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Maternal diet and breastfeeding: A case for rethinking physiological explanations for breastfeeding determinants

Lisa H. Amir [a,*], Susan M. Donath [b,c]

[a] Mother & Child Health Research, La Trobe University, VIC Australia
[b] Murdoch Childrens Research Institute, Melbourne, Australia
[c] Department of Paediatrics, University of Melbourne, VIC Australia

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ABSTRACT

Background: Although some authors explain determinants of breastfeeding that occur in a dose–response manner as evidence of causality, we argue that dose–response relationships are not proof of a biological relationship between the variables. The relationship between maternal smoking and breastfeeding and maternal obesity and breastfeeding are similar: increasing levels of smoking or obesity are associated with shorter duration of breastfeeding. However, maternal infant feeding intention is a strong predictor of breastfeeding duration.
Aims: In this paper we present data on another variable with a clear dose–response relationship with breastfeeding duration – maternal diet – as a case study to argue that a dose–response relationship does not imply causality.
Study design: Secondary analysis of cross-sectional survey.
Subjects: Nationally representative sample of 3544 singleton infants in Longitudinal Study of Australian Children, 2004.
Outcome measures: Maternal intake of fruit and vegetables; breastfeeding duration.
Results: Adjusted Odds Ratios (AOR) for breastfeeding at 6 months for daily maternal fruit and vegetable intake (reference group = no fruit/vegetables): 1 serve AOR 1.6 (95%CI 1.0, 2.6); 2 serves AOR 2.3 (1.5, 3.5); and 6 or more serves AOR 4.4 (2.8, 6.8).
Conclusions: Although higher maternal intake of fruit/vegetables is associated with longer breastfeeding duration, this is not a biological causal relationship. There are possible biological explanations for altered milk supply in women who smoke or are obese, but not for fruit/vegetable intake. We call for a broader understanding of the social determinants of infant feeding and suggest that all breastfeeding studies measure maternal infant feeding intention as an important determinant.

1. Introduction

Although some authors explain determinants of breastfeeding that occur in a dose–response manner as evidence of causality, we argue that dose–response relationships are not proof of a biological relationship between the variables. Among the well-known determinants of breastfeeding, socio-economic status, maternal age, education, obesity and smoking [1], several maternal characteristics have a dose–response like relationship to breastfeeding duration. Breastfeeding rates decrease as the number of cigarettes smoked by the mother increases [2] and as maternal body mass index (BMI) increases [3]. Some authors assume that the dose–response relationship indicates a physiological basis. Looking at the results of their meta-analysis of smoking and breastfeeding, Horta and colleagues concluded "Evidence such as that just described adds biological plausibility and coherence to the causal inference that maternal smoking increases the risk of early weaning…" [4 p. 305]; while Rasmussen concludes that the dose–response relationship between maternal BMI and early cessation of breastfeeding [5] provides "compelling evidence that a biological mechanism may underlie this association" [6 p. 113].

Although we do not rule out a possible physiological effect of maternal smoking or obesity on successful lactation, we have argued that maternal infant feeding intention is a major determinant of breastfeeding duration [3,7]. We have shown that women who smoke and women who are overweight and obese are less likely to *intend* to breastfeed and less likely to *commence* breastfeeding than non-smokers/normal weight women [3,7] — thus it is their lower level of breastfeeding intention rather than any physiological effect which is responsible for lower rates of breastfeeding. The effect of intention and smoking were clearly seen in data from the Avon Longitudinal Study of Parents and Children (ALSPAC): smokers with a strong intention to breastfeed were more likely to succeed at breastfeeding

* Corresponding author at: Mother & Child Health Research, La Trobe University, 215 Franklin St, Melbourne 3000, Australia. Tel.: +61 3 8341 8577; fax: +61 3 8341 8555.
E-mail address: l.amir@latrobe.edu.au (L.H. Amir).

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than non-smoking women with lower breastfeeding intentions [7]. The independent effect of intention was much stronger than the independent effect of smoking [7].

However, we may have been too cautious in our carefully worded conclusions:

- "Conclusion: Although there is consistent evidence that women who smoke breastfeed their infants for a shorter duration than non-smokers, the evidence for a physiological mechanism is not strong" [8 p. 45];
- "Therefore, it is likely that psychosocial factors are largely responsible for the lower rates of breastfeeding found in women who smoke compared to those who do not smoke". [2 p. 121];
- "There is evidence from epidemiological studies that overweight and obese women are less likely to breastfeed than normal weight women. The reasons may be biological or they may be psychological, behavioural and/or cultural." [3 p. 1].

It seems that some researchers continue to believe in simplistic physiological explanations regarding smoking – "reduction in smoking could address 11.9% of the prevalence of not initiating breastfeeding in this population" [9] (p. 1609) – and obesity – "Further understanding of these associations is needed because it remains unclear whether they are causal …" [10]. So, in this paper we present data on another variable with a clear dose–response association with breastfeeding duration – maternal diet – and use it as a case study to further our argument that the presence of a biological gradient does not imply a physiological cause. We conduct a secondary analysis of data on maternal fruit and vegetable consumption and rates of breastfeeding in Australian infants at six months, collected in a nationally representative sample.

One of the few studies we found in our literature search of "breastfeeding" and "maternal diet" or "mothers diet" was a study of 789 pregnant women in Leicester, UK [11]. Haslam and colleagues found that intention to breastfeed was associated with other "positive maternal health-related behaviours and beliefs". Women *intending* to breastfeed were less likely to smoke, more likely to have increased folic acid and vitamin intake [11].

The only study we found that has reported maternal diet and breastfeeding used data from the third US National Health and Nutrition Examination Survey (NHANES III); all mothers (n = 578) with children aged 3 or younger at the time of the interview, who breastfed, were included [12]. Seven health-enhancing behaviours were examined in a logistic regression analysis. Smoking < 100 cigarettes in a lifetime, consuming five or more fruits and/or vegetables daily, and visiting a dentist annually were significantly associated with breastfeeding among the mothers. Women who ate at least 5 fruits/vegetables per day had an adjusted odds of breastfeeding of 1.8 (95%CI 1.5, 2.9) [12].

2. Methods

The Longitudinal Study of Australian Children (LSAC) is being implemented by a large multidisciplinary research consortium lead by the Australian Institute of Family Studies [13]. During 2004, over 10,000 children and their families were recruited to the study from a sample selected from the Health Insurance Commission's (HIC) Medicare database [14]. The sample is broadly representative of all Australian children (citizens and permanent residents) in each of two selected age cohorts: children born between March 2003 and February 2004 (infants, n = 5000) and children born between March 1999 and February 2000 (children aged four to five years, n = 5000).

Written informed consent was obtained for each participating child, and the study was approved by the Australian Institute of Family Studies Ethics Committee.

The main data collection for Wave 1 was a face-to-face interview with the parent who knew the child best (Parent 1) [14]. In 97% of cases, Parent 1 was the biological mother. The final response to the recruitment of children in the infant cohort was 57% of those families who were sent a letter by the HIC.

This secondary analysis is based on 3544 singleton infants (from the infant cohort) for whom complete data were available for the following variables:

- maternal variables: SEIFA (Socio-Economic Indexes for Areas) is calculated from the Index of Relative Socio-economic Disadvantage (IRSED): based on area of residence of the child, includes measures of income, education and occupational status, based on data from the latest available census, in a collection district which, in urban areas, is roughly equivalent to a small group of suburban blocks or about 250 dwellings [15], age, education level, smoking in pregnancy, fruit and vegetable consumption;
- infant variables: type of delivery, ever breastfed, breastfeeding at 6 months.
- breastfeeding variables were derived from these questions: "Was child ever breastfed?" and "How old was child when he/she completely stopped being breastfed?" Thus, exclusive breastfeeding was not addressed, and some children were continuing to breastfeed at time of interview.
- maternal diet variables were calculated with the following questions: "How many serves of vegetables do you usually eat each day?" (A "serve" = 1/2 cup of cooked vegetables or 1 cup salad vegetables); "How many serves of fruit do you usually eat each day?" (A "serve" = 1 medium piece or two small pieces of fruit or 1 cup of diced pieces). The Australian Guide to Healthy Eating recommends that women aged 19–60 years eat 5 serves of vegetables, legumes and 2 serves fruit per day; for breastfeeding women, the recommendations are 7 serves of vegetables, legumes and 5 serves fruit [16].

2.1. Analysis

We used multivariable logistic regression, adjusted for maternal age, education, smoking, level of socio-economic disadvantage of the geographical location of the child's household and caesarean birth, to estimate the adjusted odds ratios of breastfeeding for at least 6 months for each additional daily serve of fruit or vegetables.

3. Results

The characteristics of the sample are presented in Table 1. Sixteen percent of the sample smoked during pregnancy, and 30% gave birth via Caesarean section. The mothers' intake of fruit and vegetables can be seen: only about 43% ate 2 or more serves of fruit and 5% ate the recommended 5 or more serves of vegetables daily.

The duration of breastfeeding is shown according to maternal fruit intake in Fig. 1, vegetable intake in Fig. 2, and total fruit and vegetable consumption in Fig. 3. Women who ate one serve of fruit or vegetables daily were more likely to continue breastfeeding than those who ate no fruit or vegetables. All figures show a clear increase in breastfeeding with each increase in serve of fruit or vegetables. Table 2 reports the proportion of women who initiated breastfeeding ("ever breastfed") and continued to breastfeed at three and six months postpartum, for each serve of fruit and vegetables consumed.

Women who ate two serves of fruit daily had an Odds Ratio of 2.6 (95%CI 2.1, 3.1) for breastfeeding at six months compared to women who ate no fruit. The effect of eating vegetables was even stronger: women who ate four or more serves of vegetables daily had an Odds Ratio of 5.4 (95% CI 3.8, 7.6) for breastfeeding at six months compared to women who ate no vegetables. See Table 3 for full list of Odds Ratios.

After using logistic regression to adjust for possible confounding variables (maternal age, education, SEIFA, smoking, Caesarean birth), all levels of fruit and vegetable intake remained statistically significantly

Table 1
Characteristics of sample (n = 3544).

Characteristics	N (%)
Maternal age (years)	
15–24	386 (11%)
25–30	1090 (31%)
31–34	1118 (32%)
35+	951 (27%)
Maternal education	
Did not complete secondary school	516 (15%)
Completed secondary school	527 (15%)
Certificate	867 (24%)
Diploma	360 (10%)
University degree	1245 (35%)
Other	30 (1%)
Population quintile of socioeconomic disadvantage (SEIFA index)	
Highest disadvantage quintile	562 (16%)
2nd quintile	757 (21%)
3rd quintile	713 (20%)
4th quintile	762 (21%)
Least disadvantage quintile	751 (21%)
Maternal smoking in pregnancy	
Any smoking in pregnancy	582 (16%)
Smoked <10/day in pregnancy	176 (5%)
Smoked 10–<20/day in pregnancy	281 (8%)
Smoked ≥20/day in pregnancy	123 (3%)
Maternal fruit intake (serves/day)	
None	732 (21%)
1	1275 (36%)
2	973 (27%)
3 or more	565 (16%)
Maternal vegetable intake (serves/day)	
None	210 (6%)
1	891 (25%)
2	1158 (33%)
3	788 (22%)
4 or more	498 (14%)
Maternal fruit/vegetable intake (serves/day)	
None	132 (4%)
1	319 (9%)
2	618 (17%)
3	677 (19%)
4	729 (21%)
5	503 (14%)
6 or more	567 (16%)
Method of birth	
Caesarean delivery	1055 (30%)
Breastfeeding	
Ever breastfed	3292 (93%)
Any breastfeeding at 3 months	2557 (72%)
Any breastfeeding at 6 months	2028 (57%)

associated with breastfeeding at six months. Adjusted Odds Ratios (AOR) for breastfeeding at six months for daily maternal fruit and vegetable intake (reference group = no fruit or vegetables): 1 serve AOR 1.6 (95%CI 1.0, 2.6); 2 serves AOR 2.3 (1.5, 3.5); 6 or more serves AOR 4.4 (2.8, 6.8) for breastfeeding at 6 months postpartum.

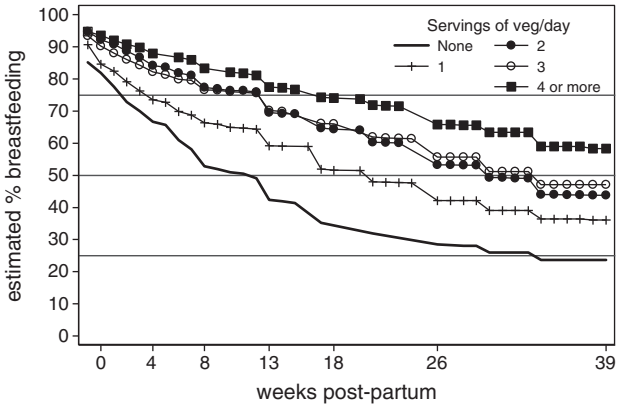

Fig. 2. Duration of breastfeeding by maternal vegetable consumption.

4. Discussion

A dose–response relationship refers to a defined biological effect in an exposed population [17 p. 54]. Last defines it as "the relationship of observed outcomes (responses) in a population to varying levels of a protective or harmful agents such as a medication or an environmental contaminant" [17 p. 54]. In general, it is accepted that a dose–response relation is one of the factors providing evidence of a biological relationship between two variables, and therefore causality [18–19]. However the relationship could also be caused by confounding [18]. Rothman and Greenland give the example of birth rank and Down syndrome: the biologic gradient is not causal: maternal age is the confounding factor [19].

We believe this is the first report of the relationship between maternal diet and duration of breastfeeding. This study shows a clear gradient in the odds of breastfeeding for six months as the maternal intake of fruit/vegetables increases: 1.6, 2.3, 3.5, 2.6, 3.7, 4.3 for 1 to 6 serves respectively, after adjusting for the available confounding factors. Only 27% of women who ate no fruit or vegetables continued breastfeeding for six months, compared to about 70% of women consuming 6 or more serves daily. Maternal infant feeding intention is likely to be the most important confounding factor. Unfortunately we do not have information on maternal infant feeding intention in this dataset, but would expect to see a much stronger relationship between breastfeeding intention and breastfeeding duration than for maternal diet and breastfeeding.

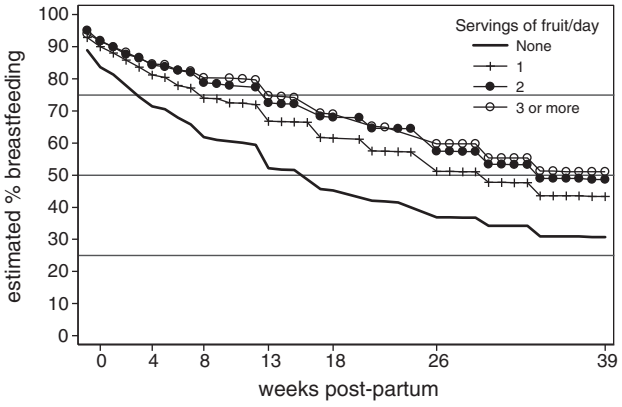

Fig. 1. Duration of breastfeeding by maternal fruit consumption.

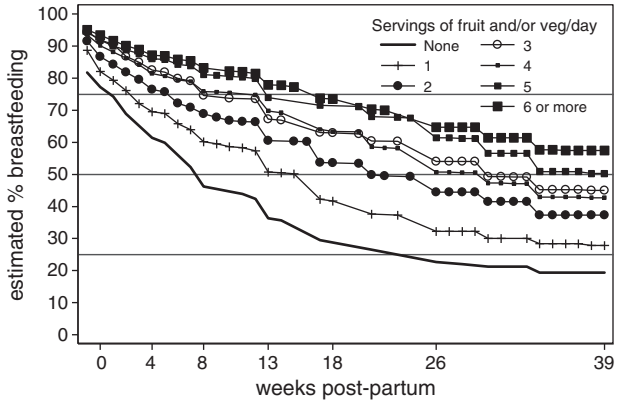

Fig. 3. Duration of breastfeeding by maternal fruit and vegetable consumption.

Table 2
Breastfeeding (ever, 3 and 6 months) by maternal fruit and vegetable intake.

	Ever breastfed (n = 3292)	Any breastfeeding at 3 months (n = 2557)	Any breastfeeding at 6 months (n = 2028)
	N (%)	N (%)	N (%)
Maternal fruit intake (serves/day)			
None	651 (89%)	436 (60%)	304 (42%)
1	1185 (93%)	918 (72%)	730 (57%)
2	925 (95%)	753 (77%)	627 (64%)
3 or more	531 (94%)	450 (80%)	367 (65%)
Maternal vegetable intake (serves/day)			
None	179 (85%)	103 (49%)	67 (32%)
1	808 (91%)	575 (65%)	425 (48%)
2	1097 (95%)	879 (76%)	696 (60%)
3	736 (93%)	596 (76%)	484 (61%)
4 or more	472 (95%)	404 (81%)	356 (71%)
Maternal fruit/vegetable intake (serves/day)			
None	108 (82%)	56 (42%)	35 (27%)
1	283 (89%)	184 (58%)	119 (37%)
2	566 (92%)	410 (66%)	305 (49%)
3	639 (94%)	498 (74%)	408 (60%)
4	682 (94%)	545 (75%)	424 (58%)
5	475 (94%)	402 (80%)	340 (68%)
6 or more	539 (95%)	462 (81%)	397 (70%)

We don't believe anyone would suggest that providing new mothers with a daily apple would increase the proportion of women maintaining breastfeeding. We argue that it is highly unlikely that this gradient is biological. Although Pesa and Shelton suggest that "The adequacy of the maternal diet may affect the formation, composition, or secretion of milk" [12 p. 123], it is generally accepted that maternal diet plays only a small part in successful lactation [20]. It would be over-simplistic to begin a programme to increase maternal fruit and vegetable intake in order to improve community breastfeeding rates.

It is well known that mothers have a strong influence on their family diet; young children are highly influenced by their home food environment [21–22]. The family food preparer is usually the mother and *her* intake of fruit and vegetables predicts family members' fruit/vegetable intake [23]. Therefore it is not surprising that mothers who are motivated to eat fruit and vegetables will also be motivated to breastfeed their infants.

Table 3
Effect of fruit and vegetable consumption on breastfeeding at 6 months.

	Unadjusted Odds ratio	Adjusted Odds ratio[a]
Maternal fruit intake (serves/day)		
None	1	1
1	1.9 (1.6, 2.3)	1.6 (1.3, 1.9)
2	2.6 (2.1, 3.1)	1.8 (1.4, 2.2)
3 or more	2.6 (2.1, 3.3)	1.9 (1.5, 2.4)
Maternal vegetable intake (serves/day)		
None	1	1
1	1.9 (1.4, 2.7)	1.7 (1.2, 2.3)
2	3.2 (2.4, 4.4)	2.4 (1.8, 3.4)
3	3.4 (2.5, 4.7)	2.4 (1.7, 3.4)
4 or more	5.4 (3.8, 7.6)	3.7 (2.6, 5.4)
Maternal fruit/vegetable intake (serves/day)		
None	1	1
1	1.6 (1.1, 2.6)	1.6 (1.0, 2.6)
2	2.7 (1.8, 4.1)	2.3 (1.5, 3.5)
3	4.2 (2.8, 6.4)	3.4 (2.2, 5.2)
4	3.9 (2.5, 5.8)	2.7 (1.8, 4.2)
5	5.8 (3.8, 8.9)	3.9 (2.5, 6.0)
6 or more	6.5 (4.2, 9.9)	4.4 (2.8, 6.8)

[a] Adjusted for maternal age, education, SEIFA, smoking, caesarean birth.

Going back to our systematic review of smoking and breastfeeding, we reported that smokers were less likely to intend to breastfeed, to initiate breastfeeding and to breastfeeding for shorter durations than non-smokers; with a relationship between heavier cigarette intake and lower breastfeeding rates [2]. However, in some populations, women who smoke have high rates of breastfeeding [24–25], which makes it unlikely that nicotine levels are directly responsible for the lower breastfeeding rates. Theoretically, nicotine could reduce milk supply and milk-ejection by restricting blood flow to the breast. One study in Chile found lower milk intake in infants of smokers [26], whereas a study in Sweden found no difference in milk intake between infants of smokers and non-smokers [27]. Hopkinson and colleagues found that smoking was a predictor of milk production in their study of seven smoking mothers of preterm infants, but smoking only accounted for 8% of the variability in milk production between 2 and 4 weeks, and infant feeding intention (apart from initiation) was not measured [28]. Mothers with low motivation to provide breast milk for their infants may be "going through the motions" of expressing, but may not be using techniques to enhance milk ejection that highly motivated mothers use. Indeed, Sisk and colleagues found that very low birth weight infants whose mothers were counselled to smoke as little as possible, but not discouraged from milk expression, were equally as likely to be breast milk fed as infants of non-smokers [29].

Likewise, in our review of obesity and breastfeeding, we found lower rates of breastfeeding as maternal BMI increased, yet breastfeeding is high in some populations where obesity is common, such as indigenous women in Canada [30]. To date, few studies have examined the possible physiological effects of obesity on lactation in humans [6,31]. The negative effects of maternal medical conditions (e.g. gestational diabetes, Caesarean birth, delayed first feed) need to be taken into account before the effect of obesity per se can be described. It would be useful to compare highly motivated women with high BMIs without diabetes or other medical conditions, with uncomplicated vaginal births and immediate skin-to-skin contact to similar women with normal BMIs.

The results from this paper strengthen our call for a broader understanding of the social determinants of breastfeeding [32]. We need to respect lay knowledge about infant feeding. It is not enough to convey the message that breastfeeding is better for babies: "this needs to be explored, evaluated and its meaning deconstructed in relation to particular contexts… race, class and ethnicity and highly significant in doing this." [33 p. 237] We need to acknowledge the barriers individuals face in taking up health promotion messages [33]. Health promotion needs to address health inequalities and work in communities on issues identified by communities themselves [33].

We believe the dose–response relationship between maternal diet and breastfeeding arises from social differences rather than biology; likewise the gradients between maternal smoking and breastfeeding and maternal obesity and breastfeeding are not necessarily biological or causal. Maternal infant feeding intention is likely to be an important confounding factor [34]. Unfortunately we do not have information on maternal infant feeding intention in this dataset, but would expect to see a much stronger relationship between breastfeeding intention and breastfeeding duration than for maternal diet and breastfeeding — as we reported for the ALSPAC study and smoking [7]. Given the importance of maternal infant feeding intention [35], researchers should measure and report intention along with other maternal variables.

5. Conclusions

Evidence of dose–response relationships between breastfeeding and other variables in observational studies should not be taken as

evidence of biological causation. Although it is tempting for researchers to assume that a gradient indicates a causal biological relationship, we should carefully consider potential confounding factors. In studies of breastfeeding practices, one of the most important confounder is maternal infant feeding intention which we regard as a mandatory data item.

Conflict of interest

The authors have no conflict of interest to declare.

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Ethical statement

Written informed consent was obtained for each participating child, and the study was approved by the Australian Institute of Family Studies Ethics Committee.

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