Breastfeeding to 12 Months and Beyond: Nutrition Outcomes at 3 to 5 years

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Breastfeeding to 12 Months and Beyond: Nutrition Outcomes at 3 to 5 years

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**Registration:** TARGet Kids! practice-based research network (www.clinicaltrials.gov; NCT01869530); www.targetkids.ca

**Abbreviations:**
- NutriSTEP® - Nutritional Screening for Every Preschooler
- SD – standard deviation
- WHO - World Health Organization
- CPS - Canadian Paediatric Society
- AAP - American Academy of Pediatrics
- TARGet Kids! - The Applied Research Group for Kids
- RCS – restricted cubic spline
ABSTRACT

Background: Little is known about nutrition outcomes in preschoolers associated with breastfeeding duration beyond 12 months of age.

Objective: To examine the association between total breastfeeding duration and nutrition outcomes at 3 to 5 years of age.

Design: A cross-sectional study of healthy children, ages 3–5 years, recruited from 9 primary care practices in Toronto was conducted through the TARGet Kids! research network. Parents completed standardised surveys, including the Nutrition Screening for Every Preschooler (NutriSTEP) used to assess nutrition risk.

Results: A total of 2987 children were included. 92% of children were breastfed and the mean (±SD) breastfeeding duration was 11.4 (8.4) months. The prevalence of nutrition risk (score>20) was 17.0%. We examined breastfeeding duration as a continuous variable. Using restricted cubic spline modeling, we confirmed a nonlinear relationship between breastfeeding duration and NutriSTEP score, dietary intake and eating behavior subscores, sugar-sweetened beverage and sweet-savoury snack consumption. Segmented linear regression was used to examine this nonlinear relationship in a piecewise approach. We found a decreasing trend in NutriSTEP score for children breastfed for 0–6 months (β= -0.14; 95% CI: -0.29, 0.004), a significant decrease in NutriSTEP score for children breastfed for 6–12 months (β= -0.20; 95% CI: -0.33, -0.07), with no statistically significant change after 12 months (β= 0.09; 95% CI: -0.07, 0.24) and beyond. The mean NutriSTEP score was: 17.1 (7.4) for no breastfeeding; 15.9 (6.5) for >0–6 months; 13.9 (6.2) for >6–12 months; 13.7 (6.3) for >12–18 months; 14.6 (6.7) for >18–24 months; 14.3 (6.8) for >24–36 months.
Conclusion: Breastfeeding for up to 12 months was associated with decreased nutrition risk, and healthier eating behaviors and dietary intake at 3 to 5 years of age. We found insufficient evidence of additional benefit for breastfeeding beyond 12 months of age.

Word count: 300
INTRODUCTION

The toddler period is a critical period for ‘learning to eat’ and establishing good eating habits. Children are particularly vulnerable to nutrition risk as they transition from a milk diet to a family-based table food diet (1). Food preferences and self-regulatory eating behaviors are thought to be influenced by early infant feeding practices (1). Breastfeeding is the first feeding experienced by many infants, and may influence later nutrition outcomes and eating behaviors (1).

The World Health Organization (WHO) recommends exclusive breastfeeding for the first 6 months of life with introduction of complementary foods at 6 months and continued breastfeeding up to 2 years of age or beyond (2). This recommendation has been endorsed by the Canadian Paediatric Society (CPS) (3). The American Academy of Pediatrics (AAP) concurs with the WHO recommendations and recommends “continuation of breastfeeding for 1 year or longer as mutually desired by mother and infant” (4). The US Preventive Service Task Force recommends primary care interventions to promote breastfeeding; Healthy People 2020 aims to increase breastfeeding rates including breastfeeding to 12 months (5, 6). Benefits associated with breastfeeding include reduced morbidity from gastrointestinal infection, improved child cognitive development, reduced incidence of immune related diseases and childhood cancers, and lower risk of obesity (2, 7). However, the systematic review supporting the WHO recommendation is based on exclusive breastfeeding in the first 6 months of life; less is known about the health benefits or harms of longer durations of breastfeeding, in the months following the introduction of complementary foods (8).

Several studies have examined the relationship between breastfeeding duration and childhood nutrition outcomes, including consumption of meat, water, milk, juice, fruits,
vegetables, sugar-sweetened beverages, sweets, and savory snacks (9-17), as well as problematic eating behaviors (10-13, 18, 19), and obesity (20). These studies concluded that longer duration of breastfeeding was associated with improved nutrition outcomes. However, these studies focused on outcomes in the first 12 months of life (9-13, 19, 20), and little is known about outcomes associated with breastfeeding duration beyond 1-2 years of age, as recommended by the WHO, CPS and AAP.

Other studies examining breastfeeding duration beyond 12 months concluded that longer breastfeeding duration was associated with improved nutrition outcomes, healthier eating behaviors, and reduced risk of obesity (14-18, 20). However, for all of these studies, breastfeeding duration was treated as a categorical rather than a continuous variable; the longest duration of breastfeeding examined was an open-ended category of >12 months. Furthermore, these studies did not examine the possibility that the relationship may be nonlinear.

Understanding the influence of feeding practices during the critical toddler years, beyond the first year of life, on nutrition outcomes is an important research gap (1). To address this gap, our objective was to examine the association between total breastfeeding duration up to 36 months of age and later nutrition outcomes at 3 to 5 years of age.
METHODS

Study Design

This was a cross-sectional study of healthy urban children participating in The Applied Research Group for Kids (TARGGet Kids!) Cohort (www.targetkids.ca) (21). Consent was obtained from parents of all participating children and ethics approval was obtained from the Research Ethics Boards at the Hospital for Sick Children and St. Michael’s Hospital (www.clinicaltrials.gov; NCT01869530).

Participants

Children were eligible if they were enrolled in the TARGGet Kids! cohort between December 2008 to September 2013, were aged 3 to 5 years old, and did not have any health conditions affecting growth (e.g., cystic fibrosis) or chronic conditions except asthma. We excluded children with missing data on exposure or outcome variables. Children with total breastfeeding duration >36 months were also excluded (Figure 1).

Data Source

TARGGet Kids! is an ongoing open longitudinal cohort study enrolling healthy children from birth to 5 years old, at 9 primary healthcare settings in Toronto, Canada. The primary aims of TARGGet Kids! are to examine healthy growth and development trajectories of infants and preschool-age children, and to link early life exposures to health problems. The TARGGet Kids! cohort profile describing the study protocol and recruitment procedures has been previously published (24). Briefly, sociodemographic, lifestyle and nutritional information are collected during scheduled health supervision visits through a parent-completed standardised survey based on the Canadian
Community Health Survey (22). Medidata RAVE is used as the secure electronic data repository.

**Variables**

The main predictor variable was total breastfeeding duration, which refers to the “duration of breastfeeding of any kind” (including exclusive or non-exclusive). This information was gathered from parents by asking them for a response to the following question, “For how long has your child been breastfed?” Maternal recall has been found to be a valid and reliable estimate of breastfeeding duration (23). Children who were never breastfed were classified as having a total breastfeeding duration of 0 months, and children currently breastfeeding were classified as having a total breastfeeding duration equal to their current age.

The primary outcome measure was the total score on the parent-completed Nutrition Screening for Every Preschooler (NutriSTEP) questionnaire (24). The NutriSTEP is a screening tool that was designed to identify preschool children, 3 to 5 years of age, who are at nutrition risk. Nutrition risk is defined as, “the presence of characteristics or risk factors that can lead to impaired nutritional status” (24). The NutriSTEP has been validated in a Canadian sample of multicultural children using a nutritional assessment (including a parent-completed 3-day food record, growth measurements, and a clinical assessment) completed by one of three specially trained dietitians as the criterion measure (24). NutriSTEP is comprised of 17 equally weighted items and the questions are partitioned into 5 subscales: dietary intake, eating behaviors, parental concerns about food and activity, screen time duration (television, computer or video game use), and the use of supplements (25). Each question has two to five response options, and responses range in score from 0 (no nutrition risk) to 4 (nutrition risk). The responses to 17 items can be
summed to obtain a total score (ranging from 0 to 68); higher scores indicate increased nutrition risk (24). A total NutriSTEP score > 20 indicates that a child is at nutrition risk (24).

There were four secondary outcome measures: NutriSTEP dietary intake score, NutriSTEP eating behaviors score, sugar-sweetened beverage consumption and sweet-savoury snack consumption. The 6-item NutriSTEP dietary intake score includes the items (response indicating risk): my child usually eats grain products (≤3 servings per day); my child usually has milk products (≤2 servings per day); my child usually eats fruit (≤2 servings per day); my child usually eats vegetables (≤1 serving per day); my child usually eats meat, fish, poultry or alternatives (≤1 serving per day); and my child usually eats ‘fast food’ (≥2 times per week).

Parents responded by indicating the daily frequency their children ate the specified food groups. The dietary intake score ranges from 0 to 24. A dietary intake score > 7 indicates nutrition risk. The 5-item NutriSTEP eating behaviors score includes the items (response indicating risk): whether children were allowed to decide how much they ate (sometimes to never); whether they ate while watching television (most of the time to always); the number of meals they ate per day (≤2 times per day); the presence of gagging or trouble swallowing while eating (sometimes to most of the time); and whether the child is not hungry at mealtimes because he/she drinks all day (sometimes to most of the time). This score ranges from 0 to 20. An eating behaviors score > 6 indicates nutrition risk. When the number of subscale items is below 7, mean inter-item correlation (\( \rho \)) provides an estimate of reliability that is independent of scale length (26). We calculated a mean inter-item correlation of 0.18 for the dietary intake score and 0.14 for the eating behaviors score; a value within the range of 0.15 to 0.20 for outcome measures that measure broad characteristics is recommended (27).
Sugar-sweetened beverage consumption was determined based on the response to the questions in the health survey about 1) sweetened drinks (e.g., Kool Aid, Sunny D) and 2) soda or pop: “Circle how many cups of each drink your child has currently in a typical day (if none then circle 0; 1 cup=8 ounces=250 ml)”. The response options included 0, ½, 1, 2, 3, 4, 5+ cups per day; sugar-sweetened beverage consumption was equal to the sum of the two responses.

Sweet-savoury snack consumption was derived in a similar manner, based on the following question in the health survey about 1) sweets or candy and 2) chips or fried snacks: “Circle how many servings of each food your child has in a typical day”. The response options included 0, ½, 1, 2, 3, 4, 5+ servings per day; sweet-savoury snack consumption was equal to the sum of the two responses.

Covariates that we a priori identified from the literature might influence the relationship between total breastfeeding duration and nutrition outcomes included child age in months, sex, birthweight, bottle use in bed, minimum age in months that complementary food was introduced (e.g. infant cereal, cow’s milk or juice), and number of siblings. Maternal characteristics included as covariates were: the mother’s age in years at the time of the child’s birth, ethnicity, education and household income. Six-digit postal codes were used to obtain the median after-tax neighbourhood income for each participant’s family, using the Statistics Canada Postal Code Conversion File and data from the 2006 Canadian Census (28).

Statistical Analysis

Descriptive statistics were computed for the main predictor, primary and secondary outcomes, and covariates. For our initial analysis, linear regression was used to model the association between total breastfeeding duration and the total NutriSTEP score (primary outcome) adjusting
for prespecified and clinically relevant covariates. All covariates were included in all adjusted
analysis models regardless of statistical significance (29). Four separate multivariable linear
regression models were developed with total breastfeeding duration as the main predictor and all
secondary outcomes: eating behavior score, dietary intake score, sugar-sweetened beverage
consumption and sweet-savoury snack consumption. To assess model fit and check the
assumption of linearity, residual plots were generated.

After all models violated the ordinary least squares regression assumption of linearity, we
first used restricted cubic spline (RCS) modeling as a visual tool to confirm a nonlinear
relationship between total breastfeeding duration and all nutrition outcomes (30). To determine
knot points that we used in subsequent analyses, we also used the RCS curve to visually estimate
the approximate locations (breastfeeding duration in months) at which nutrition risk changed
magnitude or direction of slope in our cohort (Supplemental Figure 1). On the basis of the RCS
curve and to align with the timing of scheduled health supervision visits (31), we placed knot
points at 6, 12, 18, and 24 months of total breastfeeding duration. Selecting these knot points
allowed us to quantify the relationship between breastfeeding duration and nutrition over a wide
range of breastfeeding duration as a continuous variable while allowing for non-linearity, in a
manner that is clinically relevant. We next used segmented linear regression to allow for multiple
linear relationships between total breastfeeding duration, using these prespecified knot points at
6, 12, 18, and 24 months, and the NutriSTEP total score. Segmented linear regression was used
to estimate the association between total breastfeeding duration and the remaining secondary
outcomes. Five separate RCS models (one model per outcome) were fitted with 4 knots to match
the intervals used in segmented linear regression.
Finally, we used quantile regression to determine if the relationship between predicted total NutriSTEP score and total breastfeeding duration was homogeneous. We assessed the effect of total breastfeeding duration on the 10th, 25th, 50th (median), 75th, 90th, 95th, and 99th conditional quantiles of the total NutriSTEP score, allowing the relationships to be nonlinear by use of RCS. Missing covariate data were assumed to satisfy the missing-at-random criterion; these data were handled by multiple imputation using the fully conditional specification method (32). The maximum rate of missing data for any variable was 19%. Statistical significance was defined as $P < 0.05$; all statistical tests were two-sided. Statistical analyses were conducted using SAS software (English) Version 9.4 (Cary, North Carolina, USA) and R statistical software Version 3.3.1.
RESULTS

Participant Characteristics

A total of 2987 children ages 3 to 5 years old in the TARGet Kids! cohort meeting study eligibility criteria were identified and included in the analyses. The majority of children were breastfed (92%) and the mean total breastfeeding duration was 11 months (range: 0 to 36 months). The mean (±SD) total NutriSTEP score was 14.6 (6.5). The prevalence of nutrition risk (score > 20) was 17.0%. The mean NutriSTEP dietary intake and eating behavior subscores were 7.1 (3.3) and 3.7 (2.2), respectively. Children had a daily mean intake of 1.2 (1.3) cups of sugar-sweetened beverages and 0.8 (0.9) servings of sweet-savoury snacks. Participant characteristics are presented in Table 1.

Association between Total Breastfeeding Duration and Nutrition Outcomes

We first constructed multivariable linear regression models of total breastfeeding duration assuming the relationship with nutrition risk to be linear. After adjusting for relevant covariates, every 1-month increase in total breastfeeding duration was associated with a decrease in total NutriSTEP score -0.05 (95% CI: -0.08, -0.02), dietary intake score -0.02 (95% CI: -0.04, -0.01), eating behaviors score -0.03 (95% CI: -0.04, -0.02), and sugar-sweetened beverage -0.02 (95% CI: -0.03, -0.02) and sweet-savoury snack -0.01 (95% CI: -0.01, -0.001) consumption (not shown). However, all models violated the ordinary least squares regression assumption of linearity.

Using RCS modeling, we confirmed a nonlinear relationship between total breastfeeding duration and NutriSTEP total score, dietary intake and eating behavior subscores (Supplemental Figure 1), and sugar-sweetened beverage and sweet-savoury snack consumption (not shown).
Segmented linear regression allowed us to examine this nonlinear relationship and estimate the
association between total breastfeeding duration and the NutriSTEP total score in a piecewise
approach (Table 2). Total breastfeeding duration was included as the five variables of a 4-knot
RCS model with knots prespecified at 6, 12, 18, and 24 months of total breastfeeding duration to
primarily coincide with the timing of regularly scheduled health supervision visits according to
current guidelines (31). Supplemental Figure 2 shows the plot of this RCS regression (grey
lines represent the nonlinear association with 95% CI) fitted with 4 knots to match the intervals
used in segmented regression (black lines represents the linear trends with each unit increase in
6-month breastfeeding duration interval); this plot depicts a decreasing trend in predicted total
NutriSTEP score for the 0–6 month total breastfeeding duration interval (β= -0.14; 95% CI: -
0.29, 0.004), a significant decrease in predicted total NutriSTEP score for the >6–12 month total
breastfeeding duration interval (β= -0.20; 95% CI: -0.33, -0.07), and then no statistically
significant change after 12 months (β= 0.09; 95% CI: -0.07, 0.24) and beyond (also shown in
Table 2).

The mean (±SD) total NutriSTEP score for each breastfeeding duration interval was: 17.1
(7.4) for no breastfeeding; 15.9 (6.5) for >0–6 months; 13.9 (6.2) for >6–12 months; 13.7 (6.3)
for >12–18 months; 14.6 (6.7) for >18–24 months; and 14.3 (6.8) for >24–36 months. Using
quantile regression, we determined that of the various conditional quantiles of the predicted total
NutriSTEP score, only children with the highest score (in the 99th quantile) appear qualitatively
different, showing a decrease in predicted total NutriSTEP score with breastfeeding beyond 12
months; however, given this quantile is represented by a small group, this estimate may not be
reliable (Figure 2).
Findings based on segmented regression for the NutriSTEP dietary intake and eating behavior scores mirrored those of the total NutriSTEP score (Table 2). We found a significant decrease in sugar-sweetened beverage consumption for the 0–6 month (β= -0.07; 95% CI: -0.10, -0.04) and a borderline significant decrease for the >12–18 month (β= -0.03; 95% CI: -0.06, -0.01) total breastfeeding duration intervals. We also found a significant decrease in sweet-savory snack consumption only for the >6–12 month (β= -0.02; 95% CI: -0.04, -0.02) total breastfeeding duration interval (Table 3). Statistically significant covariates associated with increased nutrition risk and increased sugar-sweetened beverage and sweet-savory snack consumption included: older child age, more bottle use in bed, older minimum age complementary food was introduced, non-European maternal ethnicity, lower maternal education. Lower neighborhood household income was significantly associated with increased nutrition risk and increased sugar-sweetened beverage consumption (Supplemental Tables 1 and 2).
We examined nutrition outcomes at 3 to 5 years of age in children with breastfeeding durations ranging from 0 to 36 months. We found that breastfeeding for up to 12 months was associated with decreased nutrition risk and healthier dietary intake including decreased sugar-sweetened beverage consumption and healthier eating behaviors. Our findings support recommendations that infants continue breastfeeding to 12 months (2-4). However, we found insufficient evidence of additional benefit in later nutrition outcomes by continuing to breastfeed beyond 12 months of age.

Our study objectives and methods were most similar to those of Perrine et al. who examined data from 1,355 US children participating in the Infant Feeding Practices Study II (16). They concluded that breastfeeding is associated with healthier dietary intake at 6 years of age; water, fruit, and vegetable consumption were positively associated, and sugar-sweetened beverage intake was inversely associated with breastfeeding duration. There are several similarities between our study and the study by Perrine et al. (16), specifically: examination of the association between breastfeeding duration and later nutrition outcomes; inclusion of families with higher education and income than in the general population; and, inclusion of important covariates such as maternal age, ethnicity, education, marital status, income, and child age, birth weight and number of siblings. There are also differences from our study. First, Perrine et al. (16) categorized breastfeeding duration and the final category was an open ended category of ≥12 months; we examined breastfeeding duration as a continuous variable up to 36 months. They measured nutrition outcomes using a dietary screener that had not been formally validated for their age group; we used a validated screening tool of nutrition risk (24). Finally, for their analyses, they used logistic regression; we used RCS modeling and segmented linear regression.
to examine the nonlinear relationship between breastfeeding duration and later nutrition outcomes. These similarities and differences may explain why both studies found a positive association between breastfeeding duration and nutrition outcomes up to 12 months of age; however, in our study we found no evidence of additional benefit beyond 12 months of age.

Other investigators examined the relationship between breastfeeding and later childhood nutrition outcomes. In a national sample of 2 to 8 year old Australian children, higher scores indicating a healthy, meat and vegetable dietary pattern were associated with ever breastfed versus never breastfed (14). A study involving data from four European cohorts found that breastfeeding duration was positively associated with fruit and vegetable intake in 2 to 4 year old children (15). However, the longest breastfeeding duration category examined was ≥6 months.

Some investigators examined longer durations of breastfeeding and later childhood nutrition or eating behavior outcomes. Soldateli et al. (17) undertook a secondary analysis of data from a randomized trial conducted in Brazil with outcomes assessed in children at 4 to 7 years. Vegetable consumption was positively associated with breastfeeding for 12 months or longer compared with less than 12 months, but fruit consumption was not. In an observational analysis of data from the Promotion of Breastfeeding Intervention Trial (PROBIT) conducted in Belarus with outcomes assessed in children aged 11 years, problematic eating attitudes were inversely associated with longer durations of breastfeeding, although the statistical test for trend was weak (18). However, for all of these studies, the longest duration of breastfeeding examined was an open-ended category of ≥12 months.

Recognizing the gap in research on feeding practices in the second and third years of life (1), our team has undertaken previous research focusing on this age group. We have found that children breastfed for more than 1 year had lower iron status, lower vitamin D status, and an
increased risk of dental caries (33-35). Taken together, these findings suggest that ongoing research targeting this age group is important.

Although not examined directly in our study, previous investigators have explored mechanisms to understand the relationship between infant feeding practices, such as breastfeeding and bottle feeding, and toddler food preferences and eating behaviors that ultimately influence growth and nutritional trajectories. Feeding directly at the breast may improve infants’ ability to self-regulate milk intake and develop appetite cues, in contrast to the tendency toward bottle emptying for bottle fed infants (1, 36, 37). In addition, infants fed breast milk may develop broader food preferences due to familiarization with a variety of food flavours from early experiences with their mother’s milk, whereas formula fed infants are only familiar with formula flavors (1). It is also possible that maternal health beliefs influence breastfeeding initiation and later feeding practices. These mechanisms, linking breastfeeding to improved outcomes, may be prominent in the first year of life. However, in the second year of life, as children transition from milk feeding to family-based table food, other mechanisms are at play.

Parent use of ‘food to soothe’ infant distress has been postulated as valid construct (38, 39). Mother-reported use of feeding to soothe at 6 months has been shown to be associated with longer duration of breastfeeding as compared with mothers who reported little or no use of feeding to soothe (39). It is possible that the practice of feeding to soothe beyond 12 months (by either direct feeding at the breast or bottle feeding) may disrupt self-regulatory eating behaviors and the development of healthy appetite cues, leading to poorer nutritional status.

Strengths of our study include the large sample of children (a total of 2987), including 1058 children with breastfeeding duration between 12 and 36 months. In our study, we examined breastfeeding duration as a continuous variable rather than as an open-ended category of >12
months and used nonlinear statistical methods to visually describe the relationship between total breastfeeding duration and nutrition risk. In addition, we adjusted for a number of potential confounding variables in our analyses. Our primary outcome was the NutriSTEP, which was developed and validated in a population of multicultural Canadian children, similar to those participating in our study (24). Our study has limitations. First, we measured total breastfeeding duration by parental self-report, which may be subject to recall error. However, a review of several studies found maternal recall to be a valid and reliable estimate of breastfeeding duration (23). In addition, our analytical approach examining breastfeeding duration by specifying 6-month total breastfeeding duration intervals is less likely to exhibit measurement error due to recall. Furthermore, national surveys in Canada and the United States have used similar questions (40, 41). Second, while the total NutriSTEP score (our primary outcome) was validated and a score > 20 indicates that a child is at nutrition risk (24), NutriSTEP dietary intake and eating behavior subscores (secondary outcomes) and their respective cut points have not been validated. However, cut points of (>7/24=30%) and (>6/20=30%) for each of the subscores use a similar weighting (>20/68=30%) as the total NutriSTEP score. Third, this study was cross-sectional, and hence causality cannot be determined. Finally, our study participants recruited from primary care practices in Toronto may not be representative of children in other settings; however, the level of education and income in our cohort is similar to women of childbearing age in Toronto (42). Additionally, the prevalence of nutrition risk was similar to another Canadian study of this age group (24). The mean total breastfeeding duration in our study was 11 months. While there is a paucity of current national data on total breastfeeding duration, the Canadian Maternity Experiences Survey (2006) and the US Infant Feeding Practices Study II
(2005-2007) found that about half of 6 month old infants continue to receive breast milk, suggesting that our study findings are relevant to a large number of infants (43, 44).

Conclusion

We found that breastfeeding for up to 12 months was associated with decreased nutrition risk, healthier dietary intake and healthier feeding practices in children 3 to 5 years of age. However, we found insufficient evidence of additional benefit for breastfeeding beyond 12 months of age. Our study is the first to examine for a nonlinear relationship between total breastfeeding duration up to 36 months of age and later nutrition outcomes. These findings need to be replicated to identify the duration which maximizes the benefits of breastfeeding.
Acknowledgments

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Conflict of Interest (COI) Statement: PCP reports receiving a grant from the Hospital for Sick Children Foundation during the conduct of the study. PCP reports receiving the following grants unrelated to this study: a grant from Canadian Institutes of Health Research (FRN # 115059) for an ongoing investigator-initiated trial of iron deficiency in young children, for which Mead Johnson Nutrition provides non-financial support (Fer-In-Sol® liquid iron supplement) (2011-2017); and peer-reviewed grants for completed investigator-initiated studies from Danone Institute of Canada (2002-2004 and 2006-2009), Dairy Farmers of Ontario (2008-2010). CMB reports previously receiving a grant for a completed investigator-initiated study from the Sickkids Centre for Health Active Kids (CHAK) (2015-2016) involving the development and validation of a risk stratification tool to identify young asymptomatic children at risk for iron deficiency. JLM reports receiving an unrestricted research grant for a completed investigator-initiated study from the Dairy Farmers of Canada (2011-2012). PDW reports that he is an international lactation consultant certified by the International Board of Lactation Consultant Examiners. These agencies had no role in the design, collection, analyses or interpretation of the results of this study or in the preparation, review, or approval of the manuscript. DWHD, JAJ, KAC, CSB, CM report no conflicts of interest.
Authors’ Contributions

CMB, JAJ and PCP designed research; JAJ, PDW, KAC, JLM, CSB, and CM conducted research; CMB and PCP analyzed data; DWHD performed the statistical analysis; CMB and PCP wrote the paper; PCP had primary responsibility for final content. All authors read and approved the final manuscript.
REFERENCES


42. Statistics Canada. Median total income, by family type, by census metropolitan


Table 1. Characteristics of study participants, 3 to 5 years old\textsuperscript{1}

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n=2987, No. (%) or Mean ± SD</th>
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<td><strong>Child characteristics</strong></td>
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<td>Age, mo</td>
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<td>Birthweight, kg</td>
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<td>Never</td>
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</tr>
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<td>Occasionally or most of the time</td>
<td>300 (10.8)</td>
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<td>Age complementary food introduced, months</td>
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<td>Number of siblings</td>
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</tr>
<tr>
<td>African/Caribbean/Latin American</td>
<td>202 (7.0)</td>
</tr>
<tr>
<td>Other\textsuperscript{2}</td>
<td>176 (6.1)</td>
</tr>
<tr>
<td>Maternal Education</td>
<td></td>
</tr>
<tr>
<td>College/University</td>
<td>2632 (90.2)</td>
</tr>
<tr>
<td>High school or less</td>
<td>286 (9.8)</td>
</tr>
<tr>
<td>Neighborhood household income, Can $\textsuperscript{3}</td>
<td>60,300 ± 27,200</td>
</tr>
<tr>
<td><strong>Total breastfeeding duration, months</strong></td>
<td>11.4 ± 8.4</td>
</tr>
<tr>
<td>None</td>
<td>236 (7.9)</td>
</tr>
<tr>
<td>&gt; 0 – 6 mo</td>
<td>700 (23.5)</td>
</tr>
<tr>
<td>&gt; 6 – 12 mo</td>
<td>993 (33.2)</td>
</tr>
<tr>
<td>&gt; 12 – 18 mo</td>
<td>654 (21.9)</td>
</tr>
<tr>
<td>&gt; 18 – 24 mo</td>
<td>237 (7.9)</td>
</tr>
<tr>
<td>&gt; 24 – 36 mo</td>
<td>167 (5.6)</td>
</tr>
<tr>
<td><strong>Nutritional outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>NutriSTEP total score</td>
<td>14.6 ± 6.5</td>
</tr>
<tr>
<td>&gt; 20 – 68\textsuperscript{4}</td>
<td>508 (17.0)</td>
</tr>
<tr>
<td>NutriSTEP dietary intake subscore</td>
<td>7.1 ± 3.3</td>
</tr>
<tr>
<td>&gt; 7 – 24</td>
<td>1236 (41.4)</td>
</tr>
<tr>
<td>NutriSTEP eating behaviors subscore</td>
<td>3.7 ± 2.2</td>
</tr>
<tr>
<td>&gt; 6 – 20</td>
<td>306 (10.2)</td>
</tr>
<tr>
<td>Sugar-sweetened beverage consumption, cups</td>
<td>1.2 ± 1.3</td>
</tr>
<tr>
<td>Sweet-savoury snack consumption, servings</td>
<td>0.8 ± 0.9</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Numbers may not add to the total due to missing values
\textsuperscript{2}Other includes: Canadian Aboriginal, Oceania, mixed ethnicity, unknown: child is adopted
\textsuperscript{3}Can $ = Canadian dollar
"cut-point indicating moderate (21–25) to high (26–68) nutrition risk"
<table>
<thead>
<tr>
<th>Predictor</th>
<th>Total NutriSTEP Score</th>
<th>Dietary Intake</th>
<th>Eating Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>P Value</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>Total breastfeeding duration:2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–6 mo</td>
<td>-0.14 (-0.29, 0.004)</td>
<td>0.057</td>
<td>-0.06 (-0.14, 0.15)</td>
</tr>
<tr>
<td>&gt;6–12 mo</td>
<td>-0.20 (-0.33, -0.07)</td>
<td>0.002</td>
<td>-0.08 (-0.15, -0.01)</td>
</tr>
<tr>
<td>&gt;12–18 mo</td>
<td>0.09 (-0.07, 0.24)</td>
<td>0.27</td>
<td>0.02 (-0.07, 0.10)</td>
</tr>
<tr>
<td>&gt;18–24 mo</td>
<td>0.02 (-0.18, 0.21)</td>
<td>0.87</td>
<td>0.03 (-0.08, 0.13)</td>
</tr>
<tr>
<td>&gt;24–36 mo</td>
<td>-0.01 (-0.16, 0.14)</td>
<td>0.88</td>
<td>-0.02 (-0.10, 0.06)</td>
</tr>
</tbody>
</table>

1Negative values indicate a decrease in nutrition risk, positive values indicate an increase in nutrition risk.
All models adjusted for age, sex, birthweight, bottle use in bed, minimum age in months that complementary food was introduced, number of siblings, maternal age, maternal ethnicity, maternal education, and median after-tax neighbourhood household income.
2β-coefficients are estimates for change in total NutriSTEP, dietary intake, and eating behaviors scores associated with each unit increase in 6-month breastfeeding duration interval.
Table 3. Segmented linear regression model for the association between total breastfeeding duration and sugar-sweetened beverage and sweet-savory snack consumption at 3 to 5 years (n=2987)\(^1\)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Sugar-Sweetened Beverage Consumption</th>
<th>Sweet-Savory Snack Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\beta) (95% CI)</td>
<td>(P) Value</td>
</tr>
<tr>
<td>Total breastfeeding duration: (^2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–6 mo</td>
<td>-0.07 (-0.10, -0.04)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>&gt;6–12 mo</td>
<td>-0.01 (-0.03, 0.02)</td>
<td>0.57</td>
</tr>
<tr>
<td>&gt;12–18 mo</td>
<td>-0.03 (-0.06, -0.01)</td>
<td>0.048</td>
</tr>
<tr>
<td>&gt;18–24 mo</td>
<td>-0.01 (-0.05, 0.03)</td>
<td>0.52</td>
</tr>
<tr>
<td>&gt;24–36 mo</td>
<td>0.03 (-0.01, 0.06)</td>
<td>0.08</td>
</tr>
</tbody>
</table>

\(^1\)Negative values indicate a decrease in nutrition risk, positive values indicate an increase in nutrition risk.
All models adjusted for age, sex, birthweight, bottle use in bed, minimum age in months that complementary food was introduced, number of siblings, maternal age, maternal ethnicity, maternal education, and median after-tax neighbourhood household income.
\(^2\)\(\beta\)-coefficients are estimates for change in sugar-sweetened beverage and sweet-savoury snack consumption associated with each unit increase in 6-month breastfeeding duration interval.
FIGURE TITLES AND LEGENDS

Figure 1. Participant flow chart

Figure 2. Quantile regression to examine the effect of total breastfeeding duration on quantiles of the total NutriSTEP score at 3 to 5 years (n=2987)

Adjusted [for child age, sex, birthweight, bottle use in bed, minimum age that complementary food was introduced, number of siblings, maternal age, maternal ethnicity, maternal education and median after-tax household income] quantile regression to examine the effect of total breastfeeding duration (x axis) on quantiles of the predicted total NutriSTEP score (y axis).