RESEARCH
Commentary

Concerns About Current Breast Milk Intake Measurement for Population-Based Studies

Lauren Thomas Berube, MS, RDN; Rachel Gross, MD, MS; Mary Jo Messito, MD; Andrea Deierlein, PhD, MPH; Michelle Katzow, MD; Kathleen Woolf, PhD, RDN

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ADVANCES IN BREASTFEEDING RESEARCH IN THE past 3 decades have provided evidence of associated health outcomes for both the mother and child.[1] As a result, several professional organizations promote exclusive breastfeeding as the optimal source of infant nutrition until 6 months of age.[2-4] Recently, the scope of breastfeeding research has expanded to identify associations between breastfeeding and several population health outcomes, such as nutritional status, growth and development, cognition, allergies and asthma, and other long-term health outcomes.[5,6] Findings are largely supported by studies that rely on maternal recall to compare outcomes based on breastfeeding status. However, many researchers want to quantify breast milk intake and assess dose-dependent benefits in combination-fed infants. Current approaches to measure breast milk intake by means of maternal recall are inconsistent and may inadequately estimate intake in combination-fed infants. Using such methodology may misclassify breast milk intake and lead to errors in assessing nutritional status or analyzing associations between breastfeeding and health outcomes throughout the lifespan. This commentary describes approaches used to measure breast milk intake by means of maternal recall, discusses concerns with these approaches, and suggests future directions.

CHALLENGE OF ESTIMATING MILK INTAKE BY MEANS OF MATERNAL RECALL

Estimating milk intake by means of maternal recall is challenging because actual intake from the breast is unknown, and breast milk composition and rate of transfer are variable from day to day, feed to feed, and mother to mother.[7-9] Other factors—including infant age, sex, and weight; use of bottles, pacifiers, and other devices; caregiver responsiveness and feeding style; and length of breastfeeding exclusivity and duration—are also thought to influence intake.[10-12] Accurate techniques to measure breast milk intake include test weighing (weighing the infant before and after each feeding) and the doubly labeled water method (giving the infant a small dose of water with two stable isotopes and collecting urine and saliva).[13,14] However, these approaches can be timely and costly, require training, and may not be appropriate for research studies with large sample sizes.[15] Instead, large interventions and observational studies rely on maternal recall in the form of a simple questionnaire or 24-hour dietary recall to estimate milk intake from the breast. Researchers must determine the best approach for collection and analysis of maternal recall, and available analytical approaches must provide consistent results.

BREASTFEEDING INTENSITY AND CATEGORICAL BREASTFEEDING DEFINITIONS

Breastfeeding intensity expresses breast milk intake as a ratio or percentage. In the 1988 National Maternal-Infant Health Survey, investigators created a lactation intensity ratio, ranging from 0 to 1, to estimate amount of breastfeeding; and several other studies use this approach to assess infant feeding by means of maternal recall.[16-21]

Breastfeeding intensity can be expressed as a ratio by using the following equation: *[Breast milk feeds on average over 24 hours/(Breast milk feeds+formula feeds+cow's milk feeds+other milk feeds on average over 24 hours)]*. It can also be expressed as a percentage (by multiplying the ratio equation by 100).

Breastfeeding intensity cannot provide estimates of milk volume or energy intake and only accounts for the number of feedings without distinguishing the volume consumed per feed or the energy density of the milk. However, for population-based research, this approach may be appropriate for assessment of dose-dependent benefits over time. In addition, breastfeeding intensity can be used to develop broader categorical breastfeeding definitions. Intensity can be dichotomized to the predominant form of milk feeding (ie, $<$75% to 80% of total milk feeds vs $\geq$75% to 80% of total milk feeds).[22] Alternatively, broad categories, such as combination-fed or partially breastfed, may be subdivided based on breastfeeding intensity as low ($<$20% of total milk feeds), medium (20% to 80%), or high ($>$80%).[23]

Categorical breastfeeding definitions can also be generated using simple screening questionnaires and differentiate among general breastfeeding behaviors. For example, exclusive breastfeeding, predominant/almost exclusive breastfeeding, or partial/any breastfeeding categories can be

defined from screeners based on specific guidelines from breastfeeding organizations, such as the World Health Organization.[23,24] Categorical definitions derived from screening questionnaires are limited by potential response bias and misclassification.[25] Mothers may inaccurately respond to screeners or feel pressured to report exclusive breastfeeding even if they cannot, or chose not to, accomplish this goal. In addition, despite attempts to make breastfeeding definitions more consistent, several studies use their own definitions, and there continues to be a push among researchers studying breastfeeding to create and follow more precise definitions. Finally, breastfeeding definitions cannot quantify intake or estimate energy intake from breast milk.

BREASTFEEDING VOLUME CALCULATIONS

Calculations apply standard coding amounts to estimate population-based breast milk intake. These calculations are not designed for measuring intake at the individual level. Rather, calculations are used to estimate average volume intake of a population, which can be converted to energy intake using food composition tables or dietary software programs.[26-28] Analyses of breast milk intake from observational studies—such as the Feeding Infants and Toddlers Study, the National Health and Nutrition Examination Survey, and the Avon Longitudinal Study of Parents and Children—use calculations to estimate breast milk volume by means of maternal recall based on infant age. Two calculations are currently used in research. The first assumes that formula replaces breast milk intake (Replacement Calculation), whereas the second assumes that formula is added to breast milk intake (Addition Calculation). In the following sections, these calculations are discussed, and information about their origins, limitations, and discrepancies is provided.

Replacement Calculation

The replacement calculation assigns a daily volume of milk for breastfed infants and assumes that other milks (ie, formula and expressed breast milk) replace breast milk intake. This calculation suggests that combination-fed infants naturally limit intake at the breast in response to receiving milk from another source. Breastfed infants aged 0 to 5.9 months are assigned 780 mL (26 fl oz) of breast milk per day, which is the Dietary Reference Intake for breast milk in infants younger than 6 months.[29] If the infant is fed any other milk, that amount is subtracted from 780 mL, and total volume from the breast is what remains.[30,31] If the total volume of other milk exceeds 780 mL, each reported breast feed is considered 89 mL (3 fl oz) of breast milk. Analyses of data from large national surveys, such as the National Health and Nutrition Examination Survey and the Feeding Infants and Toddlers Study, use this calculation to provide estimates of breast milk volume by means of maternal recall.[32-36]

This calculation is derived from a 1983 study by Dewey and Lonnerdal[30] and a 1993 study by Heinig and colleagues,[31] which assessed breast milk intake in exclusively breastfed and predominantly breastfed infants using test weighing in the home. Dewey and Lonnerdal[30] measured breast milk intake in 20 infants, and Heinig colleagues[31] measured breast milk intake in 73 infants. To measure breast milk intake, Dewey and Lonnerdal[30] collected 2-day test weights each month, without correcting for insensible water loss. Infants in the study by Heinig and colleagues[31] were weighed every 3 months over a 4-day period with correction for insensible water loss. Dewey and Lonnerdal[30] found an average breast milk intake of 787 mL/d over the first 6 months. The average corrected breast milk intake in the study by Heinig and colleagues[31] was 790.5 g/d over the first 6 months. Additional research confirms that average milk intake of exclusively breastfed infants is between 700 and 800 mL/d during the first 5 months of life.[37] In addition, a pooled analysis that assessed breast milk intake using the doubly labeled water method in 737 predominantly breastfed infants aged 0 to 24 months revealed the mean intake to be 780 mL/d.[38] Although this calculation is supported by other research and national guidelines for use in exclusively or predominantly breastfed infants, evidence is inconclusive as to whether combination-fed infants practice the same sort of consumption behavior and have a similar average breast milk intake.[39] This replacement calculation may misclassify the actual amount of breast milk consumed by potentially underestimating breast milk intake in combination-fed infants.

Addition Calculation

The addition calculation assigns an amount of milk per breast feed and adds other milk volume to breast milk volume. This calculation suggests that combination-fed infants do not limit intake at the breast in response to receiving milk from another source. This calculation assumes that infants younger than 6 months consume 125 mL (4 fl oz) of breast milk for each single feeding that lasts longer than 10 minutes. For feedings that last less than 10 minutes, a percentage of 125 mL is used to estimate total intake (eg, 12.5 mL/min).[40-42] The daily breast milk volume is calculated by totaling breast milk volume from single feedings and adding it to the volume of other milks. Analyses of the Avon Longitudinal Study of Parents and Children birth cohort used this calculation to descriptively analyze milk intake and inferentially assess the relationship between infant energy intake at 4 months and risk of childhood obesity.[43-45]

This calculation is based on a validated report showing that maximum breast milk intake for older infants (6 to 12 months) was 100 mL/feeding and findings from a 1988 study by Paul and colleagues[41] in which 3- and 4-month-old exclusively and predominantly breastfed infants were found to consume more milk per feed than older infants.[40-42] Paul and colleagues[41] measured breast milk intake of 48 infants younger than 6 months using 4-day test weighing at home without correction for insensible water loss. Mean breast milk volume per feed was approximately 146 mL in male infants and 136 mL in female infants. Based on these results, the volume of 125 mL is used in the calculation to adapt it to younger infants. Although the initial 100-mL volume was validated in older infants by comparing estimates by means of maternal recall to the doubly labeled water method, the 125 mL amount has not been validated in younger infants. Paul and colleagues[41] found that mean breast milk intake per day was 785 mL in male infants and 715 mL in female infants, which confirms the replacement calculation assumption in exclusively and predominantly male breastfed infants. The addition calculation may misclassify intake in both