INFANT FEEDING PRACTICES AND WEIGHT STATUS AMONG WIC PARTICIPANTS

by

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ABSTRACT

MORIUM BABLY. Infant feeding practices and weight status among WIC participants (Under the direction of DR ELIZABETH RACINE)

Appropriate infant and child feeding practices and balanced nutrition can significantly reduce malnutrition and can contribute to optimal physical, mental, and developmental growth of children. Childhood obesity is a major public health concern in the United States and is associated with both physical and psychological consequences and decreased health-related quality of life. Early life feeding practices and nutrients intake starting from birth to 2 years can significantly contribute to the development of obesity. This dissertation aimed to develop three manuscripts to understand the association between infant feeding practices including bottle feeding practices, initiation of added sugar and added sugar intake, and children's BMI-for-age percentile at 36 months old among Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participants. First manuscript examined the association between added sugar consumption at young age and BMI-for-age percentile at 36 months old among WIC participants. Second manuscript examined factors associated with initiation of added sugar among WIC participants. Third manuscript examined the association between usual daily intake of added sugar at young age and BMI-for-age percentile at 36 months old among WIC participants. Data were from the WIC Infant and Toddler Feeding Practices Study-2 (ITFPS-2). The ITFPS-2, a longitudinal study of WIC participants (mothers and their children) began in 2013. First, Cox proportional hazards model was used to identify factors associated with bottle cessation, and multivariate linear regression to examine the association between age of bottle cessation and BMI. Second, Cox proportional hazards model examined factors associated with introducing added sugar. Third, bivariate analysis was used to examine the association between usual daily intake of added sugar before age 2 years old and BMI-for-age-percentile at 36 months old. The first research study indicated about 34% of children used a bottle longer than 12 months, and 13% longer than 18 months. Bottle cessation at older ages was associated with Hispanic ethnicity, multiparity, low income, low education, higher caregiver weight, and not initiating breastfeeding, and adjusted children's BMI-for-age percentile at age 36 months increased by 0.47 for each additional month of bottle use. The second research study indicated about 25% of children initiated added sugar at or before 7 months. Contributing factors were caregiver's race/ethnicity, education, employment, weight status, parity, child sex, and premature birth (all $p<0.05$). The third research study indicated the mean added sugar intake ≤7 months, 8-13 months, and 14-24 months were 0.23 teaspoon (tsp), 3.44 tsp, and 11 tsp, respectively. Bivariate analysis indicated added sugar intake before 2 years old is associated with children's BMI-for-age-percentile at 36 months old. These research studies indicated a need for health care advocacy programs and intervention to educate the caregivers to practice appropriate feeding practices among infants and children aged 2 or younger.

DEDICATION

In dedication to my elder brother, Mahbub Barakat Rubel, whose absence and memories will always chase me. Brother Rubel, I am fulfilling our parent's dream which we promised to fulfill together, now, your one is on my shoulder. May I continue to achieve the goals we dreamt of together. You inspire me to achieve each goal of my life. This milestone is in your name!

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LIST OF ABBREVIATIONS

WHO- World Health Organization

ITFPS-2- Infant and Toddler Feeding Practices Study 2

DGA- Dietary Guidelines for Americans

USDA- U.S. Department of Agriculture

WIC- The Special Supplemental Nutrition Program for Women, Infants, and Children

AAP- American Academy of Pediatrics

CDC- Centers for Disease Control and Prevention

SNAP-Supplemental Nutrition Assistance Program

TANF-Temporary Assistance for Needy Families

NHANES-National Health and Nutrition Examination Survey

HEI- Healthy Eating Index

SSB- sugar-sweetened beverage

BMI- Body Mass Index

TPB- Theory of Planned Behavior

AAPD- The American Academy of Pediatric Dentistry

CPHM- Cox proportional hazards mode

CHAPTER 1: INTRODUCTION

In the United States, until 2020, there were no dietary guidelines available for infants and children from birth to 24 months. In the previous iterations of the United States (US) Dietary Guidelines for Americans (DGA), guidelines were provided for those 2 years and older, however the most recent DGA iteration, published in December 2020, includes infants and children aged two years and younger (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). The new guidelines give researchers an opportunity to assess the diet quality of those birth to 2 years. More evidence-based scientific research is needed to understand what caregivers were practicing in terms of infant feeding before the recommendations were made (Raiten et al., 2014; Stoody et al., 2019).

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) includes a large segment of the lower-income American population aged 2 years and younger, who are also particularly vulnerable to food security, poor diet quality, and have a higher obesity rate (Au et al. 2018; [Centers for Disease Control and Prevention (CDC), 2019]). My dissertation research uses data from the longitudinal WIC Infant and Toddler Feeding Practices Study (ITFPS-2). Using these data, I examined the temporal association between infant feeding practice and nutrient intake patterns from birth to 24 months and children’s weight status at 36 months.

Appropriate infant and child feeding practices and balanced nutrition can significantly reduce malnutrition and can contribute to optimal physical, mental, and developmental growth of children [World Health Organization (WHO), 2018]. Common infant feeding practices include appropriate breastfeeding, bottle use, balanced nutrient intake, and the introduction of solid foods. Balanced nutrition in infancy and especially during the first 2 years of life supports long-term health promotion and disease prevention (Raiten et al., 2014). I focused on three young child feeding behaviors: initiation of added sugar, usual daily added sugar intake at three timepoints, and bottle cessation. I examined the relationship between these feeding behaviors and weight status at 36 months of age.

Alongside practicing appropriate breastfeeding and complementary feeding, the American Academic of Pediatrics also recommends weaning an infant off of the bottle by 12 months to avoid adverse child health outcomes including childhood obesity, tooth decay, and iron deficiency (Brotanek et al., 2005; Avila et al., 2015; Bonuck et al., 2014; AAP, 2020). Delayed bottle cessation may lead to excessive protein and energy intake, increasing the risk of overweight or obesity (Bonuck et al., 2014). In addition, excess milk intake can also displace the appetite for solid food which will be more beneficial than milk to meet the growing nutrients needs of children (Bonuck et al, 2014).

Added sugar intake at a young age also plays an important role in children's health. Added sugar intake is associated with an increased risk of dental caries, cardio-metabolic risk factors, asthma, and overweight among children (Paglia et al., 2016; Vos et al., 2017; Park et al., 2013). The Dietary Guidelines for Americans and the American Heart Association recommend delaying added sugar initiation until age 24 months (Vos et al., 2017; U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). Research in the United States indicates added sugar intake is higher among low-income children (Thompson et al., 2005; Herrick et al., 2020). High consumption of added sugar is not only associated with morbidities but also associated with excess energy intake and poor diet quality. Many low-income children suffer the effects of food insecurity resulting lack of access to healthy food and ended up consuming food and beverage with added sugar (Thompson et al., 2005).

Inappropriate infant feeding behaviors can lead to health issues including obesity. Childhood obesity is a major public health concern in the United States. In 2016, the prevalence of obesity among children aged 2-5 years old was about 14%, which is compared to 5% obese in a healthy population (CDC, 2019). Children who are obese are at greater risk of various morbidities including type 2 diabetes mellitus, hypertension, elevated blood pressure, dyslipidemia, nonalcoholic fatty liver diseases, and disability including mobility impairment (Cote et al., 2013; Kumar et al., 2017). Childhood obesity is also associated with psychological consequences including poor self-esteem, anxiety, depression, and decreased health-related quality of life (Sawyer et al., 2011; Morrison et al., 2015). CDC, 2019). In 2016, 14% of WIC children (ages 2-4 years) were obese. This percentage has decreased from a high of 15.5% reported in 2010. The WIC child obesity prevalence differs by race/ethnicity where a greater percentage of Hispanic children (16.4%) are obese as compared to non-Hispanic White (12.1%) and non-Hispanic blacks (11.4%) children (CDC, 2019b).

Early life feeding practices and nutrient intake starting from birth to 2 years can significantly contribute to the development of obesity (Botton et al., 2008). As mentioned above low-income infants and children are more susceptible to overweight or obesity compared to high-income children in the US. About half of the infants in the US participate in WIC, which is a federal program especially designed for low-income families. Using longitudinal data from WIC, I explored the feeding behaviors of this vulnerable population.

The WIC ITFPS-2 provided an opportunity to study the longitudinal relationship between three infant and child dietary practices and their role in child weight at 36 months. These data also helped us understand the frequency and predictors of these dietary practices, which to date have not been well studied. Finally, in the United States, the children at greatest risk of poor health are those from low-income households. The WIC ITFPS-2 data is limited to low-income families from a variety of cultural groups allowing us to study variability in feeding practices among low-income populations in the US.

l.1 Literature Review

Special Supplemental Nutritional Program for Women, Infants, and Children (WIC)

The United States Department of Agriculture (USDA) Food and Nutrition Service Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is a federal program established in 1975 (U.S. Department of Agriculture, 2019). WIC provides participants with 1) supplemental nutritious foods, 2)healthy eating information and, and 3)referrals to health care (U.S. Department of Agriculture, 2019).To meet income eligibility criteria for WIC recipients are either i) at or below 185 percent of the federal poverty line, or ii) participating or eligible for participating in other need-based programs i.e., Medicaid, the Supplemental Nutrition Assistance Program (SNAP), or Temporary Assistance for Needy Families (TANF). Those that are pregnant, post-partum, and between the ages of birth to 5 years may be eligible for WIC benefits. The nutrition risk eligibility criteria for WIC among children ages 1-5 are being at risk of malnutrition such as for overweight, underweight, anemic, and poor dietary intake (USDA Food and Nutrition Service, 2018). In the 2019 fiscal year, WIC provided services to about 1.5 million women, 1.6 million infants, and 3.5 million children (U.S. Department of Agriculture, 2019). Research indicates WIC has contributed significantly to improving dietary intake, reducing food insecurity and malnutrition, and improving the overall quality of life (Colman et al., 2012; Kreider et al., 2016; Hamner et al.,2019; Hartline-Grafton, 2019).

Foods most often included in the WIC food package are milk, cheese, butter, eggs, beans, fruit juice, cereal, and grains. In 2009 the food packages were revised to better align with the US Dietary Guidelines. The revised food package allows participants to buy more fruits and vegetables, decreases the fruit juice allowance in half, reduces cheese, requires lower-fat milk for children 2 to 4 years old, and replaces refined-grain products with whole-grain (Daepp et al., 2019). Several studies have examined the impact of the WIC food package revisions on diet quality and child weight status. The studies found the revision of WIC food packages improved the child diet quality (Schultz et al,2015; Tester et al., 2016). Research also showed that the WIC food package revisions reduced obesity prevalence among young children (Chaparro et al., 2019; Chiasson et al., 2013). For instance, a study by Daepp and colleagues found that before the food package revision the prevalence of obesity among WIC children was increasing by 0.23 percentage points annually. However, after the 2009 food package revisions childhood obesity rates declined by 0.34 percentage points (Daepp et al., 2019).

Added sugar intake pattern among infants/children

Added sugar refers to all sugars, syrups, or caloric sweeteners added during food preparation, processing, and food manufacturing (Bowman, 2017). The US Dietary Guidelines advisory committee and American Heart Association recommend that added sugar intake be limited to <10% of total energy intake for children 2 years old and older. This is the equivalent of about 6 teaspoons (25 grams) per day for children ages 2 years to 19 years (World Health Organization, 2003; Millen et al., 2016; Vos et al., 2017). To date, the US Dietary Guidelines for Americans and the American Heart Association recommend avoiding foods and beverages with added sugar for children 2 years and younger (Vos et al., 2017).

Added sugar intake is associated with adverse health conditions among children. For example, studies indicate added sugar intake is a potential cause of tooth decay (Paglia et al., 2016; Chi and Scott, 2019). Studies also suggest added sugar intake is associated with an increased risk of cardiovascular disease among US children (Vos et al., 2017). Additional studies suggest added sugar consumption in the form of sugar-sweetened beverages is associated with elevated blood pressure (Kell et al., 2014), altered lipid profiles (Kosoba et al., 2013), and asthma (Park et al., 2013) among children.

Three studies have examined added sugar intake of children under age 2. First, Herrick and colleagues conducted a cross-sectional study among 1,211 children aged 0-23 months using National Health and Nutrition Examination Survey (NHANES) 2011-2016 to explore added sugar intake among US children to identify the common sources of added sugar. The study also assessed the trends of added sugar intake using data from NHANES 2005-2006 through 2015-2016 (n=2,795). The researchers found that toddlers aged 12-23 months consumed more added sugar per day compared to infants aged 0-12 months (5.8 vs. 0.9 teaspoons). Added sugar intake was higher among non-Hispanic Black toddlers (8.2 tsp) compared to toddlers from other races (Hispanic 5.9 tsp; non-Hispanic White 5.3 tsp; non-Hispanic Asian 3.7 tsp). The common sources of added sugar for infants were yogurt, baby food snacks, and sweet bakery products and for toddlers were fruit drinks and sweet bakery products. The mean consumption of added sugars among infants decreased from 1.4 tsp in 2005-2006 to 0.8 tsp in 2015-2016. A similar trend was also observed among toddlers, with decreased added sugar intake from 6.7 in 2005-2006 tsp to 5.2 tsp in 2015-2016 (Herrick et al., 2020).

Second, an observational study was conducted to explore the diet quality of 5,955 WIC participant children ages 7 to 24 months. The study used 24-h dietary recall and diet quality survey, using an adapted Complementary Feeding Utility Index for 7-12 months old, and used the Healthy Eating Index- 2015 (HEI-2015) for 13- 24 months old. The HEI represents food groups and dietary elements that are recommended for limited consumption including added sugar. Thus, higher scores are recommended for these components because higher scores reflect lower intakes. For example, in this study, the HEI component score for added sugar intake was

10 for 13 months old and 9.5 for 24 months old indicating higher added sugar intake over time (Au et al., 2018).

Third, a cross-sectional study was conducted using NHANES 2009-2014 data to examine the intake and leading sources of added sugar, saturated fats, and sodium among breastfeeding children <5 years. The researchers found that the mean ± SE added sugar intake was 10.1% ± 0.2% of total energy (Wang et al., 2018). The study results also indicated that added sugar consumption increased rapidly among infants, birth to 12 months, and then more gradually up to age 2, with lowest consumption among infants and toddlers born to women with higher income. These researchers found that the common sources of added sugar among 5 years and younger were cakes/cookies/pastries/pies, sweets, and fruit juice drinks or fruit-flavored drinks (Wang et al., 2018).

The following studies explored added sugar intake among children 2 years of age and over. Vos and colleagues conducted a cross-sectional study among 6,412 children aged 2-19 years using NHANES 2009-2012. They found that children aged 2-5 years and 6-11 years consumed an average of 54 grams and 80 grams of added sugar per day, which is 13% and 16% of their total energy, respectively (Vos et al., 2017). This was an amount that is much higher than the WHO recommendation of no more than 25 grams of added sugar per day for children aged 2-19 years (World Health Organization, 2003). Chi and Scott, 2019 conducted a cross-sectional study with 3,441 children ages 18 years and younger using NHANES 2011-2012. The study found that added sugar intake ranged from 4 grams per day for children aged 2 years to 102.1 grams for children aged 18 years. The study also found that non-Hispanic white children ages 18 years and younger consumed more added sugar (80.3 grams) compared to non-white children (non-Hispanic Black 72.2; Hispanic 65.4). The study also found a positive association between added sugar intake and dental caries among children 18 years and younger in the US (Chi and Scott, 2019). Similarly, Kranz and colleagues conducted a cross-sectional study among 5,437 children aged 2 to 5 years and found children aged 2-3 years consumed less added sugar compared to children 4-5 years (13 tsp vs. 17 tsp) which was 15% and 17% of total energy, respectively. The main sources of added sugar were fruit juice, soft drinks, and desserts e.g., pies, cookies, and cake (Kranz and Siega-Riz, 2002).

Since there is limited research that has examined “added sugar” intake among children, I also explored sugar-sweetened beverage (SSB) intake among children because sweetened beverages are often recognized as a primary source of added sugar intake (Bowman, 2017). There has been one study that explored the association between sugar-sweetened beverage consumption during infancy and childhood obesity. Pan and colleagues conducted a longitudinal study among 1,180 children to examine the association between sugar-sweetened beverage intake during infancy (before 12 months) and obesity at 6 years. The authors found that obesity prevalence was higher among the children who consumed sugar-sweetened beverages during infancy compared to children that did not consume sugar-sweetened beverages during infancy (17% vs. 8.6 %) (Pan et al., 2014).

Few studies have examined the association between SSB and obesity among children 2 years and older. For example, Watowicz and colleagues found about two-thirds (66%) of children aged 2-18 years consume over 7% of their total calories from sugar-sweetened beverages (Watowicz et al., 2015). Similarly, another study found that 25% of US children consume one or more sweetened beverages per day (Sylvetsky et al., 2017). Sweetened beverage intake is also associated with obesity among low-income 3-5-year-old African- American children (Lim et al., 2009). Two other cross-sectional studies also found a similar association between SSB consumption and higher weight status among children in the US (Ariza et al., 2004; DeBoer et al., 2013).

Few studies have explored the association between SSB consumption and overweight or obesity among participants in federal food assistance programs. For example, a cross-sectional study conducted among WIC participants aged 3-5 years indicated that SSB consumption was 72% higher among overweight/obese children compared to under/normal-weight children (Charvet and Huffman, 2019). Similarly, Twarog and colleagues conducted a cross-sectional study among Supplemental Nutrition Assistance Program (SNAP) eligible US children aged 2-17 years to examine the SSB consumption and overweight. These researchers found that SNAP-eligible children were more likely to consume more SSB compared to children who did not receive the benefits (76% vs. 70%). This study also suggested that these children, especially Hispanic children are at greater risk of obesity attributable to SSB consumption (OR 1.93, CI 1.07, 3.50) (Twarog et al., 2020).

Bottle feeding practices

Prolonged bottle use or delayed bottle cessation after the recommended age of 12 months is a potential risk factor for tooth decay, iron deficiency, and overweight among the children (Brotanek et al., 2005; Avila et al., 2015; Bonuck et al., 2014). Delayed bottle cessation can also adversely affect children’s dietary patterns including restricted diet, poor chewing technique, and food refusal (Avery & Baxter, 2001).

A few studies found that bottle use beyond 12 months was a risk factor for obesity. For example, Bonuck and Kahn conducted a cross-sectional survey study among 95 WIC participants” children aged 18 months to 4 years residing in New York to examine the association between prolonged bottle use beyond 12 months of age and BMI status among children. The researchers found prolonged bottle use was significantly associated with obesity (>95th % BMI) (Bonuck and Kahn, 2002). Bonuck and colleagues conducted a study among 3027 children aged 3-5 years using NHANES III to examine the association between bottle use and BMI of young children. The researchers found each additional month of bottle use was associated with increased odds of higher BMI (OR 1.03, 95% CI 1.01, 1.05) (Bonuck et al., 2004). Similarly, Bonuck and colleagues conducted another study among 150 children aged 12 to 60 months residing in a lower-income neighborhood. They found that children with prolonged bottle use until 36 months were more likely to be obese compared to the children who weaned within the recommended age of 12 months (Bonuck et al., 2010). Finally, Gooze and colleagues conducted a study among 6,750 US children using Early Childhood Longitudinal Study to examine the association between prolonged bottle use at 24 months and the risk of obesity at 5.5 years of age. The study found that prolonged bottle use had increased odds of obesity at 5.5 years (OR 1.33, 95% CI 1.05, 1.68) (Gooze et al., 2011).

In contrast, a few studies found no association between prolonged bottle use and obesity. For example, Bonuck and colleagues also conducted a randomized control trial. Three hundred caregivers of infant WIC participants were randomized to a bottle-weaning intervention group or a control group. The researchers found no relationship between weight status and bottle use duration (Bonuck et al., 2014). Similarly, Safer et al conducted a study among 165 children and did not find an association between prolonged bottle use and the risk of obesity or higher BMI among children (Safer et al., 2001).

Summary

Most previous studies focused on added sugar intake among children ages 2-18 years; less research is available for children 2 years and younger. In addition, the studies conducted among young children are cross-sectional and lack accounting for longitudinal intake and its effect on children's BMI percentile at 3 years. No study has examined the association between added sugar intake before 2 years and children's BMI percentile at 3 years or examined initiating added sugar among infants and young children. In addition to added sugar intake, it is also important to explore bottle use patterns among the low-income population in the US. The prior literature examining the association between prolonged bottle use or delayed bottle cessation and weight or BMI status among children has contradictory results warranting further investigation.

Considering the prevalence of childhood obesity in the US, it is important to explore if feeding practices and nutrient intake including initiation of added sugar, usual daily added sugar intake at three timepoints, and bottle use during infancy have any effect on weight status among children. Prior research except the study by Pan et al. and Gibbes and Forste are not longitudinal and lack evidence on temporal association between infant feeding practices and weight status at 36 months. In addition, there is still lack of evidence-based research among infants and young children, births to 2 years, to understand how caregivers were feeding the infants and children without any formal recommendations from DGA.

1.2 Theoretical Framework

Theory of Planned Behavior

The Theory of Planned Behavior (Figure 1) focuses on individual motivational factors as determinants to influence or perform a certain behavior (Ajzen, 1991). Theory of Planned Behavior considers that the best predictor of performing a behavior is the behavioral intention which is regulated by social normative perceptions and attitude toward the behavior. Theory of Planned Behavior (TPB) posits that intention is the principal determinant of behavior and intentions are determined by attitudes or behavioral beliefs, subjective norms, perceived behavioral control, and behavioral outcomes. According to Ajzen (1991), attitude refers to individuals' positive or negative perception to perform a certain behavior. Attitude toward a behavior is determined by an individual's expected outcome or the attributes of performing the behavior which is also known as behavioral belief. Ajzen (1991) defined subjective norm as the expectation of society in valuing and supporting certain behavior. Subjective norm posits that an individual's family, significant others, or society have an important effect on an individual's decision-making process. Another concept in TPB is perceived control, defined by Ajzen (1991) as individual's belief in their ability to perform a given behavior. Theory of Planned Behavior assumes a causal chain linking behavioral belief, normative belief, and control beliefs to behavioral intentions and behaviors via attitudes, subjective norms, and perceived control. Moreover, these variables are often influenced by external or background variables including social-demographic variables (Ajzen, 1991) (Figure 1).

Prior research has used TPB to examine mothers' feeding practices and to plan interventions that promoted appropriate feeding practices (Choy and Isong, 2018; Ismail, Alina, Wan Muda, & Bakar, 2016; Horodynski et al., 2007; Dodgson, Henly, Duckett, & Tarrant, 2003

). Existing research also applied TPB to predict childhood obesity and to develop interventions to prevent childhood obesity (Hackman and Knowlden, 2014; Andrews et al., 2010). Since TPB has been utilized to predict both infant feeding practices and childhood obesity, I used this conceptual theory to frame my dissertation research. The TPB posits a framework for understanding caregiver's beliefs and attitudes about infant feeding practices including bottle feeding and added sugar initiation and feeding.

Behavioral Intention

According to TPB, behavioral intention, whether or not a person is willing to practice a certain behavior, is the important predictor of certain behavior. In my dissertation, caregiver's behavioral intention was their assessment of the behavior of prolonging bottle use and initiation of added sugar during infancy. For example, if caregivers have strong behavioral intention to promote prolonged bottle use and to introduce added sugar during infancy, then they are more likely to engage in the behavior than those with weak behavioral intention. Also, if a caregiver intends to introduce added sugar during infancy, she is more likely to purchase foods or drinks with added sugar compared to the caregivers who did not intend to introduce added sugar during infancy. TPB posits the likelihood of performing behavioral intention and behavior is determined by: i) attitude/behavioral belief, ii) subjective norms, and iii) perceived behavioral control (Figure 1).

i) Attitude/ behavioral belief

Attitude/behavioral belief refers to the caregiver's assessment of the behavior as positive and negative. For example, in my dissertation, if a caregiver has a positive attitude that bottle feeding helps to soothe the baby, then she is more likely to practice prolonged bottle use.

Similarly, if a caregiver believes that initiation of added sugar does not have any negative health impact on children, then she is more prone to introduce added sugar during infancy (Figure 1).

ii)Subjective norms

Subjective norms refer to one's belief about whether family, friends, and significant others of the caregiver will approve or disapprove of the behavior. TPB acknowledges that social and demographic factors can provide valuable information about possible precursors of behavior and subjective norms (Ajzen, 2020). In my dissertation, I do not have variables to measure how family and friends of the caregiver, e.g., the mother or husband influences the practice of certain behavior. However, I can measure how social, demographic, and health factors influence the subjective norms. However, I can measure how social, demographic, and health factors are influencing the subjective norms.

Thus, my dissertation aims to explore how social, demographic, and health factors influence subjective norms to perform certain behavior (Figure 1).

iii) Perceived behavioral control

Perceived behavioral control refers to one's belief that she or he has person can control over performing the behavior and her or his the person's perceptions about how easy or difficult it is to adopt certain behavior. In my dissertation, perceived behavioral control is the caregiver's overall perception of how much they can control to bottle feed and to introduce added sugar to the children. In my dissertation, perceived behavioral control refers to the perceptions of caregivers about how easy or difficult it will be to adhere to the infant feeding recommendations (Figure 1).

Social, demographic, and health characteristics of mothers (caregivers) and infants

As mentioned earlier TPB acknowledges external factors including social, demographic, and health characteristics can provide valuable information about the behavior, that the theory itself cannot provide. Inspired by this assumption of TPB, my dissertation also explored how social, demographic, and health characteristics influence the three primary concepts of TPB to perform a certain behavior.

Outcome

In my dissertation, the TPB provides a framework for understanding caregiver's attitudes, subjective norms, and perceived behavioral control to perform infant feeding practices including bottle feeding and initiation of added sugar. Thus, these infant feeding behaviors (initiation of added sugar, usual daily added sugar intake at three timepoints, and bottle use) contribute to outcomes including children's body mass index (Figure 1).

Guided by this TPB model, the overall objective of this dissertation was to provide insight into the factors that influence caregiver's behavior of infant feeding practices and the associations of these behavioral practices with children's body mass index.

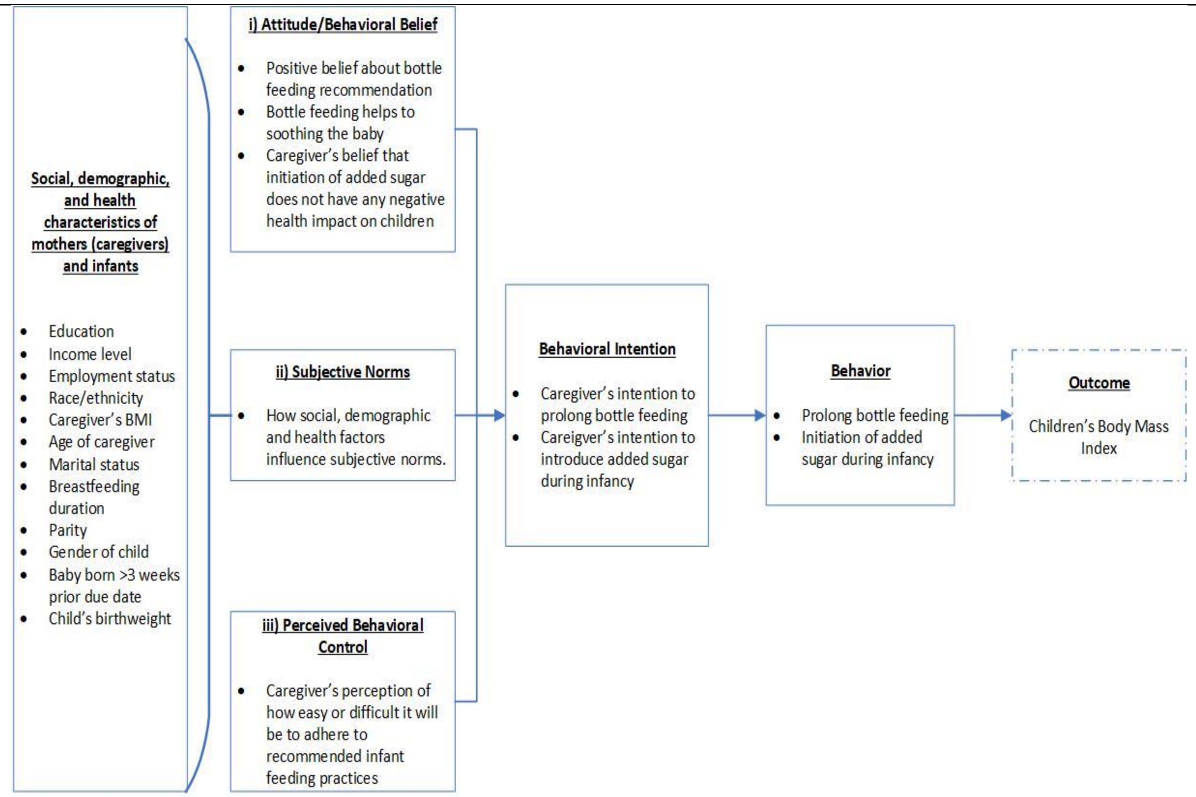

Figure 1: Theoretical Framework to understand the predictor of infant feeding practices and its effect on children's body mass index using the Theory of Planned Behavior.

1.3 Aims and hypothesis

Overall aim

The purpose of my dissertation research was to understand the association between infant feeding practices, nutrition intake, and childhood obesity among low-income families in the US. To address the childhood obesity outcome, I conducted three studies using WIC Infant Feeding and Toddler Feeding Practices Study-2 (ITFPS-2), a longitudinal study that sampled a nationally representative sample of caregivers and their children enrolled in the WIC program. I used this longitudinal study to explore the temporal association between feeding practices and nutrient intake patterns throughout birth to 24 months and children's BMI-for-age percentile at 36 months.

Research questions

The dissertation followed a three-manuscript format. Each study and research question are listed below.

Study 1: The purpose of study one was to explore the factors predicting the age of bottle cessation and to examine the association between age of bottle cessation and BMI at 36 months among low-income children in the US. Study three explored the following research questions.

1.1) What factors are associated with the age of bottle cessation?

1.2) How is the age of bottle cessation associated with children's BMI-for-age percentile at 36 months?

Study 2: The purpose of study two was to examine the initiation of added sugar intake and to examine the factors associated with the initiation of added sugar.

This study explored the following research questions.

2.1) At what age children are being introduced to added sugar?

2.2) What factors are associated with the initiation of added sugar among low-income children in the US?

Study 3: The purpose of study three was to examine the relationship between usual daily added sugar intake at three timepoints (0-7 months, 8-13 months, and 14-24 months) and children's BMI-for-age percentile at 36 months. Study three explored the following research questions.

3.1) What is the usual daily added sugar intake among the low-income children aged 0-7 months, 8-13 months, and 14-24 months?

3.2) How is the usual daily added sugar intake at three-time points is associated with children's BMI-for-age percentile at 36 months?

CHAPTER 2: Age of bottle cessation and BMI-for-age percentile among children aged 36 months participating in WIC

[This Manuscript has been published in Childhood Obesity]

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Abstract

Background: Children's age at bottle weaning typically ranges from 12-24 months. The recommended age of bottle weaning varies. The American Academy of Pediatrics recommends weaning by 12 months; The American Academy of Pediatric Dentistry recommends 12-15 months; The US Department of Agriculture recommends 18 months. Prolonged bottle use is associated with dental caries, iron-deficiency anemia, and child overweight or obesity. We examined factors associated with age of bottle cessation, and the association between age of bottle cessation and body mass index (BMI)-for-age percentile at age 36 months among Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participants.

Methods: Data were from the WIC Infant and Toddler Feeding Practices Study-2 (ITFPS-2). The ITFPS-2, a longitudinal study of WIC participants (mothers and their children) began in 2013. We used Cox proportional hazards models to identify factors associated with bottle cessation, and multivariate linear regression to examine the association between age of bottle cessation and BMI.

Results: About 34% of children used a bottle longer than 12 months, and 13% longer than 18 months. Bottle cessation at older ages was associated with Hispanic ethnicity, multiparity, low income, low education, higher caregiver weight, and not initiating breastfeeding. The adjusted

children's BMI-for-age percentile at age 36 months increased by 0.47 for each additional month of bottle use.

Conclusion: Prolonged bottle use was associated with increased children's BMI-for-age percentile. Future research is warranted to determine the optimal age to recommend bottle cessation for WIC participants.

Introduction

Prolonged bottle use is associated with dental caries (Avila et al. 2015) and iron-deficiency anemia (Brotanek et al.. 2005; Bonuck et al., 2003; Lampe et al., 1997). Yet, the recommended age to bottle wean varies. The United States Department of Agriculture's (USDA) Food and Nutrition Service (FNS) recommends weaning children off the bottle by age18-months (USDA, 2002). The American Academy of Pediatrics (AAP) recommends bottle weaning by age 12 months [American Academy of Pediatrics (AAP, 2020)]. The American Academy of Pediatric Dentistry (AAPD) recommends 12-15 months (American Academy of Pediatric Dentistry, 2017). Research conducted on bottle feeding reported bottle weaning ranging from 12-24 months. (Lampe et al., 1997; Bonuck and Kahn, 2002; Bonuck et al., 2004; Bonuck et al., 2010; Gooze et al., 2011).

A few researchers have found that delayed bottle cessation was associated with childhood obesity. Bonuck and Kahn, 2002; Bonuck et al., 2004; Bonuck et al., 2010; Gooze et al., 2011). During infancy children may engage in oral sucking behavior (Baker et al., 2018) and may also become emotionally attached to the bottle (Frazier et al., 1998). Due to the emotional attachment to bottle (Frazier et al., 1998). and oral sucking behavior, (Baker et al., 2018) children may demand or drink excessive amounts of caloric dense liquids such as whole milk, formula, and juice (Bonuck et al., 2010; DiMegelio et al., 2000; Hyden et al., 2013). It is possible that caregivers who delay bottle cessation tend to purchase and offer such liquids more often than other caregivers and resulting childhood obesity. A few researchers have examined the relationship between bottle cessation and children's weight status (Lampe et al., 1997; Bonuck et al., 2004; Bonuck et al., 2010; Gooze et al., 2011).

Bonuck and colleagues conducted a preliminary study of children of 95 participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), aged 18-56 months, and found an association between prolonged bottle use and obesity Bonuck et al., 2010) Similarly, Bonuck and colleagues conducted two observational studies, one of 3,027 children aged 3-5 years and another of 150 children aged 12-60 months, and found an association between delayed bottle cessation and higher BMI (Bonuck et al., 2004; Bonuck et al., 2010). In a longitudinal study, Gooze and colleagues found that bottle cessation delayed to 24 months was associated with higher odds of child obesity around age 5 years (Gooze et al., 2011). In contrast, Safer and colleagues, who explored the same topic, did not find an association between prolonged bottle use and children's BMI (Safer et al., 2001).

While previous studies have examined the association between delayed bottle cessation and obesity, there is still a paucity of evidence related to the risk factors associated with delayed bottle cessation. In addition, previous studies found an inconsistent association between delayed bottle cessation and obesity, a topic that requires further investigation. To address these topics, our primary study aim was to identify factors associated with age of bottle cessation; the secondary aim was to examine the association between age of bottle cessation and children's BMI-for-age percentile at age 36 months among WIC participants. The results of this study can help researchers understand the association between prolonged bottle use and childhood obesity among the low-income population in the United States.

Methods

Data Source and Study Design

The WIC Infant and Toddler Feeding Practices Study-2 (WIC ITFPS-2), also known as the “Feeding My Baby” study, is a longitudinal national study of caregivers and their children enrolled in WIC. The WIC ITFPS-2 is conducted under the direction of the United States Department of Agriculture (USDA) Food and Nutrition Service in collaboration with Westat, WIC State Agencies, and WIC sites. The WIC ITFPS-2 aims are to examine feeding practices, associations between WIC services and those practices, and the health and nutrition outcomes of children receiving WIC (US Department of Agriculture, 2017).

In 2013, WIC ITFPS-2 participants were recruited from 80 large WIC sites across 27 U.S. states and territories. Eligible WIC sites were limited to those expected to enroll at least 30 new study-eligible cases each month. These WIC sites were selected using stratified two-stage sampling. To participate in WIC ITFPS-2 women had to be: i) pregnant, or with an infant less than 2.5 months old, ii) enrolled in WIC for this pregnancy or child for the first time, iii) at least 16 years old, and iv) a speaker of English or Spanish. The participants will remain in the study until turning 9 years old. Based on eligibility criteria, 4,367 women were recruited during a 20-week window between July 1, 2013 and November 18, 2013. The interviews are conducted by telephone in English or Spanish. All participants provided written informed consent during enrollment. Detailed sampling strategies can be found in the WIC ITFPS-2: Infant Year Report (US Department of Agriculture, 2017).

To collect longitudinal data, follow-up telephone interviews with the participants are conducted every 2 to 6 months starting from the prenatal period. Once the child was born, interviews are conducted at months: 1, 3, 5, 7, 9, 11, 13, 15, 18, 24, 30, 36, 42, 48, 54, 60, and 72

(US Department of Agriculture, 2017). The data are weighted to represent the national population of infants enrolled in WIC-study eligible clinics between July to November 2013, and further adjusted to account for interview nonresponse (US Department of Agriculture, 2017). The average response rate between enrollment and 36 months was about 60%.[17]

Sample

The study population for the current analysis includes information about children from birth to age 36-months participating in the WIC ITFPS-2 (n=1,194). Our exclusion criteria for the study were: i) missing information on age of bottle cessation, ii) caregiver refused or did not know the age of bottle cessation, and iii) missing information on BMI-for-age percentile at 36-months of age (Figure 1).

Outcome measures

The primary outcome was age of bottle cessation. This variable was constructed from the question asked in the 9, 11, 13, 15, 18, and 24-month interviews, "how old was your child when he/she stopped using a bottle?" For the descriptive analyses the age of bottle cessation was categorized into four groups based on AAP and USDA recommendations: 1 week to 9 months (weaned prior to AAP and USDA recommendations) (USDA, 2002; AAP, 2014), 10 to 12 months (AAP recommendation range) (AAP, 2014), 13 to 18 months (USDA recommendation range) (USDA, 2002), and 19 months or more (prolonged bottle use based on AAP and USDA recommendations) (USDA, 2002; AAP, 2014). The categorization into four groups was done to explore the characteristics of caregivers who stopped bottle use at various ages.

The secondary outcome was children's BMI-for-age percentile at 36-months (Bonuck et al., 2005; Bonuck et al.,2004). Child weight and length were measured during the child's WIC clinic visit by clinic staff and, in some cases, data were given by healthcare providers. The child's BMI-for-age percentile was calculated based on the child's age at the time of the weight and height measurement, which was between about 32-40 months. WIC ITFPS-2 staff calculated child BMI-for-age percentile based on World Health Organization guidelines (World Health Organization, 2021).

Independent measures

The measures for the primary aim were caregiver's: caregiver's age at childbirth (16-19 years, 20-25 years, and 26 years or older) (Houle et al.,2019), caregiver's ethnicity (Hispanic, non-Hispanic, non-Hispanic White, non-Hispanic African American, and non-Hispanic others) (Jones, 2018), marital status (married and not married) (Kim and Jang, 2018), caregiver's education, (high school or less and more than high school) (Aryeetey et al.,2017), caregiver's employment status (full time, part time and not working) (Jones, 2018), household poverty level (75% of the federal poverty guideline or below, above 75%-130% of the federal poverty guideline, above 130% of the federal poverty guideline) (Adom et al.,2019), caregiver's weight status (normal or underweight, overweight, obese) (Khashayar et al., 2018), parity (first birth, second birth, third or more birth) (Pesch et al., 2019), breastfeeding duration (Houle et al.,2019), child birth weight (low, normal, and high) (Woo Baidal et al.,2016), child sex (male and female) (Khashayar et al., 2018), and premature birth (yes, no) (Bonnet et al., 2019).

Statistical Analysis

Descriptive analyses examined the frequencies of the primary outcome measures and independent variables. The Chi-square test was used to examine differences between the characteristics. The Cox proportional hazards model (CPHM) (Binder, 1992) adjusted by survey weights was used to examine the factors associated with age of bottle cessation. This analysis provided hazard ratios (HRs) and 95% confidence intervals (CIs), where a hazard ratio more than 1 refers to extended age of bottle cessation. more

For both analyses, statistical significance was determined at p <0.05; all analyses were conducted using weighted procedures that accounted for the complex study design using SAS 9.4 (SAS, 2010). The current study was deemed exempt under federal regulations [45 CFR 46.102 (e or l) and 21 CFR 56.102(c)(e)(l)]. The institutional review board (IRB) at University of North Carolina at Charlotte detmermined that this research did not require IRB review.

Results

Characteristics of the Sample

The characteristics of the study sample are shown in Table 1. Of the 1,195 children, all used a bottle at some point of time: for 9% bottle cessation occurred between 1 week-9 months; for 57% bottle cessation occurred between 10-12 months; for 21% bottle cessation occurred between 13-18 months; and for 13% bottle cessation occurred at 19 months or more. More than half of the caregivers were not married (67%), not working (58%), had an educational level of high school or less (60%), and were 26 years of age or older (52%). About half (49%) of the caregivers identified as Hispanic, 20% as non-Hispanic White, and 25% as non-Hispanic African American. About two-thirds of participants (64%) had a household income below 75% of the federal poverty level. The characteristics of caregivers in the sample were consistent with mothers enrolled in WIC (US Department of Agriculture, 2017). There were significant differences between the various characteristics based on bottle use with p-value 0.0001 (Table 1).

Factors associated with age of bottle cessation

Based on our CPHM analyses, of the twelve individual covariates examined, nine were associated with age of bottle cessation (Table 2). The factors that had a significant association with the age of bottle cessation were: household poverty level; child sex, birth >3 weeks before due date, and breastfeeding initiation; and caregiver's race/ethnicity, education level, employment status, BMI status, and parity.

Children whose caregivers worked full time, had an older age of bottle cessation (HR 1.09, CI 1.07,1.11). In addition, the age of bottle cessation was older among children who were not breastfed compared to children who were breastfed (HR 1.18, CI 1.16,1.20). As caregiver parity increased, child's age at bottle cessation also increased (second birth vs. first birth HR 1.06, CI 1.05-1.08: third or more birth vs. first birth HR 1.07, CI 1.06-1.09). Across racial/ethnic groups, Hispanic caregivers bottle fed longer than White caregivers (HR 1.08, CI 1.06, 1.10) and African American caregivers weaned their children from the bottle earlier than White caregivers (HR 0.74, CI 0.72, 0.75). Finally, if a child was born >3 weeks before the due date, the age of bottle cessation was more likely to be older compared to a child who was not born >3 weeks prior to the due date (HR 1.08, CI 1.06-1.11) (Table 2).

Association between age of bottle cessation and children's BMI-for-age at age 36-months

Simple linear regression showed a significant relationship between age of bottle cessation and children's BMI-for-age percentile at age 36-months (Table 3). The unadjusted slope coefficient for bottle use duration was 0.49 ($p=0.02$). In adjusted analysis the relation was slightly attenuated but remained statistically significant ($p=0.03$). The adjusted slope coefficient for bottle use was 0.47, which indicates that the BMI-for-age percentile of children increased by 0.47 for each additional month of delayed bottle cessation (Table 3).

Discussion

We addressed a gap in the literature by exploring the association between social and demographic characteristics and age of bottle cessation. We also explored the association between age of bottle cessation and BMI-for-age percentile of children in a national WIC sample of women with low incomes and their infants in the United States. Results indicated that about a third of the children participating in WIC had bottle cessation delayed past the AAP recommended age of 12 months (13% delayed past 18 months as recommended by the USDA); this result is generally consistent with prior research (Bonuck et al., 2014; Bonuck et al., 2004; Bonuck et al., 2010).

Many of the factors that were found in prior research to be associated with prolonged bottle use (race/ethnicity, household poverty level, and caregiver’s education level, employment status, and BMI category) (Frazier et al.,1998; Kaste and Gift., 2000) were also found to be significant determinants of age of bottle cessation in our study. For example, consistent with previous research, caregivers with lower income were more likely to prolong bottle use (Frazier et al.,1998; Bonuck et a., 2004). Prior research also indicated that working caregivers were more likely to practice prolonged bottle feeding than non-working caregivers (Frazier et al., 1998; Kaste and Gift., 2000). Our adjusted analysis also found a similar association. However, our study used a more recent and diverse sample to infer the determining factors associated with prolonged bottle cessation. Our study included several social and demographic factors that were not explored in previous studies and were found as potential risk factors for prolonged bottle use among the WIC participants. These social and demographic risk factors were parity, breastfeeding initiation, sex of child, and child born >3 weeks before due date.

We also found older age of bottle cessation was associated with increased children’s BMI-for-age percentile at age 36 months, consistent with some related studies (Bonuck and

Kahn, 2002; Bonuck et al., 2004; Bonuck et al., 2010; Gooze et al., 2011). However, the results of our study were not consistent with those of Safer and colleagues (Safer et al., 2001). Their study examined the effect of prolonged bottle use on children's BMI among children whose caregivers were primarily non-Hispanic White and highly educated. The difference in results may be due in part to the fact that our analysis used a sample of women enrolled in WIC, who have lower education (Safer et al., 2001).

Although not a primary aim of our study, it is useful to note the inconsistent recommendations for age at bottle cessation, which range from 12 to 18 months. Gillham and colleagues examined how healthcare providers, including 721 pediatricians (MDs) and 1,005 pediatric dentists (PDs) interpreted bottle weaning guidelines (Gillham et al., 2019). These researchers found that about half of MDs (49%) and 58% of PDs suggested that bottle weaning should begin at 12 months; 28% of MDs and 17% of PDs recommended starting bottle weaning at 9 months (Gillham et al., 2019). About 80% of the MDs and PDs indicated the average weaning time should be 3 months (Gillham et al., 2019). In a report from Year 1 of the WIC Infant Toddler Feeding Practices Study-2 (ITFPS-2), researchers found that among WIC nutritionists, more than 87% had knowledge about the ages for bottle weaning recommended by one or more of the organizations described above; however, it is not clear which recommendation the WIC nutritionists follow (US Department of Agriculture, 2017). Aside from pediatricians, WIC nutritionists may be the only other healthcare provider that caregivers with low-income often rely on for accurate nutrition education (US Department of Agriculture, 2017). Caregivers are often unaware of both bottle weaning recommendations and adverse effects of prolonged bottle weaning. Healthcare providers (e.g., pediatricians, registered dietitian nutritionists) may provide inconsistent information about recommended age of bottle cessation, which may confuse caregivers (Gillham et al., 2019). Considering the adverse health outcome associated with prolonged bottle feeding, defining consistent guidelines across healthcare provider organizations would be useful. The guidelines could help to inform caregivers about optimal bottle weaning practices.

Limitations and Strengths

Our study has limitations. Since age of bottle cessation was self-reported, response bias is possible. Also, even though child's weight and height were not self-reported, error may have occurred if standard measurement protocols were not followed (Harris et al., 2021). Finally, while our study adjusted the results for many potential confounders, residual and unmeasured confounding could still be present.

Our study has several strengths. Ours is the first to examine bottle cessation among a national population of WIC participants, with a notably larger sample size than used in previous studies. The findings are generalizable to low-income populations in the United States enrolled in WIC. Further, our study provided the opportunity to explore the longitudinal effect of age of bottle cessation on children's BMI-for-age percentile at age 36 months. Bias should be limited given that the outcome variables weight and height were not self-reported.

Conclusion

Our study found that, depending on the recommendations followed, between 13-34% of WIC participants bottle feed longer than recommended. A number of factors associated with older age of bottle weaning were identified, such as caregiver identifying as Hispanic, the caregiver working full time, and the caregiver not intending to breastfeed as reported at study enrollment. Future research to better understand why some women in some sub-groups wean from the bottle at an older age than others is warranted. Finally, our study adds to the body of research that suggests that bottle weaning at an age older than recommended may be associated with higher body weight. It would be useful for future research to examine reasons for a positive relationship between age of bottle weaning and child weight and to examine the mechanism behind the association.

Author Disclosure Statement:

No competing financial interests exits.

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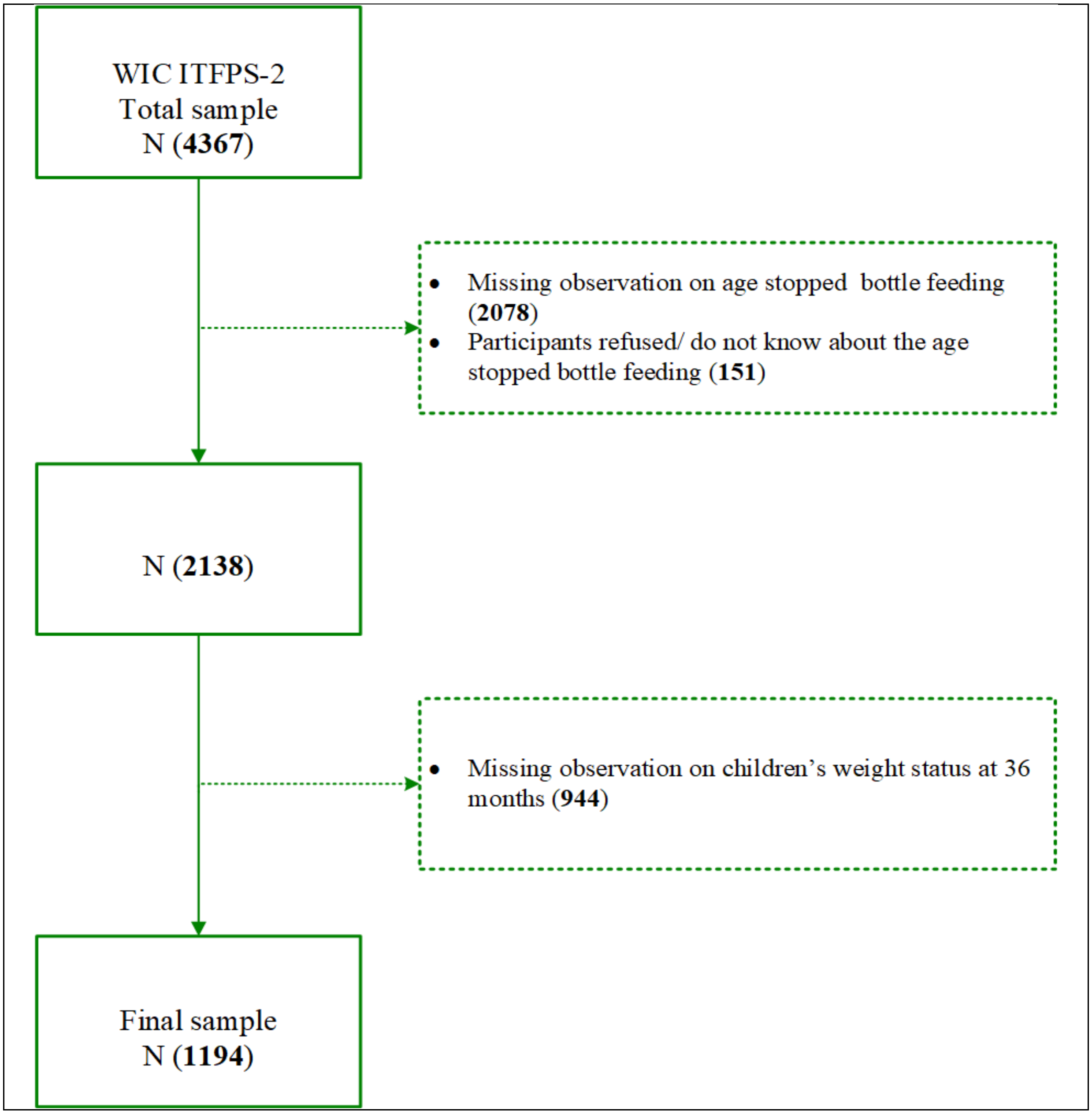

Figure 2: Steps used to select the analytic sample, WIC[a] Infant and Toddler Feeding Practices Study 2.

[a]Special Supplemental Nutrition Program for Women, Infants, and Children

Table 1a: Social and demographic characteristics for participants in WIC[a] Infant and Toddler Feeding Practices Study-2, by age of bottle cessation (N=1,194)

		Age of Bottle Cessation n (%)[b,f]			
Characteristics[e]	Full sample 1,194	1 week-9 months 107 (9%)	10-12 months 676 (57%)	13-18 months 257 (21%)	19 month or more 153 (13%)
Age of caregiver at childbirth					
16-19 years	121 (10.3)	5 (2.4)	73 (10.8)	28 (12.1)	15 (9.5)
20-25 years	470 (37.6)	42 (34.9)	274 (38.5)	103 (39.1)	51 (33)
26 years or older	603 (52.1)	60 (62.7)	329 (50.6)	127 (48.8)	87 (57.5)
Caregiver's Race/Ethnicity					
Hispanic	465 (48.5)	47 (63.4)	227 (43.7)	108 (44.4)	83 (65)
Non-Hispanic White	285 (20.1)	19 (16.9)	160 (19.2)	64 (21.5)	42 (23.3)
Non-Hispanic African American	338 (24.7)	28 (14.2)	232 (31.4)	61 (23.7)	17 (6.4)
Non-Hispanic others	103 (6.7)	13 (5.4)	54 (5.7)	25 (10.4)	11 (5.3)
Marital status					
Married	384 (33.1)	40 (44.9)	198 (30.1)	86 (33.2)	60 (37.8)
Not married	810 (66.9)	67 (55.1)	478 (69.1)	172 (66.8)	93 (62.2)
Caregiver's education					
High school or less	697 (60)	66 (69.3)	405 (61.9)	142 (53.9)	84 (56.3)
More than high school	497 (40.1)	41 (30.7)	271 (38.1)	116 (46.1)	69 (43.7)
Caregiver's employment status					
Full time (35 hours or more)	272 (21.9)	16 (12.8)	159 (21.5)	58 (25.6)	39 (22.4)
Part time	239 (19.7)	23 (17.6)	140 (21)	49 (18.2)	27 (18.2)
Not working	607 (58)	63 (69.5)	334 (57.2)	133 (54.9)	77 (59.4)
Household poverty level at enrollment					
<75% of poverty guideline	741 (63.5)	68 (56.4)	435 (67.7)	142 (54.2)	96 (67)
75% -130% of poverty guideline	330 (27.5)	31 (27.8)	175 (24.8)	83 (36)	41 (23.5)

>130% of poverty guideline	123 (9)	8 (15.8)	66 (7.5)	33 (9.8)	16 (9.5)
Caregiver's BMI category at screening[c]					
Normal or underweight	480 (42.8)	48 (49.9)	261 (42.5)	110 (39.9)	61 (44.8)
Overweight	334 (26.8)	27 (21.3)	196 (27.1)	68 (31.4)	43 (21.2)
Obese	380 (30.4)	32 (28.8)	219 (30.4)	80 (28.7)	49 (34)
Parity					
First birth	499 (40.1)	38 (38)	294 (41.3)	104 (40)	63 (36.8)
Second birth	331 (29.9)	26 (23.6)	194 (31.6)	71 (26.7)	40 (32.3)
Third or more birth	364 (30)	43 (38.5)	188 (27.1)	83 (33.3)	50 (30.9)
Child birth weight[d]					
Low	78 (5.5)	5 (3.9)	46 (5.3)	16 (5.91)	11 (6.2)
Normal	1104 (94)	102 (96.1)	622 (94.3)	239 (92.9)	141 (93.8)
High	12 (0.48)	None	8 (0.4)	3 (1.2)	None
Sex of Child					
Male	628 (51.2)	52 (42.8)	352 (52)	137 (50.6)	87 (54.2)
Female	566 (48.8)	55 (57.2)	324 (48)	121 (49.4)	66 (45.8)
Child born >3 weeks before due date					
Yes	118 (10)	8 (10.2)	64 (9.8)	27 (9.3)	19 (11.4)
No	1001 (90)	91 (89.8)	633 (90.2)	220 (90.6)	121 (88.6)
Children's BMI status at 36 months[c]					
Underweight	60 (4.4)	7 (3.3)	33 (4)	14 (6.8)	6 (2.2)
Normal	780 (66.1)	85 (81.7)	424 (66.2)	179 (66.2)	92 (56.3)
Overweight	160 (12.6)	6 (6.1)	97 (11.2)	32 (14.5)	25 (18.9)
Obese	194 (16.9)	9 (8.9)	122 (18.6)	33 (12.6)	30 (22.6)
Breastfeeding Initiation					
Yes	979 (84.5)	95 (83.2)	531 (81.4))	225 (88.5)	128 (90.7)
No	215 (15.5)	12 (16.8)	145 (18.6)	33 (11.5)	25 (9.3)
mean ± standard deviation					
Children's BMI-for-age percentile at 36 months[e]	68 (28.4)	59.8 (27.1)	68.6 (28.7)	67.9 (28.2)	71.1 (27.8)
Breastfeeding duration in months	8.4 (12.4)	7.2 (13.3)	8.3 (12.3)	9.1 (12.6)	8.8 (11.9)

[a]Special Supplemental Nutrition Program for Women, Infants, and Children
[b] Total weighted sample sizes and percentages for each characteristic across the groups.
[c]Caregiver and children's BMI-for-age percentile categorization defined by World Health Organization[18]
[d]Child birth weight, low birth weight= less than or equal to 5 lbs. 9 oz, normal birth weight= between 5 lbs. 9 oz. and 9 lbs. 14 oz. and high birth weight= 9 lbs. 14 oz[17]
[e]BMI-for-age-percentile calculated using the World Health Organization growth chart and calculation tools[18]
[f]There were significant difference among the various characteristics with p value 0.0001 based on the age of bottle cessation

Table 1b: Cox proportional hazard model showing the associations between age of bottle cessation and the participant characteristics, WIC[a] Infant and Toddler Feeding Practices Study-2, n=1,194

Characteristics	Hazard Ratio	95% CI	*p*-value
Age of caregiver at childbirth			
16-19 years	1.00	0.98-1.03	0.61
20-25 years	Reference	Reference	
26 years or older	1.02	0.98-1.01	0.40
Caregiver's Race/Ethnicity			
Hispanic	1.08	1.06-1.10	<.0001
Non-Hispanic White	Reference	Reference	
Non-Hispanic African American	0.74	0.72-0.75	<.0001
Non-Hispanic Others	0.89	0.87-0.91	<.0001
Marital status			
Married	Reference	Reference	
Not married	1.00	0.98-1.01	0.45
Caregiver's education			
High school or less	0.90	0.89-0.91	<.0001
More than high school	Reference	Reference	
Caregiver's employment status			
Full time (35 hours or more)	1.09	1.07-1.11	<.0001
Part time	1.01	1.00-1.03	<.0001
Not working	Reference	Reference	
Household poverty level at enrollment			
<75% of poverty guideline	1.06	1.04-1.08	0.0236
75% -130% of poverty guideline	1.08	1.05-1.10	0.0006
>130% of poverty guideline	Reference	Reference	
Caregiver's BMI category at screening[b]			
Normal or underweight	Reference	Reference	
Overweight	0.98	0.97-1.00	0.0075
Obese	1.07	1.05-1.08	<.0001
Parity			
First birth	Reference	Reference	
Second birth	1.06	1.05-1.08	<.0001
Third or more birth	1.07	1.06-1.09	<.0001
Breastfeeding initiation			
Yes	Reference	Reference	
No	1.18	1.16-1.20	<.0001
Child birth weight[c]			
Low	0.97	0.94-1.01	0.097
Normal	Reference	Reference	
High	1.07	0.95-1.13	0.404
Sex of Child			
Male	Reference	Reference	

Female	1.07	1.06-1.08	<.0001
Child born >3 weeks before due date			
Yes	1.08	1.06-1.11	<.0001
No	Reference	Reference	

[a]Special Supplemental Nutrition Program for Women, Infants, and Children
[b]Caregiver and children's BMI categorization defined by World Health Organization[23]
[c]Child birth weight, low birth weight= less than or equal to 5 lbs. 9 oz, normal birth weight= between 5 lbs. 9 oz. and 9 lbs. 14 oz. and high birth weight= 9 lbs. 14 oz[14]

Table 1c: Unadjusted and adjusted linear regression models showing the association between age of bottle cessation and child body mass index (BMI) percentile at 36-months of age, WIC[a] Infant and Toddler Feeding Practices Study-2.

	Unadjusted			Adjusted[b]		
Exposure variable	Child BMI-for-age percentile at 36 months of age	SE	*p*-value	Child BMI-for-age percentile at 36 months of age	SE	*p*-value
Age of Bottle cessation	0.49	0.22	0.02	0.47	0.22	0.03

[a]Special Supplemental Nutrition Program for Women, Infants, and Children
[b]Adjusted for caregiver's age at childbirth, caregiver's education, income, and race

CHAPTER 3: Factors associated with the initiation of added sugar among low-income young children participating in the Special Supplemental Nutrition Program for Women, Infants, and Children in the US

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Abstract: Added sugar intake at a young age is associated with chronic diseases including cardiovascular diseases, asthma, elevated blood pressure, and overweight. Dietary Guidelines for Americans 2020-2025 and American Heart Association recommend delaying introduction added sugar until age 2. This study aimed to identify: the timing of added sugar initiation; factors associated with added sugar initiation; and the top five added sugar foods and beverages consumed by infants and children at three age ranges (<7 months, 8-13 months, and 14-24 months). Data were from the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Infant and Toddler Feeding Practices Study-2, a longitudinal, national population of WIC participants enrolled in WIC eligible clinics (n=3,835). Cox proportional hazards model examined factors associated with introducing added sugar. About 25% of children initiated added sugar at or before 7 months. Contributing factors were caregiver's race/ethnicity, education, employment, weight status, parity, child sex, and premature birth (all $p<0.05$). The top added sugar foods consumed between 1-24 months were cereal, crackers, apple sauce, dessert, sweetened beverages, yogurt, syrup and preserves, and cookies. Further research to examine the impact of early initiation of added sugar on health outcomes and taste preferences is warranted.

Keywords: Added sugar; WIC children; Initiation of added sugar; US infants and children

1. Introduction

The United States (US) Dietary Guidelines Advisory Committee and American Heart Association recommend that added sugar intake be limited to <10% of total energy intake for children 2 years old and older (Millen et al., 2016; Vos et al., 2017). This is the equivalent of about 6 teaspoons (25 grams) of sugar per day for children ages 2 to 19 years (World Health Organization, 2003; Millen et al., 2016; Vos et al., 2017). The Dietary Guidelines for Americans 2020-2025 recommends avoiding foods and beverages with added sugar for children 2 years and younger (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). The American Heart Associated also suggests parents should not initiate added sugar consumption among children under the age of 2 years (Vos et al., 2017). "Added sugar" is often defined as all sugars, syrups, or caloric sweeteners added during food preparation, processing, and food manufacturing (Bowman, 2017).

Previous researchers have found that added sugar intake at a young age is negatively associated with health. Higher levels of added sugar intake are associated with an increased risk of dental caries (Paglia et al., 2016), cardio-metabolic risk factors (Vos et al., 2017), asthma (Park et al., 2013), elevated blood pressure (Kell et al., 2014), excess energy intake, poor diet quality, (Magriplis et al., 2021) and overweight among children (Herrick et al., 2020). In addition, there are disparities in added sugar intake by income: lower income children have higher added sugar intake (Thompson et al., 2005; Herrick et al., 2020). Higher consumption of added sugar among lower income children contributes to health disparities over the life course.

Research on this topic is sparse. Thus, it is not known how much added sugar children ages 2 years and younger consume and when added sugar was introduced. To our knowledge, there have only been three studies in this area. Herrick and colleagues conducted a cross-sectional study among 1,211 children ages birth-23 months in the US. The researchers found that those ages 12 to 23 months consumed more added sugar per day compared to infants ages birth to <12 months (5.8 vs. 0.9 teaspoons) (Herrick et al., 2020). Au et al. (2018) conducted an observational study to estimate the diet quality among 5,955 Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participant children ages 7 to 24 months. Using the Healthy Eating Index, the authors found that added sugar intake increased as children increased in age from 13 to 24 months. Wang et al. conducted a cross-sectional study to examine the intake and sources of added sugar, saturated fats, and sodium among non-breastfeeding children aged 5 years and younger in the US. The researchers found that mean ± SE added sugar intake was 10.1% ± 0.2% of total energy. There is also a lack of research documenting the sources of added sugar foods that children under age 2 years consume. Herrick and colleagues found that the common sources of added sugar intake were yogurt, baby food snacks, and sweet bakery products for infants and fruit drinks, and sweet bakery products for toddlers (Herrick et al., 2020) and Wang et al. identified that the common sources of added sugar among 5 years and younger were cakes/cookies/pastries/pies, sweets, and fruit juice drinks or fruit-flavored drinks.

Previous studies used nationally representative sample of US infants and toddlers to examine the added sugar consumption (Herrick et al; Wang et al.). Even though Au and colleagues conducted a study among low-income population, but their objective was to examine the diet quality of infants and toddlers. No research that we are aware of has examined added sugar initiation and intake among low-income US infants and toddlers. Given the association between added sugar consumption during childhood and related morbidities and dietary habits later in life, it is useful to understand when added sugar consumption begins.

Thus, our study had three objectives. The first aim was to document the timing of added sugar initiation. The second was to determine individual-level factors associated with added sugar initiation. The third aim was to identify the top five added sugar food and beverages (hereafter food items) consumed by low-income infants and children at three age ranges. We used data from the WIC Program, sponsored by the United States Department of Agriculture (USDA). The goal of WIC is to provide nutritious food to supplement diets, information on healthy eating, and referrals to health care for low-income women, infants, and children up to 5 years (U.S. Department of Agriculture, 2019).

2. Materials and Methods

2.1. Data source and Study Design

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Infant and Toddler Feeding Practices Study-2 (WIC ITFPS-2) is also known as the "Feeding My Baby" study. The WIC ITFPS-2 is a longitudinal national study of caregivers and their children. This study examines feeding practices, associations between WIC services and those practices, and the health and nutrition outcomes of children receiving WIC. The study investigators collaborate with the USDA Food and Nutrition Service, Westat, WIC State Agencies, and WIC sites [14].

During a 20-week window between July 1, 2013, and November 18, 2013, study participants were recruited from 80 large WIC sites across 27 US states and territories. Eligible WIC sites were limited to those expected to enroll at least 30 new study-eligible cases each month. Stratified two-stage sampling methodology was used to choose these WIC sites. Child participants are recruited through interviews with the primary caregiver. To participate in WIC ITFPS-2 women had to be: i) pregnant, or with an infant less than 2.5 months old, ii) enrolled in

WIC for this pregnancy or child for the first time, iii) at least 16 years old, and iv) a speaker of English or Spanish. A total of 4,367 women were recruited. The children are enrolled while the mother was pregnant, or after birth until the child was age 2.5 months, and then remain in the study until the child turns 9 years old. Detailed sampling strategies can be found in the WIC ITFPS-2: Infant Year Report (U.S. Department of Agriculture, 2019).

To collect longitudinal data, interviewers conducted follow-up telephone interviews in English or Spanish every 2 to 6 months starting during the prenatal period. Once the child was born, telephone follow up interviews are conducted when the infants and children are 1, 3, 5, 7, 9, 11, 13, 15, 18, 24, 30, 36, 42, 48, 54, 60, and 72 months of age. The follow-up interviews are scheduled based on the birthday of the children; the interview window starts 14 days before the child turns the age of the interview (e.g., 14 days before the child is 24 months old) and closes 28 days after the child turns that age (e.g., 28 days after the child is 24 months old). All caregivers provided written informed consent during enrollment. The data are weighted to represent the national population of caregivers, infants, and children enrolled in WIC-study eligible clinics between July to November 2013, and further adjusted to account for interview nonresponse. The average response rate between enrollment and 24 months was about 60% (U.S. Department of Agriculture, 2019).

All post-birth interviews except the 30, 42, and 54-month interviews included a 24-hour dietary recall using the Automated Multi-Pass Method (AMPM) to gather information on nutrient intake. The 24-hour dietary recall that used the USDA AMPM was administered over phone during the interview. In the AMPM, caregivers were asked to recall and report the child's dietary intake including all foods, beverages, and dietary supplements for each event during the past 24 hours. During the interview, caregivers also received a package of measuring guides to help them report their child's portion sizes. This information was recorded by the interviewer and then coded and translated into calories, nutrients, and food group value (U.S. Department of Agriculture, 2019).

2.2. Sample

Of the total WIC ITFPS-2 participants (N=4367), we excluded those who did not provide information on child added sugar intake from the analysis (n=532). The analytic sample for our study includes information about infants and children from birth to 24 months (n=3,835).

2.3. Outcome measures

The outcome measure for objectives 1 and 2 is the month of added sugar initiation. Questions about total daily nutrient intake for 1- month old through 24-month-olds were collected via 24-hour dietary recall using the USDA's AMPM. The outcome measure for objective 3 is the top 5 added sugar food items infants and children consumed. This information was also captured from AMPA where participants reported dietary intake including all foods, beverages, and dietary supplements for each event during the past 24 hours.

2.4. Age stratification for objectives 1 and 3

Based on relevant previous work on infant feeding practices (Kell et al., 2014; (Papoutsou et al., 2018; Barrera et al., 2018) we categorized infants and toddlers into three age groups: ≤7 months, 8-13 months, and 14-24 months. Infants and toddlers reach different feeding milestones during these three age ranges (Infant and Toddler Forum, 2014). During birth to months infants are introduced to food other than breast-milk (especially between 4-6 months), start learning taste preferences and may easily accept new food, and mostly depend on caregivers for food choice (Barrera et al., 2018); between ages, 8-13 months children start to recognize food by sight, smell, and taste; and between ages, 14-24 months children start to develop food preferences and begin rejecting certain foods or begin demanding certain foods, including those with added sugar food (Infant and Toddler Forum, 2014; Birch et al., 2007; Nicklaus 2017).

2.5. Independent measures explored to address objective 2

To determine factors associated with the month of added sugar initiation, we examined several individual-level social and demographic factors identified as predictors of diet quality in previous research. Specifically, we studied the following independent measures: age at childbirth (16-19 years, 20-25 years, and 26 years or older) (Houle et al.,2019); race/ethnicity (Hispanic, non-Hispanic, non-Hispanic White, non-Hispanic African American, and non-Hispanic others) (Jones, 2018); marital status (married and not married) (Kim and Jang, 2018); education, (high school or less and more than high school) (Aryeetey et al.,2017); employment status (full time, part time and not working) (Jones, 2018); household poverty level (75% of the federal poverty guideline or below, above 75%-130% of the federal poverty guideline, above 130% of the federal poverty guideline) (Adom et al.,2019); body-mass-index (BMI) status at enrollment (normal or underweight, overweight, obese) (Khashayar et al., 2018); parity (first birth, second birth, third or more birth) (Pesch et al., 2019); child birth weight (low, normal, and high) (Woo Baidal et al., 2016); sex of the child (male and female) (Khashayar et al., 2018); and child born before 3 weeks prior due date (yes, no) (Bonnet et al., 2019).

2.6. Statistical Analysis

To identify the timing of added sugar initiation (objective 1) descriptive analysis was conducted. To determine factors associated with added sugar initiation (objective 2), we used Cox proportional hazard model (CPHM), adjusted by survey weights. This analysis provided hazard ratios (HRs) and 95% confidence intervals (CIs), where a hazard ratio of more than 1.0 refers to the early initiation of added sugar. To determine the variables to keep in the adjusted model we conducted a bivariate analysis. We kept those that were significant in the bivariate analysis in the adjusted model. To identify the top five added sugar food items consumed by WIC participants at various age ranges (objective 3), we used descriptive statistics to identify the five food items most frequently consumed at ages ≤7 months, 8-13 months, and 14-24 months. For analyses, statistical significance was determined at $p<0.05$; all analyses were conducted using weighted procedures that accounted for the complex study design using SAS 9.4. This study was deemed exempt under federal regulations [45 CFR 46.102 (e or l) and 21 CFR 56.102(c)(e)(l)]. The Institutional Review Board (IRB) at [University blinded] determined that this research did not require IRB review.

Results

The study sample characteristics are shown in Table 1. Of the 3,835 children, added sugar was initiated among 25% before or at 7 months, 65% between 8 to 13 months, 10% between 14 to 24 months of age, and 13% subsequently after 24 months of age. About half of caregivers were 26 years or older (48%) and identified as Hispanic (51%). More than half of the caregivers were not married (67%), not working (61%), had a high school diploma or less (62%), and had income below 75% of the federal poverty level (62%). About half of the children were male (50%) and majority had normal birth weight (92%) (Table 1). These characteristics were consistent with participants enrolled in WIC [14].

Of the 11 individual-level factors considered, all were significantly associated with early initiation of added sugar in adjusted analysis (Table 2). Across racial/ethnic groups, Hispanic, non-Hispanic White, and non-Hispanic others were more likely to introduce added sugar early compared to non-Hispanic African Americans (Hispanic HR 1.30, CI 1.29-1.32; non-Hispanic White HR 1.08, CI 1.07-1.09; non-Hispanic others HR 1.05, CI 1.07-1.09). Caregivers with less than high school education were more likely to introduce added sugar early compared to caregivers with more education (HR 1.07, CI 1.07-1.08). Caregivers with household poverty level at <75% of the federal poverty guideline were more likely to initiate early added sugar compared to caregivers with household poverty level at >130% of poverty guideline (HR 1.03, CI 1.01-1.04). Caregivers who were overweight or obese were more likely to initiate added sugar (HR 1.04, CI 1.04-1.05). Finally, early added sugar consumption was more likely if a child was born >3 weeks before their due date compared to children who were not born >3 weeks prior to the due date (HR 1.07, CI 1.05-1.08) (Table 2).

The top 5 added sugar contained food items consumed at 1-7 months and 8-13 were baby cereal, crackers, apple sauce, dessert, and cookies. The top 5 added sugar contained foods consumed at 14-24 months were crackers, sweetened beverages, yogurt, syrup and preserves, and presweetened cereal (Table 3).

4. Discussion

We addressed a notable gap in the literature by exploring the timing of added sugar initiation and the association between social and demographic characteristics and initiation of added sugar intake. The results suggested one-quarter of participants initiated added sugar before or at 7 months. Nearly 90% of children (87%) initiated added sugar by 24 months of age. This added sugar intake at an early age may have adverse life-long health consequences including overweight, obesity, cardiovascular diseases, asthma, and dental caries, as well as worse dietary habits [9-10], With the added sugar consumption infants and toddlers may not intake the important nutrients that are needed at this age for their overall physical and mental wellbeing [23].

Individual-level factors significantly associated with added sugar intake at three age ranges among children (race, income, education, children sex) in the present study were consistent with those of previous research (Wang et al., 2018; Herrick et al., 2020). In the study by Herrick et al. (2020), the researchers found that non-Hispanic Black women were more likely to consume higher amounts of added sugar compared to people in other racial and ethnic groups (Herrick et al., 2020). In contrast, we found that non-Hispanic Black women were more likely to delay the initiation of added sugar. Herrick et al. conducted a cross-sectional analysis among infants and toddlers using data from the nationally representative US National Health and Nutrition Examination Survey. The difference in results may be due in part to the fact that our study participants, who are enrolled in WIC, have notably lower income and less education. Additional research to explore the amount and timing of added sugar intake among different racial and ethnic groups would be useful. We explored several individual-level factors not examined by previous researchers, including parity and if a child was born >3 weeks before the due date.

The top sources of added sugar for infants aged 1-13 months were baby cereal, crackers, apple sauce, dessert, and cookies; top sources for infants and children 14-24 months were crackers, sweetened beverages, yogurt, syrup, and preserves, and pre-sweetened cereal. Our results for top sources of added sugar were consistent with the study by Herrick et al. (2020), where the participants were of similar age (Herrick et al., 2020). However, Wang et al. (2018) identified cakes/ cookies/ pastries/ pies, sweets, and fruit juice drinks or fruit-flavored drinks to be top sources of added sugar among children 5 years and (Wang et al., 2018). This finding is useful because this information can help to develop strategic interventions and health promotion campaigns to reduce added sugar intake at young age. Caregivers may not be aware that the foods they provide contain added sugar. Therefore, it is important to educate caregivers on the sources of added sugar in children's diet and when these foods are being first introduced into their diet.

According to the professional nutrition and health community, added sugar should not be included in the diet until age 2 years; limiting added sugar intake to less than 10 percent of calories per day starting at age 2 years is recommended to reduce the risk of related morbidities (Vos et al.,2017; U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). We found that only 13% of WIC children delayed added sugar initiation until 2 years. These findings suggest that lower-income children may be at risk of developing negative health outcomes related to added sugar intake.

Practicing appropriate feeding during infancy is important because children begin to learn food and taste preferences during infancy (Birch et al., 2007; Nicklaus, 2017). Eating behaviors developed during this age are more likely to evolve later in life (Nicklaus, 2017). Thus, caregivers should be aware of the feeding practices since infants are dependent on caregivers for the food. Our study results suggest that women with lower-income and less education may be more likely to initiate added sugar in the diet of infants and toddlers. Healthcare professionals and WIC nutritionists can be useful resources to communicate information about the adverse effects of added sugar initiation at an early age. Moreover, intervention is needed to educate the caregivers about the negative health outcomes associated with added sugar consumption at an early age. Previous researchers have proposed effective interventions to improve infant feeding practices including breastfeeding and bottle-feeding among women participating in WIC (Campos et al., 2020). Similar interventions can be adapted to inform the caregivers participating in WIC about the recommendation about added sugar intake and negative health outcomes associated with added sugar intake.

Added sugar intake at young age cause or exacerbates chronic diseases (Park et al., 2013; Kell et al., 2014; Vos et al., 2017; Herrick et al., 2020). The Dietary Guidelines for Americans recognize the importance of evidence-based research and strategies to reduce added sugar intake at young age. Therefore, evidence-based and theory-based intervention is needed to understand strategies to reduce added sugar intake. Moreover, there remains a lack of research in this area. First, further research is needed to understand the association between added sugar intake during infancy and preference for added sugar among young children and if the association has long-term health consequences later in life. Second, qualitative research is needed to understand caregiver’s behaviors associated with introducing added sugar among infants and young children, to understand the degree to which caregivers are aware of the food items that contain added sugar, and to understand if caregivers are aware of the adverse effect of added sugar at young ages. Third, it is important to understand the patterns of added sugar consumption, specifically the variations in volume and frequency of added sugar intake and to examine whether different added sugar intake patterns influence growth and health outcomes. Fourth, future research to better understand why women in some sub-groups initiate early added sugar than others would be useful. Lastly, it is noteworthy to mention that when the WIC ITFPS-2 interview began in July 2013 there were no formal recommendations about added sugar intake for those birth to 2 years. The American Heart Association provided its recommendations in 2017 (Vos et al., 2017) the Dietary Guidelines for Americans provided its recommendations in December 2020 (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). Thus, it would be useful to extend this research in the future to understand the timing of added sugar initiation after these recommendations were made (Raiten et al., 2014; Stoody et al., 2019).

Strengths and limitations

Our study has several strengths. To our knowledge, this is the first study to examine the initiation of added sugar intake and to identify the factors associated with initiation of added sugar intake among a national population of WIC participants. The study findings are generalizable to low-income populations in the US enrolled in WIC. Our study is also the first to examine three age ranges of infants and toddlers. We also explored several other factors that have not been considered in the existing related research and were found as potential risk factors for initiation of added sugar at early age.

Our study also has limitations. The information about added sugar was collected by the 24-hour recall method. While this method is widely used to identify food, energy, and nutrient intake it also has limitations. The 24-hour recall method depended on participants' memory; participants may not accurately recall food consumption. Moreover, since the information about added sugar initiation is self-reported, response bias is possible. Finally, the study was conducted among the WIC population. Thus, the study findings are not generalizable to the US population of children.

5. Conclusions

In conclusion, the results of our study suggest added sugar initiation begins during infancy among lower income children. The contributing factors associated with added sugar intake at three age ranges among infants and young children include race/ethnicity, income, education, parity, and child sex. Considering the adverse effect of added sugar, it would be useful to better understand the added sugar intake behavior and added sugar feeding behavior among children and caregivers and how this behavior may influence children's diet quality and their development of eating behavior later in life. The study results indicate a need for health care advocacy programs and intervention to educate the caregivers to stop or limit added sugar consumption among infants and children aged 2 or younger.

6. Patents

Author Contributions: Conceptualization, M.B. and E.F.; methodology, M.B. and R.P.; validation, M.B., R.P, S.L and E.F.; formal analysis M.B. and R.P.; writing—original draft preparation, M.B; writing—review and editing, M.B., R.P, S.L and E.F.; supervision, R.P, S.L and E.F. All authors have read and agreed to the published version of the manuscript.

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Table 2a: Social and demographic characteristics for participants in WIC[1] Infant and Toddler Feeding Practices Study-2, by month of added sugar initiation, N=3835.

	Study Participants Weighted column % N=3835	Earliest reported feeding infant/toddler added-sugar ≤24 months[2] Weighted column % n=3328 (87%)			Introduced added sugar subsequently after 24 months[2] n=507(13 %)
Characteristics[3]	≤7 to 24 months	≤7 months n (%) 834 (25)	8 to13 months n (%) 2155(65%)	14 to ≤24 months n (%) 339 (10)	>24 months
Age of caregiver at childbirth					
16-19 years	450 (12.8)	120 (15.7)	221 (9.7)	43 (13.0)	76 (18.0)
20-25 years	1591 (39.5)	355 (40.7)	887 (39.1)	144 (39.3)	205 (42.6)
26 years or older	1779 (47.6)	358 (43.5)	1057 (51.2)	152 (47.7)	212 (39.4)
Caregiver's Race/Ethnicity					
Hispanic	1560 (50.7)	327 (51.0)	871 (49.0)	147 (53.0)	215 (50.0)
Non-Hispanic White	1018 (23.9)	230 (23.0)	586 (26.1)	59 (15.8)	143 (27.0)
Non-Hispanic African American	885 (18.1)	198 (19.3)	502 (18.2)	96 (22.1)	89 (15.4)
Non-Hispanic others	326 (7.2)	70 (6.8)	174 (6.7)	30 (9.1)	52 (7.6)
Marital status					
Married	1148 (33.2)	225 (30.6)	687 (34.1)	94 (38.7)	142 (27.3)
Not married	2672 (66.8)	608 (69.4)	1468 (65.9)	245 (61.3)	351 (72.7)
Caregiver's education					
High school or less	2368 (61.5)	533 (68.4)	1279 (58.3)	228 (68.5)	328 (73.5)
More than high school	1442 (38.5)	298 (31.6)	872 (47.7)	110 (31.5)	162 (26.5)
Caregiver's employment status[4]					
Full time (35 hours or more)	669 (19.8)	151 (17.4)	412 (19.2)	61 (25.5)	45 (24.7)
Part time	625 (18.9)	168 (18.9)	375 (19.4)	52 (12.3)	30 (19.5)
Not working	1829 (61.3)	480 (63.8)	1123 (61.4)	143 (61.9)	83 (53.8)

Household poverty level at enrollment					
<75% of poverty guideline	2415 (61.8)	563 (68.8)	1318 (60.5)	219 (59.3)	315 (62.1)
75% -130% of poverty guideline	1035 (27.3)	207 (22.9)	594 (27.8)	99 (32.9)	135 (26.6)
>130% of poverty guideline	385 (10.9)	64 (8.4)	243 (11.7)	21 (7.8)	57 (11.2)
Mother's BMI category at screening					
Normal or underweight	1716 (46.1)	578 (29.7)	1197 (55.5)	155 (46.2)	253 (48.3)
Overweight or obese	2119 (53.9)	683 (70.3)	958 (44.5)	205 (53.8)	254 (50.1)
Parity					
First birth	1593 (43.0)	375 (44.9)	891 (42.5)	123 (35.0)	204 (41.9)
Second birth	1030 (26.1)	206 (26.3)	584 (25.8)	108 (35.0)	132 (25.4)
Third or more birth	1197 (30.9)	252 (29.8)	680 (31.7)	108 (30.0)	157 (32.7)
Childbirth weight					
Low	278 (6.8)	57 (7.4)	153 (7.3)	30 (8.9)	38 (7.1)
Normal	3492 (92.1)	766 (91.4)	1972 (91.6)	306 (90.3)	448 (92.1)
High	50 (1.1)	10 (1.2)	30 (1.1)	3 (0.88)	7 (0.77)
Child Sex					
Male	1961 (50.3)	428 (48.8)	1089 (49.2)	184 (57.9)	260 (46.9)
Female	1874 (49.7)	406 (51.3)	1066 (50.8)	155 (42.1)	247 (48.7)
Baby born >3 weeks before due date					
Yes	356 (9.2)	59 (9.6)	218 (10.2)	41 (14.4)	38 (8.0)
No	3068 (90.7)	690 (90.4)	1738 (89.8)	258 (85.6)	382 (92.0)

[1]Special Supplemental Nutrition Program for Women, Infants, and Children

[2]The interview could be administered 14 days before and 28 days after the child turns the age of the interview.

[3]Missing observations range from 0% to 10% depending on the variable unless noted otherwise.

[4]Missing 714 responses, 18.6% of the sample.

Table 2b: Adjusted[1] Cox proportional hazards model showing the associations between initiation of added sugar and the participant characteristics, WIC[2] Infant and Toddler Feeding Practices Study-2.

Characteristics	Hazards Ratio	(95% CI)	*p*-value
Age of caregiver at childbirth			
16-19 years	0.90	0.89-0.91	<.0001
20-25 years	0.94	0.93-0.95	<.0001
26 years or older	Reference	Reference	
Caregiver's Race/Ethnicity			
Hispanic	1.30	1.29-1.32	<.0001
Non-Hispanic White	1.08	1.07-1.09	<.0001
Non-Hispanic African American	Reference	Reference	
Non-Hispanic Others	1.05	1.04-1.07	<.0001
Marital status			
Married	Reference	Reference	
Not married	1.01	1.00-1.02	0.0361
Caregiver's education			
High school or less	1.07	1.07-1.08	<.0001
More than high school	Reference	Reference	
Caregiver's employment status			
Full time (35 hours or more)	1.13	1.12-1.14	<.0001
Part time	1.11	1.10-1.12	<.0001
Not working	Reference	Reference	
Household poverty level at enrollment			
<75% of poverty guideline	1.03	1.01-1.04	<.0001
75% -130% of poverty guideline	1.00	0.99-1.01	0.4614
>130% of poverty guideline	Reference	Reference	
Caregiver's Weight Status			
Normal or underweight	Reference	Reference	
Overweight or obese	1.04	1.04-1.05	<.0001
Parity			
First birth	Reference	Reference	
Second birth	0.95	0.94-0.96	<.0001
Third or more birth	0.94	0.93-0.95	<.0001
Child birthweight			
Low	0.90	0.89-0.92	<.0001
Normal	Reference	Reference	
High	0.97	0.94-1.00	0.0232
Child Sex			
Male	Reference	Reference	

Female	1.04	1.04-1.05	<.0001
Premature birth			
Yes	1.07	1.05-1.08	<.0001
No	Reference	Reference	

[1]Adjusted for caregiver's age at childbirth, race/ethnicity, marital status, education, employment status, household poverty level, weight status, parity, childbirth weight, child sex, and premature birth.
[2]Special Supplemental Nutrition Program for Women, Infants, and Children

Table 3: Top sugar contained food consumed by months. WIC[1] Infant and Toddler Feeding Practices Study-2.

Ranking	1-7 months	8-13 months	14-24
1	Baby cereal	Baby cereal	Cracker
2	Craker	Craker	Sweetened Beverage
3	Apple sauce	Apple sauce	Yogurt
4	Dessert	Dessert	Sugar, syrup, preserves
5	Cookie	Cookie	Presweetened cereal

[1]Special Supplemental Nutrition Program for Women, Infants, and Children

CHAPTER 4: Association between usual daily added sugar intake at three timepoints (0-7 months, 8-13 months, 14-24 months) and BMI-for-age percentile at 36 months old among low-income population in the USA

Abstract

Background: Added sugar intake at a young age is associated with chronic morbidities. The Dietary Guidelines for Americans and the American Heart Association recommends avoiding foods and beverages with added sugar for children 2 years and younger.

Objective: The first objective was to document the usual daily intake of added sugar among infants and toddlers, birth to 2 years. The second objective was to examine the association between the usual daily intake of added sugar at ≤7 months, 8-13 months, and 14-24 months and BMI-for-age percentile at 36 months among the low-income population in the US.

Method: The data are from the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Infant and Toddler Feeding Practices Study-2 (WIC ITFPS-2), a longitudinal, national population of WIC participants, women, and their children enrolled in WIC eligible clinics (n=1,886). Bivariate analysis was used to examine the association between added sugar consumption before age 2 years old and BMI-for-age-percentile at 36 months old.

Results: The mean usual daily intake of added sugar i ≤7 months, 8-13 months, and 14-24 months were 0.23 teaspoon (tsp), 3.44 tsp, and 11 tsp, respectively. Bivariate analysis indicates added sugar intake before 2 years old is associated with children's BMI-for-age-percentile at 36 months old.

Conclusion: Usual daily intake of added sugar increased gradually from infant to toddles. Future research to examine the impact of usual daily intake of added sugar on diet quality of infants and toddlers is warranted.

Introduction

Added sugar intake at a young age contributes to negative health consequences including dental caries (Paglia et al., 2016), asthma (Park et al., 2013), elevated blood pressure (Kell et al., 2014), cardiovascular diseases (Vos et al., 2017), and overweight among children (Herrick et al., 2020). Added sugar intake at a young age is critical because dietary patterns develop in childhood are likely to affect the diet quality throughout life (Mikkila et al., 2005). The Dietary Guidelines for Americans and the American Heart Association recommends avoiding foods and beverages with added sugar for children 2 years and younger (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020; Vos et al., 2017).

Childhood obesity is a major public health challenge in the United States. In 2016, the prevalence of obesity among children aged 2-5 years old was about 14%, which is compared to 5% obese in a healthy population [Centers for Disease Control and Prevention (CDC), 2019]. Childhood obesity is associated with morbidities including type 2 diabetes mellitus, hypertension, elevated blood pressure, dyslipidemia, nonalcoholic fatty liver diseases, and disability including mobility impairment (Cote et al., 2013; Kumar et al., 2017). Childhood obesity is not only associated with physical morbidities but also associated with psychological and emotional conditions, including poor self-esteem, anxiety, depression, and decreased health-related quality of life (Sawyer et al., 2011; Morrison et al., 2015). Obesity is more common among lower-income children (19%) compared to higher-income children (11%) in the US (CDC, 2019).

Three studies have explored added sugar intake among children 2 years and younger. These researchers found that added sugar intake increased gradually from infants to toddlers (Herrick et al., 2020; Wang et al., 2018; Au et al., 2018). None of the previous studies except Au et al. explored added sugar consumption among low-income populations who are more likely to have higher consumption as compared to high-income population (Wang et al., 2018). However, Au et al. examined the total diet quality of children aged 2 years and younger, but not only the added sugar consumption at young age. In addition, limited studies have examined the association between added sugar consumption among children 2 years and younger and its effect on weight. One study examined the association between sugar-sweetened beverage consumption among infants younger than 12 months and obesity at 6 years; the researchers found obesity prevalence was higher among the children who consumed sugar-sweetened beverages (SSB) during infancy compared to children that did not consume sugar-sweetened beverages during infancy (8.6 % vs. 17%) (Pan et al., 2014). A few of the previous studies that explored the association between SSB and weight status among children 2 and older and found that SSB consumption was associated with overweight and obesity (Watowicz et al., 2015; Lim et al., 2009; Charvet and Huffman, 2019; Twarog et al., 2020). Previous studies expect Pan et al. were cross-sectional and were conducted among children 2 years and older. However, Pan et al. only explored SSB consumption rather than total added sugar consumption from both SSB and foods.

While previous studies have examined the association between added sugar consumption and childhood obesity among children 2 years and older, there is still paucity of evidence related to usual daily added sugar intake at a younger ages and child weight later in life. Moreover, to the best of our knowledge, no previous research has explored the association between usual daily intake of added sugar at young age and child Body Mass Index for age percentile (BMI-for-age percentile) at 36 months among the low-income population who are the vulnerable population for childhood obesity. In addition, there is still a lack of research to understand how usual daily added sugar intake at various age ranges among low-income populations in the US. To address these gaps, the current study used longitudinal data from Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Infant and Toddler Feeding Practice-2 (ITFPS-2) to examine two objectives. The first objective was to document the usual daily intake of added sugar among infants and toddlers, birth to years. The second objective was to examine the association between the usual daily intake of added sugar at ≤7 months, 8-13 months, and 14-24 months and BMI-for-age percentile at 36 months among the WIC participants.

Methods

Data Source and Study Design

WIC ITFPS-2 is an ongoing longitudinal study of caregivers and their children enrolled in WIC. The children are enrolled in the study while the mother was pregnant, or after birth until the child was age 2.5 months, and then remain in the study until the child turns 9 years old. The ITFPS-2 collects information on infant feeding practices, the association between WIC services and those practices and growth, health, and nutrition outcomes of children receiving WIC (US Department of Agriculture, 2017).

The study participants were recruited from July 1, 2013, to November 18, 2013 from 80 large WIC sites across 27 U.S. states and territories using and these sites were chosen using stratified two-stage sampling methodology. Eligibility criteria to participate in this study were: i) pregnant, or with an infant less than 2.5 months old, ii) enrolled in WIC for this pregnancy or child for the first time, iii) at least 16 years old, and iv) a speaker of English or Spanish. Based on these criteria, 4,367 women were recruited during the 20 weeks recruitment period. Detailed sampling strategies can be found in the WIC ITFPS-2: Infant Year Report (US Department of Agriculture, 2017).

All longitudinal data collection was completed using follow-up telephone interview in English or Spanish every 2-6 months starting prenatally and when the babies are 1, 3, 5, 7, 9, 11, 13, 15, 18, 24, 30, 36, 42, 48, 54, 60, and 72 months of age. The follow-up interviews are scheduled based on the birthday of the children; the interview window starts 14 days before the child turns the age of the interview (e.g., 14 days before the child is 24 months old) and closes 28 days after the child turns that age (e.g., 28 days after the child is 24 months old). All participants provided informed consent at the time of study enrollment (US Department of Agriculture, 2017).

All post-birth interviews except the 30, 42, and 54-month interviews were included a 24-hour dietary recall using the Automated Multi-Pass Method (AMPM) to gather information on nutrient intake. The 24-hour recall used the USDA's 24-hour dietary recall system, which started with the AMPM interview. In the AMPM, caregivers were asked to recall and report the child's dietary intake including all foods, beverages, and dietary supplements for each event during the past 24 hours. During the interview, caregivers also received a package of measuring guides to help them report their child's portion sizes. This information was recorded by the interviewer and then coded and translated into calories, nutrients, and food group value (US Department of Agriculture, 2017).

Sample

Of the total WIC ITFPS-2 participants (N=4,367), we excluded those who did not provide information on child added sugar intake at ≤24 months (n=0) and children's BMI-for-age percentile at 36 months of age from the analysis (n=2,481). The analytic sample for our study includes information about children from birth to age 24 months (n=1,886).

The independent measures

The independent measures for this study were the usual daily intake of added sugar measured in teaspoons. Information about daily nutrient intake for 1- month old through 24-month-olds was collected via 24-hour dietary recall using the USDA's AMPM. The information about usual daily added sugar intake was captured in teaspoon (tsp) from AMPA where participants reported dietary intake including all foods, beverages, and dietary supplements for each event during the past 24 hours. Ten percent of the sample participated in a second recall to estimate the usual intake. For this study usual daily intake of added sugar was categorized based on median (50^{th} percentile) consumption across three age ranges.

Outcome measures

The outcome measure for this study was children's BMI-for-age percentile at 36-months. Child weight and length were measured during the child's WIC clinic visit by clinic staff and, in some cases, data were given by healthcare providers. Based on World Health Organization Guidelines WIC ITFPS-2 staff calculated child BMI-for-age percentile between 32-40 months.

Age stratification

Usual daily intake of added sugar was measure based on median (50^{th} percentile) usual daily intake across three age ranges: ≤7 months, 8-13 months, and 14-24 months. This categorization of various age ranges is consistent with previous research on infant feeding practices (Papoutsou et al., 2018; Herrick et al., 2020). Infants and toddlers reach different feeding milestones during these age ranges (Infant and Toddler Forum, 2014; Birch et al., 2007; Nicklaus 2017).

Statistical Analysis

We conducted descriptive analyses to examine the frequencies of the primary outcome measures and independent variables. We presented the distribution of usual daily added sugar intake across three age ranges using boxplots. We also conducted bivariate chi-square tests to examine the association between i) any added sugar intake vs. no added sugar intake between ≤7 months and BMI-for-age-percentile at 36 months, ii) usual daily intake of 2 tsp of added sugar vs. usual daily intake more than 2 tsp of added sugar at 8-13 months and BMI-for-age-percentile at 36 months, and iii) usual daily intake of 9 tsp of added sugar intake vs usual daily intake more than 9 tsp of added sugar at 14-24 months and BMI-for-age percentile at 36 months.

We used SAS to conduct all the statistical analyses. A longitudinal weight was used to represent the national population of infants enrolled in WIC study eligible clinics between July to November 2013 and to compensate for both the unequal sampling rates and nonresponse. The significance level was set to $p<0.05$.

Results

Table 1 shows the social and demographical characteristics of our sample population. Of the 1,886 participants, about half of caregivers were 26 years or older (52%). More than half of the participants had an income below 75% of the federal poverty level, were not married (63%), and had an education level of high school or less (61%). About half of the participants identified as Hispanic (57%), 19% as non-Hispanic White, and 17% as non-Hispanic African American. The mean usual daily intake of added sugar at ≤7 months, 8-13 months, and 14-24 months were 0.23 teaspoon (tsp), 3.44 tsp, and 11 tsp, respectively (Table 1). The characteristics of caregivers in the sample were consistent with mothers enrolled in WIC (US Department of Agriculture, 2017).

Figure 1 shows boxplots of the distribution of the usual daily intake of added sugar across various age ranges. The median usual daily intake of added sugar at 8-13 months was 2 tsp and at 14-24 months was 9 tsp. The maximum amount of usual daily intake of added sugar at ≤7 months, 8-13 months, and 14-24 months were 17.7 tsp, 78.4 tsp, and 60.6 tsp, respectively (Figure 1).

Table 2 shows the unadjusted bivariate analysis for the usual daily intake of added sugar at three age ranges and BMI-for-age percentile at 36 months. There were significant association between the any usual daily intake of added sugar at ≤7 months, usual daily intake of added sugar more than 2 tsp at 8-13 months, and usual daily intake of added sugar more than 9 tsp at 14-24 months and BMI-for-age percentile at 36 months (all p-value=<0.0001) (Table 2).

Discussion

We addressed a gap in the literature by examining the association between the usual daily intake of added sugar before 2 years and children BMI-for-age percentile at 36 months in a national WIC sample of women with low incomes and their infants in the US. Results indicated that the average usual daily intake of added sugar increase gradually from infants to toddlers where added sugar intake at ≤7 months, at 8-13 months, and 14-24 months were 0.23 teaspoon (tsp), 3.44 tsp, and 11 tsp, respectively; this result is generally consistent with prior research (Au et al., 2018; Wang et al., 2018). While added sugar intake is not recommended before 2 years old (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020; Vos et al., 2017), our study found one quarter of infants had added sugar before or at 7 months and the percentage of added sugar intake increases by age.

The study results also indicates usual daily intake of added sugar before 2 years is associated with children's BMI-for-age percentile at age 36 months old. This study finding is consistent with previous findings (Au et al., 2018). As mentioned earlier, there has been lack of research to understand the association between the usual daily intake of added sugar among infants and toddlers and children's weight status later in life. Thus, more longitudinal research is needed among diverse populations to understand the temporal association between added sugar intake before 2 years and children weight status later in life.

Due to added sugar intake children may not consume nutrients that are essential at young age for their overall physical and mental wellbeing. Thus, a need for future research exists to understand the impact of added sugar intake on children's diet quality and examine the association of added sugar intake with long-term health diseases. Moreover, future qualitative research is needed to understand caregiver's behavior to feeding added sugar to their children.

This study not only emphasized the high volume of usual daily intake of added sugar for the low-income infants and toddlers in the US but also described the association between added sugar intake at young age and children BMI-for-age percentile at 36 months old. Such findings have implications for WIC participants. It is worth mentioning that there was not any recommendation for added sugar intake for children 2 years and younger when the study participants began the survey in July 2013. Therefore, it would be useful to extend this research in the future to understand the consumption of added sugar after these recommendations were made. In addition, caregivers may not be cognizant of the negative health outcomes related to usual daily intake of added sugar at a young age. Thus, interventions are needed to encourage the caregivers to adhere to the current recommendations for added sugar and inform them about the negative health consequences related to the usual daily intake of added sugar at young age.

Strengths and limitations

This study has several strengths. The findings are generalizable to low-income populations in the United States enrolled in WIC. In addition, this study provided the opportunity to explore the longitudinal effect of usual daily intake of added sugar at various age ranges on children's BMI-for-age percentile at age 36 months. Bias should be limited given that the outcome variables weight and height were not self-reported.

This study has some limitations. Since the usual daily intake of added sugar was self-reported, response bias is possible. Also, even though child's weight and height were not self-reported, errors may have occurred if standard measurement protocols were not followed. The data about usual daily intake of added sugar was collected by the 24-hour recall method. While this method is widely used to identify food, energy, and nutrient intake it also has limitations. The 24-hour recall method depended on participants' memory; participants may not accurately recall food consumption. Lastly, since the study was conducted among WIC population, the study results are not generalizable to the US population of children.

Conclusion

Added sugar intake is a serious public health concern in the US. Our study results suggest that usual daily intake of added sugar increases gradually among infants to toddlers. Future research is needed to better understand the factors that motivate caregivers to provide children with added sugar. Also, research to examine if caregivers are aware of the foods that contain added sugar is warranted. Given the negative health outcome associated with added sugar at young age, the health care professionals should develop interventions to limit the added sugar intake among children in the US.

Table 3a**:** Social and demographic characteristics for participants in WIC[a] Infant and Toddler Feeding Practices Study-2, n=1,886.

Characteristics[b]	N=1,886 Weighted column % mean ± standard error
mean ± standard error	
Usual daily intake of added sugar ≤7 months[c]	0.23 (1.0)
Usual daily intake of added sugar 8-13 months	3.44 (5.0)
Usual daily intake of added sugar 14-24 months	10.98 (10.0)
Children's BMI-for-age percentile at 36 months[e]	69 (28.2)
Weighted column (n) %	
Usual daily intake of added sugar ≤7 months	
Yes	1447 (22.5)
No	439 (77.5)
Usual daily intake of added sugar 8-13 months (quantile intake in tsp)	
≤0.20 tsp	485 (24.8)
0.21-3	958 (49.6)
4-6 tsp	84 (4.0)
>6 tsp	359 (21.6)
Usual daily intake of added sugar 14-24 months	
≤3 tsp	443 (25.1)
4-9 tsp	529 (28.6)
10-15 tsp	414 (21.6)
>15 tsp.	500 (24.8)
Age of caregiver at childbirth	
16-19 year	188 (11.2)
20-25 years	716 (36.3)
26 years or older	982 (52.5)
Caregiver's Race/Ethnicity	
Hispanic	872 (57.4)
Non-Hispanic White	427 (19.2)

Non-Hispanic African American	424 (17.0)
Non-Hispanic others	157 (6.4)
Marital status	
Married	631 (37.1)
Not married	1255 (62.9)
Caregiver's education	
High school or less	1134 (60.8)
More than high school	750 (39.2)
Caregiver's employment status	
Full time (35 hours or more)	356 (20.1)
Part time	343 (17.8)
Not working	988 (62.0)
Household poverty level at enrollment	
<75% of poverty guideline	1181 (62.3)
75% -130% of poverty guideline	525 (27.3)
>130% of poverty guideline	180 (10.4)
Mother's BMI category at screening	
Normal or underweight	798 (44.8)
Overweight	522 (24.2)
Obese	566 (30.1)
Parity	
First birth	782 (43.1)
Second birth	508 (26.0)
Third or more birth	596 (30.9)
Childbirth weight	
Low	135 (7.6)
Normal	1729 (91.2)
High	22 (1.2)
Child Sex	
Male	976 (50.8)
Female	910 (48.2)
Baby born >3 weeks before due date	
Yes	178 (9.9)
No	1557 (90.0)

[a]Special Supplemental Nutrition Program for Women, Infants, and Children

[b]Missing observations ranges from 0% to 10% depending on the variable, unless noted otherwise.

[c] Usual daily intake of added sugar is in teaspoon (tsp)

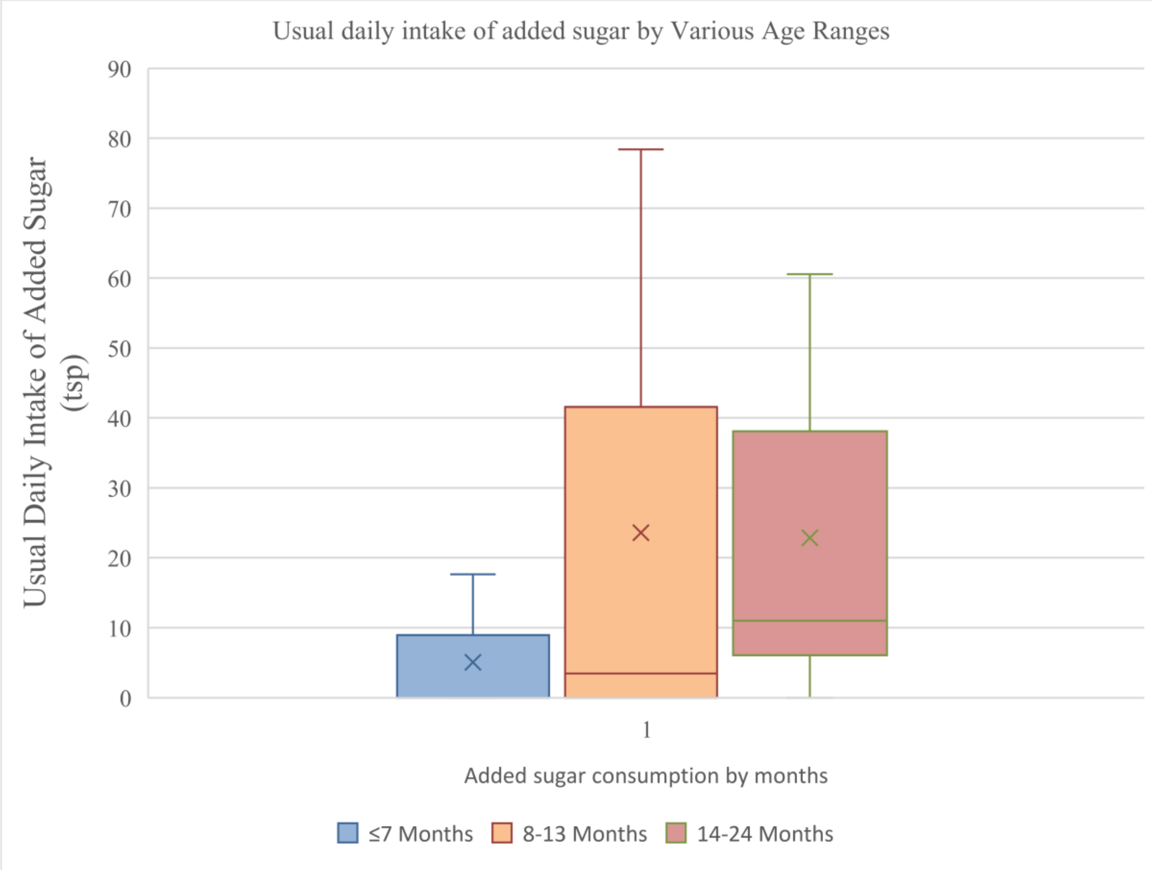

Figure 3: Median usual daily intake of added sugar across various age ranges, WIC Infant and Toddler Feeding Practices Study-2.

Table 3b: Bivariate analysis showing association between usual daily intake of added sugar[a] at three age ranges and BMI-for-age percentile at 36 months old, WIC[b] Infant and Toddler Feeding Practices Study-2

Usual daily intake of added sugar	Children BMI-for-age percentile	
	Chi-square values	P-value
≤7 Months	10.4	<.0001
8-13 Months	16.0	<.0001
14-24 Months	9.8	<.0001

[a]Weighted
[b]Special Supplemental Nutrition Program for Women, Infants, and Children
Note: All p-values are weighted

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CHAPTER 5: CONCLUSION

Review of Major Findings

The purpose of my dissertation was to understand the association between infant feeding practices, nutrition intake, and childhood obesity among low-income families in the US. To address the objectives of this dissertation, I conducted three studies that examined the factors associated with caregiver's behavior of infant feeding practices including bottle feeding, added sugar initiation, and added sugar feeding, and the consequence of these feeding behavioral practices on children's BMI-for-age-percentile at 36 months participating WIC. The study findings were aligned with the theory used to guide the dissertation studies.

The first study results indicated that older age of bottle cessation was associated with increased children's BMI-for-age percentile at 36 months. Factors that were significantly associated with age of bottle cessation were race/ethnicity, education level, employment status, caregiver's weight status, household poverty level, parity, child gender, and premature birth.

The second study results indicated about one-third of the children initiated added sugar before or at 7 months. Factors that were associated with the initiation of added sugar intake were caregiver's race/ethnicity, education, employment, weight status, parity, child sex, and premature birth. The top added sugar contained foods consumed between 1-24 months are cereal, crackers, apple sauce, dessert, sweetened beverage, yogurt, syrup and preserves, and cookies.

The third study results indicated the mean usual daily intake of added sugar at ≤7 months, 8-13 months, and 14-24 months were 0.23 teaspoon (tsp), 3.44 tsp, and 11 tsp, respectively. Bivariate analysis indicates added sugar intake before 2 years old is associated with children's BMI-for-age-percentile at 36 months old.

Overall Innovation

The three studies offer contributions to the existing literature. To the best of my knowledge, the first study was the first to explore the association between age of bottle cessation and BMI-for-age-percentile at 36 months on a national population of WIC participants and used a notably larger sample size compared to previous studies conducted on similar topic. The second paper was the first to examine the initiation of added sugar intake and to determine the factors associated with the initiation of added sugar among WIC participants. Lastly, the third paper was first to examine the association between the usual daily intake of added sugar at various age ranges and BMI-for-age percentile at 36 months among WIC participants.

Public Health Implications

This dissertation used a national representative of WIC participants to explore the infant feeding practices among infants and young children and their effects on children's BMI-for-age percentile at 36 months. The study findings have the potential to inform the health care professionals to develop interventions and to promote appropriate infant feeding practices including bottle feeding and added sugar intake at young age. About half of infants in the US participate in WIC. Thus, prevention and intervention strategies implemented in WIC could notably improve the quality of health of low-income infants and children. Results of my dissertation studies suggest that it would be useful for WIC to implement a few strategies to promote appropriate infant feeding, for example, i) communicate the benefits of bottle cessation by the recommended age; ii) eliminate messages that promote or encourage bottle feeding after 12 months; iii) implement a program of recycling or exchanging bottles with sippy cups to discourage delayed bottle cessation; iv) educate the health outcome of initiation of added sugar at young age; v) inform the caregivers about the foods that contain added sugar.

The study results suggest among a sample of low-income mothers and infants, disadvantaged mothers were more likely to use a bottle longer and initiate added sugar at young age. Thus, these study findings can also inform dietetics practice for future educational interventions aimed at infants of WIC participants who are often likely to have delayed bottle cessation and have introduced added sugar at young age.

Strengths and Limitations

The studies collectively address a crucial gap in the existing literature by providing evidence-based research using large, nationally representative data on the dietary intake of infants and toddlers in low-income households in the US. Since the data were longitudinal, the studies provided some evidence on the temporal association between infant feeding practices and weight status at age 36 months. In addition, considering the complex sampling design of ITFPS-2 the study findings are generalizable to the low-income populations in the US enrolled in WIC. Due to the fact the information on children's BMI-for-age percentile was obtained using objective methods, the possibility of nondifferential misclassification of outcome is limited. The average response rate at 36 months was 60%, thus limiting the response bias.

Despite the strengths of the study, there are also limitations. The study population is children enrolled in WIC. Thus, the findings are not generalizable to the US population at this age. Due to the fact, the data on the exposure bottle feeding in duration and initiation of added sugar was self-reported, there is a potential for nondifferential misclassification of the exposure. In addition, the 24-hour recall method was used to gather information about added sugar intake. The 24-hour recall method is extensively depending on participants' memory and therefore they may not recall the accurate food consumption and duration. Even though the studies controlled for all potential confounders, residual and unmeasured confounding could still be present.

Directions for Future Research

Appropriate infant feeding practices and balanced nutrient intake are vital for infant and young child growth, physical and mental development, and overall health. Thus, continuous, and further research is needed to contribute to evidence-based strategies to improve health and reduce the risk of morbidities at young age. First, qualitative research is needed to understand the social or behavioral context influencing infant feeding choice. Second, research is needed to understand the development of taste preferences for added sugar and the impact on dietary intake and health outcomes. Third, research is needed to understand the role of water and beverages including fruit juices and sugar-sweetened beverages in the dietary intake of infants and toddlers. Fourth, research is needed to understand how infant feeding including bottle feeding and added sugar feeding impacts on cognitive, behavioral, and growth of children. Fifth, research is needed to understand the energy and nutrients requirements for children to promote optimal growth and physical development. Sixth, research is needed to understand how prolonged bottle feeding influences diet quality and development of eating behavior later in life. Seventh, it is important to understand the impact of food insecurity on infant feeding practices and their overall cognitive, behavioral, and physical well-being. Eighth, more longitudinal and randomized control trials of intervention are needed to understand the effective strategies to improve and promote appropriate infant feeding practices. Lastly, research is needed to understand the influence of federal food assistance programs on children's diet quality and eating behavior.

early life of children, especially the first 2 years is a critical period because dietary habits develop during this age and influence health later in life. Thus, it is important to practice appropriate feeding behavior to promote health, prevent disease and improve overall growth. In order to practice appropriate feeding practices, caregivers should be aware of the latest recommendations of feeding practices and should be aware of the health consequences associated with feeding behavior. The dietary intake during early life is also important to maintain healthy body weight. Childhood obesity is a serious public health concern. Thus, health care professionals should always advise and educate the caregivers on balanced nutrient feeding to maintain the healthy weight of the children. Early interventions may offer potentially efficacious opportunities to develop the dietary patterns later in life.

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