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Original article

Association of long-duration breastfeeding and dental caries estimated with marginal structural models

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A R T I C L E I N F O

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A B S T R A C T

Purpose: To estimate the association between breastfeeding 24 months or beyond and severe early childhood caries (S-ECC).

Methods: Within a birth cohort ($n = 715$) from low-income families in Porto Alegre, Brazil, the age 38-month prevalence of S-ECC (≥4 affected tooth surfaces or ≥1 affected maxillary anterior teeth) was compared over breastfeeding duration categories using marginal structural models to account for time-dependent confounding by other feeding habits and child growth. Additional analyses assessed whether daily breastfeeding frequency modified the association of breastfeeding duration and S-ECC. Multiple imputation and censoring weights were used to address incomplete covariate information and missing outcomes, respectively. Confidence intervals (CIs) were estimated using bootstrap resampling.

Results: Breastfeeding 24 months or beyond was associated with the highest adjusted population-average S-ECC prevalence (0.45; 95% CI, 0.36 to 0.54) compared with breastfeeding less than 6 months (0.22; 95% CI, 0.15 to 0.28), 6–11 months (0.38; 95% CI, 0.25 to 0.53), or 12–23 months (0.39; 95% CI, 0.20 to 0.56). High-frequency breastfeeding enhanced the association between long-duration breastfeeding and caries (excess prevalence due to interaction: 0.13; 80% CI, −0.03 to 0.30).

Conclusions: In this population, breastfeeding 24 months or beyond, particularly if frequent, was associated with S-ECC. Dental health should be one consideration, among many, in evaluating health outcomes associated with breastfeeding 24 months or beyond.

Introduction

The World Health Organization (WHO) recommends continued breastfeeding up to age 2 years or beyond [1], and failure to breastfeed is associated with poor health consequences for both mother and child [2,3]. However, the nature of the relationship between dental caries and the age to which children are breastfed remains uncertain. Caries is among the most common diseases worldwide and often goes untreated, particularly in low-resource settings [4–6], with negative quality of life implications [7]. Some laboratory models suggest that human milk can cause caries [8,9], particularly in combination with added sugars [10], whereas some report no demineralization of tooth material by human milk alone [11]. The epidemiologic literature [12] includes studies that support a positive association between long-duration breastfeeding and early childhood caries (ECC) [13–16] and others that do not [17,18].

Breastfeeding timing relative to other feeding habits complicates study of breastfeeding duration and ECC. Early breastfeeding cessation might accelerate the introduction of particular foods [19,20], and the foods consumed early in life likely influence caries development [21–23]. In turn, early-life food experiences might also influence the duration to which a breastfeeding child continues nursing [19]. Regression modeling is problematic in the presence of such time-dependent confounding, in which a variable (e.g., early-life food experiences) can be part of a causal pathway between an earlier aspect of exposure (e.g., early breastfeeding) and the outcome, whereas simultaneously operating as confounder with respect to a later aspect of exposure (e.g., continued breastfeeding). Marginal structural models (MSMs), in contrast, have been used to make causal inference from observational data in the presence of time-varying covariates [24–28]. Such techniques are particularly relevant for exposures, such as breastfeeding, that cannot be easily assigned as a randomized intervention.

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We aimed to estimate the association between long-duration breastfeeding (≥24 months) and severe-ECC (S-ECC) in a birth cohort of urban, low-income Brazilian children. We hypothesized that long-duration breastfeeding is associated with greater caries occurrence. We secondarily hypothesized that the association between long-duration breastfeeding and S-ECC is stronger if daily breastfeeding episodes are more frequent.

Methods

Participants

We followed a birth cohort nested in a cluster-randomized trial in Porto Alegre, Brazil. The community water supply is optimally fluoridated [29], and 52 public health care centers provide primary medical services predominantly to low-income residents. A stratified random sample ($n = 20$ health centers) was selected from 31 eligible clinics for participation in the original trial of health care worker training [30,31].

In 2008, 715 of 736 eligible pregnant women with appointments at participating clinics agreed to enroll their children in a cohort to track health outcomes (Fig. 1). The trial had provided intervention clinics with health care worker training that promoted healthful infant complementary feeding for incorporation into maternal counseling. After 3 years, the intervention did not extend the total duration of breastfeeding (hazard ratio for breastfeeding cessation, 0.94; 95% confidence interval, 0.79 to 1.11), although the mean duration of exclusive breastfeeding was increased [30]. S-ECC was not lowered significantly among children born to intervention group clinic attendees [31].

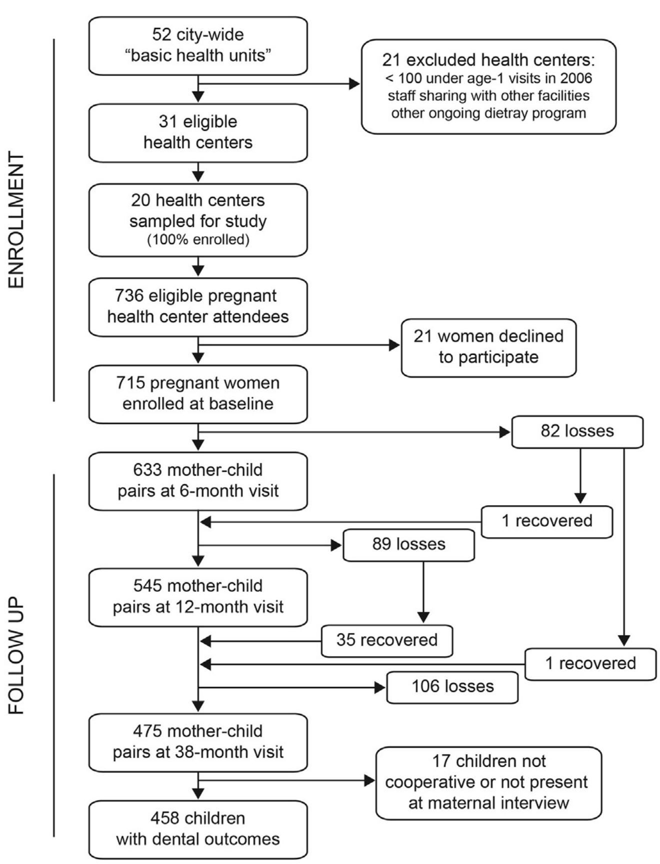

Fig. 1. Flow of participants. Pregnant women were recruited from 20 municipal health centers in the city of Porto Alegre, Brazil and followed to a mean child age of 38 mo.

Baseline variables

Trained fieldworkers collected baseline (during pregnancy) sociodemographic information via structured questionnaires. Data included maternal age, household size, maternal education (≤8 years), maternal smoking (current vs. never/former smoker), indoor bathroom (yes/no), city region (indicators for eight geo-administrative districts), parity (first child yes/no), maternal partner status (married or partnered vs. single, separated, or widowed), household income (≤1500 Brazilian reais monthly; approximately $900 US in 2008), outside income source (e.g., government support), social class (Brazilian Association of Economic Research Institutes classification ≤ C), and low body mass index (BMI) (≤18, based on measured height and self-reported pre-pregnancy weight). Child sex and birth date were collected at age 5–9 months.

Time-varying behaviors and anthropometry

Infant growth and feeding habits were recorded at each of three home visits, corresponding to mean ages of 6 months (range: 5–9), 12 months (range: 11–15), and 38 months (range: 31–46). Infant length and child height were collected following standard protocol and converted to height/length-for-age Z-scores using WHO standards [32]. At each visit, mothers were asked whether they had ever breastfed and whether they were currently breastfeeding. Breastfeeding duration represented the age to which any breastfeeding continued, regardless of complementary feeding. Breastfeeding mothers were asked how frequently they nursed daily (0, 1, 2–3, or "many times," separately for day and night). Mothers no longer breastfeeding were asked at what age (in months) breastfeeding ceased.

At the 6-month assessment, the number of feeding bottles consumed in the preceding day was recorded (later categorized 0, 1–3, ≥4). Sugar in the bottle corresponded to consuming one or more bottle containing any sweet additive: table sugar, powdered or liquid artificial chocolate, soft drinks, or powdered artificial juice. Questionnaires addressed use of commercially prepared infant formula and the age of introduction of 32 specific foods (e.g., fruits, beans, soft drinks, candies). At the 12-month assessment, the questionnaire posed whether 29 specific items were consumed in the previous month and the weekly consumption frequency of five complementary foods (fruits, vegetables, beans, meats, organ meats). Two feeding indices measured dietary patterns to account for foods consumed in combination and to increase the efficiency of the analysis [33]. The indices were created specifically for this analysis due to a lack of existing diet indices specific to cariogenic feeding behaviors in comparable populations. The first, referred to here as the food introduction index, was the count of low nutrient-density and/or presumably cariogenic foods introduced before age 6 months: added sugar, candy, chips, chocolate, chocolate milk, cookies, fruit-flavored drink, gelatin, honey, ice cream, soft drinks, and sweet biscuits. The second, termed here as the first-year feeding index, summed the food introduction index with the count of the following foods recorded at the 12-month assessment: added sugar in a drink, candy, cake, chips, chocolate, chocolate milk, cookies, creamed caramel, fruit-flavored drink, gelatin, honey, ice cream, other confection, soft drinks, and sweet biscuits.

At the 38-month assessment, data were collected regarding bottle use, height-for-age Z-scores, and tooth brushing with fluoride dentifrice. Although these variables are likely associated with S-ECC, we did not consider them confounders because our cutpoint for defining the exposure (breastfeeding ≥24 months) temporally preceded these measures. However, we estimated separate models that included these variables as a sensitivity check.