overall, there did not appear to be significant differences in feeding practices between infants in CC vs. PC groups for infants receiving WIC assistance.

Introduction

Infant feeding practices have been suggested to be an important contributor to obesity risk and may be a good target for intervention [47]. It is recommended for infants to be breast-fed exclusively for 6 months following birth, followed by a slow introduction of complementary foods after 6 months of age [41, 42, 43]. One-third of U.S. infants have been reported to consume foods earlier than the recommended 4 to 6 month age period by the American Academy of Pediatrics (AAP) [41]. The timing of complementary foods and drinks is a critical part of an infant's development, feeding patterns and weight status. Infants who started eating solid foods prior to 4 months were more likely to have discontinued breastfeeding by 6 months of age and were fed fatty, sugary food and sweetened drinks by 1 year of age [46].

Extensive research has demonstrated that WIC participants are less prone to breastfeed, with or without formula supplementation, compared to non-WIC participants [57-67]. WIC is a federal grant program provided from the USDA Food and Nutrition Service that serves pregnant women, infants and children. In particular, this program serves approximately 2.2 million infants per month [34, 56]. The WIC food package was revised on December 6, 2007 and enforced on October 1, 2009, in accordance with the 2005 Dietary Guidelines for Americans and infant feeding recommendations by the AAP to encourage and support longer breastfeeding, to delay introduction of complementary foods, and to offer a more diverse variety of foods.

Currently in society, there are many dual career households. As a result, a majority of infants in the U.S. raised in these households spend a large amount of time in CC settings outside of their home. Thus, CC providers can influence the food consumption patterns of infants. Kim and Peterson reported that infants cared for by a relative was associated with the introduction of solid foods before 4 months of age and increased infant weight gain at 9 months of age [23]. Relative care was associated with lower breastfeeding initiation rates and higher rate of early introduction of solid foods [12]. There was also a decreased duration of breastfeeding, introduction of solid foods earlier than recommended and increased weight gain in infants receiving CC when compared to those receiving PC. Infants who began CC less than 3 months of age were less likely to have ever been breast-fed and more likely to have an early introduction to solid foods. In addition, infants attending part time CC or care by relatives had a greater weight gain over the first 9 months when compared to infants under PC. Among the WIC population, children in relative care had a greater risk of short breastfeeding duration compared to PC users [70]. Non-WIC participants using relative care or center-based care also had a greater risk for short breastfeeding duration compared to PC users [70]. Of these limited studies involving CC use in infants, the weaning diet was not completely assessed, specifically in the introduction and type of solid foods consumed by infants between CC and PC. Also, it is unknown whether infant feeding practices are a key risk factor on weight gain in CC during infancy [30-32].

Herein, the objective of this study was to assess infant feeding practices specifically in breastfeeding, formula feeding and the time of introduction and type of solid foods consumed between infants in CC and PC. We hypothesized that unhealthy feeding practices, defined as decreased rate of breastfeeding and early introduction of fruit juice and complementary solid foods, would be more common in CC compared to PC.

Methods

Subjects

Mothers and infants were recruited in the waiting room at the Champaign Urbana Public Health Department WIC office. Mother-infant dyads must have been enrolled in WIC in order to enroll in the study. Our inclusion criteria were that infants must be within the ages of 2 to 8 months of age during the time of recruitment and must be enrolled in WIC program with mother. A sample of 107 mother-infant dyads completed our study from October 2009 to August 2011, with an initial response rate of 278 pairs. After completion of the study, we excluded 2 infants from our study sample because they were not enrolled in WIC, but were visiting the Champaign Urbana Public Health Department for other reasons. Recruitment was concurrent with the new rules for the WIC food package which was enacted in October, 2009. Child care providers were defined as any non-parental caregivers such as relatives, home-based caregivers and center-based caregivers. Using the 2007 National Survey of Children's Health definition, CC was defined as infants receiving 10 hours or more per week of care from a non-parental caregiver [143].

Data collection

An explanation of the study procedure is summarized in Figure 3.1. Briefly, study participants were informed of the study through flyers, case managers, and by being approached by the research staff in the waiting room of the WIC office. The trained research staff inquired about the age of the infant prior to soliciting participation in the study. Mothers were informed that this research study was to investigate parent and CC feeding practices and its effect on infant growth. All of the study procedures were approved by the University of Illinois Institutional Review Board before the start of the study.

The mothers were asked to complete a study questionnaire and a 3-day infant food record. After completion of the survey and 3-day food record, the mother/caregiver was given a gift certificate. Upon recruitment, mother/caregiver provided informed consent and personal contact information. The consent form enabled our research staff to collect additional demographic information and growth data of the mother infant dyad from the WIC database.

Within one week of recruitment, each mother/caregiver was contacted via follow-up telephone call reminding her about the study, asked if she had started the survey, and food record and asked if there were any questions. The research staff briefly reviewed the details of completing the food record.

Measures of feeding practices

Feeding practices of the infant were assessed by a 3-day food record during 2 weekdays and 1 weekend day. Food records documented the time of feeding, the person feeding the child (e.g. mother, grandmother, father, etc), amount of solid food offered, and amount and type of feeding (formula or breast milk). If formula was fed, mothers recorded the brand of formula, preparation of the formula and type of water used. If mothers planned to directly breastfeed their baby, they recorded the number of minutes that the baby was actually feeding. Estimation of breast milk intake was derived from total daily breast milk intake based on the age of the child [144]**.** A food picture aid was provided with the food record for accurate measurement of portion size and adapted from the FITS study [22, 145]. Solid food was defined as any cereal or baby food in jars or finger foods. In order to complete the 3-day food record, mothers using CC communicated with the child's care provider/teacher for information about the child's food and drink consumption during those CC hours. We used the Nutrition Data System for Research (NDSR) software to analyze the 3-day food record. NDSR calculated the number of infant formula servings for each feeding using the reference USDA serving of 5 oz. An average of the infant formula servings was calculated over the 3 days for each subject. In addition, NDSR calculated the food servings for each individual food both in grams and reference servings based on each feeding. Definition of different food groups and their serving sizes were based on the USDA Food Guide Pyramid and Dietary Guidelines for Americans 2005 [146]. An average of the food servings was calculated over the 3 days for each subject.

Additional feeding practice questions were asked by survey questionnaire. Study participants were given the option of completing the survey by paper or online version. The survey provided questions about the age at introduction of solid foods, types and quantity of food offered, the types and quantity of beverage choices offered frequency of feedings, practices on the introduction of solid foods for infants, preparation practices of infant formula, and response to feeding cues. Breastfeeding duration was calculated using the survey question "How old was your child when you stopped breastfeeding?" If the participant did not complete this response and marked that they were currently breastfeeding from a previous question, we used the child's current age as the breastfeeding duration (months). Alternatively, if they marked "No" to the question "Was your child ever breast-fed?" we estimated a breastfeeding duration of zero. Current and exclusive breastfeeding rates were based on dichotomous Yes/No questions from the survey. Age of solid food introduction was obtained from the survey, with a response of "never" or completing the age (months). If the infant had not yet been introduced to solid foods, their data were excluded from any analysis comparing food servings or types of foods between PC and CC. A total of 35 subjects in PC and 23 subjects in CC were excluded for that reason. Other feeding practices questions asked if the child had ever been fed cereal, ever been fed pureed baby food and ever been fed cow's milk was created into a dichotomous Yes/No variable from a survey question which asked for the age of introduction of cereal, baby food, and cow milk. Formula introduction was based on a survey question asking the age they began feeding formula, with options for a response including "never" or completing the age (months).

Previous reports of infant feeding practices have relied on food frequency questionnaires (FFQ) to assess diet quality. However, FFQ are based on recall and, therefore, may not be completely accurate due to bias in memory and desire to only include foods and feeding practices that are deemed to be healthy [129]. Thus, the strength of our study was based on the food diary method, which is considered to be a more accurate measurement tool.

Measures of demographic information

Information related to the infant and families were provided by the WIC database. The WIC database provided demographic information such as the infant's race or ethnicity, birth date, birth weight, birth length, additional weight, height and lab tests on follow-up visits. The maternal information included duration of the pregnancy for the child, pre-pregnancy weight, pregnancy weight gain, and any pregnancy complications. The family information provided was family size and composition, household income, education, employment, and family history of medical conditions. The WIC data was accessed by the Cornerstone System, which is the database system for the state of Illinois.

In addition, the survey questionnaire provided similar birth information of the infant, such as birth date, birth weight, birth length, duration of pregnancy, pregnancy-related medical conditions (diabetes, anemia, hypertension), maternal weight status pre and post pregnancy, maternal marital and financial status, household income, employment status, household size, and CC information such as the reasons for using CC and the number of hours of CC use.

Statistical analysis

Statistical analysis was conducted using SAS version 9.2 (SAS Institute, Inc Cary, NC). Prior to formal analysis, preliminary analysis included searching the collected data for errors. In addition, the data were checked for normality using the Shapiro-Wilks test and homogeneity of variance using the Brown-Forsythe test using the GLM procedure. Descriptive statistics (mean, SD, frequencies, percentage) were calculated for samples between CC and PC group. For continuous variables, we used a 2 way t-test using TTEST procedure in SAS to test for differences between CC and PC groups. For categorical variables, we used a χ^2 test using FREQ procedure in SAS with chi square option to test the null hypothesis that the particular variable was distributed similarly between CC and PC. For linear regression analysis, the GLM procedure in SAS was used with the LSMEANS option to obtain means of adjusted food group servings for the PC and CC group. Confounding variables used to adjust for the food group servings were child age (months), gender, and race/ethnicity.

Results

Table 3.1 displays demographic characteristics of the study sample. The age of mothers and infants were similar between PC and CC users during the time of recruitment, with an average of 26 years and 4 months old, respectively. A majority of both PC and CC user infants were born full term at 37 to 40 weeks to U.S.-born parents. However, there was a larger percentage of white and black/African American mothers and infants in both groups, compared to the Hispanic/Latino, American Indian, Asian and Mixed. In addition, a slightly larger percentage of PC mothers were married compared to CC mothers, yet not statistically significant. However, the percentage of single mothers (i.e. mothers living alone without a significant other) was greater ($p=0.04$) in the CC group. Maternal employment rates were higher ($p<0.01$) in the CC group. Household income was greater ($p<0.01$) in the PC group, but household size was similar.

Figures 3.2-3.7 describe feeding practices within the current sample. Figure 3.2 shows the average breastfeeding duration was 2.15 ± 1.4 months and did not differ by CC use. Figure 3.3 shows the current breastfeeding rates did not differ by care type. Current breastfeeding rates were approximately 70%, 50%, 35%, 25%, 9%, and 6.5% of infants at 1, 2, 3, 4, 5, and 6 months of age, respectively. Exclusive breastfeeding rates are indicated in Figure 3.4. As shown, PC infants had a numerically greater rate of exclusive breastfeeding in the first 4 months compared to CC infants, although not statistically significant ($p>0.05$). Age of formula introduction shown in Figure 3.5 did not differ by care type. Although not statistically different, there was a numerically greater percentage of formula introduction at birth in the PC group (42% of infants) compared to the CC group (32% of infants), $p>0.05$. In the first 4 months of age, 90-100% of infants were introduced to formula. Age of solid food introduction indicated in Figure 3.6 also did not differ by care type. The average age of solid food introduction was 4.4 ± 1.0 months. Other feeding practice measures were shown in Figure 3.7. The percentage of infants ever fed cereal, pureed foods, and cow's milk did not differ by care type. However, there was numerically greater rates of CC infants ever fed cereal (45% CC vs 35% PC) and pureed foods (47% CC vs 34% PC). The average month of formula introduction was earlier (p value=0.03) for PC (0.9 ± 1.2 months) than for CC (1.66 ± 1.6 months).

Table 3.2 shows the average food servings consumed by infants based on the standard USDA servings, adjusted for child age and gender. These data represent only the infants who began eating solid foods (PC n=24, CC n=23). There were numerically greater servings of grains, dairy and fat servings and less infant formula and human milk in the CC group, although not reaching statistical significance except for infant formula ($p>0.05$). Fruit and vegetable servings were also numerically greater in the PC group yet not reaching statistical significance.

Table 3.3 provides a list of the most frequent foods served by infants in PC and CC. As shown, CC infants consumed approximately double the type of foods in their diet compared to the PC infants. Table 3.4 shows the number and percentage of infants consuming different foods. This table indicates that the most consumed foods were infant formula, followed by grains, fruits and vegetables.

Discussion

Main study findings revealed no significant differences in the rates of breastfeeding or formula feeding by care type. There was a trend for higher rates of exclusive breastfeeding in the PC group. Additionally, the CC group had a trend of more servings of grains, dairy and fats and less servings of formula and breast milk. Solid food introduction did not differ based on care type and met the AAP recommendations of 4 to 6 months of age. Yet, solid food introduction practices in this study did not follow the new WIC food package rules that were enforced in October 2009 at the start of our study. This finding suggests that mothers did not yet adapt their feeding practice to the new rules of introducing solid foods at 6 months of age. More time may have been necessary to determine the effect of the new WIC food package on infant feeding practices.

In this study, we expected that infants in CC would have had a decreased rate of breastfeeding and earlier introduction of complementary foods, considering the larger percentage of single unmarried mothers earning a lower income in the CC setting [147]. Previous reports have shown that the lower prevalence of breastfeeding among single mothers and families of lower socioeconomic status. However, the lack of differences found between the CC and PC groups could be explained by the inherent characteristic of the WIC population. WIC participation has shown to be prevalent in decreased incidence and duration of breastfeeding duration and early formula introduction [36, 37].

There are limited reports about the comparison of feeding practices in CC and PC in the infant population. Kim and Peterson reported that infants cared for by a relative was associated with a higher percentage of infants introduced to solid foods before 4 months of age, lower breastfeeding initiation rates and a decreased duration of breastfeeding for infants who began CC less than 3 months of age [23]. In addition, Shim et al. reported WIC participation and CC use to be independently associated with short breastfeeding duration [70]. In particular, WIC participants using relative care had a greater likelihood to discontinue breastfeeding before the age of 6 months, followed by WIC infants in center-based and non-relative care. However, our study did not detect differences by CC in solid food introduction or breastfeeding rates, even though the average age of CC introduction in our study was 2 months. In addition, our definition of CC was different than that of Shim's study, as our study was based on the number of hours in non-parental care and Shim's study was based on CC setting. We were unable to control for differences in CC settings in this study, such as relative, center-based or non-relative care.

Infant feeding practices in this study were compared to the infant feeding practices in WIC population of 4 to 6 month old infants from the FITS study as a reference [57]. Average breastfeeding duration of 2 months was shorter than the reference breastfeeding duration of 4 months in the WIC population. Exclusive breastfeeding rates were approximately 7% infants at 4 months, but dropped to 0% at 5 and 6 months of age compared to the 4% exclusive breast-fed WIC infants at 4 to 6 months of age from the FITS study [57]. Similar to previous reports, our study subjects reported problems with breastfeeding due to low milk supply, mother worries about the child not receiving enough, infection of the breast, broken breast pump, recommendations to supplement with formula by a dietitian or doctor, poor latching, not enough time for mother to pump due to work or other child responsibilities, or the mother was taken medications that were not safe for breastfeeding [73, 74].

Rates of formula feeding in our study were similar to the 95 % of WIC infants fed formula by 4 months of age reported previously [57]. Yet, when compared to the 75-80% of U.S. infants fed formula by 4 months of age, the prevalence of formula use in our study was higher [40]. The percentage of infants ever fed baby cereal, pureed foods and cow's milk was lower in this study compared to the reference 4 to 6 month old WIC infants from the FITS study. This finding may be related to the fact that the age of our study sample was wider, from 2 to 8 months old.

Solid food introduction at 4 months in our study matched the national sample of WIC infants. When comparing the servings of food groups by CC use, our study findings indicated that infants in CC are consuming less milk (infant formula and breast milk) and more foods, particularly grains, dairy and fat. When looking at the list of foods in Table 3.3, there is a larger breadth of foods offered to CC infants compared to PC infants. The greater variability of foods may be a reflection of the foods served from the menus in the various CC settings. These results support our study hypothesis of less breastfeeding and greater introduction of solid foods and juice in the CC group. The study findings contrast with the national CFOC standards for CC facilities because these standards encourage breastfeeding support by CC staff, not to feed solid foods before 6 months of age, and to feed infants based on a feeding plan from the parent or physician. The results from our study are consistent with Illinois regulations, because the state lacks specific laws in CC that promote breastfeeding and prevent introduction of solid foods before 6 months of age.

CACFP provides structured meal pattern requirements for infants in CC. This program helps to meet infant nutrient requirements by offering foods of high nutritional quality and protect against potential negative effects of inadequate food intake in the mother's absence. However, the CACFP program is subject to regulations by each state and depends on the infant current feeding routine set by the mother [87]. Currently, there are only 6 U.S. states with adequate CC regulations supporting lactation according to the 2011 CDC Breastfeeding Report Card, suggesting inadequate support for breastfeeding mothers across the U.S. [148]. Thus, there is room for improvement in state regulations to support breastfeeding mothers and to improve complementary feeding practice standards for infants.

Our study has some limitations related to serving sizes, reporting bias, CC definition, age range, study design and sample size. First, the standard USDA food servings are not adjusted for the infant population. There are currently no standardized serving sizes for foods specifically in the infant population. Therefore, the numbers of the food servings were represented in small quantities. There may have been reporting bias by mothers as they recorded the diet of their infants, such as underestimating potentially "unhealthy" foods or overestimating formula/milk. We also used a CC definition based on the number of hours, which may have not been ideal. Instead, the type of CC setting, such as formal centers or informal settings, have shown differences in feeding practices as revealed by others [23, 70]. Furthermore, this study recruited infants of a wide age range (2 to 8 months). However, even when controlling for child age and gender, no differences were found in feeding practices. In addition, we did not control for differences in CC settings, such as center-based, relative and non-relative care, and their compliance with CACFP. We used a cross-sectional study design, in that feeding diary and questionnaire was measured once, limiting the ability to investigate causal relationships. Finally, our study used a relatively low sample size from one WIC office which might have prevented us from detecting differences between CC and PC. In addition, study results are not completely generalizable to the U.S.WIC infants.

Our study also had some strengths. First, our feeding diaries were based on a 3-day record, rather than a diet recall, allowing the subjects to record the foods/drinks as they were consumed and decreasing the risk of recall bias. The questionnaire also asked questions about current infant feeding practices rather than retrospective questions.

In conclusion, this study demonstrated that CC use did not influence overall feeding practices. Follow-up studies are necessary to understand the long-term effects of feeding practices between infants in informal care compared to formal care and parental care.

Figure 3.1. Description of study procedure

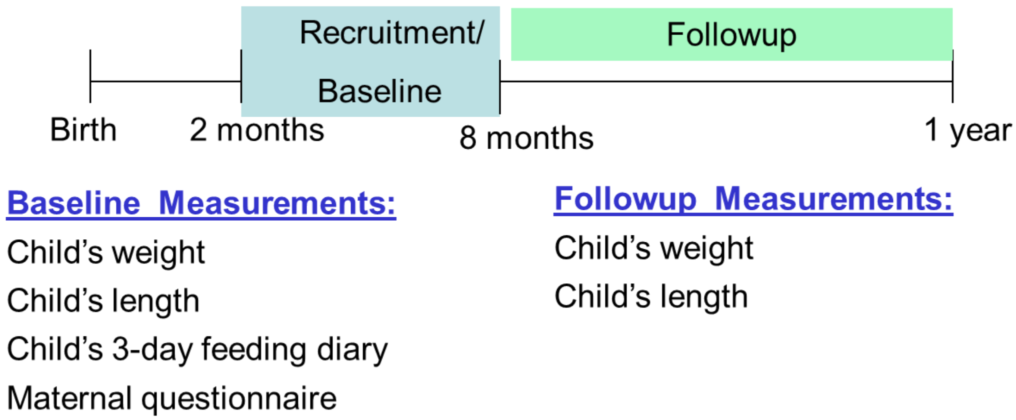
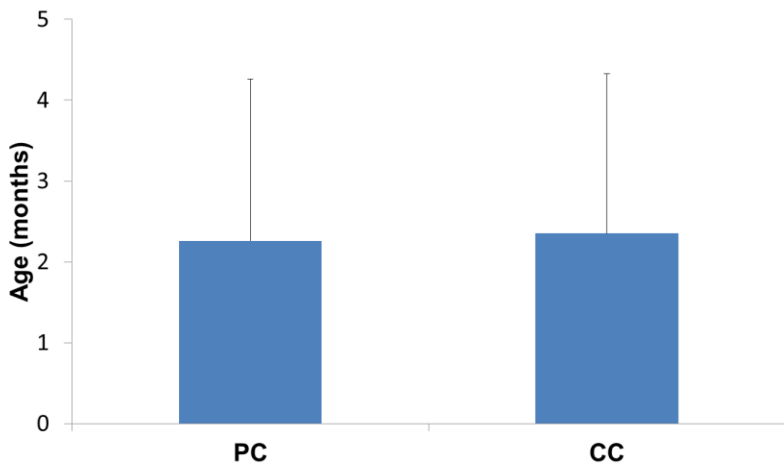
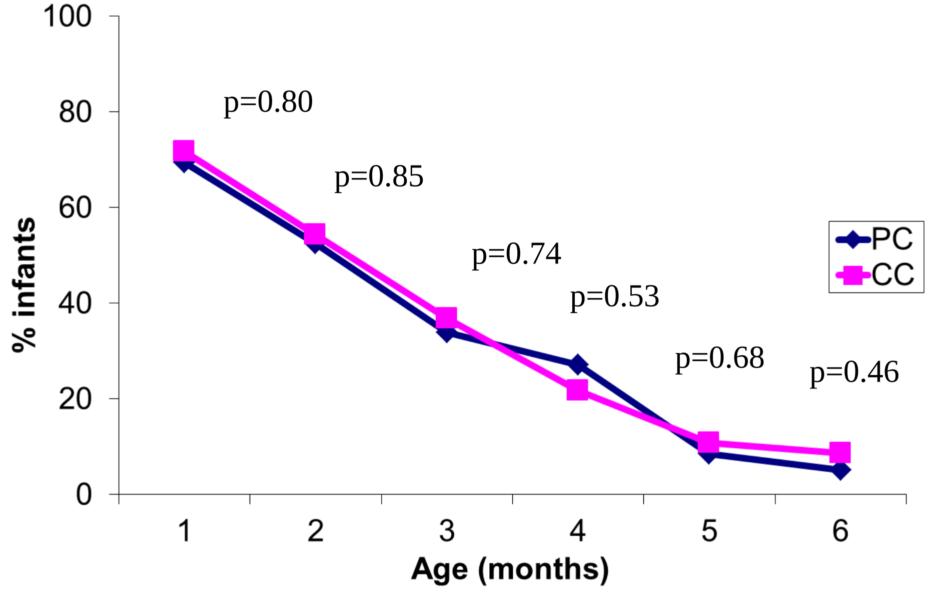


Figure 3.2: Comparison of breastfeeding duration by care type[1,2]



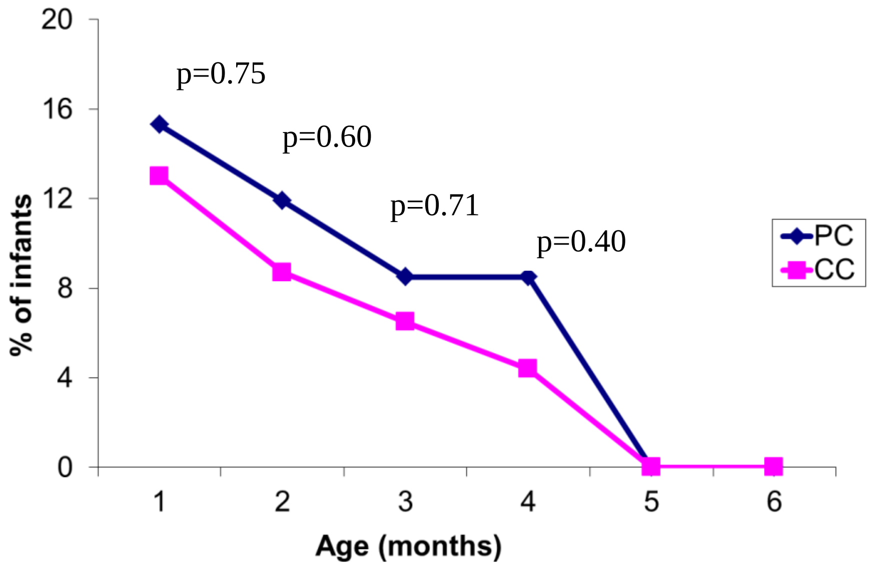
[1]PC=parental care, CC=child care
[2] mean ± standard deviation, p=0.8

Figure 3.3: Comparison of current breastfeeding rates at the time of recruitment by care type[1]



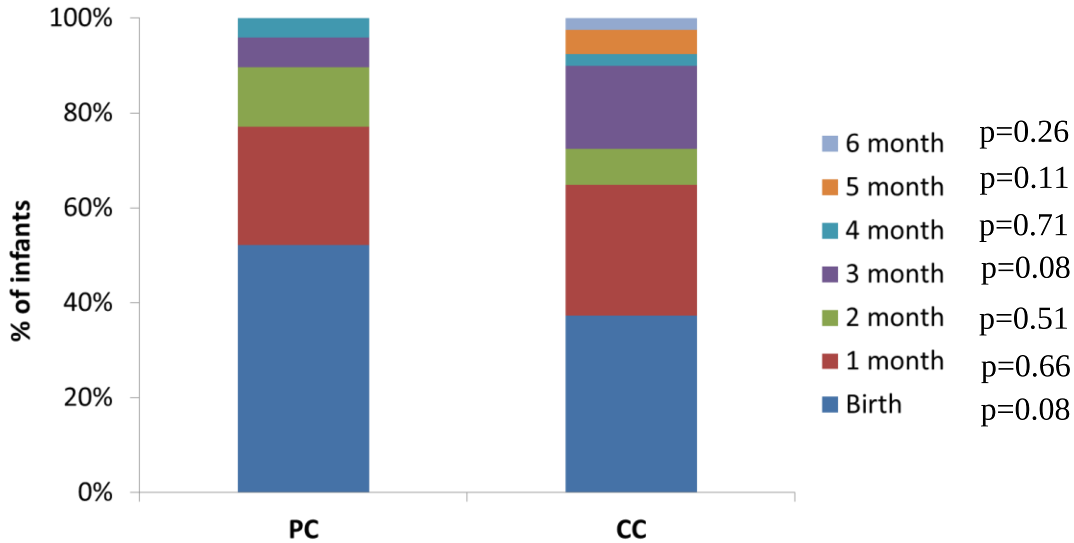
[1]PC=parental care, CC=child care

Figure 3.4: Comparison of exclusive breastfeeding rates at the time of recruitment by care type[1]



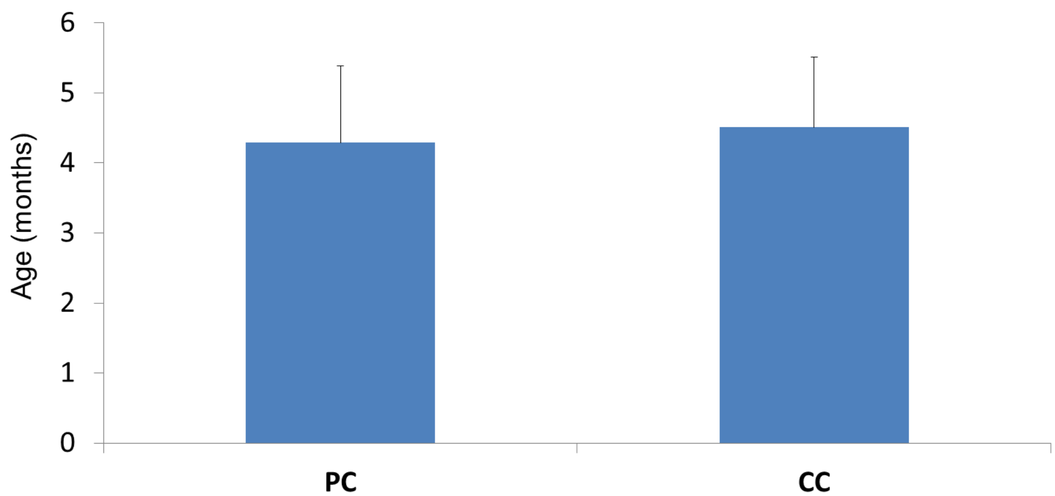
[1]PC=parental care, CC=child care

Figure 3.5: Comparison of the age of formula introduction by care type[1]



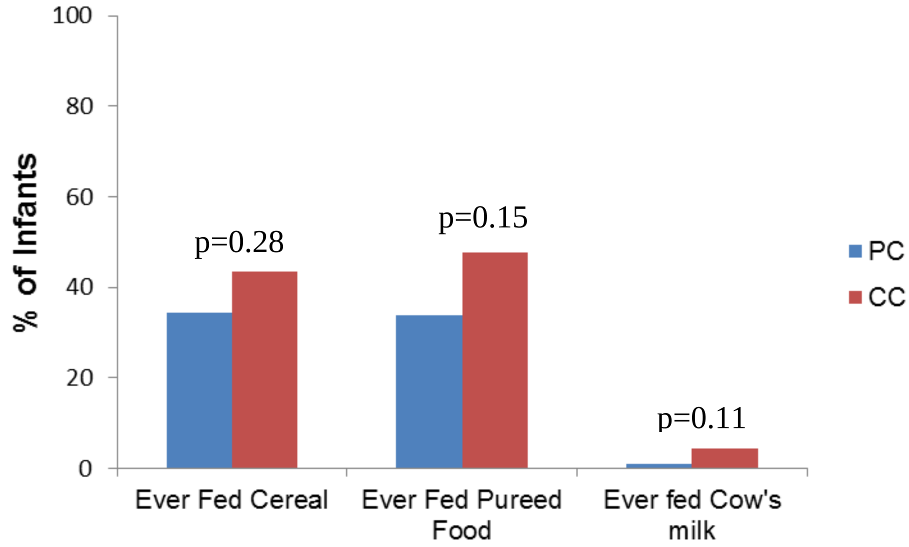
[1]PC=parental care, CC=child care

Figure 3.6: Comparison of the age of solid food introduction by care type[1,2]



[1]PC=parental care, CC=child care
[2] mean ± standard deviation, p=0.54

Figure 3.7: Comparison of feeding practices by care type among infants who began complementary foods[1]



[1]PC=parental care, CC=child care

Tables

Table 3.1: Characteristics of the study sample participants[1,2]

Child characteristics	Total Subjects (n=105)	Parental care (N=59)	Child Care (N=46)	p value
Age CC introduction (months)	2.41 ± 1.4	2.0 ± 1.1	2.48 ± 1.4	0.45
CC hr/wk	13.1 ± 15.9	0.64 ± 2.0	29 ± 11.0	<0.01
Child age(recruitment)	4.10 ± 1.7	3.9 ± 1.5	4.3 ± 1.9	0.24
Birth wt (kg)	3.31 ± 0.5	3.3 ± 0.5	3.3 ± 0.58	0.65
Birth length (cm)	51.0 ± 3.4	51.2 ± 3.1	50.9 ± 3.8	0.69
Gestation age	38.9 ± 1.9	39 ± 1.8	38.9 ± 2.1	0.86
Gestation term				
Preterm (<37wk)	13 (12.4)	8 (13.8)	5 (10.9)	0.97
Term (37-41wk)	85 (80.9)	47 (81.0)	38 (82.6)	
Postterm (>41 wk)	5 (4.76)	3 (5.2)	2 (4.4)	
Child gender				
Male	38 (36.2)	21 (35.6)	17 (36.9)	0.89
Female	67 (63.8)	38 (64.4)	29 (63.0)	
Child Race/Ethnicity				
Hispanic/Latino	8 (7.6)	5 (8.5)	3 (6.5)	0.71
American Indian/Alaska Native	2 (1.9)	2 (3.4)	0	

Table 3.1 (Cont)	Total Subjects (n=105)	Parental care (N=59)	Child Care (N=46)	p value
Black/African American	30 (28.6)	15 (25.4)	15 (32.6)	
Asian	8 (7.6)	5 (8.5)	3 (6.5)	
White	46 (43.8)	27 (45.8)	19 (41.3)	
Mixed	19 (18.1)	10 (16.9)	9 (19.6)	
<u>Maternal Characteristics</u>				
Maternal education	13 ± 2.6	12.9 ± 2.6	13.2 ± 2.5	0.59
Maternal age	26.0 ± 5.4	26.4 ± 5.7	25.5 ± 5.0	0.53
Married	46 (43.8)	28 (47.5)	18 (39.1)	0.39
Single parent home	41 (39.1)	18 (30.5)	23 (50)	0.04
<u>Maternal Race/Ethnicity</u>				
Hispanic/Latino	5 (4.8)	3 (5.1)	2 (4.4)	0.73
American Indian/Alaska Native	2 (1.9)	2 (3.4)	0	
Black/African American	30 (28.6)	15 (25.4)	15 (32.6)	
Asian	8 (7.6)	5 (8.5)	3 (6.5)	
White	56 (53.3)	31 (55.4)	25 (54.4)	
Mixed	5 (4.8)	3 (5.1)	2 (4.4)	
Hispanic	4 (3.8)	3 (5.1)	1 (2.2)	
<u>Maternal place of birth</u>				
U.S. born	92 (87.6)	50 (84.8)	42 (91.3)	0.31
Foreign born	13 (12.4)	9 (15.3)	4 (8.7)	
Pre-pregnant BMI	31.7 ± 20.7	31.7 ± 22.3	31.7 ± 18.3	0.99
<u>Pre-pregnant BMI weight category</u>				
Underweight	2 (2.3)	1 (1.8)	1 (2.9)	0.71
Normal weight	46 (51.7)	30 (54.6)	16 (47.1)	
Overweight	15 (16.9)	10 (18.2)	5 (14.7)	
Obese	25 (28.1)	13 (23.6)	12 (35.3)	
Post-pregnant BMI	32.6 ±19.5	32.3 ± 20.6	32.9 ± 18.1	0.86
<u>Post-pregnant BMI weight category</u>				
Underweight	2 (2.3)	1 (1.8)	1 (3.0)	0.51
Normal weight	33 (37.1)	24 (42.9)	9 (27.3)	
Overweight	20 (22.5)	12 (21.4)	8 (24.2)	
Obese	34 (38.2)	19 (33.9)	15 (45.4)	
<u>Maternal employment</u>				
Yes	47 (44.8)	13 (22.0)	34 (73.9)	<0.01
No	58 (55.2)	46 (77.9)	12 (26.1)	
<u>Household characteristics</u>				
Household income	13,389.6 ± 9620	15,986 ± 10284	9,967 ± 7489.5	<0.01
Household size	3.8 ± 1.1	3.8 ±1.1	3.8 ±1.2	0.75

[1] mean ± standard deviation
[2] n (%)

Table 3.2: Food servings per day among infants who began complementary foods [1,2]

Food group	PC(N=24)	CC (N=23)	p value
Fruit	0.48 ± 0.40	0.24 ± 0.41	0.24
Vegetable	0.41 ± 0.26	0.36 ± 0.27	0.68
Grain	1.74 ± 0.43	2.05 ± 0.44	0.15
Protein	0.47 ± 0.23	0.41 ± 0.24	0.63
Dairy	<0.01 ± 0.03	0.02 ± 0.03	0.13
Fats	<0.01 ± 0.02	0.05 ± 0.02	0.12
Juice	<0.01 ± 0.13	<0.01 ± 0.14	0.48
Infant formula	4.89 ± 0.58	4.31 ± 0.61	0.03
Human milk	2.75 ± 0.93	2.16 ± 0.98	0.18

[1]Data expressed as mean ± standard deviation.
[2]PC=parental care; CC= child care

Table 3.3: Top foods consumed by childcare type among infants who began complementary foods

Parental care		Child Care	
Food	**Grams/day**	**Food**	**Grams/day**
Peaches	142	Cream of wheat	272
Pears	122	Oatmeal & mixed fruit	113
Mixed cereal	114	Mixed fruit juice	105
Dessert	113	Ham	101
Mixed fruits	105	Pear juice	94
Carrots	92	Bananas	89
Peas	89	Oatmeal	79
Dinner	88	Sweet potato	73
Turkey	85	Water	68
Squash	78	Vegetables	66
Chicken	71	Eggs	65
Apple juice	67	Orange juice	62
Sweet potatoes	67	Apple juice	62
Electrolyte drink	63	Peas	60
Applesauce	61	Green beans	59
Green beans	61	Barley cereal	59
Bananas	61	Rice cereal	58
Cereal w/ fruit	59	Chicken	57
Mixed vegetables	57	Strawberries	57
Water	44	Squash	56
Beets	37	Mixed fruit	55
Oatmeal	33	Yogurt	53
Rice cereal	29	Cottage cheese	53
Biscuit	22	Apple sauce	50
Apple prune juice	16	Dinner	47

Table 3.3 (Cont)

Child Care	
Food	**Grams/day**
Peaches	46
Noodles	45
Fruit juice	45
Asparagus	44
Dessert	43
Pears	40
Carrots	39
Fruit punch	31
Turkey	28
Beets	28
Pizza	28
Formula	19
Potatoes	18
Crackers	13
Chicken soup	7
Baked beans	5
Gerber puffs	5
Stuffing	4
Sausage	3
Pancake	2

Table 3.4: Percentage of infants consuming different food groups by care type

	Total Subjects		Parental care		Child Care	
Food	**n**	**%**	**n**	**%**	**n**	**%**
Fruit						
Citrus juice	3	2.9	0	0.0	3	6.5
Fruit juice excluding citrus juice	15	14.3	6	10.2	9	19.6
Citrus fruit	0	0.0	0	0.0	0	0.0
Fruit excluding citrus fruit	32	30.5	18	30.5	14	30.4
Vegetables						
Dark-green vegetables	1	1.0	1	1.7	0	0.0
Deep-yellow vegetables	30	28.6	13	22.0	17	37.0
Tomato	1	1.0	0	0.0	1	2.2
White potatoes	2	1.9	0	0.0	2	4.4
Fried potatoes	1	1.0	0	0.0	1	2.2
Other starchy vegetables	18	17.1	9	15.3	9	19.6
Legumes (cooked dried beans)	1	1.0	0	0.0	1	2.2
Other vegetables	21	20.0	10	17.0	11	23.9
Grains						
Grains, flour and dry mixes-whole grain	5	4.8	2	3.4	3	6.5
Grains, flour and dry mixes-refined grain	42	40.0	20	33.9	22	47.8
Loaf-type bread and plain rolls-refined grain	1	1.0	0	0.0	1	2.2
Other breads (quick breads, corn muffins, tortillas) - Refined grain	1	1.0	0	0.0	1	2.2
Crackers-some whole grain	2	1.9	0	0.0	2	4.4
Crackers-refined grain	1	1.0	0	0.0	1	2.2
Pasta-refined grain	2	1.9	0	0.0	2	4.4
Ready-to-eat cereal-whole grain	1	1.0	1	1.7	0	0.0
Cakes, cookies, pies, pastries, danish, doughnuts and cobblers -some whole grain	1	1.0	1	1.7	0	0.0
Cakes, cookies, pies, pastries, danish, doughnuts and cobblers -refined grain	2	1.9	1	1.7	1	2.2

Table 3.4 (Cont)	Total Subjects		Parental care		Child Care	
	n	**%**	**n**	**%**	**n**	**%**
Baby food grain mixtures-refined grain	1	1.0	1	1.7	0	0.0
Miscellaneous baby food mixtures	4	3.8	0	0.0	4	8.7
Meat, fish, eggs, nuts, seeds						
Lean fresh pork	1	1.0	0	0.0	1	2.2
Lean poultry	4	3.8	3	5.1	1	2.2
Cold cuts and sausage	1	1.0	0	0.0	1	2.2
Baby food meat mixtures	8	7.6	4	6.8	4	8.7
Eggs	2	1.9	0	0.0	2	4.4
Dairy						
Milk-reduced fat	4	3.8	1	1.7	3	6.5
Ready-to-drink flavored milk -low fat and fat free	1	1.0	0	0.0	1	2.2
Cheese-full fat	1	1.0	0	0.0	1	2.2
Cheese-reduced fat	1	1.0	0	0.0	1	2.2
Yogurt-artificially sweetened whole milk	1	1.0	0	0.0	1	2.2
Infant formula	99	94.3	56	94.9	43	93.5
Infant formula-nondairy	9	8.6	5	8.5	4	8.7
Fats						
Margarine-reduced fat	3	2.9	0	0.0	3	6.5
Shortening	1	1.0	0	0.0	1	2.2
Sweets						
Sugar	1	1.0	0	0.0	1	2.2
Baby food dessert	4	3.8	2	3.4	2	4.4
Beverages						
Sweetened fruit drinks	1	1.0	0	0.0	1	2.2
Unsweetened water	18	17.1	9	15.3	9	19.6
Nondairy-based sweetened meal Replacement/supplement	1	1.0	1	1.7	0	0.0
Sauces and condiments-regular	1	1.0	0	0.0	1	2.2

Chapter 4:

Assessment of Infant Nutrient Intake by Child Care Use

Abstract

Several nutrients are important for the proper growth and development of infants during the first year of life. It is unknown if there are differences in nutrient intake for the infant population between child care (CC) as compared to parental care (PC). This study assessed the differences in nutrient intake of CC vs. PC in infants receiving the Special Supplemental Nutrition Program for Women Infants and Children (WIC) assistance. This study sampled 105 infants 2 to 8 months of age from the Champaign Urbana WIC office from October 2009-August 2011. Mothers completed a 3-day food record, and survey at the time of recruitment to assess their infant's nutrient intake, and demographic characteristics. Child care was defined as infants receiving 10 hours or more per week of care from a non-parental caregiver.

Infants in CC had an average of 29 hours of care per week compared to the 0.64 hours in the PC group ($p<0.01$). A larger ($p<0.01$) percentage of mothers were employed in the CC group (73.9%) compared to the PC group (22%). However, the household income was greater ($p<0.01$) in the PC group ($15,986 ± $10,284 PC vs. $9,967± $7,489.5 CC) but no differences in household size. In addition, there was a higher ($p=0.04$) percentage of single parents in the CC group compared to PC (30.5 % PC vs. 50% CC). There were no differences in child birth weight, length, gestation, gender, race/ethnicity or age at recruitment, as well as maternal age, education, race/ethnicity, or BMI status by care type.

Overall, CC use did not affect energy, macronutrient or most micronutrient intakes in infants 2 to 8 months old, likely due to the milk/formula based diet. Calcium intake was significantly greater ($p=0.05$) in the CC group. In addition, an older child age and the greater

number of servings of infant formula predicted greater caloric intake in the infant diet. There were no concerns about inadequacy of any specific nutrients when compared to the adequate intake (AI) reference values. In conclusion, this study demonstrated that CC use did not influence differences in overall nutrient intake. Follow-up studies are necessary to understand the long term effects of nutrient intake between infants and children in CC and PC as their diet transitions from a milk-based to food-based diet.

Introduction

Several nutrients are important for the proper growth and development of infants during the first year of life. Major sources of energy, macronutrients and micronutrients are accounted for by infant formula and breast milk, followed by a gradual transition to baby foods and table foods within the first year of life. After infant formula/breast milk, infant cereal provides the second or third largest source of thiamin, riboflavin, niacin, vitamin B-6, calcium, iron, zinc, magnesium, potassium and phosphorus and third or fourth primary source of vitamin C and E for infants [48]. Juice provides a large source of vitamins and minerals due to its high consumption rates [48]. As baby foods are being introduced into the infant diet, there is a high consumption of vitamin A and potassium due to foods such as carrots, sweet potatoes, and winter squash [48].

Based on a nationally representative sample of infants and toddlers in the U.S., it has been shown that energy intake is already exceeded by 10% as early as 4 to 6 months of age and 23% at 7 to 12 months of age [103]. Yet, all nutrients exceeded the AI for infants less than 12 months of age [103]. These trends in nutrient intake in U.S. infants are similar to WIC infants as reported by the FITS study [57].

Due to the increase in maternal employment, 42% of infants participate in CC in the U.S. [18]. Therefore, CC is a crucial environment for infants and children to meet daily dietary intake. The AND recommends that a child receives one half to two-thirds of RDA from CC when a child spends 8 hours or more in CC [96]. In a study comparing the nutrient intake of half-day to full-day preschool children at Head Start, children met one-third of RDA while in CC for energy, calcium, iron, zinc, and vitamin E if they attended CC 5 to 6 hours/day [26]. There was more daily calcium, vitamins A, C and B-12 consumed by children in the full-day Head Start program, compared to the half-day children [26]. However, all groups of children exceeded the recommendations for saturated fat, and the percentage of calories from fat and cholesterol were exceeded in the morning only and full-day groups [26]. The ratio of calories from protein, carbohydrate and fat was similar for all 3 groups of children, representing approximately 15%, 54% and 31% respectively. [26]. Currently, there is limited information about nutrient intake for the infant population between CC as compared to PC [23].

Thus, further studies are necessary in infant populations during the first year of life. This study aimed to assess the differences in nutrient intake of infants enrolled in CC compared to PC. Our hypothesis was that all infants would meet or exceed the current AI reference values for macro and micro nutrients, with greater intake in the CC group.

Methods

Subjects

Mothers and infants were recruited in the waiting room at the Champaign Urbana Public Health Department WIC office. Mother-infant dyads must have been enrolled in WIC in order to enroll in the study. Our inclusion criteria were that infants must be within the ages of 2 to 8 months of age during the time of recruitment and must be enrolled in WIC program with mother. A sample of 107 mother-infant dyads completed our study from October 2009 to August 2011, with an initial response rate of 278 pairs. After completion of the study, we excluded 2 infants from our study sample because they were not enrolled in WIC, but were visiting the Champaign Urbana Public Health Department for other reasons. Recruitment was concurrent with the new rules for the WIC food package which was enacted in October, 2009. Child care providers were defined as any non-parental caregivers such as relatives, home-based caregivers and center-based caregivers. Using the 2007 National Survey of Children's Health definition, CC was defined as infants receiving 10 hours or more per week of care from a non-parental caregiver [143].

Data collection

An explanation of the study procedure is summarized in Figure 4.1. Briefly, study participants were informed of the study through flyers, case managers, and by being approached by the research staff in the waiting room of the WIC office. The trained research staff inquired about the age of the infant prior to soliciting participation in the study. Mothers were informed that this research study was to investigate parent and CC feeding practices and its effect on infant growth. All of the study procedures were approved by the University of Illinois Institutional Review Board before the start of the study.

The mothers were asked to complete a study questionnaire and a 3-day infant food record. After completion of the survey and 3-day food record, the mother/caregiver was given a gift certificate. Upon recruitment, mother/caregiver provided informed consent and personal contact information. The consent form enabled our research staff to collect additional demographic information and growth data of the mother infant dyad from the WIC database.

Within one week of recruitment, each mother/caregiver was contacted via follow-up telephone call reminding her about the study, asked if she had started the survey, and food record and asked if there were any questions. The research staff briefly reviewed the details of completing the food record.

Measures of Nutrient intake

Nutrient analysis was conducted of the food records using Nutrition Data System for Research (NSDR) (version 2008, University of Minnesota, Minneapolis). The NDSR analysis provided a detailed assessment of the distribution of energy, macronutrient and micronutrient intake derived from solid foods, breast milk or formula, and other fluids.

Nutrient intake of infants was assessed by a 3-day food record during 2 weekdays and 1 weekend day. Food records documented the time of feeding, the person feeding the child (e.g. mother, grandmother, father, etc), amount of solid food offered, and amount and type of feeding (formula or breast milk). If formula was fed, the food record asked for the brand of formula, preparation of the formula and type of water used. If mothers were directly breastfeeding their baby, they recorded the number of minutes that the baby was actually feeding. However, there was wide variation in breast milk volume output per minute reported in the literature due to differences in milk flow rates (i.e. time to first milk ejection, and number of milk ejections per feeding) [149-151] and differences in suckling (stimulatory pressure) patterns [152, 153]. Estimation of breast milk intake in our study was derived from total daily breast milk intake per age (months) of the child using the reference provided by Neville et al. [144]**.** This reference followed a test-weighing procedure, using an electronic scale, to quantify the volume of breast milk transfer from the mother to the infant at each breastfeeding. Breast milk intake was quantified in 1 month intervals for 12 months using a 48-hour test-weighing. In this study, infants were exclusively breast-fed for at least 4 months followed by the introduction to solid foods (4-9 months) and formula (after 4 months). The mean values of the monthly breast milk intake per day from Neville's study were validated against 15 comparable studies and proved to be similar.

In our study, the daily breast milk volume was estimated based on the age (months) of the child, divided into the number of breast milk feedings per day and entered in NDSR as breast milk volume per feeding. If there was other liquids (formula, juice, water) consumed in the 24 hours of the feeding diary, the volume of the other liquids were entered separately into NDSR and deducted from the daily total breast milk volume. The nutrient analysis of breast milk was completed in NDSR, which uses the nutrient analysis for human breast milk (NDB Number 01107) from the U.S.D.A. National Nutrient Database for Standard Reference.

A food picture aid was provided with the food record for accurate measurement of portion size and was adapted from Ziegler et al. [145]. Solid food was defined as any cereal or baby food in jars or finger foods. Similar to the FITS study, we expressed age specific daily nutrient intake, in order to compare to the AI reference values of 0 to 5 month old and 6 to 12 month old infant for each nutrient [95]. Units were expressed in calories/day for energy, grams/day for carbohydrate, protein, fat, milligrams/day for vitamins C, E, B-6 , thiamin, riboflavin, niacin, calcium, phosphorus, magnesium, iron, zinc, sodium, potassium, and micrograms/day for folate, vitamin B-12, A, D, K. One outlier was excluded from the final nutrient analysis due to suspected maternal over-reporting of the food record, as the mother reported large quantities of age inappropriate foods. There were 2 subjects used in the final nutrient analysis that were only based on 2 days.

Statistical Analysis

Statistical analysis was conducted using SAS version 9.2 (SAS Institute, Inc Cary, NC). Prior to formal analysis, preliminary analysis included searching the collected data for errors. In addition, the data was checked for normality using the Shapiro-Wilks test and homogeneity of variance using the Brown-Forsythe test under the GLM procedure. All nutrients were not normally distributed, except for saturated fat, but all nutrients met the homogeneity of variance assumption.

Descriptive statistics (mean, standard deviation) were calculated for samples between CC and PC group. Since a majority of the nutrients were not normally distributed, a non-parametric test was conducted to test for comparison of nutrient intake between CC and PC groups using the NPAR1WAY procedure in SAS with Wilcoxon option. In addition, the nutrient intake of both CC and PC infants was compared against the AI. All nutrients were expressed as nutrient density, with each nutrient expressed per 1000 kcal [154].

For linear regression analysis, the GLM procedure in SAS was used with the LSMEANS option to obtain the mean caloric intake for the PC and CC groups. Regression analyses were conducted on energy (kcal) to compare between care type (CC/PC), adjusted for confounding variables. These confounding variables included child age (mo), child gender (male/female), race/ethnicity (black, mixed, latino,and white as reference group), maternal education (yr), maternal age (yr), maternal prepregnancy BMI (kg/m^2), birth weight (kg), birth order (# of child in the family from oldest to youngest), household income ($/yr), and household size (# people/house). We also controlled for the influence of breastfeeding duration (mo), infant formula (# svgs based on standard USDA 5 oz. svg), and solid food introduction (before 4 mo of age/ at or after 4 mo of age).

Results

Table 4.1 shows nutrient intake comparison between PC and CC across all nutrients for all subjects 2 to 8 months. Results showed greater (p=0.05) calcium intake in CC group. As indicated in Chapter 3 Tables 3.3-3.5, there were more dairy foods, such as yogurt and cottage cheese, offered to infants in the CC group. All other nutrients did not show significant differences between PC and CC group, but the CC group showed numerically higher vitamin and mineral intake.

Table 4.2 shows the energy regression model, displaying the slope β estimates, standard error, p value and correlation adjusting for maternal, child, household variables as well as feeding practices. Energy intake was most affected by child age ($\beta=34.8$, $p<0.01$) and servings of infant formula ($\beta=86.0$, $p<0.01$) but not by CC arrangement.

Table 4.3 shows a comparison of nutrients to Dietary Reference Intake (DRI) values, AI, for infants 0 to 5 months of age enrolled in CC and PC. As shown, energy intake was within the middle of the recommended estimated energy requirements (EER) range for 0 to 5 months of age. Fat intake was similar to the AI for 0 to 5 month old infants. All other nutrients exceeded the AI reference values.

Table 4.4 shows a comparison of nutrients to AI for infants 6 to 8 months of age enrolled in CC and PC. Similar to Table 4.3, energy intake was within the middle of the recommended EER range for 6 to 12 months of age. All other nutrients exceeded the AI reference values. Fat and carbohydrate intake were within the recommended AI levels, but protein and micronutrients exceeded the AI [95].

Discussion

The main finding from this study is that CC use did not affect energy, macronutrient or most micronutrient intake in infants 2 to 8 months old. Calcium intake was statistically greater in the CC group. The older child age and the greater number of servings of infant formula led to greater caloric intake in the infant diet.

The CC group showed a numerical pattern of higher vitamin and mineral intake, which was likely a reflection of the greater food intake in the CC group as seen in Chapter 3, Tables 3.3-3.5. The macronutrient composition for both the CC and PC group did not differ likely due to the milk/formula based diet. Calcium intake was higher in the CC group, which follows a previous report of greater calcium, vitamins A, C and B-12 sources from foods consumed by children in the full-day Head Start program, compared to the half-day children [26].

There were no concerns about inadequacy of any specific nutrients when compared to the AI reference values for both 0 to 5 month old and 6 to 8 month old infants, as shown in Tables 4.3 and 4.4 of this chapter. For infants, the complete distributions of nutrient requirements are not available because the AI levels are based on observed or experimentally calculated estimates from healthy infants who are assumed to be adequate [155]. As such, we were limited in our assessment as there is no recommended dietary allowance (RDA), estimated average requirements (EAR), or tolerable upper limit (UL) currently available for this population [155].

These values were compared to the nutrient intake values found in the FITS study, which included infants of 4 to 24 months of age in a national representative sample [95]. The FITS study divided the usual intake distributions into percentile estimates within the infant population. The percentiles were divided into 0 to 5 month age range followed by a separate 6 to 11 month group. Tables 4.3 and 4.4 values were compared to the 0 to 5 month and 6 to 11 month nutrient distributions in Appendix E from the FITS study. When compared to FITS study infants 0 to 5 months of age, subjects in that same age range from our study had numerically greater average intake of protein, dietary fiber, vitamin C, vitamin K, calcium, phosphorus, magnesium, iron, zinc, sodium, and potassium, but had similar percentile distributions as compared to FITS shown in Appendix E. In addition, subjects from our study had slightly lower average intake of energy, folate, and vitamin A compared to the similar FITS study infants, but the range of nutrient distributions were similar as compared to FITS. When compared to FITS study infants 6 to 11 months of age, subjects 6 to 8 months old from our study were below the average intake for macro and micronutrients, but the range of nutrient distributions were similar as compared to FITS shown in Appendix E. Because the percentile distribution was similar for the 6 to 8 month old infants, differences in sample size could possibly explain the lower average nutrient intake from our study. Overall, nutrient intake from our study was similar to national sample of U.S. infants from the FITS study.

Similarly, the intake levels in our 2 to 6 month old age group were comparable to the nutrient intake of infants from Skinner et al. [104]. These infants consisted of a group primarily of white, middle- and upper-socioeconomic status from metropolitan areas of Tennessee. In comparison to the 2 to 4 month infants from this study, our 2 to 5 month infants had a greater intake of magnesium, potassium, sodium, zinc and lesser amounts of vitamin E and K. In addition, our infants 6 to 8 months old were lower in calcium, iron, phosphorus, vitamin E, vitamin K, thiamin, riboflavin and niacin and higher in zinc compared to Skinner's study of 6 and 8 month old infants. However, in general, both groups of infants consumed a similar range of nutrients in the 2 to 6 month age group.

Some study limitations may have been reporting bias by mothers as they recorded the diet of their infants, such as underestimating potentially "unhealthy" foods or overestimating formula/milk. Furthermore, this study used a CC definition based on the number of hours, which may have not been ideal. Instead, the type of CC setting, such as formal centers or informal settings, have shown differences in feeding practices as revealed by others [23, 70]. In addition, we used a cross-sectional study design, with the food record measured once, limiting the ability to investigate causal relationships. Finally, our study used a relatively low sample size from one WIC office which might have prevented us from detecting differences between CC and PC. In addition, study results are not completely generalizable to the U.S.WIC infants.

Our study also had some strengths. Our food records were based on 3 days, rather than a diet recall, allowing the subjects to record the foods/drinks as they were consumed and decreasing the risk of recall bias. Previous reports of infant feeding practices have relied on food frequency questionnaires (FFQ) to assess diet quantity and quality. However, FFQ are based on recall and, therefore, may not be completely accurate due to bias in memory and desire to only include foods and feeding practices that are deemed to be healthy [129].

In conclusion, this study demonstrated that CC use did not influence differences in overall nutrient intake, except for calcium. Instead, child age and the number of servings of infant formula affected energy intake in our study. Follow-up studies are necessary to understand the long-term comparison of nutrient intake between infants and children in CC and PC as their diet transitions from a milk-based to food-based diet. These results can help develop new strategies for intervention to improve infant feeding practices in the CC setting.

Figure 4.1. Description of study procedure

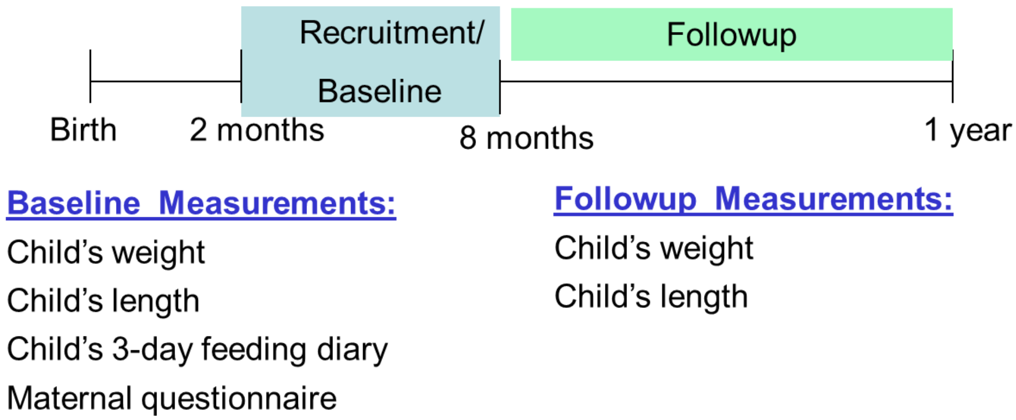


Table 4.1. Daily nutrient consumption for infants 2 to 8 months of age enrolled in CC and PC [1,2]

	PC (N=59)	CC (N=46)	p value
Energy (kcal)	564.9 ± 23.0	557.6 ± 25.5	0.73
Macronutrients			
Carbohydrate (g/d)	113.0 ± 13.4	117.6 ± 15.5	0.37
Protein (g/d)	20.5 ± 3.8	21.6 ± 4.1	0.46
Total fat (g/d)	52.4 ± 7.0	49.8 ± 8.1	0.43
Saturated fat (g/d)	22.5 ± 4.0	21.2 ± 4.5	0.51
Monounsaturated fat (g/d)	19.4 ± 2.9	17.8 ± 3.9	0.86
Polyunsaturated fat (g/d)	8.8 ± 1.4	9.1 ± 2.6	0.21
% Calories macronutrients			
% calories from carbohydrate	44.8 ± 5.5	47.1 ± 6.8	0.41
% calories from protein	8.2 ± 1.4	8.7 ± 1.5	0.44
% calories from fat	46.8 ± 6.0	44.8 ± 7.5	0.45
Fiber			
Dietary fiber (g/d)	2.0 ± 3.0	2.7 ± 3.5	0.53
Soluble dietary fiber (g/d)	0.8 ± 1.2	1.2 ± 1.7	0.67
Insoluble dietary fiber (g/d)	1.2 ± 1.8	1.5 ± 2.1	0.44
Vitamins			
Vitamin C (mg/day)	108.5 ± 23.3	110.2 ± 24.9	0.18
Vitamin E (mg/day)	7.5 ± 3.9	8.3 ± 3.6	0.07
Thiamin (mg/day)	0.7 ± 0.3	0.8 ± 0.3	0.64
Riboflavin (mg/day)	1.1 ± 0.4	1.3 ± 0.4	0.65
Niacin (mg/day)	8.6 ± 3.6	10.0 ± 3.9	0.27
Pantothenic acid (mg/day)	4.3 ± 0.7	4.5 ± 0.9	0.17
Vitamin B-6 (mg/day)	0.5 ± 0.2	0.6 ± 0.3	0.56
Vitamin B-12 (μg/day)	2.3 ± 1.0	2.5 ± 0.9	0.11

Table 4.1 (Cont)	PC (N=59)	CC (N=46)	p value
Folate (µg/day)	141.2 ± 43.6	153.4± 48.0	0.80
Vitamin D (µg/day)	10.9 ± 6.0	11.6 ± 4.7	0.09
Vitamin A (µg RAE[3]/day)	915.8 ± 134.5	954.9 ± 235.7	0.38
Vitamin K (µg/day)	60.9 ± 31.4	72.7± 38.6	0.57
Minerals			
Calcium (mg/day)	742.1 ± 192.3	788.2 ± 187.3	0.05
Phosphorus (mg/day)	418.6 ± 149.7	465.4 ± 156.3	0.26
Magnesium (mg/day)	93.8 ± 33.7	105.5 ± 37.4	0.73
Iron (mg/day)	15.13 ± 10.2	18.62 ± 11.6	0.06
Zinc (mg/day)	7.9 ± 3.4	8.4 ± 2.9	0.52
Sodium (mg/day)	323.1 ± 75.6	357.6 ± 115.6	0.82
Potassium (mg/day)	1083.3 ± 240.2	1166.1 ± 266.1	0.22

[1] PC=parental care; CC=child care
[2] Data expressed as mean ± standard deviation; all nutrients expressed per 1000 kcal.
[3] RAE=retinol activity equivalents

Table 4.2. Energy (kcal) regression model

Category	Variable	Beta estimate	Std error	p value
Maternal	Prepregnancy BMI (kg/m^2)	-0.55	0.5	0.27
	Level of education (yr)	-0.42	4.9	0.93
	Maternal age (yr)	-1.01	2.4	0.68
	CC use (0=CC, 1=PC)	7.31	21.3	0.73
Child	Gender (0=males, 1=females)	6.52	22.1	0.77
	Age (mo)	34.8	8.4	<0.01
	Birthweight (kg)	0.46	18.3	0.98
	Black race (0=Black, 1=not Black)	10.99	25.5	0.67
	Mixed race (0=Mixed, 1=not Mixed)	40.19	32.8	0.23
	Latino race (0=Latino, 1=not Latino)	32.92	37.1	0.38
	Birth order (# order of child in family)	-8.69	15.5	0.58
Household	Income ($/year)	-<0.01	<0.01	0.39
	Household size (# people/house)	11.42	12.7	0.37
Feeding	Infant formula (# of servings)	86.05	8.2	<0.01
	Breastfeeding duration (mo)	1.19	6.1	0.85
	Solid Introduced at 4 mo (0=greater than or equal to 4 mo; 1=less than 4 mo,)	-18.58	25.8	0.47

Table 4.3. Comparison of nutrients to adequate intake (AI) for infants 2 to 5 months of age enrolled in CC and PC (n=84)

			Percentile				
Nutrient	**AI**	**Mean ± SD**	**10th**	**25th**	**50th**	**75th**	**90th**
Energy (kcal/d)	438-645 (EER[1])	589.56 ± 158.18	426.3	487.9	562.3	652.8	805.4
Macronutrients							
Carbohydrate (g/d)	60	66.53 ± 22.08	46.9	53.1	59.3	77.3	101.1
Protein (g)	9.1	12.20 ± 4.07	8.0	8.9	11.3	14.8	16.9
Total fat (g/d)	31	30.83 ± 8.16	21.7	24.1	30.9	35.3	40.1
Saturated fat (g/d)		13.16 ± 3.73	8.9	10.1	13.2	15.8	17.6
Dietary fiber (g/d)		0.89 ± 1.64	0.0	0.0	0.0	0.8	3.5
% Calories macronutrients							
% Calories from fat		47.28 ± 5.95	40.5	44.6	47.6	50.9	55.0
% Calories from carbohydrate		44.64 ± 5.54	38.1	41.1	44.0	46.7	52.8
% Calories from protein		8.35 ± 1.38	6.3	7.8	8.5	9.2	10.0
Vitamins							
Vitamin C (mg/d)	40	62.74 ± 20.87	40.3	45.8	57.6	73.8	93.9
Vitamin E (mg/d)	4	4.57 ± 2.60	0.7	2.9	4.7	5.9	7.6
Thiamin (mg/d)	0.2	0.43 ± 0.28	0.1	0.3	0.4	0.6	0.7
Riboflavin (mg/d)	0.3	0.70 ± 0.37	0.3	0.4	0.7	0.9	1.1
Niacin (mg/d)	2	5.42 ± 3.20	1.5	3.4	4.9	7.4	8.6
Pantothenic acid (mg/d)		2.59 ± 0.82	1.8	1.9	2.4	3.1	3.8
Vitamin B-6 (mg/d)	0.1	0.33 ± 0.21	0.1	0.2	0.3	0.4	0.5
Total folate (μg/d)	65	85.14 ± 39.45	41.1	55.3	78.2	102.3	132.0
Vitamin B-12 (μg/d)	0.4	1.41 ± 0.70	0.4	1.0	1.4	1.8	2.3
Vitamin D (μg/d)	5	6.77 ± 3.75	0.7	5.1	6.8	8.9	11.4
Vitamin A (μg RAE[2]/d)	400	544.76 ± 182.04	377.8	421.4	494.2	627.4	767.2
Vitamin K (μg/d)	2	36.92 ± 22.26	2.4	25.4	38.3	50.8	63.6

Table 4.3 (Cont)	AI	Mean ± SD	10th	25th	50th	75th	90th
Minerals							
Calcium (mg/d)	210	457.62 ± 183.71	257.9	314.3	417.6	563.0	676.0
Phosphorus (mg/d)	100	257.49 ± 128.35	115.0	154.6	232.0	325.8	452.5
Magnesium (mg/d)	30	56.98 ± 30.51	24.6	33.9	51.2	71.2	97.1
Iron (mg/d)	0.27	9.95 ± 8.26	0.2	5.6	8.9	13.4	16.8
Zinc (mg/d)	2	4.90 ± 2.53	1.4	3.2	4.9	6.4	7.9
Sodium (mg/d)	120	199.95 ± 87.07	130.8	141.4	177.4	229.7	285.3
Potassium (mg/d)	400	638.98 ± 250.65	400.5	440.0	569.0	766.1	1009.5

[1] EER=estimated energy requirements
[2] RAE= retinol activity equivalents.

Table 4.4 Comparison of nutrients to adequate intake for infants 6 to 8 months of age enrolled in CC and PC (n=21)

			Percentile				
Nutrient	**AI**	**Mean ± SD**	**10th**	**25th**	**50th**	**75th**	**90th**
Energy (kcal/d)	608-844 (EER[1])	705.18 ± 133.33	541.6	605.5	669.3	782.7	862.1
Macronutrients							
Carbohydrate (g/d)	95	90.60 ± 21.90	67.6	74.3	91.7	105.1	119.3
Protein (g)	11	15.64 ± 4.44	11.2	13.5	15.5	17.4	20.6
Total fat (g/d)	30	31.80 ± 7.80	25.2	26.8	30.9	35.2	38.9
Saturated fat (g/d)		13.45 ± 3.78	10.2	10.8	12.8	14.7	15.8
Dietary fiber (g/d)		4.20 ± 2.52	1.4	2.5	3.9	5.8	7.2
% calories macronutrients							
% calories from carbohydrate		50.58 ± 6.53	40.9	46.0	50.1	55.6	56.4
% calories from protein		8.76 ± 1.64	7.1	7.4	8.7	10.1	10.7
% calories from fat		40.55 ± 6.93	32.5	35.3	40.8	46.5	48.8
Vitamins							
Vitamin C (mg/d)	50	82.76 ± 27.67	44.6	61.6	82.9	99.7	110.2
Vitamin E (mg/d)	5	5.56 ± 2.55	1.2	4.8	6.2	7.9	8.2

Table 4.4 (Cont)	AI	Mean ± SD	10th	25th	50th	75th	90th
Thiamin (mg/d)	0.3	0.53 ± 0.24	0.2	0.4	0.5	0.6	0.8
Riboflavin (mg/d)	0.4	0.86 ± 0.33	0.4	0.6	0.9	1.1	1.2
Niacin (mg/d)	4	7.00 ± 3.15	2.9	5.0	7.3	8.1	9.2
Pantothenic Acid (mg/d)		3.05 ± 0.85	2.3	2.6	3.0	3.4	3.7
Vitamin B-6 (mg/d)	0.3	0.49 ± 0.22	0.2	0.4	0.5	0.6	0.8
Total Folate (µg/d)	80	110.84 ± 34.59	72.1	85.9	111.7	133.7	136.7
Vitamin B-12 (µg/d)	0.5	1.65 ± 0.78	0.5	1.4	1.6	1.9	2.2
Vitamin D (µg/d)	5	6.86 ± 4.16	0.8	5.0	6.8	8.6	10.2
Vitamin A (µg RAE[2]/d)	500	684.56 ± 244.96	440.9	518.7	629.0	804.1	979.8
Vitamin K (µg/d)	2.5	51.90 ± 20.74	25.1	43.1	53.0	69.0	73.3
Calcium (mg/d)	270	505.43 ± 152.33	338.8	402.5	515.6	587.0	606.6
Phosphorus (mg/d)	275	328.49 ± 123.14	186.1	278.6	357.1	363.7	389.9
Magnesium (mg/d)	75	81.91 ± 29.75	50.3	56.4	88.5	94.8	102.7
Iron (mg/d)	6.9	11.99 ± 6.89	2.8	8.6	11.7	15.2	18.9
Zinc (mg/d)	2.5	5.33 ± 2.02	2.1	4.3	5.6	6.7	7.4
Sodium (mg/d)	370	238.21 ± 75.60	166.3	196.0	222.7	255.8	325.6
Potassium (mg/d)	700	918.35 ± 255.07	631.3	729.1	940.1	1070.6	1214.7

[1] EER=estimated energy requirements
[2] RAE= retinol activity equivalents.

Chapter 5:

Impact of Early Feeding Practices on Growth Indices at 12 months of age by Child Care Use.

Abstract

Greater number of hours in child care (CC) use during the first 6 months of life has been reported to increase weight for length (WFL) z-score at 1 year of age and increase body mass index (BMI) z-score at 3 years of age [15]. Herein, this study investigated the impact of CC use on growth specifically the change in WFL, weight for age (WFA) and length for age (LFA) z-score at 1 year of age for infants receiving the Special Supplemental Nutrition Program for Women Infants and Children (WIC). Multivariate regression models were used to examine the association between CC use, feeding practices and child and maternal demographics on the change in growth. A sample of 105 infants 2 to 8 months of age were recruited from the Champaign Urbana WIC office from October 2009-August 2011. At recruitment, a 3-day food record and survey were used to assess the infant's feeding practices, and demographic characteristics. Average follow-up weight and length measurements were taken at 10.1 ± 2.7 months. Child care was defined as infants receiving 10 hours or more per week of care from a non-parental caregiver.

Infants in CC had an average of 29 hours of care per week compared to the 0.64 hours in the parental care (PC) group ($p<0.01$). A larger ($p<0.01$) percentage of mothers were employed in the CC group (73.9%) compared to the PC group (22%). However, the household income was greater ($p<0.01$) in the PC group ($15,986 ± $10,284 PC vs. $9,967± $7,489.5 CC) but no differences in household size. In addition, there was a higher ($p=0.04$) percentage of single parents in the CC group compared to PC (30.5 % PC vs. 50% CC). There were no differences in

child birth weight, length, gestation, gender, race/ethnicity or age at recruitment, as well as maternal age, education, race/ethnicity, or BMI status by care type.

For growth measures, infants in PC had a greater change in WFL ($\beta=2.06, p=0.05$) and WFA ($\beta=1.69, p=0.01$) z-score from baseline to follow-up, after adjusting for feeding practices and child, maternal and household characteristics. There were no differences by CC use in the LFA z-score over the first year of life.

The strongest predictors of the change in WFL z-score were maternal pre-pregnancy BMI ($\beta=0.14, p<0.01$), birth order ($\beta=1.63, p<0.05$), maternal age ($\beta=-0.34, p<0.01$), birth weight ($\beta=-1.77, p=0.06$), non-black/African American ($\beta=3.09, p=0.02$) and male gender ($\beta=-2.12, p=0.06$). Change in WFA z-score was affected by a lower birth weight ($\beta=-1.74, p<0.01$), greater pre-pregnancy BMI ($\beta=0.09, p<0.01$), and fewer servings of infant formula ($\beta=-0.53, p=0.05$). Change in LFA was unaffected by CC use ($\beta=1.69, p=0.11$), but affected by lower pre-pregnancy BMI ($\beta=-0.04, p=0.04$) and by black race ($\beta=-2.54, p=0.05$).

In conclusion, this study demonstrated that CC use may have influenced the change in WFA and WFL, but not for LFA z-scores during infancy. Follow-up studies are necessary to understand the long term effects of CC impacting weight gain between infants in informal care compared to formal care and parental care.

Introduction

Approximately 10% of infants and toddlers in the U.S. have been classified as overweight based on their high WFL [2]. Previous research has shown that infants who gain weight rapidly during the first 2 years of life are more likely to be overweight later in childhood

[3, 4, 156, 157]. Consequently, body size and rate of weight gain in infancy has a significant impact on obesity risk in childhood and adulthood [138].

It has been suggested that early childhood obesity can be explained by dietary consumption patterns during infancy [72]. For example, prolonged breastfeeding has been shown to significantly reduce a child's risk of obesity, with a significant dose response relationship occurring between breastfeeding duration and the incidence of overweight and obesity [31, 47]. For every month that an infant is breast-fed up to 9 months, the risk of later obesity decreases by 4% [114]. Infant formula, when fed exclusively for the first 6 months, has led to higher growth rates in weight, length and skinfold thickness compared to breast-fed infants [44]. In the last half of infancy, a weight difference of 400 grams by 9 months and 600-650 grams at 12 months has been reported between breast-fed and formula-fed infants, with a larger percentage of formula-fed infants having WFL measurements greater than the 90^{th} percentile [118]. Thus, breastfeeding has proved to be beneficial over formula feeding on weight status and prevention of obesity.

Early solid food introduction, on the other hand, has not been shown to lead to a larger overall size in infancy [44]. Yet, the quality of foods served during infancy may be predictive of the child's diet quality and weight status later in life [129]. At 6 to 12 months of age, a diet characterized with home-prepared foods, fruits and vegetables and compliant with infant feeding guidelines was associated with greater weight gain compared to an 'adult' diet characterized by breads and processed foods, independent of the type of milk feeding [44]. By 4 years of age, children fed a diet of high quality during infancy, which is defined as compliant with infant feeding guidelines, were leaner compared to those fed an 'adult' diet during infancy [129].

Child care providers can strongly influence the food consumption patterns and affect the eating habits of infants [22]. It has been reported that more hours of CC in someone else's home during the first 6 months of life were significantly associated with increased WFL z-score at 1 year of age and increased BMI z-score at 3 years of age [15]. Use of informal CC has also been shown to be positively associated with BMI z-score at 2 years of age as well as a larger change in BMI z-score between 1 and 2 years of age [156]. Kim and Peterson reported that infants cared for by a relative was associated with the introduction of solid foods before 4 months of age and increased infant weight gain at 9 months of age [23]. In addition, infants attending part time CC or care by relatives had a greater weight gain over the first 9 months when compared to infants under PC [23]. However, further research is warranted in the infant population to understand the associations of the CC environment and dietary intake in infants.

The objective of this study was to investigate the impact of CC use on growth specifically the change in WFL, WFA and LFA z-score at 1 year of age. Our hypothesis was that unhealthy feeding practices would be more common in the CC group, such as decreased breastfeeding and early solid food introduction, and would lead to a higher WFL and WFA z-score at 1 year of age.

Methods

Subjects

Mothers and infants were recruited in the waiting room at the Champaign Urbana Public Health Department WIC office. Mother-infant dyads must have been enrolled in WIC in order to enroll in the study. Our inclusion criteria were that infants must be within 2 to 8 months of age during the time of recruitment and must be enrolled in WIC program with mother. A sample of 107 mother-infant dyads completed our study from October 2009 to August 2011, with an initial response rate of 278 pairs. After completion of the study, we excluded 2 infants from our study sample because they were not enrolled in WIC, but were visiting the Champaign Urbana Public Health Department for other reasons. Recruitment was concurrent with the new rules for the WIC food package which was enacted in October, 2009. Child care providers were defined as any non-parental caregivers such as relatives, home-based caregivers and center-based caregivers. Using the 2007 National Survey of Children's Health definition, CC was defined as infants receiving 10 hours or more per week of care from a non-parental caregiver [143].

Data collection

An explanation of the study procedure is summarized in Figure 5.1. Briefly, study participants were informed of the study through flyers, case managers, and by being approached by the research staff in the waiting room of the WIC office. The trained research staff inquired about the age of the infant prior to soliciting participation in the study. Mothers were informed that this research study was to investigate parent and CC feeding practices and its effect on infant growth. All of the study procedures were approved by the University of Illinois Institutional Review Board before the start of the study.

The mothers were asked to complete a study questionnaire and a 3-day infant food record. After completion of the survey and 3-day food record, the mother/caregiver was given a gift certificate. Upon recruitment, mother/caregiver provided informed consent and personal contact information. The consent form enabled our research staff to collect additional demographic information and growth data of the mother infant dyad from the WIC database.

Within one week of recruitment, each mother/caregiver was contacted via follow-up telephone call reminding her about the study, asked if she had started the survey, and food record and asked if there were any questions. The research staff briefly reviewed the details of completing the food record.

Measures of Feeding Practices

Feeding practices of the infant were assessed by a 3-day food record during 2 weekdays and 1 weekend day. Food records documented the time of feeding, the person feeding the child (e.g. mother, grandmother, father, etc), amount of solid food offered, and amount and type of feeding (formula or breast milk). If formula was fed, mothers recorded the brand of formula, preparation of the formula and type of water used. If mothers planned to directly breastfeed their baby, they recorded the number of minutes that the baby was actually feeding. Estimation of breast milk intake was derived from total daily breast milk intake based on the age of the child [144]**.** A food picture aid was provided with the food record for accurate measurement of portion size and adapted from the FITS study [22, 145]. Solid food was defined as any cereal or baby food in jars or finger foods. In order to complete the 3-day food record, mothers using CC communicated with the child's care provider/teacher for information about the child's food and drink consumption during those CC hours. We used the Nutrition Data System for Research (NDSR) software to analyze the 3-day food record. NDSR calculated the number of infant formula servings for each feeding using the reference USDA serving of 5 oz. An average of the infant formula servings was calculated over the 3 days for each subject. In addition, NDSR calculated the food servings for each individual food both in grams and reference servings based on each feeding. Definition of different food groups and their serving sizes were based on the USDA Food Guide Pyramid and Dietary Guidelines for Americans 2005 [146]. An average of the food servings was calculated over the 3 days for each subject.

Additional feeding practice questions were asked by survey questionnaire. Study participants were given the option of completing the survey by paper or online version. The survey provided questions about the age at introduction of solid foods, types and quantity of food offered, the types and quantity of beverage choices offered frequency of feedings, practices on the introduction of solid foods for infants, preparation practices of infant formula, and response to feeding cues. Breastfeeding duration was calculated using the survey question "How old was your child when you stopped breastfeeding?" If the participant did not complete this response and marked that they were currently breastfeeding from a previous question, we used the child's current age as the breastfeeding duration (months). Alternatively, if they marked "No" to the question "Was your child ever breast-fed?" we estimated a breastfeeding duration of zero. Current and exclusive breastfeeding rates were based on dichotomous Yes/No questions from the survey. Age of solid food introduction was obtained from the survey, with a response of "never" or completing the age (months). If the infant had not yet been introduced to solid foods, their data were excluded from any analysis comparing food servings or types of foods between PC and CC. A total of 35 subjects in PC and 23 subjects in CC were excluded for that reason. Other feeding practices questions asked if the child had ever been fed cereal, ever been fed pureed baby food and ever been fed cow's milk was created into a dichotomous Yes/No variable from a survey question which asked for the age of introduction of cereal, baby food, and cow milk. Formula introduction was based on a survey question asking the age they began feeding formula, with options for a response including "never" or completing the age (months).

Previous reports of infant feeding practices have relied on food frequency questionnaires (FFQ) to assess diet quality. However, FFQ are based on recall and, therefore, may not be completely accurate due to bias in memory and desire to only include foods and feeding practices that are deemed to be healthy [129]. Thus, the strength of our study was based on the food diary method, which is considered to be a more accurate measurement tool.

Measures of demographic information

Information related to the infant and families were provided by the WIC database. The WIC database provided demographic information such as the infant's race or ethnicity, birth date, birth weight, birth length, additional weight, height and lab tests on follow-up visits. The maternal information included duration of the pregnancy for the child, pre-pregnancy weight, pregnancy weight gain, and any pregnancy complications. The family information provided was family size and composition, household income, education, employment, and family history of medical conditions. The WIC data was accessed by the Cornerstone System, which is the database system for the state of Illinois.

In addition, the survey questionnaire provided similar birth information of the infant, such as birth date, birth weight, birth length, duration of pregnancy, pregnancy-related medical conditions (diabetes, anemia, hypertension), maternal weight status pre and post pregnancy, maternal marital and financial status, household income, employment status, household size, and CC information such as the reasons for using CC and the number of hours of CC use.

Growth measures

Weight and length information for the children in our study was obtained by the Cornerstone System at the Champaign Urbana Public Health Department WIC office. The weight and length was collected by the WIC staff according to WIC procedures using an infant weigh scale, and a calibrated length board. After the scale was properly calibrated and zeroed out, the infant was positioned in the center of the scale tray and weighed to the nearest 0.01 kg or ½ oz. in the nude or in a clean diaper. The infant was then repositioned on the scale and reweighed. To improve quality of the measurements, the average of the two body weights was recorded if the weights were in closest agreement with each other.

Infant length was obtained using a calibrated length board with a fixed headpiece and a movable footpiece that is perpendicular to the surface of the table. Infants were placed on their back in the flat recumbent position in the center of the length board. The child would look straight up with both legs fully extended, feet positioned flat against the footpiece, and the toes pointing upwards. Infant did not wear any shoes and only wore light clothing or diaper only. The length was measured twice up to the nearest 0.1 cm or 1/8 inch. Length measurements were repeated by a second measurer and must be within 1 cm or ¼ inch agreement.

Growth measures were evaluated by WFL, WFA and LFA z-score at baseline and follow-up times. WFL, WFA and LFA z-scores were calculated using a SAS macro program provided by the World Health Organization (WHO). This software calculated the z-score using the age and gender criteria from the 2009 WHO growth standards reference data [158].

The main growth measure was the change in WFL z-score at baseline and follow-up times, which was calculated using the difference in the z-scores. However, WFA and LFA were also evaluated at baseline, follow-up and change in z-scores for additional indices of growth. The units of the z-scores are standard deviation. Baseline weight and length measurements were used at the time of infant's enrollment in WIC program after birth (age range 0.07-4.6 months). Follow-up weight and length measurements were taken at 1 year of age or the last available measurements closest to 1 year (age range 5.2-13.2 months). We excluded 25 subjects from the analysis because there were no available weight and/or length information at both of the baseline or follow-up time points.

WFL z-scores were compared against the WHO criteria for weight status to determine classifications of underweight, normal weight or overweight [1]. These criteria classify underweight as WFL z-score <-2, normal weight -2<WFL z-score <2 and overweight WFL z-score >2. Finally, the weight classifications were compared by PC and CC groups.

Statistical analysis

Statistical analysis was conducted using SAS version 9.2 (SAS Institute, Inc Cary, NC). Prior to formal analysis, preliminary analysis included searching the collected data for errors. Descriptive statistics (mean, SD, frequencies, percentage) were calculated for samples between the CC and PC group. For categorical variables, we used a χ^2 test using FREQ procedure in SAS with chi square option to test the null hypothesis that the particular variable was distributed similarly between CC and PC. For linear regression analysis, the GLM procedure in SAS was used with the LSMEANS option to obtain means of WFL, WFA and LFA z-score for the PC and CC group.

Multiple linear regression models were used to examine the association between CC use on the change in WFL, WFA, LFA z-score, adjusting for feeding practices and child and maternal demographics. Specific confounding variables included maternal pre-pregnancy BMI (kg/m^2), maternal age (yr), maternal education (yr), child baseline and follow-up age (mo), child birthweight (kg), child birth order (# child in the family from oldest to youngest), household income ($/yr), household size (# people/house), infant formula (# svgs based on standard USDA 5 oz. svgs), and breastfeeding duration (mo). Binary variables included maternal single status, maternal CC use (PC=less than 10 hrs/week non-parental care/CC=greater than 10 hours/week non-parental care), child gender (male/female), child black/African American race (black/non-black), Mixed (mixed/not mixed) and Latino (Latino/non-Latino) child race, and solid introduction (solids introduced before 4 mo/ at or after 4 mo of age).

Results

The average age at time of baseline measurements was 1.53 ± 0.7 months while the average follow-up measurements were 10.3 ± 2.7 months. Table 5.1 shows the comparison of WFL, WFA and LFA z-scores at baseline, follow-up and change by CC use. The PC group had significantly greater WFL and WFA z-scores at follow-up and change, but the baseline z-scores did not differ by CC use. Yet, there were no differences by CC use in the LFA at baseline, follow-up and change.

Table 5.2 describes the variables involved in the regression model for the change in WFL. The change in WFL z-score was affected ($p=0.05$) by CC use, with the PC group having a greater change in WFL z-score. Child birth order affected ($p<0.05$) the change in WFL z-score. The black/African American race variable was significant, where non-black infants had a greater ($p=0.02$) change in WFL. Child gender and birth weight showed a trend in significance, with males ($p=0.06$) and lower birth weight infants ($p=0.06$) having a greater change in WFL. Other child characteristics, such as baseline and follow-up age, did not affect the change in WFL. Of the maternal characteristics, pre-pregnancy BMI ($p<0.01$) and maternal age ($p<0.01$) significantly affected the change in WFL z-score. Maternal education or single status did not significantly impact the change in WFL z-score. Household income and size did not affect the change in WFL. Finally, feeding practices such as the number of servings of infant formula, breastfeeding duration and whether they introduced solid foods before or after 4 months did not impact the change in WFL z-score.

Table 5.3 describes the variables involved in the regression model for the change in WFA. Change in WFA z-score was affected by CC use ($p=0.01$), with PC group having a greater change in WFA compared to those in CC. In addition, lower birth weight ($p<0.01$), greater pre-pregnancy BMI ($p<0.01$), and fewer servings of infant formula ($p=0.05$) affected the change in WFA z-score. All other child, maternal, household and feeding variables did not affect the change in WFA z-score.

Table 5.4 describes the variables involved in the regression model for the change in LFA z-score. CC use did not affect the change in LFA, but was affected by lower pre-pregnancy BMI ($p=0.04$) and black race ($p=0.05$). All other child, maternal, household and feeding variables did not affect the change in LFA z-score.

Tables 5.5 and 5.6 shows the comparison of WFL z-scores at baseline and follow-up time points. Both figures indicated no differences by care type. In addition, 80% or more of infants are classified on the normal weight status based on the WHO classification. Approximately 14% of infants were classified as underweight at baseline, but only 2% at follow-up. There were more overweight infants at follow-up (11% PC vs 5.7% CC) compare to baseline (2.2% PC and 2.9% CC).

Discussion

Major findings in this study revealed that the change in WFA and WFL z-score, as well as follow-up z-scores, was significantly affected by CC use. Infants in PC had a greater change in WFA and WFL compared to those in CC. No differences by CC use were found in LFA z-scores.

Higher pre-pregnancy BMI, younger maternal age, non-black infants and higher birth order impacted the greater change in WFL z-score. There was also a strong trend for PC group, male infants and lower birth weight infants to have a greater change in WFL. Similarly, the change in WFA z-score was significantly affected by a lower birth weight and greater pre-pregnancy BMI. Change in LFA z-score was unaffected by CC use, but significantly affected by a lower pre-pregnancy BMI and by black race.

Infant feeding practices, such as breastfeeding duration, introduction of solid foods before or after 4 months and the number of servings of infant formula, did not affect the change in WFL or LFA z-score. However, fewer servings of infant formula impacted the change of WFA z-score. Similar to our study results, van Rossem et al. showed that early introduction of solid foods into an infant diet did not affect the change in WFL over the first 2 years of life [122]. However, there was a greater breadth in the type of foods served to infants in the CC group which more closely resembled an 'adult diet' and is likely a reflection of the menu served at CC. In addition, the PC group had a pattern of greater fruit and vegetable consumption. As reported by Baird et al., infants fed an 'adult diet' with more breads and processed foods showed less weight gain from 6 to 12 months, and a diet characterized by home-prepared foods, fruits and vegetables compliant with the infant feeding guidelines gain faster from 6 to 12 months, independent of the type of milk feeding [44]. Therefore, the lower change in WFL and WFA z-score in the CC group could be explained by the composition of the diet in the CC group. Other feeding practices, such as the duration of breastfeeding and timing of complementary food introduction before or after 4 months of age, did not affect WFL, WFA or LFA change in our study, similar to previous reports measuring breastfeeding and timing of complementary foods on adiposity at 5 and 7 years of age [30, 125].

Infancy involves rapid growth and development where birth weight doubles by 4 to 6 months of age [159]. Weight gain may not follow a linear trend due to rapid gain (catch-up growth) in the first few weeks of life followed by slower rate in later months [160, 161]. As such, this period reflects a critical time for energy balance and development of obesity such that early weight gain could influence a genetic predisposition to obesity in childhood and adulthood [160-163]. Every 420 kJ/day increase in energy intake and every 100 g of weight gain increase in the first 4 months has been shown to increase the risk of overweight at 3,5 and 7 years of age [160, 164]. As reported in Chapter 4 Table 4.1, PC infants in our study had a numerically greater intake of energy compared to the CC infants. Thus, the greater change in WFL and WFA z-score in the PC infants may be a result of the higher energy intake.

Weight gain and energy intake in infancy is primarily a reflection of infant appetite, and parent feeding practices [164]. Because infants are unable to eat independently, feeding in the first year of life requires control by the parent or CC provider [165]. It has been demonstrated that greater maternal control over infant feeding in the first 6 months led to slower weight gain from 6 to 12 months compared to mothers with moderate or low control [165]. We hypothesize that the patterns in WFL and WFA z-scores may be affected by different levels of control during feeding by parents and CC provider in our study. It could be possible that infants in CC group had more pressure to eat by the parents or CC providers, thus leading to less weight gain compared to the PC group. However, we did not measure the level of maternal or CC provider's control in this study, but would be an interesting variable to explore in future studies.

Our significant study results were similar to previous literature that maternal pre-pregnancy BMI was associated with a greater rate of weight gain during the first year as well as later in childhood [166-168]. Birth order was shown in our study to affect the WFL change, similar to a longitudinal study that noted the first born was significantly smaller and thinner compared to subsequent siblings [169]. Low birth weight infants are also known as a risk factor for greater weight gain and obesity in later life [117, 133]. Male infants were shown to have a greater change in WFL as supported by other infant feeding studies examining body composition [170, 171]. However, maternal education did not significantly impact the child's change in WFL z-score in our study, contradictory to previous report showing that ≥ 13 years parental education was related to a lower incidence of overweight/obesity in children [133].

One major study limitation in this study was the short duration of the weight and length measurements to determine change in WFL z-score. In addition, the questionnaire was measured once, limiting the ability to completely determine relationships between weight status and changes in feeding practices. In addition, our study used a relatively low sample size from one WIC office which might have prevented us from detecting further differences between CC and PC. Study results are not completely generalizable to the U.S.WIC infants. Furthermore, this study used a CC definition based on the number of hours, which may have not been ideal. Instead, the type of CC setting, such as formal centers or informal settings, have shown differences in feeding practices as revealed by others [23, 70].

Our study also had some strengths. The weights and lengths were measured longitudinally from trained professionals at the WIC office, thus ensuring the reliability of the measurements. In addition, the food records were based on 3 days, allowing the mother to fill out the record as she is feeding her child, and not relying on memory warranted for a 24 hour recall.

In conclusion, this study demonstrated that CC use may have influenced the change in WFL and WFA z-score, but not in LFA change during infancy. Follow-up studies are necessary to understand the long term effects of CC impacting weight gain between infants in informal care compared to formal care and parental care. These results can help develop new strategies for intervention to improve infant feeding practices in the CC setting.

Figure 5.1. Description of study procedure

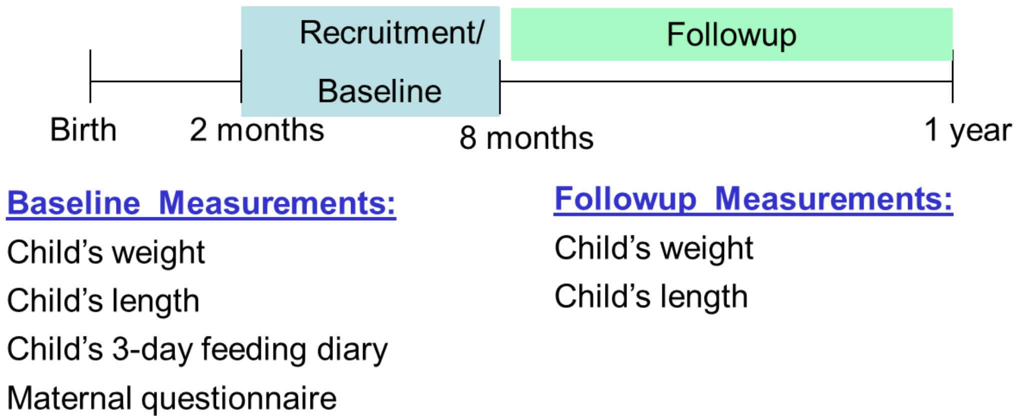


Table 5.1. Comparison of adjusted growth measure indices by CC use [1, 2, 3]

Growth Indices	PC (n=45)	CC (n=35)	p value
WFL baseline	0.22 ± 0.60	0.11 ± 0.70	0.86
WFL follow-up	1.83 ± 0.96	-0.05 ± 1.10	0.05
WFL change	1.69 ± 1.00	-0.36 ± 1.20	0.05
WFA baseline	-0.40 ± 0.23	-0.33 ± 0.27	0.76
WFA follow-up	1.20 ± 0.63	-0.34 ± 0.73	0.01
WFA change	1.61 ± 0.67	-0.08 ± 0.77	0.01
LFA baseline	-1.42 ± 0.91	-0.19 ± 1.05	0.18
LFA follow-up	0.38 ± 0.67	-0.07 ± 0.77	0.50
LFA change	1.79 ± 1.02	0.10 ± 1.18	0.11

[1]Data expressed as mean ± standard error.
[2]WFL= weight for length, WFA=weight for age, LFA=length for age.
[3]Z-scores were adjusted based on regression model in Table 5.2.

Table 5.2. Regression model for the change in the weight for length z-score

Category	Variable	Beta estimate	Std error	p value
Child	Gender (0=male 1=female)	-2.12	1.08	0.06
	Birth weight (kg)	-1.77	0.90	0.06
	Birth order (# of child in family)	1.63	0.80	<0.05
	Baseline age (mo)	0.11	0.69	0.89
	Follow-up age (mo)	0.24	0.19	0.21
	Mixed (0=mixed 1=not mixed)	-1.09	1.55	0.49
	Latino (0=Latino 1=not Latino)	0.50	1.66	0.77
	Black (0=Black 1=not Black)	3.09	1.31	0.02
Maternal	CC use (0=CC 1=PC)	2.06	1.04	0.05
	Pre-pregnancy BMI (kg/m^2)	0.14	0.02	<0.01
	Mom education (yr)	0.39	0.26	0.14
	Maternal age (yr)	-0.34	0.12	<0.01
	Single status (0=single 1=not single)	-1.68	1.17	0.16
Household	Household income ($/yr)	<0.01	<0.01	0.46
	Household size (# of people)	-0.10	0.71	0.89
Feeding	Breastfeeding duration (mo)	-0.33	0.30	0.28
	Infant formula (# servings/day)	-0.26	0.41	0.53
	Solid introduction at 4 months (0= greater than or equal to 4 mo; 1= less than 4 mo)	-0.45	0.98	0.64

Table 5.3. Regression model for the change in weight for age z-score

Category	Variable	Beta estimate	Std error	p value
Child	Gender (0=male 1=female)	-0.54	0.69	0.44
	Birth weight (kg)	-1.74	0.58	<0.01
	Birth order (# of child in family)	-0.23	0.51	0.66
	Baseline age (mo)	-0.02	0.43	0.97
	Follow-up age (mo)	0.10	0.12	0.39
	Mixed (0=mixed; 1=not mixed)	-0.38	0.99	0.70
	Latino (0=Latino; 1=not Latino)	-0.73	1.07	0.50
	Black (0=Black; 1=not Black)	1.22	0.84	0.15
Maternal	CC use (0=CC 1=PC)	1.69	0.66	0.01
	Pre-pregnancy BMI (kg/m^2)	0.09	0.01	<0.01
	Mom education (yr)	-<0.01	0.16	0.96
	Maternal age (yr)	-0.11	0.08	0.16
	Single status (0=single 1=not single)	-0.96	0.75	0.20
Household	Household income ($/yr)	<0.01	<0.01	0.87
	Household size (# of people)	<-0.01	0.45	0.99
Feeding	Breastfeeding duration (mo)	-0.17	0.20	0.38
	Infant formula (# svgs/day)	-0.53	0.26	0.05
	Solid introduction at 4 months (0=greater than or equal to 4 mo; 1=less than 4 mo)	-0.55	0.63	0.39

Table 5.4. Regression model for the change in length for age z-score

Category	Variable	Beta estimate	Std error	p value
Child	Gender (0=male 1=female)	0.68	1.07	0.53
	Birth weight (kg)	-0.62	0.88	0.49
	Birth order (# of child in family)	-1.43	0.79	0.08
	Baseline age (mo)	-0.60	0.68	0.39
	Follow-up age (mo)	-0.13	0.18	0.47
	Mixed (0=mixed; 1=not mixed)	0.04	1.53	0.98
	Latino (0=Latino; 1=not Latino)	-2.22	1.62	0.18
	Black (0=Black; 1=not Black)	-2.54	1.28	0.05
Maternal	CC use (0=CC 1=PC)	1.69	1.02	0.11
	Pre-pregnancy BMI (kg/m^2)	-0.05	0.02	0.04
	Mom education (yr)	0.02	0.26	0.93
	Maternal age (yr)	-0.04	0.12	0.73
	Single status (0=single 1=not single)	0.85	1.14	0.46
Household	Household income ($/yr)	<-0.01	0.01	0.62
	Household size (# of people)	-0.02	0.70	0.98
Feeding	Breastfeeding duration (mo)	0.04	0.27	0.89
	Infant formula (# svgs/day)	-0.49	0.40	0.22
	Solid introduction at 4 months (0=greater than or equal to 4 mo; 1=less than 4 mo)	0.24	0.93	0.80

Table 5.5. Comparison of baseline weight for length z-score status by care type [1,2,3]

	PC (n=45)	CC (n=35)	p value
underweight	6 (13.33)	5 (14.29)	0.98
normal	38 (84.44)	29 (82.86)	
overweight	1 (2.22)	1 (2.86)	

[1]Data expressed as n (%).
[2] PC=parental care; CC=child care.
[3] underweight=less than -2 z score; normal=between -2 and 2 z-score; overweight=greater than 2 z-score.

Table 5.6. Comparison of follow-up weight for length z-score status by care type [1,2,3]

	PC (n=45)	CC (n=35)	p value
underweight	1 (2.22)	1 (2.86)	0.69
normal	39 (86.67)	32 (91.43)	
overweight	5 (11.11)	2 (5.71)	

[1]Data expressed as n (%).
[2] PC=parental care; CC=child care.
[3] underweight=less than -2 z score; normal=between -2 and 2 z-score; overweight=greater than 2 z-score.

Chapter 6:

Conclusions and Future Directions

The child care (CC) setting represents a crucial environment for infants and children to establish healthy feeding practices in order to prevent overweight and obesity [7]. Children are enrolled in CC during critical stages of growth and development. Most parents rely on their CC providers to encourage healthy eating behaviors, offer foods of high nutritional value as well as promote physical activity [172]. Promotion of healthy eating behaviors early in life is essential for preventing childhood obesity, obtaining optimal growth/development, and encouraging overall health. As such, CC practices and policies have the potential to impact long term health, encourage healthy eating behaviors, guide and support food learning experiences, support breastfeeding mothers, and educate parents on their child's nutrition needs [173]. Thus, CC provides an opportunity to foster healthy eating behaviors in a large number of children. This study focused on investigating the association between parental care (PC) and CC on infant feeding practices, food consumption, nutrient intake and growth in infants receiving the Special Supplemental Nutrition Program for Women Infants and Children (WIC) assistance.

The WIC population was selected as our study sample because WIC serves half of the all infants in the U.S., thus representing a large group of infants in the country [37]. In addition, WIC mothers are at risk for practicing unhealthy eating behaviors, such as early introduction of formula and complementary foods with decreased rates of breastfeeding [36, 37]. Their children aged 1-4 years old are more likely to be overweight compared to their higher income counterparts [36, 37, 57]. Thus, the WIC population could be at greater risk for overweight and obesity.

The main finding in this study is that CC use may have influenced differences in the change in WFL and WFA z-score, with the PC group to have a greater change in WFL and WFA. However, CC use did not influence differences in overall feeding practices, nutrient intake nor LFA z-score change during infancy.

This is the first study to report feeding practices, nutrient intake and WFL between WIC infants in CC and PC. There was a low incidence of breastfeeding prevalence and duration found in our study for both groups, which maybe a reflection of the WIC population. Based on the findings from this study of low breastfeeding rates, enhancements to the current nutrition education programs in WIC to encourage breastfeeding and delay the introduction of infant formula are needed. Haughton et al. reported that WIC participants did not seek out assistance for breastfeeding support from WIC staff, health care providers or lactation consultants due to lack of awareness and inadequate access to the lactation services [174]. Mothers reported choosing formula feeding instead of breastfeeding due to their concerns about adequate breast milk supply, postpartum medications, problems with infant latching onto the breast, milk intolerance, delayed lactogenesis, or concerns about mothers returning back to work or school soon [73].

Nutrition education programs in WIC have been criticized for being too superficial due to short duration of education sessions and lack of participation obligation [175]. A majority of infants in our study were introduced to solid foods at 4 months of age, suggesting that further education could be necessary to encourage WIC mothers to introduce solid foods at 6 months of age based on the American Academy of Pediatrics (AAP) and World Health Organization (WHO) feeding recommendations and according to the new rule for the WIC food package. However, Bronner et al. reported that WIC mothers did not differ in introducing solids and non-milk liquids to their infants compared non-WIC mothers, as these decisions are largely influenced by social factors such as peer pressure, family, tradition and culture [176, 177]. Thus, it is important to understand the motivation for mothers to introduce solid foods early and develop nutrition education interventions using these factors [176].

Chapter 4 assessed the comparison of nutrient intake for infants in PC and CC infants. Similar to the FITS study, nutrient adequacy was not a concern for infants in PC or CC in our study because the foundation of their diet comes from breast milk and/or infant formula. To our knowledge, this is the first report of nutrient intake for infants in CC. Future follow-up studies are warranted to determine if CC differences in nutrient intake exist as children transition to a food based diet.

Chapter 5 examined the differences in change in WFL, WFA and LFA z-score, the implications of this study would be to target mothers with high pre-pregnancy BMI, younger mothers, mothers of male infants, and mothers of low birth weight infants about the importance of recommended feeding guidelines to prevent risk of overweight and obesity in their children. However, it has been reported by WIC mothers that larger infants are more healthy and is the result of successful feeding practices [178]. WIC mothers have expressed stress and strong emotional response about the perception that their infant could possibly not be getting enough nourishment, thus further supporting their decision to provide additional infant formula, introduce solid food earlier, and feed extra baby food to ensure that the baby is “full” [73, 74]. As such, WIC mothers have not expressed concern about the possible effects of obesity later in life based on feeding environment or if solid foods were introduced too early before 4 months of age [74]. Targeted nutrition education to mothers is important regarding how feeding decisions could impact obesity status later if life. Even though the CC group had a larger breadth of foods consumed, there was a smaller change in WFL and WFA z-score compared to the PC group. However, follow-up studies are necessary to understand maternal feeding styles compared to CC teacher feeding styles on the effects of infant diet and long term weight status.

Finally, this study was unable to measure differences between informal care vs. formal care. Future longitudinal studies are warranted to explore the role of informal care vs. formal care on feeding practices, nutrient intake and growth. In particular, there is limited knowledge about feeding practices and nutrient intake in the informal CC settings. Approximately, 33-53% of children ≤ 5 yrs old are cared for in unlicensed settings in the U.S. [179]. Children enrolled in home-based CC may potentially be at a greater risk for childhood obesity, since less than half of family CC providers receive any regular nutrition education [180]. There has been some evidence that home-based care by relatives or care in someone else's home provides a greater risk for increased weight gain in comparison to center-based care and parental care. Home-based care has also been associated with decreased breastfeeding, early introduction of complementary foods, and decreased offerings of new foods.

In addition, informal CC settings are not required to comply with the same state regulations as formal CC centers, such as the provision of water readily available, restriction of sugar sweetened beverages and foods of low nutritional value, support for breastfeeding, prevent the use of coercion for child to eat and limitation of the use of food as a reward [181]. In the only nationally representative study of family CC homes participating in the federal regulated Child and Adult Care Food Program (CACFP), nutritional concerns were identified in the menus of these CC homes, despite the required meal pattern regulations mandated by CACFP. These concerns included the lack of fruit or vegetable in one third of snack and breakfast meals, as well as meals/snacks surpassing the recommended guideline for saturated fat [182]. Other studies noted insufficient offerings of iron-based foods and low-fat milk, as well as frequent offerings of fruit juice, and unhealthy foods for celebrations/holidays [183]. Thus, there remains opportunity for improving the nutritional quality of foods and encouraging healthy eating behaviors for children in informal CC. Several obesity prevention interventions have been designed for CC centers and preschools, but remain underutilized in the informal CC setting. These results can help develop new strategies for intervention to improve infant feeding practices in the CC setting.

In conclusion, the effects observed in this study of the comparison of PC and CC invites further investigation of the long term effects of CC use. There are many facets of the CC environment and different types of CC that influence a child's feeding practice and growth, and more research is needed to help close the gap in knowledge between CC and PC infants.

Appendix A:

Infant feeding recommendations by the American Academy of Pediatrics

The recommendations by the American Academy of Pediatrics for infant feeding includes:

1) Breastfeed exclusively for approximately the first 6 months, continue until 12 months.

2) Supplement breast-fed infants with iron after four to six months.

3) Iron-fortified infant formula is an appropriate substitute for breastfeeding in the first year.

4) Introduce solid foods when the infant is developmentally ready, typically in the four to six month age range.

5) Juice may be introduced in the diet of infants after six months of age; if introduced, 100% juices should be used, and juice should be limited to four to six ounces daily.

6) Delay the introduction of cow's milk until one year of age; cow's milk should be whole milk during the second year of life. [41]

The position of the Academy of Nutrition and Dietetics (AND) for breastfeeding is "that exclusive breastfeeding provides optimal nutrition and health protection for the first 6 months of life and breastfeeding with complementary foods from 6 months until at least 12 months of age is the ideal feeding pattern for infants. Breastfeeding is an important public health strategy for improving infant and child morbidity and mortality, and improving maternal morbidity, and helping to control health care costs." [43]

Based on conclusions from the Feeding Infants and Toddlers Study (FITS) [41], it is suggested to educate parents and caregivers on the following infant feeding recommendations:

a) introducing appropriate first solid foods such as iron-fortified infant cereals and meats when the infant is developmentally ready.

b) offering a healthy variety of foods such as soft fruits, cooked vegetables, soft cheeses, and fortified grain products in place of energy-dense, but micronutrient-poor items.

c) breastfeeding as long as possible throughout the first year.

Appendix B:

WIC food packages

The following tables provide information on the updated WIC packages that was enforced October 1, 2009.

Table B.1 Monthly allocation of supplemental foods for infants in food packages I, II, and III

	Exclusively Formula-Fed		**Partially Breast-Fed**		**Exclusively Breast-Fed**	
	Package I (0-5 mo.)	**Package II (6-11 mo.)**	**Package I (0-5 mo.)**	**Package II (6-11 mo.)**	**Package I (0-5 mo.)**	**Package II (6-11 mo.)**
WIC Formula	0-3 mo.: 806 fl. oz. liquid concentrate or 832 RTF or 870 fl. oz. powder 4-5 mo.: 884 fl. oz. liquid concentrate or 896 fl. oz. RTF or 960 fl. oz. powder	624 fl. oz. liquid concentrate or 640 fl. oz. RTF or 696 fl. oz. powder	0-1 mo.: 104 fl. oz. powder 1-3 mo.: 364 fl. oz. liquid concentrate or 384 fl. oz. RTF or 435 fl. oz. powder 4-5 mo.: 442 fl. oz. liquid concentrate or 448 fl. oz. RTF or 522 fl. oz. powder	312 fl. oz. liquid concentrate or 320 fl. oz. RTF or 384 fl. oz. powder		
Infant Cereal		24 oz.		24 oz.		24 oz.
Infant food fruits & vegetables		128 oz.		128 oz.		256 oz.
Infant meats						77.5 oz.

Source: [184]

Table B.2 Food package III: Women minimum nutrient requirements and specifications for supplemental foods

Foods	Pregnant & partially breastfeeding up to 1 yr postpartum	Postpartum up to 6 months postpartum	Fully breastfeeding up to 1 year postpartum
Juice, single strength	144 fl. oz.	96 fl. oz.	144 fl. oz.
Infant formula	455 fl. oz. liquid concentrate	455 fl. oz. liquid concentrate	455 fl. oz. liquid concentrate
Milk	22 qt.	16 qt.	24 qt.
Breakfast cereal	36 oz.	36 oz.	36 oz.
Cheese			1 lb.
Eggs	1 dozen	1 dozen	2 dozen
Fruits & vegetables	$8.00 cash value vouchers	$8.00 cash value vouchers	$10.00 cash value vouchers
Whole wheat bread	1 lb.		1 lb.
Fish (canned)			30 oz.
Legumes, dry and/or peanut butter	1 lb. and 18 oz.	1 lb. or 18 oz.	1 lb. and 18 oz.

Source: [184]

Appendix C:

Child care standards for feeding

The Caring for Our Children-National Health and Safety Performance Standards: Guidelines for Out of Home Child Care Programs (CFOC) provides a set of health promotion standards for child care facilities. CFOC was created jointly by the American Academy of Pediatrics, American Public Health Association and the U.S. Department of Health and Human Services. These standards are:

1) Infants are fed according to a feeding plan from a parent or physician.

2) Breastfeeding is supported by the childcare facility.

3) No solid food is given before 6 months of age.

4) Infants are fed on demand.

5) Infants are fed by consistent caregivers.

6) Infants are held while feeding.

7) Infants cannot carry or sleep with a bottle.

8) Caregivers cannot feed > 1 infant at a time.

9) No cow's milk is given to children < 12 months of age.

10) Whole cow's milk is required for children 12-24 months of age.

11) No solid food is fed in a bottle. [84]

<u>CFOC menu standards</u>

1) Menus must be posted or made available to parents.
2) Menus must be dated.
3) Menus must reflect food served.
4) Menus must be planned in advance.

5) Menus must be kept on file.

6) Menus must be reviewed by a nutrition professional. [84]

<u>Guidelines for child care centers according to Academy of Nutrition and Dietetics</u>

1) Menus should be nutritionally adequate and consistent with the Dietary Guidelines for Americans.

2) Foods should be provided in quantities and meal patterns that balance energy and nutrients with children's ages, appetites, activity levels, special needs and cultural or ethnic differences in food habits.

3) Parents should be involved in the nutrition component of their CC facility.

4) Plenty of fresh fruits and vegetables and whole-grain products should be offered to children.

5) The addition of fat, sugar, and sources of sodium should be minimized.

6) Food preparation and service should be consistent with best practices for food safety and sanitation.

7) Furniture and eating utensils should be age appropriate and developmentally suitable to encourage children to accept and enjoy mealtime.

8) Child care personnel should encourage positive experiences with food and eating.

9) Caregivers should receive appropriate training in nutrition and food service

10) Child care programs should obtain consultation and technical assistance from a dietetics professional on a regularly schedule basis.

11) Nutrition education for children and for their parents should be a component of the CC program.

12) Child care programs must comply with local and state regulations related to wholesomeness of food, food preparation facilities, food safety, and sanitation. [85]

Appendix D:

Child care infant meal pattern according to the Child and Adult Care Food Program

Type of meal service	**Birth to 3 months**	**4 to 7 months**	**8 to 11 months**
Breakfast	4-6 fl. oz. of formula[1] or breast milk[2, 3]	4-8 fl. oz. of formula[1] or breast milk[2, 3] 0-3 Tbsp. of infant cereal [1, 4]	6-8 fl. oz. of formula[1] or breast milk[2, 3] 2-4 Tbsp. of infant cereal [1] 1-4 Tbsp. of fruit or vegetable or both
Lunch or Supper	4-6 fl. oz. of formula[1] or breast milk[2, 3]	4-8 fl. oz. of formula[1] or breast milk[2, 3] 0-3 Tbsp. of infant cereal [1, 4] 0-3 Tbsp. of fruit or vegetable or both[4]	6-8 fl. oz. of formula[1] or breast milk[2, 3] 2-4 Tbsp. of infant cereal [1] 1-4 Tbsp. of meat, fish, poultry, egg yolk, cooked dry beans or peas ½-2 oz. of cheese 1-4 oz. of cottage cheese 1-4 oz. of cheese food or cheese spread 1-4 Tbsp. of fruit or vegetable or both
Snack	4-6 fl. oz. of formula[1] or breast milk[2, 3]	4-6 fl. oz. of formula[1] or breast milk[2, 3]	2-4 fl. oz. of formula[1] or breast milk[2, 3] or fruit juice[5] 0-1/2 slice of bread[4,6] or 0-2 crackers[4,6]

Source: [87]

[1] Infant formula and dry infant cereal must be iron-fortified.

[2] Breast milk or formula, or portions of both, may be served; however, it is recommended that breast milk be served in place of formula from birth through 11 months.

[3] For some breast-fed infants who regularly consume less than the minimum amount of breast milk per feeding, a serving of less than the minimum amount of breast milk may be offered, with additional breast milk offered if the infant is still hungry.

[4] A serving of this component is required only when the infant is developmentally ready to accept it.

[5] Fruit juice must be full strength.

[6] A serving of this component must be made from whole-grain or enriched meal or flour.

Appendix E:

Usual intake of infants birth to 11 months of age in comparison to the Dietary Reference Intake

The FITS study examined the nutrient intake values for infants 4 to 24 months of age in a national representative sample [95, 103]. The usual intake distributions were divided into percentile estimates within the infant population. The percentiles were divided into 0 to 5 month age range followed by a separate 6 to 11 month group.

Table E.1 Usual energy intake of U.S. infants in comparison to the estimated energy requirements

Energy	**Usual intake percentiles**					
Infants 0 to 5 months of age	**10th**	**25th**	**50th**	**75th**	**90th**	**Mean**
EER[1]	501	562	622	683	763	629
Usual intake (kcal)	495	562	568	644	779	611
Infants 6 to 11 months of age						
EER	588	649	729	810	891	739
Usual intake (kcal)	583	675	807	981	1183	854

[1]EER=Estimated energy requirement.

Table E.2 Usual nutrient intake of U.S. infants 4 to 6 months of age in comparison to the Adequate Intake

Infants 4 to 6 months of age				**Usual intake percentiles**			
Nutrient	**AI[1]**	**10th**	**25th**	**Median**	**Mean**	**75th**	**90th**
Carbohydrate (g/d)	60	53	56	57	66	72	87
Protein (g/d)	9.1	8.4	8.4	10.4	11.5	13.6	16.9
Fat (g/d)	31	26	30	36	34	36	39
Vitamin C (mg/d)	40	41	41	48	60	70	86
Vitamin E (mg/d)	4	1	1	3	4	6	8
Thiamin (mg/d)	0.2	0.1	0.1	0.4	0.5	0.6	0.8
Riboflavin (mg/d)	0.3	0.3	0.3	0.6	0.7	0.9	1.2
Niacin (mg/d)	2	1	1	5	6	7	10
Vitamin B-6 (mg/d)	0.1	0.1	0.1	0.3	0.3	0.5	0.6
Folate (µg/d)	65	41	41	94	113	159	203
Vitamin B-12 (µg/d)	0.4	0.4	0.4	1.3	1.5	2.0	2.5
Calcium (mg/d)	210	260	260	354	424	528	709
Phosphorus (mg/d)	100	114	114	190	236	329	444
Magnesium (mg/d)	30	24	24	38	44	54	71
Vitamin D (µg/d)	5	0.8	0.8	6.7	6.5	9.5	10.8
Vitamin A (µg RAE)	400	407	490	491	582	593	815
Vitamin K (µg/d)	2	2	2	29	29	51	63
Iron (mg/d)	0.27	0.24	0.24	6.74	7.87	11.71	16.31
Zinc (mg/d)	2	1.4	1.4	3.4	3.8	5.7	7.0
Sodium (mg/d)	120	138	138	150	175	192	240
Potassium (mg/d)	400	414	414	513	574	681	849

[1] AI=Adequate Intake

Table E.3 Usual nutrient intake of U.S. infants 6 to 11 months of age in comparison to the Adequate Intake

Infants 6 to 11 months of age		Usual intake percentiles					
Nutrient	**AI[1]**	**10th**	**25th**	**Median**	**Mean**	**75th**	**90th**
Carbohydrate (g/d)	95	74	89	110	114	134	161
Protein (g/d)	11	11.2	14.2	19	22.4	26.5	37.2
Fat (g/d)	30	27	30	34	35	39	46
Vitamin C (mg/d)	50	52	65	83	90	106	137
Vitamin E (mg/d)	5	2	4	6	6	7	11
Thiamin (mg/d)	0.3	0.4	0.6	0.7	0.9	1.0	1.4
Riboflavin (mg/d)	0.4	0.6	0.9	1.1	1.2	1.3	1.9
Niacin (mg/d)	4	6	8	10	11	13	16
Vitamin B-6 (mg/d)	0.3	0.5	0.6	0.8	0.8	1	1.3
Folate (µg/d)	80	109	152	204	219	268	346
Vitamin B-12 (µg/d)	0.5	ND	ND	ND	2.4	ND	ND
Calcium (mg/d)	270	318	419	561	603	741	942
Phosphorus (mg/d)	275	212	306	420	471	574	796
Magnesium (mg/d)	75	56	73	95	101	122	153
Vitamin D (µg/d)	5	1.8	4.4	7.4	7.1	9.1	11.6
Vitamin A (µg RAE[2])	500	531	612	720	744	849	987
Vitamin K (µg/d)	2.5	17	31	52	61	78	111
Iron (mg/d)	11(6.9)[3]	6.3	10.3	14.6	15.8	19.9	26.6
Zinc (mg/d)	3 (2.5)[3]	3.1	4.5	6.1	6.4	7.8	9.8
Sodium (mg/d)	370	165	225	365	528	650	1104
Potassium (mg/d)	700	650	835	1079	1129	1348	1644

1 AI=Adequate Intake.
2 RAE=retinol activity equivalent.
3 Recommended dietary allowance (estimated average requirement).

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