# Association Between Bottle Size and Formula Intake in 2-Month-Old Infants 

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#### Abstract

Objective: To determine range of bottle sizes used and examine the relationship between bottle size and total daily consumption of infant formula. Methods: Cross-sectional analysis of baseline data collected as part of Greenlight, a cluster randomized trial to prevent childhood obesity at 4 pediatric resident clinics. The Greenlight study included healthy, term infants. For our analysis, parents of exclusively formula-fed infants reported volume per feed, number of feeds per day, and bottle size, which was dichotomized into small ( $<6 \mathrm{oz}$ ) or large ( $\geq 6 \mathrm{oz}$ ). We identified determinants of bottle size, and then examined relationships between bottle size and volume fed with log-transformed ordinary least squares regression, adjusting for infant age, sex, birth weight, current weight, race/ethnicity, and enrollment in Special Supplemental Nutrition Program for Women, Infants, and Children.


Results: Of 865 participants in the Greenlight study, $44 \%$ ( $\mathrm{n}=378 ; 21.8 \%$ white, $40.6 \%$ black, $35.3 \%$ Hispanic, $2.4 \%$ other) of infants were exclusively formula fed at 2 months. Median volume per day was 30 oz (interquartile range 12), and $46.0 \%$ of infants were fed with large bottles. Adjusted for covariates, parents using larger bottles reported feeding 4 oz more formula per day ( $34.2 \mathrm{oz}, 95 \%$ confidence interval 33.5-34.9 vs $29.7 \mathrm{oz}, 95 \%$ confidence interval $29.2-30.3, P=.03$ ).
Conclusions: Among exclusively formula-fed infants, use of a larger bottle is associated with parental report of more formula intake compared to infants fed with smaller bottles. If infants fed with larger bottles receive more formula, these infants may be overfed and consequently at risk for obesity.
Keywords: bottle size; formula feeding; infant growth
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## What's New

Larger bottle size is associated with more reported formula intake over a 24 -hour period. If infants fed with larger bottles are prone to be overfed and thus at risk for obesity, reducing bottle size may be an intervention to prevent obesity.

RAPID WEIGHT GAIN in the first year of life has been associated with later obesity and cardiovascular risk, even after adjusting for birth weight, breast-feeding, gestational weight gain, maternal body mass index, and maternal smoking. ${ }^{1-9}$ Risk of rapid infant weight gain may be influenced by birth weight, discordance between the infant's feeding cues and the parents' feeding behavior, early introduction of complementary foods, increased protein content of formula, and other factors. ${ }^{10-12}$ Breast-fed infants demonstrate weight gain trajectories distinct from infants who
are primarily bottle fed, ${ }^{13,14}$ and exclusive breast-feeding may be protective against obesity. ${ }^{15-17}$ Infant weight gain may depend on the mode of feeding (breast or bottle) rather than the type of milk given, and evidence suggests growth patterns of infants fed expressed breast milk via bottle may be similar to infants fed formula. ${ }^{18}$ The rate and volume of intake during bottle feeding is inherently more parent-directed and may promote overfeeding, leading to rapid weight gain and increasing the risk of obesity. ${ }^{19,20}$ Despite this potential risk, little is known regarding feeding behaviors among infants who are exclusively bottle fed.

An emerging body of literature relates food container size to volume consumed in both adults and children. ${ }^{21-24}$ A group of low-income, ethnically diverse children requested and consumed more cereal when served with a large bowl compared to a small bowl. ${ }^{21}$ A similar mechanism linking container size with volume may also exist among infants fed with bottles, yet despite marketing of
bottle sizes from 2 oz to over 10 oz , there is no consistent guidance available from clinicians as to appropriate size. Little is known about the relationship between bottle size and infant feeding, but using a bottle may encourage parents to finish a feed despite infant satiety, and using a larger bottle may encourage preparation of feeds that are larger in volume.

If bottle size relates to the amount of formula fed to infants, adjusting bottle size may be a way to decrease overfeeding and waste and prevent rapid infant weight gain and obesity. To our knowledge, no prior studies have evaluated the relationships between bottle size, volume of intake, and growth patterns in bottle-fed infants. We aimed to describe bottle size used at the 2-month well-child visit in exclusively formula-fed infants in a large cohort study and to examine if there was an association between bottle size and volume of formula intake. We hypothesized that caregivers who used larger bottles would feed their infants more formula per day.

## Methods

We performed a cross-sectional analysis of survey data from the Greenlight Intervention Study. The Greenlight study is a previously described cluster randomized trial of an obesity prevention intervention targeting children during their first 2 years of life. ${ }^{25}$ Four universityaffiliated pediatric clinics were randomized to either obesity prevention or injury prevention as an active control. Parent-infant dyads were followed from 2 months of age through 2 years of age, starting December 2009 and ending June 2014. Children were included in the Greenlight study if they presented for their 2-month well visit between 6 and 16 weeks of age and if caregivers spoke English or Spanish and agreed to participate until the child reached 2 years of age. Of the 1805 dyads assessed for eligibility, 632 were excluded, mainly for caregiver age, language (not English or Spanish), or plans to move outside the study area (Figure). We obtained written and verbal consent from parents according to the institutional review board procedures of each of the 4 sites. Data were managed through secure Research Electronic Data Capture (REDCap) ${ }^{26}$ hosted at Vanderbilt University.

For this analysis, we used responses from a questionnaire of caregivers reporting on feeding and physical activity. Exposure and outcome variables were part of a previously


Figure. Eligibility and enrollment flow.
reported questionnaire developed through synthesis of the literature and iterative review by content experts in measurement and in pediatric obesity. The instruments were translated by an advisory committee composed of 4 native Spanish-speaking members representing 4 nations in Latin America, who reached consensus on the appropriate terminology. ${ }^{27}$ The survey was administered in English or Spanish at the time of the child's 2-month well-child check once each clinic had been randomized but before any intervention. Parents answered "What type of milk does your child drink now?" with "formula only," "mostly formula and some breast milk," "mostly breast milk, but some formula," "breast milk only," or "both equally" as options. We limited our sample to include only infants whose caregivers responded "formula only." Infants who were currently fed from the breast in any amount were excluded because total volume could not be measured, and although infants fed expressed breast milk via bottle may exhibit similar feeding characteristics, we did not collect specific information regarding this subgroup.

Our main outcome was reported total amount of formula fed each day, which was calculated by taking the product of caregivers' responses to 2 questions: "In the past 24 hours, how many times was your child fed infant formula?" and "How much formula do you usually give your child at each feeding?" Our main exposure measure was bottle size. At the time of measurement, we asked parents if they had a bottle that represented the bottle they typically use to feed their child. If parents did not bring their bottles to the clinic ( $2 \%$ of sample), they chose a sample bottle of 4,6 , or 8 oz as "most like the one" used to feed the infant. For analysis, we dichotomized bottle size into large ( 6 oz or more) and small (less than 6 ounce) bottles, as a 2-monthold infant of average size would be expected to take no more than 6 oz every 3 to 4 hours. ${ }^{28}$

To assess for confounding, we examined the infant's birth weight, sex, and age in weeks, caregiver's race/ethnicity, household income, and enrollment in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). We examined WIC enrollment as a dichotomous variable, with enrollment defined as the infant having received WIC formula or food within the past month. We created a combined race/ethnicity variable from separate questions about race and Hispanic/Latino ethnicity, resulting in 4 categories: Hispanic, black non-Hispanic, other non-Hispanic, or white non-Hispanic. Annual household income was reported in 5 categories: less than $\$ 10,000$; \$10,000-19,999; \$20,000-39,999; \$40,000-59,999; and $\$ 60,000$ and more.

We examined bivariate relationships between bottle size and potential confounders, number of feeds per day, volume per feed, and total volume per day with $t$ tests, chi-square and Wilcoxon rank sum tests as appropriate, and results from nonparametric tests were not significantly different that results from parametric tests. To identify characteristics associated with size of bottle used, we used logistic regression models to examine relationships between bottle size and potential confounding variables, including race, age, sex, birth weight, household income,

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