Original Article

Maternal mental health and infant dietary patterns in a statewide sample of Maryland WIC participants

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Abstract

The study's objective was to examine the relation between maternal mental health and infant dietary intake. A cross-sectional, population-based telephone survey was employed within a statewide sample of Maryland Special Supplemental Nutrition Program for Women, Infants and Children participants. A 24-h diet recall was performed using the United States Department of Agriculture Automated Multiple-Pass Method. Analyses presented were based on 689 mother–infant pairs. Overall, 36.5% of mothers reported introducing solids to their infants early (<4 months of age), and 40% reported adding cereal to their infant's bottle. Among 0–6-month-old infants, higher infant energy intake was associated with symptoms of maternal stress [$\beta = 0.02$; confidence interval (CI): 0.01, 0.04], depression ($\beta = 0.04$; CI: 0.01, 0.06) and overall maternal psychological distress ($\beta = 0.02$; CI: 0.003, 0.03). With early introduction of solids in the model, the significant associations between infant energy intake and maternal stress and maternal psychological distress became marginal (P 's = 0.06–0.10). The association between infant energy intake and maternal depression remained significant ($\beta = 0.03$; CI: 0.01, 0.06). Among 4–6-month-old infants, intakes of breads and cereals were higher among mothers who reported more symptoms of stress ($\beta = 0.12$; CI: 0.04, 0.23), depression ($\beta = 0.19$; CI: 0.03, 0.34), anxiety ($\beta = 0.15$; CI: 0.02, 0.27) and overall psychological distress ($\beta = 0.04$; CI: 0.01, 0.07). Among 7–12-month-old infants, dietary intake was not related to mental health symptoms. Findings suggest poorer infant feeding practices and higher infant dietary intake during the first 6 months of age in the context of maternal mental health symptoms. Further research is needed to evaluate these effects on child dietary habits and growth patterns over time.

Keywords: mental health, feeding behaviours, infant/child nutrition.

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Introduction

There is strong evidence that poor maternal mental health affects child health and behavioural development through inconsistent parenting behaviours (Goodman & Gotlib 1999; Lyons-Ruth *et al.* 2000; Bosquet & Egeland 2001; Kendler 2001; Riley *et al.* 2009). Non-responsive feeding styles (e.g. lack of reciprocity between mother and child during meals,

including forcing or pressuring, overindulging, restricting or ignoring) are embedded within non-responsive parenting behaviours and can result in rapid weight gain and overweight/obesity in infants and children (Black & Aboud 2011; Hurley *et al.* 2011). Although symptoms of maternal stress, depression and anxiety have been associated with non-responsive feeding styles during infancy (e.g. forceful, restrictive, indulgent and uninvolved child-feeding

styles) (Farrow & Blissett 1999; Hurley *et al.* 2008a), whether they are also related to infant dietary intake is unknown.

Infancy presents unique stresses that can challenge overall maternal mental health and parenting (Bosquet & Egeland 2001). Infancy is also a period in which feeding behaviours and early dietary patterns are important to child growth and development and may affect preferences and eating habits later in childhood (Fox *et al.* 2004). Excess growth (e.g. rapid weight gain defined as ≥ 1 standard deviation change in weight-for-length *z*-score across infancy) among infants may be explained, in part, by the development of dietary patterns that result in high caloric intakes. Results from a national US survey of infant and toddler feeding practices have demonstrated that infants often receive solids before 6 months of age (in contrast to recommendations from the American Academy of Pediatrics), do not routinely consume fruits and vegetables, and consume more sweetened foods and beverages than recommended (Devaney *et al.* 2004; Ponza *et al.* 2004). These patterns may lead to the development of negative eating behaviours, low diet quality, increased caloric intakes and rapid weight gain during infancy.

We previously reported that symptoms of maternal stress, depression and anxiety were related to non-responsive child-feeding styles (Hurley *et al.* 2008a). Here, we examine whether maternal mental health symptoms of stress, depression or anxiety are related to dietary intake in children 0–12 months of age.

We hypothesised that infants of mothers who reported more symptoms of stress, depression or

anxiety would have higher dietary and nutrient intakes than infants of mothers who reported fewer symptoms of stress, depression or anxiety.

Material and methods

Study participants

The data set used in this analysis was derived from the population-based Maryland Infant Feeding Study (MIFS), collected between July of 2004 and July 2005. MIFS was a statewide survey designed to investigate the dietary patterns and nutritional status of Maryland Special Supplemental Nutrition Program for Women, Infants and Children (WIC) infants.

Maryland WIC provided MIFS with contact information for all WIC mothers with infants through 12 months of age. Study participants were randomly selected from the Maryland WIC population within strata based on infant age (0–4, 5–8 and 9–12 months), race/ethnicity (white, Hispanic and African American) and geographic location of residence (urban/peri-urban vs. rural/suburban). Study eligibility was limited to mothers at least 18 years of age and to those who acted as a primary caregiver and lived with the infant at least 50% of the time. Of eligible participants contacted, 65% participated, 24% refused and 10% failed to keep scheduled appointments (Hurley *et al.* 2008b). Study details are provided elsewhere (Hurley *et al.* 2008a,b).

In the current study, data on 79 (10%) participants were excluded because they did not have complete mental health and/or dietary data. Data on 13 partici-

Key messages

- Mothers who endorsed more mental health symptoms reported higher infant energy consumption during the first 6 months of life, particularly foods in the bread/cereal group; as compared with mothers who reported fewer symptoms. They were also more likely to introduce solid foods before 4 months of age and to add cereal to the infant's bottle.
- Further longitudinal research is needed to examine:
 - the directionality of the relations between maternal mental health symptoms and infant's nutritional status;
 - the mechanisms linking maternal mental health and children's nutritional status;
 - the role that maternal perceptions of infants' growth and/or temperament plays in maternal mental health and feeding behaviour; and
 - whether interventions targeting the prevention or treatment of mental health symptoms improve dietary and growth patterns of infants.

pants were excluded from analyses because energy intake was reported at three times above or below the estimated energy requirements. Five participants who had infants 13 months of age by the time of the interview were retained in the analysis. There were no differences among participants with or without complete data in race/ethnicity, maternal age, education, parity, marriage, and infant age, gender and birthweight.

Procedures

A cross-sectional telephone survey was conducted. A written description of the project was mailed to potential participants explaining that an interviewer would call to ask questions about their infant's eating patterns and behaviours and about their emotional well-being. An interviewer called and after obtaining informed consent, conducted the interview. All materials were written in English and Spanish. Six trained telephone interviewers (three bilingual) administered the survey in the participant's preferred language.

Study approval was obtained from the Maryland Department of Health and Mental Hygiene Institutional Review Board, the University of Maryland Institutional Review Board, and the Johns Hopkins Committee on Human Research. Verbal consent was obtained at recruitment. Mothers received a \$10.00-gift certificate and a list of health and social services.

Measures

Infant diet

Infant dietary intake was assessed via a 24-h dietary recall, using the US Department of Agriculture (USDA) Automated Multiple-Pass Method, 2.3 (AMPM) (USDA 2004a). The AMPM is a well-tested, computerised, 24-h dietary recall collection system linked to a comprehensive food and nutrient database (USDA 2004a). The dietary intake data were used to estimate intakes of energy, nutrients and food groups. The food group classifications used in the analysis were based on the 'Continuing Survey of Food Intakes by Individuals' (USDA 2004b) and the 'Feeding Infants and Toddlers Study' (USDA ARS

1998; Fox *et al.* 2004). Foods were classified as milk, breads or cereals, fruits, vegetables, meats, and snack/desserts. Given the absence of MyPyramid serving size recommendations for children less than 24 months of age, a 'single serving size' reference for each food group was estimated using the median intakes of each food group per meal within the current sample. The reference 'single serving size' was used to calibrate the daily portions consumed by converting actual intake into multiples of the reference.

Collected interviews were imported into Survey Net, a computer-assisted food coding system developed by the USDA (Raper *et al.* 2004). Coders were monitored to ensure quality and completeness. Inter-coder reliability was 0.93.

For exclusively breastfed infants less than 7 months of age, an intake of 780-mL breast milk per day was assumed, and for infants who had both breast milk and formula, the volume of formula consumed was subtracted from 780 mL to obtain an estimate of quantity of breast milk consumed (Heinig *et al.* 1993). For infants 7 months and older, the comparable quantity was 600 mL per day as the quantity of breast milk for those being fed no other milk than breast milk. As with younger infants, the volume of formula consumed was subtracted from 600 mL for infants who consumed both breast milk and other milk products to estimate the quantity of breast milk consumed. Among the 65% of mothers who ever breastfed, the duration of exclusive breastfeeding (defined by an infant who received only breast milk without any additional food or drink, including water) averaged 2.1 months, dropping over the first 6 months of life (23% at 3 months and 2.2% at 6 months) (Hurley *et al.* 2008b). In the current analysis, 25.4% of the mothers reported that they were at least partially breastfeeding at the time of the interview.

During the telephone survey, mothers were asked questions about the introduction of solids and adding cereal to the infant's bottle. Specifically, they were asked: (1) 'At what age did you first give your infant foods other than breast milk or formula'; and (2) 'Have you ever added cereal to your infant's bottle?' Early introduction of solid foods was defined as mothers who reported introducing any solid foods, in

addition to breast milk and/or formula, before 4 months of age.

Maternal depression

Maternal depressive symptomatology was assessed by adapting seven items from the 10-item self-report version of the Primary Care Evaluation of Mental Disorders Patient Health Questionnaire (Spitzer *et al.* 1999). The items measure feelings of hopelessness, loss of interest or pleasure in things, low self-esteem, sleep or eating disturbances, lack of concentration, and physical symptoms such as restlessness. A four-level Likert scale was used to represent the frequency of symptoms, ranging from 0 (not at all), 1 (several days), 2 (more than half the days) to 3 (nearly every day); scores were summed with higher scores indicating more depressive symptoms. The internal consistency reliability within the MIFS sample was 0.75.

Maternal anxiety

The 6-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory measures current feelings of apprehension, tension, nervousness and worry (Van Knippenberg 1990; Marteau & Bekker 1992). A 4-level Likert scale was used to represent the intensity of symptoms, ranging from 0 (not at all), 1 (somewhat), 2 (moderately so) to 3 (very much so); scores were summed with higher scores reflecting higher levels of anxiety. The internal consistency reliability within the MIFS sample was 0.79.

Maternal stress

The Perceived Stress Scale (PSS) measures perception of stress. In the current study, stress was measured with the 4 item PSS-4 (Cohen *et al.* 1983). A 5-level Likert scale was used to represent the frequency of symptoms, ranging from 0 (never), 1 (almost never), 2 (sometimes), 3 (fairly often) to 4 (very often); scores were summed with higher scores reflecting higher degrees of perceived stress. The internal consistency reliability within the MIFS sample was 0.70.

Overall maternal psychological distress

To measure overall maternal psychological distress, we created *z*-scores for each mental health summary score (given the differences in the Likert scales between the three psychological measures) and summed them, higher scores indicate more overall maternal psychological distress.

Data analysis

Analyses were conducted using Statistical Package for the Social Sciences (SPSS) version 20.0 (SPSS Inc., Chicago, IL, USA). Descriptive data analyses included frequencies, means, medians and range values for study variables. To deal with the non-normality of the data, the bread/cereal (age 0–3, 4–6 and 7–13 months), energy (age 0–6 months) and vitamin C (age 0–6 months) variables were log transformed ($\log_{10}$), and the iron variable (age 0–6 months) was transformed using the square root function. Bivariate associations between background characteristics and the dependent and independent variables were tested to identify potential confounding variables. Associations between maternal mental health and dietary variables were tested using linear regression for continuous and logistic regression for dichotomous variables. Multivariate regressions models were examined, adjusting for potential confounding variables (e.g. infant age, gender, race/ethnicity and energy intake).

Nutrient intakes were stratified by infant age (0–6 vs. 7–12 months), recognising current infant feeding recommendations (Gartner *et al.* 2005) and the nutrient variation between a predominately human milk- and formula-based diet during the first half of infancy to one that includes a variety of complementary foods. In order to explore dietary patterns within common periods of weaning and the introduction to complementary foods, food group intakes of younger infants were further stratified (0–3, 4–6 months). For infants 0–6 months of age, the analyses examining bread/cereal intake were limited to those who had been introduced to solid foods and consumed breads/cereals in the past 24 h (0–3: *n* = 19, 4–6: *n* = 161). We assumed that the remainder had not been introduced

Table 1. Maternal and infant background characteristics*

	Overall (<i>n</i> = 689)
Maternal characteristics	
Mean age (SD)	27.0 (6.4)
Education category (%)	
<High school	20.3
High school or General Equivalency Diploma	33.9
>High school	45.8
Primiparous (%)	41.3
Married (%)	39.5
Currently breastfeeding (%)	25.4
Ever breastfed (%)	64.2
Stress (0–4) [†]	2.0 ± 0.78
Depression (0–3) [†]	1.3 ± 0.46
Anxiety (0–3) [†]	1.5 ± 0.56
Infant characteristics	
Mean age (months) (SD)	6.4 (3.3)
Race/ethnicity (%)	
White (%)	49.9
Hispanic (%)	14.2
African American (%)	35.8
Male infant (%)	52.5
Mean birthweight (g) (SD)	3272 (630)

SD, standard deviation. *Values presented are means + SD or %.

[†]Mental health scales, with the range of mean scale scores provided in parentheses.

to solid foods (0–3: *n* = 102, 4–6: *n* = 36) or had moved beyond breads/cereals (e.g. infant cereal) to more complex food (4–6: *n* = 31).

Results

Sample characteristics

Complete data were available for 689 mothers and infants (Table 1). Infants were stratified approximately equally by gender. Half (50%) were white, 36% were African American and 14% were Hispanic.

Thirteen per cent of mothers endorsed feeling symptoms of stress at least ‘sometimes’ during the past month; 13% reported experiencing depressive symptoms on ‘several days’ or more during the past 2 weeks; and nearly one-fourth (22%) reported feeling at least ‘somewhat’ anxious at the time of the interview. The maternal mental health measures were intercorrelated ($r = 0.55$ – 0.63 ; $P < 0.001$) and based

on categories specified earlier, 5% of mothers endorsed symptomatology for all three mental health variables. African-American mothers [$\beta = 0.17$, confidence interval (CI) = 0.04 – 0.30 , $P = 0.01$] reported significantly more symptoms of stress than white or Hispanic mothers. No other maternal characteristics (age, education, parity, marriage and breastfeeding status [current, initiation, or duration (exclusive and non-exclusive)] or infant characteristics (age, gender, birthweight, current weight, amount of formula consumed) were associated with any maternal mental health symptoms.

Description of infant dietary patterns

When compared with infant feeding recommendations, median usual intakes exceeded the recommendations for adequate intake for all nutrients for infants 0–6 (*n* = 349) and 7–12 (*n* = 340) months of age (Table 2), which may reflect the high use of infant formula in this sample (Devaney *et al.* 2004). In the previous 24 h, a majority (84.2%) of infants consumed solid foods (age 4–6 months). Among those consuming solids, 161 (83.8%) consumed cereal in the previous 24 h.

At the time of the interview, 16% (*n* = 19/121; between 0 and 3 months) and 71% (*n* = 161/228; between 4 and 6 months) of infants had consumed breads/cereals, 16% (*n* = 36/228; between 4 and 6 months) and 51% (*n* = 174/340; between 7 and 12 months) had consumed some type of dessert, salty snack or sweetened beverage (see descriptive statistics for other foods in Table 3). Overall, 36.5% of mothers reported introducing solids to their infants before 4 months of life (early introduction) and 40% reported adding cereal to their infant’s bottle. Mothers who reported adding cereal to their infant’s bottle were 4.2 times more likely to introduce solids before 4 months of age ($P < 0.001$).

Associations between maternal mental health and infant food intake

Among infants 4–6 months of age, higher intake (defined by total daily servings) of the bread and cereal group was statistically significantly associated

Table 2. Distribution of nutrient intakes for infants 0–6 and 7–13 months in the Maryland Infant Feeding Study ($n = 689$) *

Nutrients	Infants			Infants		
	0–6 months ($n = 349$)			7–13 months ($n = 340$)		
	AI [†]	Median	5th, 95th	AI [†]	Median	5th, 95th
Macronutrients						
Energy (kcal) [‡]	629 [‡]	670	462, 1136	739 [‡]	872	497, 1517
Protein (g d ⁻¹)	9.1	14.5	8.4, 26.6	11	21.1	9.1, 47.2
Carbohydrate (g d ⁻¹)	60	81.3	52.8, 148	95	121.9	62.8, 208
Fat (g d ⁻¹)	31	35.4	22.6, 53.3	30	33.6	17.7, 63.3
Micronutrients						
Vitamin A (mcg d ⁻¹)	400	564	407, 1043	500	61.7	279, 1382
Vitamin C (mg d ⁻¹)	40	84	40.6, 174	50	109	41.8, 257
Calcium (mg d ⁻¹)	210	550	260, 1228	270	637	246, 1293
Iron (mg d ⁻¹)	0.27	13.0	0.2, 33.3	11 [§]	16.5	3.9, 41.6
Zinc (mg d ⁻¹)	2	6.2	1.4, 11.0	3 [§]	6.7	2.1, 13.4

*Nutrients from breast milk are included based on estimates of consumption. [†]AI, adequate intake (National Academy of Sciences 2001).

[‡]Estimated energy requirement calculated based on infant gender, weight and feeding method (e.g. breast milk and/or formula intake) (FAO/WHO/UNU 2001). [§]Recommended Daily Allowance (National Academy of Sciences 2001).

Table 3. Distribution of daily intakes by food groups for infant 0–3, 4–6, and 7–13 months ($n = 689$)

	Infant age group (months)									
	0–3 (<i>n</i> = 121)				4–6 (<i>n</i> = 228)			7–13 (<i>n</i> = 340)		
	Single serving size*	<i>n</i> [†]	Median	5th, 95th	<i>n</i> [†]	Median	5th, 95th	<i>n</i> [†]	Median	5th, 95th
Food groups										
Milks [‡]	4.7 FO	121	5.6	4.4, 9.8	228	6.3	4.2, 10.7	336	5.0	1.7, 10.1
Breads/cereals	2.5 TB	19	0.34	0.03, 0.96	162	0.34	0.06, 2.5	310	1.5	0.1, 7.1
Vegetables	2.5 TB	2	–	–	104	1.6	0.22, 5.1	232	2.5	0.3, 7.2
Fruits	2.5 TB	3	–	–	133	2.0	0.45, 8.1	290	4.0	1.0, 11.3
Meats (proteins)	2.5 TB	1	–	–	21	1.3	0.02, 2.7	183	1.9	0.1, 6.4
Snacks/desserts	2.5 TB	1	–	–	36	1.3	0.09, 10.6	174	0.6	0.1, 5.6

FO, fluid ounces; TB, tablespoons. *A 'single serving size' reference (given the absence of MyPyramid serving size recommendations for children less than 24 months of age) for each food group was estimated using the median intakes of each food group per meal within the current sample. The reference 'single serving size' was used to calibrate the daily portions consumed by converting actual intake to multiples of the reference.

[†]Number of infants consuming at least once in a day. [‡]Breast milk included based on estimates of consumption.

with higher scores on maternal stress, depression and overall maternal psychological distress ($P < 0.05$), adjusting for infant age, gender and race/ethnicity (Table 4). For example (using the antilogarithm), for every 1 unit increase in the stress, depression or anxiety scale, the infant's bread/cereal consumption increased by a factor of 1.33–1.55 servings (e.g. intake increasing from 2.5 to 3.3 to 3.9 tablespoons). No significant relationships between infant food group intakes (milk, vegetables, fruits and snacks/desserts)

and maternal mental health were found for infants 0–3, 4–6 or 7–13 months of age (data not presented). Overall (0–12 months), maternal stress was positively associated with the early introduction of solids [odds ratio (OR) = 1.28; CI: 1.03, 1.59; $P = 0.02$] and with adding cereal to the infant's bottle (OR = 1.25; CI: 1.03, 1.52; $P = 0.02$). For every 1 unit increase in the stress, the likelihood of introducing solids before 4 months of age and of adding cereal to the infant's bottle increased by approximately 25%.

Table 4. Multivariate regression, adjusting for infant age, gender and race/ethnicity for infant bread/cereal intakes* with measures of maternal mental health stratified by age group (*n* = 689)

<i>n</i> **		Stress [†]		Depression [‡]		Anxiety [§]		Psychological distress [¶]	
		β	95% CI	β	95% CI	β	95% CI	β	95% CI
19	0–3 (<i>n</i> = 121)	0.34	–0.003, 0.67 [§]	0.17	–0.47, 0.81	0.27	–0.28, 0.82	0.07	–1.99, 0.39
161	4–6 (<i>n</i> = 228)	0.12	0.04, 0.23 ^h	0.19	0.03, 0.34 ⁱ	0.15	0.02, 0.27 ^j	0.04	0.01, 0.07 ^k
340	7–13 (<i>n</i> = 340)	0.01	–0.02, 0.03	0.01	–0.03, 0.04	–0.02	–0.05, 0.01	–0.001	–0.01, 0.01

CI, confidence interval. *Intake of breads/cereals was normalized using the common logarithm ($\log_{10}$) for children 0–3, 4–6 and 7–13 months of age. **Number of infant included those consuming breads/cereals in past 24 h (0–3, 4–6 months) and all infants 7–13 months of age. [†]Perceived Stress Scale. [‡]Primary Care Evaluation of Mental Disorders Patient Health Questionnaire. [§]Spielberger State-Anxiety Scale. [¶]Overall psychological distress-summed z-scores for each mental health summary score, higher scores indicate more overall maternal psychological distress. [§]*P* = 0.52; ^h*P* = 0.002; ⁱ*P* = 0.02; ^j*P* = 0.02; ^k*P* = 0.005.

Associations between maternal mental health and infant nutrient intake

Energy intake

Among infants 0–6 months of age, mothers who reported higher scores on stress, depression and overall maternal psychological distress reported higher infant intakes of energy (stress: β = 0.02; CI: 0.01, 0.04; *P* = 0.01, depression: β = 0.04; CI: 0.01, 0.06; *P* = 0.01, maternal distress: β = 0.02; CI: 0.003, 0.03; *P* = 0.02), adjusting for infant race/ethnicity. Further, we separately adjusted for the early introduction of solids and the addition of cereal to the infant's bottle because they were both related to maternal stress. With early introduction of solids in the model, the significant associations between infant energy intake and maternal stress and maternal psychological distress became marginally significant (stress: *P* = 0.10, maternal distress: *P* = 0.06). The association between infant energy intake and maternal depression remained significant (β = 0.03; CI: 0.01, 0.06; *P* = 0.02) as did all significant associations between maternal mental symptoms and infant energy intake, when adjusting for the addition of cereal to the infant's bottle.

Micronutrient intakes

Among infants 0–6 months of age, mothers who reported higher scores on stress, depression and overall maternal distress reported higher infant intakes of iron (stress: β = 0.27; CI: 0.06, 0.47; *P* = 0.01,

depression: β = 0.41; CI: 0.06, 0.76; *P* = 0.02, maternal distress: β = 0.21; CI: 0.03, 0.40; *P* = 0.03) and vitamin C (stress: β = 0.03; CI: 0.002, 0.05; *P* = 0.03, maternal distress: β = 0.02; CI: 0.001, 0.05; *P* = 0.04), adjusting for infant race/ethnicity. No significant associations were found between maternal mental health variables and vitamin A, calcium or zinc. After adjusting for infant energy intake, no significant associations were found between symptoms of maternal mental health and individual nutrient intakes.

No significant relationships between infant nutrient intake and maternal mental health were found for infants 7–12 months of age (data not presented).

Discussion

The findings of the current study suggest that maternal mental health symptomatology is associated with higher infant energy intake during the first 6 months of life, particularly foods in the bread/cereal group, early introduction of solids and incorporation of cereal in the infant's bottle. By-products of this increased consumption (e.g. often in the form of iron-fortified infant cereals) include higher intakes of some micronutrients, including iron and vitamin C. These results are particularly striking given the American Academy of Pediatrics' statement that breast milk and/or formula alone is recommended during the first 6 months of life (Gartner *et al.* 2005).

Maternal psychological distress, including symptoms of stress, depression and anxiety, is characterised by irritability, fatigue and lack of sensitive responsiv-

ity (NIMH 2012) and may increase mothers' desire for ease in caregiving. Maternal stress and anxiety may also be a response to perceived concerns regarding infant growth and/or temperament. Based on the transactional model of development (Sameroff 2009), maternal psychological distress may interfere with mothers' ability to recognise and interpret their infants' cues appropriately. Thus mothers may be more likely to respond to infant cries with food rather than other types of sensitive-responsive caregiving behaviours (e.g. talking, playing, etc.).

Two less than optimal feeding practices were associated with maternal mental health symptomatology. Adding cereal to the infant's bottle is reported in multiple populations in the United States, and research suggests that the practice is normative in some African-American populations and emanates from a desire to introduce solids early (before infants are developmentally ready to eat from a spoon), reduce infant crying and spit up, and to facilitate infant sleep (Bentley *et al.* 1999; Bronner *et al.* 1999; Corbett 2000). Further, the positive relation we found between maternal stress and infant energy intakes may be explained, at least in part, by the early introduction to solid foods. Further longitudinal studies are necessary to examine whether a mediating effect of early introduction to solids explains the relation between maternal mental health symptoms and infant energy intake. In addition, the relation between maternal mental health symptoms and infant dietary intake may reflect a relation previously described during pregnancy and adulthood suggesting that increased stress is associated with increased consumption of carbohydrates and breads and cereals among pregnant women (Hurley *et al.* 2005). Mothers who perceive or gain emotional benefit in this way may also perceive benefit for their infant.

Maternal mental health symptomatology was associated with dietary intake during the first but not the second half of infancy. There are several possible explanations. First, maternal stress was related to the early introduction of solids (often infant cereal) and adding cereal to the bottle, both of which occur primarily in the first half of infancy. Second, early on, mothers may be more stressed or their behavioural reactions to stress with respect to infant feeding may

be easier to detect (early introduction of solids). By 7 months of age, most infants consume a variety of commercial baby foods (Hurley & Black 2010), perhaps preventing detection of differences in dietary intakes by maternal mental health symptomatology. As infants experience the transition from baby foods to the family diet, differences may again be observed, thus further longitudinal studies are needed. Second, a single 24-h dietary recall is often not sufficient to describe an individual's usual intake of foods and nutrients (Gibson 2005). These issues would reduce the likelihood of detecting associations in general (Baranowski *et al.* 1999), but more so during later infancy when the number and types of food consumed increase. It should be noted that the estimated dietary intakes obtained for many food categories are consistent with published estimates from the Feeding Infant and Toddlers Study (Ponza *et al.* 2004).

Limitations that should be considered when interpreting these findings are: (1) measures of maternal mental health are brief symptoms screeners and do not suggest clinical diagnoses; and (2) representativeness to other low-income populations and the possibility of selection bias, given that 52% of the mothers in the sampling frame were never located and that 34% of those located either refused or failed to keep scheduled appointments. However, few demographic differences existed between the mothers and infants who participated and the mothers and infants who did not participate (Hurley *et al.* 2008a).

The current findings extend the sparse evidence that maternal mental health affects dietary intakes in early childhood (Ystrom *et al.* 2012). To date, most studies examining the relations between maternal mental health and infant nutritional status have been cross-sectional and conducted in low- and middle-income countries, with a finding that maternal depression is related to undernutrition (Surkan *et al.* 2011; Hurley *et al.* 2012). A few studies have linked maternal mental health symptoms to 'unhealthy' child dietary patterns (e.g. consumption of sugary foods of low nutritional value) (Ystrom *et al.* 2012) and with overweight/obesity (Surkan *et al.* 2008; Ertel *et al.* 2010). Thus, additional research is needed to better understand the relations between maternal mental health symptoms and infants' nutritional status. Three

types of future research needed include: (1) longitudinal studies to better understand the stability and directionality of the relations between maternal mental health symptoms and infants' nutritional status over time; (2) research examining the mechanisms (e.g. feeding behaviours and/or styles) linking maternal mental health and infants' nutritional status; and (3) the role that maternal perceptions of infants' growth and/or temperament plays in maternal mental health and feeding behaviour. Finally, intervention trials are needed to test whether interventions targeting the prevention or treatment of mental health symptomatology improve dietary patterns and growth outcomes of infants.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

KMH analysed and interpreted the data and wrote the initial draft of the paper. BCM provided statistical

guidance in data management and analyses. MMB and LEC assisted in the interpretation of results. All co-authors participated in the preparation of the paper and critically reviewed all sections of the text for important intellectual content.

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